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**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.

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**AIR FORCE AEROSPACE STUDIES**

**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, officerhood and professionalism, Air Force officer opportunities, military customs and courtesies, and an introduction to communication skills.

The first course focuses on the foundation of officerhood 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 second 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 communication. 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.

**AS 2001. THE EVOLUTION OF USAF AIR AND SPACE POWER I.**

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. Utilizing this perspective, the course covers a time period from the first balloons and dirigibles to the space-age global positioning systems of the Persian Gulf War. Historical examples are provided to extrapolate the development of Air Force capabilities (competencies), and missions (functions) to demonstrate the evolution of what has become today’s USAF air and space power. As a whole, the AS 2000 sequence of courses provides the student with a knowledge level understanding for the general element and employment of air and space power.

The first course covers the factors leading to the early development of air power through the use of air power during World War II. The development of oral and written communication skills is continued from the AS 1000 classes. The course includes one hour of class work and two hours of mandatory leadership laboratory per week. The AS 2001 Leadership Laboratory continues a 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 each 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 doctoral 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 junior 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 junior 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 junior officer. The third course emphasizes teambuilding, 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. The second 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 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 third 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 final course focuses on the national security process, regional studies, advanced leadership ethics, and Air Force doctrine. The final 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 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.

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 interrelationship of people and environment and applications to various fields of technology. The course includes field trips and a significant laboratory component.

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 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 bioremediation, bioenergy and metabolite engineering, bioinformatics, and mathematical modeling of biological systems.
Recommended background: high school biology and chemistry.

BB 1045 BIODIVERSITY
Cat. I
This course is an integrated survey of the plant and animal 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 kingdom 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 to 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 1040.

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 2250. CELL BIOLOGY.
Cat. I
This entry level course, recommended for all BCO, 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 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 2007-08 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 will those organisms and metabolic schemes of current or potential usefulness in bioprocess technology.
Recommended background: BB 2002, BB 2530.
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. The occurrence of neurological diseases and disorders will be discussed. Some guided reading of the primary literature will be included.
Recommended background: BB 2530, 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 2530 Cell Biology or BB 1001, Introduction to Biology. Suggested background: Concurrent Laboratory Module: BB 3511 (Nervous and Muscle Physiology). Students who have received credit for BB 2130 (Human Anatomy) may not take BB 3101 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 2530 (Cell Biology); either 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. I
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 2530, CH 1020.

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 2530, BB 2920, at least one of (BB 1045, BB 2040).
This course will be offered in 2007-08 and in alternating years thereafter.

BB 3160. BEHAVIORAL ECOLOGY.
Cat. I
This course will deal with the interface among the fields of animal behavior, ecology, and evolution. Adaptive advantage (or disadvantage) conferred by behaviors at the individual and social level will be studied. Topics will include individual decision-making in response to the environment, cooperation and conflict among individuals, kin selection, parental investment theory, sexual and natural selection and the evolution of social behavior, and sensory systems and the design of signals.
Recommended background: BB 1045, BB 2040, BB 3140.

BB 3170. PLANT MORPHOLOGY AND DEVELOPMENT.
Cat. II
This course will focus on the form and function of developing plant structures. Beginning with the unidimensional plant cell, the course will progress to include tissue and organ anatomy and will cover the phenomena responsible for defining the gross morphology of the organism. Coverage of these topics will culminate in an understanding of the integrated development of the whole plant. Some guided reading of the primary literature will be included.
Recommended background: BB 2030 and BB 2530.
This course will be offered in 2007-08 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 2007-08 and in alternating years thereafter.
Recommended background: BB 2040, BB 2920, BB 4910.

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 immunocompetence, immunogenetics and immune responses. Readings from research literature will be assigned.
Recommended background: BB 2550, BB 2920, CH 4110, and CH 4120.

BB 4008. CELLULAR 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 phages 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 viral 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 2002, BB 2550, BB 4910.

BB 4070. SEPARATION OF BIOLOGICAL MOLECULES.
Cat. I
This course provides a detailed 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 at the laboratory scale. It is intended for biology / biotechnology majors, chemical engineering and biochemistry students.
Recommended background: knowledge of the topics in CH 4110 and CH 4120.
Students who have received credit for BB 4060 may not take BB 4070 for credit.

BB 4160. POPULATION GENETICS AND PHYLOGEOGRAPHY.
Cat. II
In this course we will explore how evolutionary and geographic processes contribute to the diversity of organisms. Topics will include gene flow and population structure, empirical measures of genetic variation, the roles of genetic drift and natural selection in population genetics, theoretical modes of speciation, species concepts and definitions, and molecular phylogenetics. The course will be presented in a combination of lecture and seminar format, with readings from texts and the primary literature.
Recommended background: BB 2400, BB 2920, BB 3140, and MA 1021-1022.
This course will be offered in 2008-09 and in alternating years thereafter.

BB 4170. MOLECULAR ECOLOGY.
Cat. II
This course will emphasize the application of molecular genetic techniques to basic and applied research in ecology. The format for this course will be primarily reading- and writing-intensive seminar, with student-led study and discussion of cutting-edge primary literature. A strong background in both molecular genetics and ecology is recommended. Topics may include the use of genetic markers for studies of social evolution, molecular population genetics and phylogeography, conservation genetics, and the ecological impacts of biotechnology.
Recommended background: BB 2400, BB 2920, BB 4010 and BB 4060.
This course will be offered in 2007-08 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, cancer, Alzheimers disease, thrombosis, haemostasis, neurotropic factors, and gene therapy.
Recommended background: BB 2530.

BB 4910. ADVANCED MOLECULAR BIOLOGY.
Cat. I
This advanced level course explores 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. This course is intended for students who seek an in-depth understanding of gene function.
Recommended background: BB 2550, BB 2920, BB 4955, CH 4110, 4120 and 4130.

BB 4955. RECOMBINANT DNA PRINCIPLES AND APPLICATIONS.
Cat. I
This course surveys both theory and applications in recombinant DNA methodology. Topics covered include enzymology of DNA manipulation, construction and isolation of recombinants; plasmid and bacteriophage vectors; structural analysis of cloned DNA.
Recommended background: prior knowledge of BB 2002, BB 2550, BB 2920, BB 4010, and basic molecular biology will be assumed.

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

BIOLGIC AND BIOTECHNOLOGY LAB COURSES

BB 2901. MOLECULAR BIOLOGY, MICROBIOLOGY, AND GENETICS
Cat. 1 (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:
The use and identification of bacteria in the laboratory
Handling- Restriction digestion- and visualization- of DNA
Plasmid purification and cloning
Examples of classic genetics
Recommended background: One or more 1000/2000 BB courses

BB 2902. ENZYMES, PROTEINS, AND PURIFICATION
Cat. 1 (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:
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. 1 (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. 1 (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 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 2940 or 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 data mining, comparison of nucleotide and/or protein sequences, and the analysis of nucleotide and protein sequences. Course will be primarily computer based, but may have a small wet lab component.

Recommended background: BB 2920, BB 2901, and CH 4110.  
Concurrent or prior registration in BB 4910 or CH 4130 is recommended.  
Students who have received credit for BB 324X may not receive credit for BB 3524.

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: BB 1045 and BB 2903.  
Concurrent or prior registration in BB 3120 is recommended.  
Students who have received credit for BB 325X may not receive credit for BB 3525.

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 3035 Microbial Physiology and BB 4070/560 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.  
Specially 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.
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.

**BIOMEDICAL ENGINEERING**

The second digit for Biomedical Engineering course numbers is coded as follows:

0 — Bioinstrumentation, Biosignals, Introduction
1 — Physiology
2 — Biologic, Biosensors
3 — Design
5 — Biomechanics, Biological Systems
6 — Biofluids
8 — Biomaterials

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

**BME 1001. INTRODUCTION TO BIOMEDICAL ENGINEERING.**

Cat. I

Lectures, demonstrations, hands-on experimentation, and scientific literature readings in the major branches of biomedical engineering. A series of laboratory demonstration/experiments are utilized to complement key concepts covered in various lectures.

**BME/ECE 2204. BIOELECTRO FOUNDATIONS.**

Cat. I

An introduction to the origins and characteristics of the electric and electromagnetic signals that arise in biological tissues. Topics include the behavior of excitable cells and tissues, the intrinsic electrical and magnetic properties of biological tissues, and the response of excitable cells to electric and magnetic field stimulation. Laboratory projects include the measurement of bioelectric signals (EMG, EKG, EEG, EOC, and evoked response) and the fundamentals of data acquisition, analysis, and statistics. The principles of writing and maintaining a laboratory notebook are also developed and used.

Recommended background: BB 2550 or equivalent, PH 1120 or PH 1121.

Students who have received credit for BME 4101 may not receive credit for BME 2204.

**BME 2504. FOUNDATIONS IN BIOMECHANICS.**

Cat. I

This course is an introduction to the analysis of the musculoskeletal systems using principles of engineering mechanics. Basic principles of mechanics, stress, strain and deformation in beams are presented and used to characterize the material properties of tissues such as skin, tendon, ligament, bone and cartilage. Principles of biomechanics are also applied to the design of medical devices and bioengineered tissues. Topics include forces, moments of forces, free body diagrams, principal stresses, transverse shear stresses and beam loading.

Recommended background: BB 2550 or equivalent, MA 2051, PH 1110 or PH 1111.

Students who have previously received credit for BME 4504 may not receive credit for BME 2504.

**BME 2504. FOUNDATIONS IN BIOLOGICAL TRANSPORT PHENOMENA.**

Cat. I

This course is an introduction to the analysis of complex biological systems using principles of transport phenomena. Basic theories of momentum transport, mass transport and energy transport are presented and applied to cellular and mammalian physiology. Principles of transport phenomena are also applied to the design of medical devices and bioengineered tissues. Topics include differential and integral balances, theory of Newtonian and non-Newtonian fluids, diffusion in reacting systems and homogeneous vs. heterogeneous reaction systems.

Recommended background: BB 2550 or equivalent, MA 2051, PH 1110 or PH 1111.

Students who have received credit for BME 3101 may not receive credit for BME 2604.

**BME/ECE 3011. BIOINSTRUMENTATION 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 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 2008-09, and in alternating years thereafter.

**BME/ECE 4023. BIOMEDICAL INSTRUMENTATION DESIGN I.**

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, and BME 3011.

This course will be offered in the 2008-09 academic year and in alternating years thereafter.

**BME 4025. BIOMEDICAL INSTRUMENTATION DESIGN II.**

Cat. II

This course builds on the fundamental knowledge of bioinstrumentation and biosensors presented in BME3011. Lectures and hands-on laboratory experiments cover the principles of biosensor interfacing, low-level measurements, analog-to-digital and digital-to-analog signal conversion, microprocessor and microcontroller based biomedical instrumentation, and programming.

Recommended background: BME 2204, and BME 3011.

This course will be offered in the 2007-08 academic year and in alternating years thereafter.

**BME/ECE 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 2008-09, 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 prosthetics.

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, ME 3501), Mathematics (MA 2051).

This course will be offered in 2007-08, and in alternating years thereafter.
CHE 101. 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 stage-wise 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 203. 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 2012.

CHE 204. ADVANCED CHEMICAL PROCESSES.
Cat. I
This course builds on prior work in material and energy balances, chemical engineering thermodynamics, and stage-wise 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 301. 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 301. INTRODUCTION TO BIOLOGICAL ENGINEERING.
Cat. II
This course is an introduction to the chemical engineering principles involved in modern applications of biological engineering. Topics may include: an introduction to the field, 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 2007-08, and in alternating years thereafter.

CHE 301. APPLIED MATHEMATICS IN CHEMICAL ENGINEERING.
Cat. I
The consolidation of the methods of mathematics into a form that can be used for setting up and solving chemical engineering problems. Mathematical formulation of problems corresponding to specific physical situations such as momentum, energy and mass transfer, and chemical reactions. Analytical and numerical techniques for handling the resulting ordinary and partial differential equations and finite difference equations.
Recommended background: ordinary differential equations, partial derivatives and vectors, momentum heat and mass transfer.

CHE 301. CHEMICAL MATERIALS ENGINEERING.
Cat. II
This course is designed to provide a working knowledge in the solving of materials problems encountered by chemical engineers and in the engineering of new and improved materials used in chemical processes. The approach used is the correlation of engineering properties with atomic and microstructures, utilizing the diagnostic techniques of X-ray diffraction and spectrometry, microscopy, and phase relationships.
Topics include surface active materials such as catalysts, sorbents, filtering and separation agents, corrosion resistant materials, metals, refractories and polymers used in construction materials, particularly for pollution control.
Recommended background: basic knowledge of chemistry.
This course will be offered in 2008-09, and in alternating years thereafter.

CHE 3910. CHEMICAL AND ENVIRONMENTAL TECHNOLOGY.
Cat. II
Day trips to industrial plants provide an insight into the real world of the chemical industry. Advanced technologies for commercially producing major organic chemicals and polymers derived from them are described. Petroleum refining, catalytic and thermal petrochemical processes, soaps and detergents, specialty chemicals, and antibiotic production processes are presented at the industrial level. Large scale unit operations and processes are analyzed in the plant trips. Students see how plant layout is integrated with process and product control and environmental protection at each facility.
Particular attention is paid to plant scale processes and equipment for control of chemical spills, hazards, and environmental pollution, for safety and accident prevention, and for compliance with local and national laws.

Recommended background: general understanding of Organic Chemistry and Material Balances is assumed.

This course will be offered in 2007-08, and in alternating years thereafter.

**CHE 3920. AIR QUALITY MANAGEMENT.**

**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 2008-09, and in alternating years thereafter.

**CHE 4401. UNIT OPERATIONS OF CHEMICAL ENGINEERING I.**

**Lab**

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.**

**Lab**

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.**

**Lab**

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.**

**Lab**

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.**

**Lab**

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.

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**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 (XPS), electron microprobe, AURER, 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.**

This 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 andfluidized 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 COURSES

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

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 bioscience 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 ionic and free radical carbon-carbon bond formation.
Recommended background: CH2310, CH2320, and CH2330.
The 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 2008-09 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, electrochemical cells and the bomb calorimeter.

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 thermodynamic laws are applicable to all systems of matter, regardless of their complexity. Finally, the principles developed are applied to problems of a chemical nature, focusing on predicting the spontaneity of chemical reactions.

The material in this course will be of greatest interest to those students enrolled in the basic sciences including biology, chemistry, and physics, and in applied fields such as chemical engineering, materials science and biotechnology.

Recommended background: Students should be familiar with the material covered in the general chemistry sequence CH 1010-1040, and calculus including multi variables.

CH 3530. QUANTUM CHEMISTRY.

Cat. I

An introduction to quantum mechanics with applications to atomic and molecular species. The course will be developed systematically beginning with the postulates of quantum mechanics. The Schroedinger equation will be applied to systems such as the particle in a box, the rigid rotor, the harmonic oscillator and the hydrogen atom. Emphasis will be given to a quantum mechanical description of multielectron atoms, molecular bonding and spectroscopy.

Recommended background: a solid foundation in elementary physics and calculus.

This course is normally for students in their third year.

CH 3550. CHEMICAL DYNAMICS.

Cat. I

This course deals in a general way with the interactions between energy and molecules, and considers how energetic and structural considerations affect the outcome of molecular interactions. The manipulation of kinetic data and results is stressed. Selected topics from both organic and inorganic chemistry are analyzed in terms of reaction thermodynamics, rates and mechanisms.

Students are expected to be familiar with thermodynamics, equilibria, reaction rates and the Periodic Table of the elements.

The following three courses, CH 4110, CH 4120, and CH 4130, are a three-term sequence intended to provide a strong emphasis in biochemistry. As background for this sequence, CH 1010, CH 1020, CH 1030, CH 1040, CH 2310, CH 2320, and CH 2330, or their equivalents, are recommended.

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.

Suggested background: CH 2330.

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 detailed the following topics: Membrane Structure and Function; Channels, Carriers and Pumps; Nerve Excitation and related topics; and Molecular Biophysics of Motility.

Recommended background: prior knowledge of Biochemistry (CH 4110, CH 4120), Mechanics (PH 1110) and Electricity (PH 1120).

This course will be offered in 2007-08 and in alternating years thereafter.
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 2008-09 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 2007-08 and in alternating years thereafter.

CH 4520. 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 2007-08 and in alternating years thereafter.

CH 4550. POLYMER CHEMISTRY.

Cat. II
Fundamentals of polymer science and technology based on organic polymers. The principal mechanisms of polymerization including radical, ionic and condensation, are covered in detail. Characterization of polymers by physical means. Mechanical behavior including bulk and solution properties of polymers. Polymer syntheses and modifications including block and graft copolymerization.
Recommended background: CH 2310 and CH 2320 or equivalent.
This course will be offered in 2007-08 and in alternating years thereafter.

CH 516. CHEMICAL SPECTROSCOPY.

Advanced topics in identification of organic species and determination of molecular structure by spectroscopic methods.
Recommended background: CH 2310, CH 2320, and CH 2330.
This course will be offered in 2008-09 and in alternating years thereafter.

CH 533. PHYSICAL ORGANIC CHEMISTRY.

Mechanics of representative organic reactions, and the methods used for their evaluation. Structural, electronic, and stereochemical influences on reaction mechanisms are explored. Emphasis is on the various techniques used to obtain insights into mechanisms, and on the interplay of data and interpretation.
Suggested background: CE 1030.
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 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.  
Suggested 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 2008-09 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 ethics and professional relationships with the client, other professional organizations and groups, the public, and the regulatory system.  
Recommended background: CE 3020.  
Offered in 2007-08 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 2008-09 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 drawing, 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 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.  
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 2008-09 and in alternating years thereafter.

CE 3050. INTRODUCTION TO TRANSPORTATION ENGINEERING.  
Cat I  
This course provides an introduction to the field of transportation engineering with particular emphasis on engineering and highway design. 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, level of service analysis; geometric design of highways; paving materials and pavement design.  

CE 3051. INTRODUCTION TO PAVEMENT MATERIALS, DESIGN AND MANAGEMENT.  
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 is an introductory course in the area of environmental engineering. The course should also be of interest to students who require an overall understanding of environmental engineering problems. Topics covered include: environmental impact of population growth and energy demand, water resources, water chemistry, water quality standards, environmental microbiology, wastewater characteristics, receiving water quality and dissolved oxygen budgets, water pollution abatement, sludge management, solids and hazardous waste management, and an introduction of air and noise pollution.  
Recommended background: CH 1010 and CH 1020 or equivalent.
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 biogeochemical 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.
The 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 population growth and distribution patterns, and the impact of such patterns to the natural environment.
By using the principles and procedures of planning, the optimal growth 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 delibera-
tive choice in accordance with evaluation criteria, is obtained through extensive reading.
As such the course introduces a variety of topics of concern to engi-
neers and environmentalists.
The course is intended not only for civil engineering majors, but also for students preparing for an IQP in areas of urban or environmental concerns.

CE 3074. ENVIRONMENTAL ANALYSIS.
Cat. I
This course provides a background in the principles and techniques of assessing areas of natural environment and the application of this assessment to evaluate the inherent suitability for urban and resource based uses and facilities.
The techniques developed in this course will be useful for land use planning, site design, and the impact of engineering projects on the environment.
Suggested background: CE 3070.

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 2008-09 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 2007-08 and in alternating years thereafter.

CE 4016. 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 discus-
sion 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 2007-08 and in alternating years thereafter.

CE 4054. SOIL AND BITUMINOUS MATERIALS LABORATORY.
Cat. I
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, compres-
sion 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.

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. I
This course provides a quantitative description of the rainfall and runoff process for use in design of water resources related projects.
The topics include: the review of the hydrologic cycle, precipitation, evaporation, transpiration, infiltration, stream flow measurements, flow routing, runoff analysis, show hydrology and development of drainage estimates for development plans. The course involves a stream measurement laboratory and application of model for hydrological and hydraulic engineering applications.
Recommended background: ES 3004.

CE 4071. LAND USE DEVELOPMENT AND CONTROLS.
Cat. I
The purpose of this course is to provide an understanding of how land use controls may be used to effectively shape our physical, social, and economic development.
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 tech-
niques which a planner may use to plan the uses and development of land.
In particular, the use and limits of zoning, special permits, hammerhead lots, subdivision control, comprehensive permits, and other tools with which a developer of planner board member should be familiar will be examined in detail.

COMPUTER SCIENCE

CS 1101. INTRODUCTION TO PROGRAM DESIGN.
Cat. I
This course introduces principles of computation and programming with an emphasis on program design.
The topics include design and implementation of programs that use a variety of data structures (such as records, lists, and trees), functions, conditionals, and recursion.
Students will be expected to design, implement, and debug programs in a functional programming language.
Intended audience: students desiring an introduction to programming and program design.
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 (potentially topics include macros, lazy programming with streams, and program-
ing with higher-order functions).
Students will be expected to design, imple-
ment, and debug programs in a functional programming language.
Intended audience: students starting with substantial previous programming background.
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 2303. SYSTEMS PROGRAMMING CONCEPTS.
Cat. I
This course introduces students to a model of programming where the program- 
language exposes details of how the hardware stores and executes soft- 
ware. 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 
the system-level constructs. The course will cover several tools that assist program- 
mers in these tasks. Students will be expected to design, implement, and debug 
programs in C++ and C.

Undergraduate credit may not be earned both for this course and for CS 2005.

CS 3031. OPERATING SYSTEMS.
Cat. I
This course makes the student aware of the social, moral, ethical, and philo-
sophical impact of computers and computer-based systems.

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.

Intended audience: computer science majors and others interested in studying 
the software and hardware components of computer systems.

Undergraduate credit may not be earned both for this course and for CS 502.

Recommended background: CS 2005 or CS 2121.

CS 3041. HUMAN-COMPUTER INTERACTION.
Cat. I
This course develops in the student an understanding of the nature and impor-
tance of problems concerning the efficiency and effectiveness of human interac-
tion 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 two projects. A project might be a 
software evaluation, interface development, or an experiment.

Intended audience: computer science majors, especially juniors.

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 philo-
sophical 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 writing assignments.

Intended audience: students interested in the impact of a computer-oriented 
technology on his or her future way of life and well-being. This course is highly 
recommended for juniors.

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 theoretical foundations of computer science. These 
form the basis for a more complete understanding of the proficiency in com-
puter science.

Topics include computational models, formal languages, and an introduction to 
compatibility and complexity theory, including NP-completeness.

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

Intended audience: computer science majors and others desiring an under-
standing of the theoretical foundations of computer science.

Undergraduate credit may not be earned both for this course and for CS 503.

Recommended Background: CS 2222 and CS 2223.

Students who have credit for CS 2121 cannot receive credit for CS 3133.

Students graduating under the pre-1996 distribution requirements may satisfy the 
Theory area requirement by taking this course, although it does not count as a 
400-level course.
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.
Outcome: Students will be expected to design and implement database system applications.
Intended audience: computer science majors and others interested in studying the development of software applications with large data management requirements.
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 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.
Intended audience: computer science majors and others who expect to design software systems. 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 4023/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 2071. An ability to write computer programs in a scientific language is assumed.

CS 4033/MA 3457. 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 both for 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.
Intended audience: computer science majors.
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 2008-09 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 program, 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.
Intended audience: computer science majors and others desiring an understanding of the nature of computation.
Undergraduate credit may not be earned both for this course and for CS 553.
Recommended Background: CS 3133.
This course will be offered in 2007-08 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 2007-08 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 exemplified 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, etc.).
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.
Intended audience: computer science majors.
Undergraduate credit may not be earned both for this course and for CS 534.
Recommended background: CS 2102 and CS 2223.
Suggested background: CS 3133.

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.
Outcome: Students may be expected to design and implement software components that make up modern database systems.
Intended audience: computer science and computer engineering majors.
Undergraduate credit may not be earned both for this course and for CS 542.
Recommended background: CS 2303 and CS 3733.
This course will be offered in 2007-08 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: CS 4341 Introduction to Artificial Intelligence, MA 2611 Applied Statistics I, and CS 3431 Database Systems I.
This course will be offered in 2008-09 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.
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 3013 and a knowledge of probability, such as provided by MA 2621.
CS 4514. COMPUTER NETWORKS: ARCHITECTURE AND IMPLEMENTATION.

Cat. I
This course introduces principles and current trends in computer networks. The ISO Reference Model will be used as the framework with the course progressing through the physical, data link, network, transport, session, and presentation layers with specific examples and standards cited throughout for point-to-point, satellite, packet-radio, and local area networks.

Topics include motivation and objectives of computer networks, overview of network architectures, layered architectures, performance analysis, virtual circuits, datagrams, routing control, local area networks, internetworking, end-to-end communication, virtual terminal, file transfer protocols, and client-server programming.

Students will be expected to design and implement projects such as simulation of the network/transport layer functions, routing, congestion control, an Ethernet controller, applications using TCP/IP or remote procedure calls. Intended audience: computer science and computer engineering majors.

Undergraduate credit may not be earned both for this course and for CS 513.
Recommended background: CS 3013 and some knowledge of probability.

CS 4515. COMPUTER ARCHITECTURE.

Cat. II
This course explores modern computer architectures in terms of instruction sets and the organization of processors, controllers, memories, devices, and communication links.

Topics include an overview of computer systems, theoretical foundations, modern computer system components, pipelining of instruction sets, multifunction pipelines, parallel computer organization.

Students will be expected to design and implement programs which simulate significant components of modern computer architectures.

Intended audience: computer science and computer engineering majors.
Recommended background: CS 2011 or ECE 2801, and CS 3013.
This course will be offered in 2008-09 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.

Intended Audience: computer science and computer engineering majors.
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 2008-09 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.

Intended audience: Computer majors and minors interested in understanding how programming languages work and how to implement their own small languages.

Recommended background: CS 2303, CS 3313, 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 2007-08 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.

Intended audience: computer science majors.
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.

Intended audience: computer science majors.
Recommended background: CS 4731.
This course will be offered in 2007-08 and in alternating years thereafter.

ELECTRICAL AND COMPUTER ENGINEERING

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

0 — Circuits
1 — Fields
2 — Electronic Circuits and Systems
3 — Signals and Communication Systems
4 — Available for Future Use
5 — Machines, Power Systems
6 — Professional and Miscellaneous
7 — Projects, Laboratory, Independent Study
8 — Computers
9 — Electronic Devices

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 2101. INTRODUCTION TO ELECTRICAL AND COMPUTER ENGINEERING.

Cat. I
The objective of this course is to expose new electrical engineering students (including first year students) to the broad field of electrical engineering, introducing basic concepts of circuits and systems and their applications. Experiments based on practical devices are used to reinforce basic concepts and develop laboratory skills, as well as to provide system-level understanding.

The use of circuit simulation tools for analysis and design is introduced.

Topics: Basic concepts of electrical circuits, linear circuit analysis, op-amp circuits, simple transients, phasor analysis, amplifiers, frequency response, filters.

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

ECE 2202. 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 2111 and MA 1022.

ECE 2111. PHYSICAL PRINCIPLES OF ECE APPLICATIONS.

Cat. I
In this course students will learn the practical aspects of electromagnetics and their relation to basic DC and AC circuit theory.

The meaning of the electric and magnetic field concepts is explained and placed in context with capacitive and inductive circuits. Exploiting those concepts leads to a host of practical devices such as transformers, motors, and generators. In addition, measures to minimize the influence of stray electric and magnetic fields are analyzed as part of various shielding and grounding strategies.

The electric and magnetic circuit aspects are then presented as linear first order systems in the time and frequency domains. Issues such as time constants, impedance, and superposition are explained in detail. Building upon these basic concepts, second order systems consisting of mixed capacitive and inductive systems are analyzed in terms of their resonance effects. The second order system description will then be applied to develop the basic transmission line theory as required in high-speed digital design.

Recommended background: ECE 2111, introductory physics courses such as PH 1120 or PH 1121, MA 1024, MA 2031 (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 Amper’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, transistors, rectification, voltage regulation, limiting and clamping circuits, transistor operation, biasing, small-signal and large-signal models, transistors amplifiers, and switching applications.

Recommended background: ECE 2071.

ECE/BME 2204. BIOELECTRONIC FOUNDATIONS.

Cat. I

An introduction to the origins and characteristics of the electric and electromagnetic signals that arise in biological tissues. Topics include the behavior of excitable cells and tissues, the intrinsic electrical and magnetic properties of biological tissues, and the response of excitable cells to electric and magnetic field stimulation. Laboratory projects include measurement of bioelectric signals (EMG, EEG, EKG, EOG, and evoked response) and the fundamentals of data acquisition, analysis, and statistics. The principles of writing and maintaining a laboratory notebook are also developed and used.

Recommended background: BB 2550 or equivalent, PH 1120 or PH 1121.

Students who have received credit for BME 4101 may not receive credit for BME 2204.

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; linearity properties; impulse response, convolution, and 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 2071, 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 Z transform 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, ECE 2111, and ECE 2311; and either ECE 2201 or ECE 2801.

ECE 2801 FOUNDATIONS OF EMBEDDED COMPUTER SYSTEMS.

Cat. I

This course introduces the 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 language assembly 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, microprocessors and microcontroller architecture and assembly language programming, program development and test tools, operating system interfaces, hardware/software dependencies, and time and resource management.

Lab exercises: Introductory assembly language exercises and more advanced problems which explore topics such as logic flow, real-time programming, maintainability and software maintenance cycles. Exercises will be performed on a microcontroller and/or microprocessor based embedded systems using cross platform development tools appropriate to the target platform.

Recommended background: ECE 2022 (for ECE students) or CS 2011.

ECE/BME 3011. BIOMEDICAL INSTRUMENTATION 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.

ECE 3113. INTRODUCTION TO RF CIRCUIT DESIGN.

Cat. I

This course is designed to provide students with the basic principles of radio frequency (RF) circuit design. It concentrates on topics such as designing tuning and matching networks for analog and digital communication, satellite navigation, and radar systems.

After reviewing equivalent circuit representations for RF diodes, transistors, FETs, and their input/output impedance behavior, the course examines the difference between lumped and distributed parameter systems. Characteristics impedance, standing waves, reflection coefficients, insertion loss, and group delay of RF circuits will be explained.

Within the context of Maxwell’s theory the course will then focus on the graphical display of the reflection coefficient (Smith Chart) and its importance in designing matching circuits. Students will learn the difference between SPACE and monolithic transistors. Toward the end of the course, basic concepts of frequency-domain 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 3204.

Suggested background: ECE 2112.

ECE 3204. MICROELECTRONIC CIRCUITS II.

Cat. I

This course is the second of a two-course sequence in electronic circuit design. More complex circuits are analyzed and the effects of frequency and feedback are considered in depth. The course provides a comprehensive treatment of operational amplifier characterization and limits of feedback, the operational amplifier, and the design of operational amplifiers. Content is presented along with techniques for interfacing and analyzing analog and digital circuits.

Recommended background: MA 2051, ECE 3601, or equivalent.

ECE/BME 3205. BIOMEDICAL INSTRUMENTATION AND BIOSENSORS.

Cat. I

This course covers the use of electronic and computer systems in biomedical instrumentation and measurement. Topics include: transducers; differential amplifiers, inverting/non-inverting amplifiers, summers, differentiators, integrators, passive and active filters, the Schmitt trigger, monostable and astable oscillators, and sample-and-hold circuits, A/D converters, and D/A converters.

Recommended background: Introductory electronic-circuit design and analog-signal analysis as found in ECE 2201 and ECE 2311.

ECE 3305. AEROSPACE AVIONICS SYSTEMS.

Cat. I

This course is intended for students interested in obtaining a systems-level perspective of modern aerospace communications, navigation, and radar systems. The fundamental theory of operation of these systems is presented along with current-day applications of them.

Topics: The functional operating principles and techniques of communications, navigation (including GPS and INS), radar, and electronic warfare; performance expectations for antenna, transmitter, receiver, and transmission-line components; error sources and their effect in combination on both individual component and aggregated system performance; earth-shape approximations and their influence on system design and operation; tropospheric and ionospheric effects of radio-wave propagation; and achievable overall system accuracies.

Recommended background: MA 2052 and PH 1120 or equivalent. With extra work, this course can be successfully completed by non-ECE students. The basic concepts of electromagnetic-wave propagation and antennas will be introduced as needed.

Suggested background: ECE 2312.
ECE 3308. INTRODUCTION TO WIRELESS NETWORKS
Cat. I
This course is intended for students interested in obtaining a systems-level perspective of modern wireless networks. It starts with an overall understanding of telecommunication and computer communication networks. Then the fundamental theory of operation of wireless networks, as well as described description of example networks will be covered. Topics included in the course are an overview of computer networks, an overview of wireless network standards and protocols, radio channel modeling and medium access control, deployment of wireless infrastructures, and examples of voice- and data-oriented wireless networks using TDMA, CDMA, and CSMA access methods. Recommended background: MA 1022 and PH 1120; suggested background: ECE 2312. With extra work, this course can be successfully completed by non-ECE students. Additional applications may be covered in student projects. Recommended background: PH 1140, ECE 2311, ECE 2312.

ECE 3501. ELECTRICAL ENERGY CONVERSION.
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. Topics: Review of poly-phase circuits. Transducers and instrumentation for power and energy measurements. Rotating machines. Electromechanical transients and stability. Switchgear equipment. Selected laboratory experiments. Recommended background: ECE 2111.

ECE 3503. POWER ELECTRONICS.
Cat. I
This course is an introduction to analysis and design of power semiconductor circuits used in electric motor drives, control systems, robotics and power supply. Topics: characteristics of thyristors and power transistors. Steady-state performance and operating characteristics, device rating and protection, commutation, gating circuits, ac voltage controllers, controlled rectifiers, dc/dc converters and dc/ac inverters. Laboratory exercises. Recommended background: ECE 2201, ECE 2311 or equivalent.

ECE 3601. PRINCIPLES OF ELECTRICAL ENGINEERING.
Cat. I
Intended for students other than electrical engineers, this course is oriented towards developing competence in electrical engineering concepts on the level that the technology interfaces directly with their own discipline. The course is designed specifically to help students meet that challenge through the development of a broad systems perspective and an understanding of the principal elements of electrical engineering technology. The expectation is that students completing the course will be able to handle adequately the electrical aspects of a broad range of application topics. In addition, and most important, they will be prepared to work effectively with electrical engineers on the joint solution of complex problems. Topics covered during the course include: direct current (DC) circuit analysis and design, alternating current (AC) circuit analysis and design, circuit design using operational amplifiers, and electric machines and power systems. Selected laboratory projects are included to emphasize the direct application of the information presented in lectures. Recommended background: MA 1021-1023, MA 2051, PH 1120/1121 or equivalent.

ECE 3711. INTRODUCTION TO ELECTRO-OPTICS.
Cat. I
The purpose of this course is to give students the opportunity to acquire a fundamental understanding of optoelectronics and principles of optoelectronic device operation. At the completion of this course the students should achieve an understanding of wave phenomena and an appreciation of basic optical components. The students will obtain a background in modulation of light and a working knowledge of display devices based on photoluminescence and cathodoluminescence, and will gain insight into light emitting diodes, LED materials and liquid crystal displays. A review of the concepts of lasers will be presented, leading to an appreciation of the different laser types, especially the semiconductor laser. The students will be given a working knowledge of the optical fiber categories and operation as well as critical aspects of fiber optic communication systems. Additional applications may be covered in selected projects. Recommended background: PH 1140, ECE 2311, ECE 2201.

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, multipliers, latches, and counters. The concept of synchronous logic is introduced through the design and implementation of Mealy and Moore machines. Hardware description languages are introduced and used to describe and implement combinational and sequential circuits. Students will also learn how to use programmable logic devices to implement customized designs. 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. Introduction to hardware description languages. Lab exercises: Design, analysis and construction of combinational and sequential circuits, use of computer-aided engineering software for scheme entry and digital analysis, introduction to hardware description languages and programmable logic devices. Recommended background: ECE 2022 (for ECE students) or CS 2111. Suggested background: MA 2201/CS 2202.

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 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, I/O and control signaling, bi-directional bus interfaces, instruction execution cycles, interrupts and debugging, 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 2005, CS 2301 or CS 2303 or an equivalent background in C programming.

ECE 3810. ADVANCED DIGITAL SYSTEM DESIGN
Cat. I
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 VLSI devices. The emphasis will be on understanding functional design, layout, floor planning, designing for speed and power objectives, and testing. Finally, the integration of tools and design methodologies will be addressed through a discussion of system on a chip (SOC) integration, methodologies, design for performance, and design for test/testing. Topics: 1. hardware description languages, VHDL, system modeling, synthesis, simulation and testing of digital circuits; 2. VLSI design tools, transistor level design and behavior, layout, routing, clocking and testing. 3. design integration to achieve specific SOC goals including architecture, planning and integration, and testing. Laboratory exercises: VHDL models of combinational and sequential circuits, synthesizing these models to programmable logic devices, simulating the design, test-benchs, transistor level IC design, IC design methodologies, circuit extraction and modeling, and high level SOC design methodologies. Recommended background: ECE 3801 and experience with programming in a high-level language such as C or Pascal. Suggested background: ECE 3901 and ECE 3903.

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. Topics: filtering, frequency domain (Fourier analysis), continuous and discrete signals, determinis- tic 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 2008-09, and in alternating years thereafter.

ECE/BRME 4011. BIOMEDICAL SIGNAL ANALYSIS.
ECE/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 spread function, 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.
This course will be offered in 2008-09, and in alternating years thereafter.

ECE 4304. DIGITAL COMMUNICATION SYSTEMS.
Cat. I
This course introduces the principles of digital communication systems including digital modulation, demodulation, and optimal receiver design. The mathematical treatment of noise as a random process is developed in the context of baseband and passband transmission systems. Analytical and simulation-based techniques are developed for evaluating the performance of digital communication systems with noisy channels. Tradeoffs between modulation formats, including bandwidth-efficiency and energy-efficiency, are exposed. Practical receiver design issues including synchronization and timing recovery are also discussed.
Recommended background: ECE 3311, familiarity with Matlab, and familiarity with basic probability.

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.

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, FM detectors, 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 3901.

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 4901 if they have received credit for ECE 3901.
This course will be offered in 2007-08, and in alternating years thereafter.
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, drying, 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.  
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 3323. 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 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 2500, ME 3320), machining and manufacturing methods (ME 1800) and higher level programming capability (CS 1103 or CS 1102) is helpful.

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.**  
Cat. II  
(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.  
Offered 2007-08 and alternating years thereafter.

**FPE 521. FIRE DYNAMICS I.**  
Cat. I  
(Prerequisites: Undergraduate chemistry, thermodynamics [or physical chemistry], fluid mechanics and heat transfer.) This course introduces students to fundamental principles 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 for introducing compartment fire behavior, pre and post-flashover conditions and smoke movement.

**FPE 553. FIRE PROTECTION SYSTEMS.**  
Cat. I  
(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.**  
Cat. II  
(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.  
Offered 2006-07 and alternating years thereafter.
FPE 555. DETECTION, ALARM AND SMOKE CONTROL.
Cat. II
(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. Offered 2006-07 and alternating years thereafter.

FPE 563 (OIE 541). OPERATIONS RISK MANAGEMENT.
Cat. I
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 565. FIRESAFETY ENGINEERING EVALUATION.
Cat. II
(Prerequisites: FPE 521, FPE 553 and FPE 570.) This course develops techniques to evaluate the firesafety performance of a variety of facilities in the built environment and to produce management plans for decision making. The framework for this course is a firesafety engineering method which decomposes the firesafety system into discrete elements that can be used for quantitative evaluation using a variety of fire protection engineering and fire science materials. Offered 2006-07 and alternating years thereafter.

FPE 570. BUILDING FIRESAFETY I.
Cat. 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.
Cat. I
(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.
Cat. I
(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.
Cat. I
(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 574 (CHE 594). PROCESS SAFETY MANAGEMENT.
Cat. I
(Prerequisite: An undergraduate engineering or physical science background.) This course provides basic skills in state-of-the-art process safety management and hazard analysis techniques including Hazard and Operability Studies (HAZOP), Logic Trees, Failure Modes and Effects Analysis (FMEA) and Consequence Analysis. Both qualitative and quantitative evaluation methods will be utilized. Following a case study format, these techniques along with current regulatory requirements will be applied through case projects addressing environmental health, industrial hygiene, hazardous materials, fire or explosion hazard scenarios.

FPE 575. EXPLOSION PROTECTION.
Cat. II
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. Offered 2007-08 and alternating years thereafter.

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.
Cat. II
(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. Offered 2006-07 and alternating years thereafter.

FPE 590. M. S. THESIS.

FPE 690. PH. D. DISSERTATION.

HUMANITIES AND ARTS COURSES

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 storyboarding 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 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 2113. TOPICS IN 19TH- AND 20TH-CENTURY ARCHITECTURE.
Cat. I
This course considers the built environment in a non-technical way. It explores changes in architectural style as responses to the industrial transformation of Europe and America and to changing ideas about the purpose of art. The focus will vary from year to year and may concentrate on new uses of past styles, the architecture and planning of the industrial city, the careers of the great modern architects from Wright to Mies, or current topics in design. The central topic will remain the development of the Modern Movement in architecture. Students will use local buildings to learn the methods of architectural history and explore the aesthetic effects of architecture.
AR 3000. 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.

AR 3112. MODERNISM, MASS CULTURE, AND THE AVANT-GARDE.
Cat. I
What is the role of art to be in the modern world? Can art be a vehicle for social change, or should art be a self-critical discipline that pursues primarily aesthetic ends? What is the relationship between art and mass culture? Using primary sources, this course focuses on some of the theorists and artistic trends in the mid-nineteenth century that have sought to resolve this dilemma. These include: Ruskin, Morris and the Arts and Crafts Movement; Art For Art’s Sake; the German Werkbund and the Bauhaus; American industrial design.

AR/ID 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 IQR. There are no specific requirements for this course, although some knowledge of college-level physics, as well as an acquaintance with the visual arts, is helpful.
This course will be offered in 2008-09 and in alternating years thereafter.

ENGLISH (EN)

EN 1221. INTRODUCTION TO DRAMA: THEATRE ON THE PAGE AND ON THE STAGE.
Cat. I
The plays studied 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. Types of drama studied could include Greek Tragedy and Comedy, Roman Comedy, Cycles and Pageants of the Middle Ages, Shakespeare, Restoration, Romanticism, Neo-Classicism, French Comedy, Realism, Naturalism, and the eclectic forms in the Twentieth Century. Discussions, 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 epics. “Not marble nor the gilded monuments of princes shall outlive this powerful rhyme.”
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 sentimentality, 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 World War I to the present. The wide-ranging material represents the literary response to the broad intellectual, social, and cultural changes that mark the history of those years of ferment in the United States. The course includes selected works of fiction, drama, poetry, and essays by such writers as William Faulkner, Toni Morrison, Thornton Wilder, Sylvia Plath, Allen Ginsberg, Joy Harjo, and Michael Harper.

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 2007-08 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 manifestations, and explores the ironies, paradoxes, and continuities that have shaped this national self-image for almost 400 years. Readings include works by Puritan and Revolutionary writers, Native American leaders, Horatio Alger, Jr., William Dean Howells, F. Scott Fitzgerald, Martin Luther King, Jr., Adrienne Rich, Studs Terkel, and Archibald MacLeish.

EN 2237. AMERICAN LITERATURE AND THE ENVIRONMENT.
Cat. II
This course will examine the many ways in which American essayists, novelists, dramatists, and poets have responded to the natural world, and especially to ecological concerns voiced in contemporary times. Among the topics to be discussed in class and in papers are the changing attitudes towards the wilderness, the effects of technology on the environment, and the presence of the spiritual in nature. Readings may include works by such authors as Ernest Hemingway, Wendell Berry, Mary Oliver, Loren Eiseley, and Gary Snyder.
This course will be offered in 2008-09 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, slum life and racial prejudice) were treated more honestly in short stories and novels after 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. Among the topics to be discussed are the changes in attitudes towards the role of the artist, the effects of technology on the environment, and the presence of the spiritual in nature. Readings may include works by such authors as Ernest Hemingway, Wendell Berry, Mary Oliver, Loren Eiseley, and Gary Snyder.
(Formerly EN 3236. Students who have received credit for this course may not receive credit also for EN 3238.)

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 2008-09 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.

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 2007-08 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 works where moral issues evolve within the complications of individual lives, as depicted in fiction. Such authors as Conrad, Kesey, Camus 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 “dumbed 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 Pirsig’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/WR 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’ literary 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 3214. WRITING ABOUT DISEASE AND PUBLIC HEALTH.
Cat. I
This writing workshop focuses on the purpose 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 capture the human experience of disease and health care; 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 2211 or equivalent writing courses. Students who have taken EN 3215 may not receive credit also for EN/WR 3214.

EN/WR 3216. WRITING IN THE PROFESSIONS.
Cat. I
Studies show that engineers spend 80-90% of their professional time engaged in various kinds of communication. This course emphasizes the major contexts of writing in the professions. Focus is on making informed decisions about approaches, styles, problems, issues, sources, strategies, and human relations aspects of writing in business, industry, and other institutional settings. Special attention is given to business editing and proposal and grant writing.
Recommended background: EN 2211 or equivalent writing course.

EN/WR 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.

EN 3222. FORMS IN WORLD DRAMA.
Cat. II
The study of the major forms of world drama beginning with the Greeks and ending with contemporary forms. The student will develop the skills to analyze form and structure through dramatic content. The course may include the works of Sophocles, Euripides, Aristophanes, the Renaissance, the Restoration, Moliere, Ibsen, Strindberg, Shaw, Pirandello, and others.
This course will be offered in 2007-08 and in alternating years thereafter.

EN 3223. FORMS IN MODERN DRAMA.
Cat. II
The study of the forms in modern drama and their development from the forms of world drama. Contemporary playwrights studied could include Brecht, Bond, Schaeffer, Handke, and others, and the course will devote some concentration to the movements of the twentieth century. The course will be offered with instructor approval and in 2007-08 and in alternating years thereafter.

HUMANITIES AND ARTS COURSES 219
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, Whittier, Freeman, Wharton, Jackson, Lovercraft, and King.  
This course will be offered in 2007-08 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 2007-08 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, 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 2008-09 and in alternating years thereafter.

Students who have received credit for EN 2226 (New England Writers: Worcester) may not receive credit for EN 3233.

EN 3234. MODERN AMERICAN POETRY.  
Cat. II  
This course is a study of selected American poets and their reactions to the ferment of the modern period. A thematic approach to poetry will be emphasized. Included in the course are modern poets such as Robert Frost, T. S. Eliot, E. E. Cummings, and Marianne Moore, as well as contemporary poets such as Rita Dove, Li-Young Lee, and Robert Pinsky.  
This course will be offered in 2008-09 and in alternating years thereafter.

EN 3237. PURSING 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 2008-09 and in alternating years thereafter.

EN 3246. 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 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 15/P  
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 2225 Acting  
TH 2227 Advanced Acting  
TH 2229 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 credits, or a total of one-third unit, may be applied toward the five courses, or five one-third units, taken prior to the final sufficiency term.

IS 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. This is a course for those electing the “Basic Sufficiency for International Students.”

IS 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 audiotapes are used to record competence and poise. This is a course for those electing the “Basic Sufficiency for International Students.”

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 2516.)

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.

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 2008-09 and in alternating years thereafter.  
Recommended background: GN 3511 (Advanced German I) and GN 3512 (Advanced German II) or equivalent.
An introduction to the methods and source material historians use to study science.

Cat. I

An introduction to the study of modern European social history since the coming of 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, 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.

Cat. I

This course surveys 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.

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.

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 the growth of labor. The course will conclude with an overview of the current global involvement of the United States.

Cat. I

This course 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.

Cat. I

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.

Cat. I

This survey of American foreign policy begins with the legacy of Woodrow Wilson, continues through our apparent isolation in the 1920's, American neutrality in the 1930's, World War II, and later Cold War periods, and concludes with an overview of the current global involvement of the United States.

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.

Cat. I

This 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.

Cat. I

A survey of the major socio-economic, political, 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 2304. 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 IQP’s 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 the society and culture. Some of the topics covered include: Bourbon absolutism; the causes 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 2006-07 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 nationalist 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 2007-08 and in alternate years thereafter.

HI 2330. HISTORY OF AMERICAN SCIENCE AND TECHNOLOGY.
Cat. I
This course surveys American science and technology from the colonial period to the present. Topics will include: the influence of the Scientific Revolution in the United States; the American Industrial Revolution; the rise of science as a profession; 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 2334. EUROPEAN TECHNOLOGICAL DEVELOPMENT.
Cat. I
A survey of the development of technology in Europe from the late medieval period to World War I. Emphasis will be placed on understanding the evolution of technology within its cultural, social, and political contexts. Topics may include the military, mechanical, maritime, and building technologies of the medieval and Renaissance periods; the commonly misunderstood figure of Leonardo da Vinci; the causes and nature of the Industrial Revolution; the effects of the British Industrial Revolution in France and Germany in the 19th century; the transition from craft-based industries to those that are science based such as the dyestuffs and electrical power industries; World War I as a technological conflict.

HI 2341. CONTEMPORARY WORLD ISSUES IN HISTORICAL PERSPECTIVE.
Cat. I
This course examines the historical origins of contemporary global crises and political transformations. Students keep abreast of on-going 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 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 2007-08 and in alternating years thereafter.

HI 2342. CULTURES IN CONTACT: THE WORLD TO 1650.
Cat. II
This course surveys global history from the adoption of agriculture to the initial expansion of Islam; The Crusades; European encounters with the New World; the silk road; exchanges around the Indian Ocean; the effects of the British Industrial Revolution in France and Germany in the 19th century. We may consider topics such as racial, nationalist, feminist and nationalist 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 2007-08 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 2006-07, and in alternate years thereafter.

HI 2351. HISTORY OF ECOLOGY.
Cat. II
A survey of ecological thought from origins in ancient ideas about nature and the human place in nature, through the environmental thought of the Romantic Movement and responses to industrialization in the United States, and of the rise of ecology as a scientific discipline, this course will examine both the development of ecological sciences themselves and the relationship of the science of ecology to historically evolving schools of environmental thought.
This course will be offered in 2008-2009 and in alternate 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 through 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 ideas and goods 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 2007-2008 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 non-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 2007-2008 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 geographical focus such as cities or New England. The course will require substantial reading and writing. Suggested background: HI 2314 (American History, 1877-
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 2007-2008, 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 2007-08 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 2007-08 and in alternating years thereafter.

HI 3331. TOPICS IN SCIENCE, TECHNOLOGY, AND SOCIETY.  Cat. I
A seminar course on the relationships among science, technology, and society in Europe through a series of case studies. Topics from which the case studies might be drawn include: the harnessing of science for industrial purposes; the role of the chemical industry in war; the function of the science advisor in government; the military-industrial complex in Nazi Germany; the political views and activities of major scientists such as Einstein.
Suggested background: Courses in European history and the history of science and technology.

HI 3333. TOPICS IN AMERICAN TECHNOLOGICAL DEVELOPMENT.  Cat. I
A seminar course examining selected examples of technological change in the United States. Topics from which these case studies might be chosen include: colonial technology; mechanization of ante-bellum industry; the impact of science on Gilded-Age technology; 20th-century behavioral technologies; the evolution of the military-industrial complex; the Manhattan Project; the exploitation of space; computers and post-World-War-II technology; and the emergence of biotechnology. In addressing these cases, this seminar will employ and seek to evaluate one or more significant historical theses about the nature of technological change.
Suggested background: Some familiarity with the basic outlines and concerns of both American history and the history of American technology.

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 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 economies 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 2008-09 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 civilizations 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 2008-09 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.

IS 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. Readings will include primary and secondary sources. 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 Sufficiencies. 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 Sufficiency in the final IS/P seminar.

HU 1401. INTRODUCTION TO HUMANITIES & ARTS, I.  Cat. I
This course is open to students enrolled in the Project-based Learning Community. The course focuses on developing basic skills of humanistic inquiry: careful analysis of complex arguments and evidence; accurate description and assessment of texts; and appreciation of the diversity of opinions and interpretations of materials. Students examine core readings in history, literature, or philosophy, and participate in team-oriented projects concerning real-world problems that cross the boundaries of the humanities, sciences, mathematics and technology. Projects vary and may include areas such as the history of science, contemporary affairs, international relations, and quantitative analysis of social issues.

HU 1402. INTRODUCTION TO HUMANITIES & ARTS, II.  Cat. I
This course is open to students enrolled in the Project-based Learning Community and is a continuation of HU 1401. Students continue to read, analyze and write about core readings in history, literature, and philosophy, and complete team-oriented projects that examine real-world problems at the intersection of the humanities, sciences, mathematics, and technology. Recommended Background: HU1401, Introduction to Humanities and Arts I.

HU 1411. INTRODUCTION TO AMERICAN STUDIES.  Cat. II
This interdisciplinary course introduces students to three or four basic American Studies methodologies. Emphasis will vary according to the instructor, but usually the course will cover the following: the particular historical, cultural context (at the community and/or national level) of a few literary texts; the relationship of American art to literature in a specific time period; analysis of popular culture entertainments in market-and-message terms of production and reception. This course provides a beginning for a Sufficiency in American Studies. For a description of the American Studies sequence and offerings, see the Sufficiency section of the Undergraduate Catalog.
Suggested background: An understanding of American history and American expression.
This course will be offered in 2007-08 and in alternating years thereafter.
HU 1412. INTRODUCTION TO ASIA
Cat. I
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. II
This survey course uses an interdisciplinary approach to examine fundamental issues in African political, social, and cultural history. The course may include various topics, such as ancient African kingdoms, the influence of Islam, the Atlantic slave trade, imperialism and decolonization, contemporary democrati- zation, or African literature and art.
Suggested background: HI 1341 Introduction to Global History.
This course will be offered in 2007-08 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 technologi- cal differences in human experience—are among the concerns of the class.
The 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 prepara- tion for an international IQP or educational exchange.
Suggested background: Previous courses in Humanities.
This course will be offered in 2007-08 and in alternating years thereafter.

HU 3421. TOPICS IN MEDIEVAL AND RENAISSANCE STUDIES
Cat. II
This course examines interdisciplinary topics in the study of the medi- eval and renaissance world. The course emphasizes various types of primary source material. Topics may include the Roman, Judeo-Christian, and Germanic heritage; warfare and social structure; the emergence of the modern town; folk and popular culture; encounters with the new world; and change and continuity in early modern society. It is appropriate for students with preparation any of several areas of the humanities, including history, literature, history of science and technology, and art history.
The course will be offered in 2007-08 and in alternating years thereafter.
Suggested background: Previous courses in humanities such as AR 1111, GN 1222, GN 2223, GN 2224, HI 1322, HI 1331, HI 1341, HI 2334, MU 2612, RE 2723 or equivalent.

HU 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. Stu- dents 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 AR 1111 and HU 3411, or completion of an international IQP or an interna- tional 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 col- leges: 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. Partici- pants 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 2008-09 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, can- tata, sonata, and concerto, among others.
No prior background in music is necessary.
This course will be offered in 2008-09 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, atonal- ity, 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 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 re-harmoni- zation 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 ethnomusicalological 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 2007-08 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 3613. 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.
15/P
Students electing to take their humanities and arts Sufficiency 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.
15/P
A final (sixth term) Sufficiency 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) join 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 join forces as the WPI Festival Chorus to perform major works of the repertoire. Alden Voices performs on tour as well as 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 timpani. 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 2007-08 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 key terms and concepts as given in PY/RE 1731 and PY/RE 2731.
This course will be offered in 2007-08 and in alternating years thereafter.

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 on 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 2008-09 and in alternating years thereafter.

PY 2715. PHILOSOPHICAL THEORIES OF THE SELF.
Cat. II
This course will focus on philosophical questions concerning the nature of human identity. It will examine arguments from various philosophical traditions on topics such as the nature of personhood, self-deception, the importance or unimportance of everyday concerns, the comparative role of individual decisions and social norms, and the differences between secular and religious, Western and Eastern, political and apologetic approaches to all these issues. Authors may include some of the following: Thoreau, Kierkegaard, Hegel, Camus, Buddha, Plato, Marx, Freud and de Beauvoir.
Suggested background: familiarity with basic ethical concepts and terms (as in PY/RE 1731) and PY/RE 2731 or PY 2712.
This course will be offered in 2007-08 and in alternating years thereafter.

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 2008-09 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 worldview 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/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.

PY 3711. TOPICS IN PHILOSOPHY.
Cat. I
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 3712. PHILOSOPHY OF RELIGION.
Cat. II
This course will focus on philosophical questions concerning the following topics: the existence and nature of God; the compatibility of God and evil; the nature of religious faith and the relationship between religion, science and ethics; the developments of the nature of religious language; the philosophically interesting differences between Western and Eastern religions; philosophical critiques of the role of religion in social life. Authors may include: Hume, Kant, Kierkegaard, Buber, Tillich, Daly, Nietzsche and Buddha.
Suggested background: familiarity with basic religious concepts and terms (as in PY/RE 1731).
This course will be offered in 2008-09 and in alternating years thereafter.

PY/RE 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 PY/RE 2731 or PY 2712.

RELIGION (RE)

RE/Py 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.

RE 2721. RELIGION AND CULTURE.
Cat. I
The purpose of this course is to examine how the two institutions of religion and culture interact and mutually influence one another. To do this a variety of definitions of religion and culture will be presented as well as an analysis of how religion interacts with such cultural phenomena as economics, politics, the state, war and the basic problem of social change. The purpose of this is to obtain a variety of perspectives on both religion and culture so that one can begin to articulate more clearly the different influences that occur in the development of one’s own personal history and the culture in which one lives.
Suggested background: knowledge of key terms and concepts as given in PY/RE 1731.

RE 2722. THE PROBLEM OF EVIL.
Cat. I
Notions of good and evil shape many of our day to day religious and philosophical claims and arguments. This course concerns questions and approaches to what is often called “evil,” through a study of classical and contemporary texts and problems. The focus of the course will vary, but will include metaphysical, moral, and political ideas about how and under what conditions evils and evils differ from other religious and philosophical perspectives. This study takes into account notions of error, ignorance, wrongdoing, freedom and responsibility evident in contemporary religious and philosophical debate.

RE 2723. RELIGIONS OF THE WEST.
Cat. II
The purpose of this course is to examine, from an historical, doctrinal, scriptural and philosophical perspective, major Western religions. The course will focus primarily on Judaism, Christianity and Islam. Other religions will be examined. The course will attend to the social contexts in which these religions developed and will examine their continuing influence on Western society.
Suggested background: RE/Py 1731 and RE 2721.
This course will be offered in 2008-09 and in alternating years thereafter.

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 2007-08 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.
**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 problems of 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 what 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 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 kinds 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.

**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 expository prose, and the interaction between writer and audience. In a workshop setting, students will write a sequence of short papers and complete one longer writing project, learn to read critically and respond helpfully to each other’s writing, and make oral presentations from written texts.

**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.

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

Cat. I

This writing workshop focuses on the purpose and genres of writing about disease and public health. We will consider how medical writers communicate technical information about disease and public health to general audiences; how writers capture the human experience of disease and health care; how writers treat the public policy implications of disease; and how writers design public relations programs. We will examine such genres as the experimental article, news reports, medical advice, profiles, commentary, and public health messages.

Recommended background: EN 2211 or equivalent writing courses.

Students who have taken EN 3215 may not receive credit also for WR/EN 3214.

**WR/EN 3216. WRITING IN THE PROFESSIONS.**

Cat. I

Studies show that engineers spend 80-90% of their professional time engaged in various kinds of communication. This course emphasizes the management contexts of writing in the professions. Focus is on making informed decisions about approaches, styles, problems, issues, sources, strategies, and human-relations aspects of writing in business, industry, and other institutional settings. Special attention is given to business editing and proposal and grant writing.

Recommended background: EN 2211 or equivalent writing course.
HUMANITIES AND ARTS COURSES

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 Sufficiency, Minor, or Major.

Recommended Background: SP 2521 and SP 2522, and SP 3523.

This course will be offered in 2007-08 and in alternating years thereafter.

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 Sufficiency, Minor, or Major.

Recommended Background: SP 2521 and SP 2522.

This course will be offered in 2008-09 and in alternating years thereafter.

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 2007-08 and in alternating years thereafter.

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 2521 and SP 3522.

This course will be offered in 2008-09 and in alternating years thereafter.

SP/ID 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, 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, 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 2007-08 and in alternating years thereafter.

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 1956), the importance of Spanish Civil war, gender identity, and class and cultural authority. This course is taught in Spanish.

Recommended background: SP 2521 and SP 3522 (Advanced Spanish II) or equivalent.

This course will be offered in 2008-09 and in alternating years thereafter.

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 with 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.

Recommended background: SP 3521 and SP 3522.

Offered in the SPRING term. Offered in 2007-08 and in alternating years thereafter.

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 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 gameplay and scripted cutscenes. Students will explore and use visual storytelling techniques.

IMGD 2000. SOCIAL ISSUES IN INTERACTIVE MEDIA AND GAMES.

Cat. II

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 discover 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.

Offered in 2008-09 and in alternating years thereafter.

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), the 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 2007-08 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 games. 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 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, and create an aesthetically appealing game.
Recommended background: IMGD 1002, IMGD 3500, MU 1611.

INTERDISCIPLINARY COURSES

ID/SS 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.

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. The 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; technical education and teacher education; and techniques for teaching students who have specific learning disabilities. The course complements student teaching experiences and practical teaching opportunities in the local schools. The course is open to all students who are considering teaching as a career.
Recommended background: SS 2401, Psychology of Education.
This course will be offered in 2008-09 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 IQP. There are no specific requirements for this course; although some knowledge of college-level physics, as well as acquaintance with the visual arts, is helpful.
This course will be offered in 2008-09 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 a Sufficiency or a minor in German. As the course is conducted entirely in German sufficient structured 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 2008-09 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 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 Sufficiency, Minor, or Major.
Recommended background: SP 2521 and SP 2522, and SP 3523.
This course will be offered in 2007-08 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 Sufficiency, Minor, or Major.
Recommended background: SP 2521 and SP 2522.
This course will be offered in 2008-09 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 2006-07 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 sociocultural 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 2008-09 and in alternating years thereafter.

ID/SP 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 2008-09 and in alternating years thereafter.
IDSP 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 2008-09 and in alternating years thereafter.

MANAGEMENT

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 such as 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 2007-08 and in alternating years thereafter.

BUSINESS (BUS)

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 their major. Students may receive credit for only one of the following: MG 1050, MG 1900 and BUS 1900.

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. Students may not receive credit for both MG 1250 and FIN 1250. Students may not receive credit for both FIN 1250 and FIN 2200.

BUS 2950. BUSINESS LAW AND ETHICS.  
(formerly MG 2950)  
Cat. I  
Imparts an understanding of how law, ethics, and public policy affect modern business. Approximately two thirds of the term is devoted to coverage of fundamental substantive areas of business law (funds, contracts, property, business organizations), public policies (regulatory and promotional), and approaches to ethical analysis for decision-making. Particular attention is paid to technology-based enterprises (e.g. intellectual property, environmental regulation). The concluding portion of the course involves all students in examination of current cases in which law, ethics and human, societal and global concerns intersect with business decision-making today. Students may not receive credit for both MG 2950 and BUS 2950.

ENTREPRENEURSHIP (ETR)

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.
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.

FIN 2250. FINANCIAL SYSTEM OF THE UNITED STATES. (formerly MG 2250) 
Cat. I
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.

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 telecommunication technology to enhance business functionality. Students will analyze the development of organizational communication 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 structure. 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. I
This course focuses on the linkage between organizational strategy and networked information techniques 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 2008-09 and in alternating years thereafter.

MIS 4750. MANAGEMENT OF THE IS FUNCTION. (formerly MG 4750) 
Cat. I
This course integrates students’ background in management policy and business analysis and addresses the practical problems of developing and running an IS organization. It focuses on the planning and management required to assure systems performance and monitoring, systems reliability and quality change management, backup and recovery, security, new technology assessment and implementation, staffing and staff development. Through case studies and mini-projects students will analyze existing structures in industry IS organizations. Recommended background: MIS 3700.
Students may not receive credit for both MG 4750 and MIS 4750.
This course will be offered 2007-08 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 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; marketing controls.  
Students may not receive credit for both MKT 3651 and ORE 3651.  
This course will be offered in 2008-09 and in alternating years thereafter.

OPERATIONS AND INDUSTRIAL ENGINEERING (OIE)

OIE 2500. MANAGEMENT SCIENCE I: DETERMINISTIC DECISION MODELS.  
(formerly MG/IE 2500)  
Cat. I  
This course is designed to provide an introduction to a variety of tools and techniques found useful by modern industrial engineers, operations researchers and managers. These tools are oriented toward the creation and use of mathematical models to assist in managerial decision making in business and other organizations. The models discussed in this course deal with deterministic decision-making problems where there are constraints on available actions. Discussion centers on “classical” methods of optimization and basic methods of linear programming. It is expected that the student will develop an ability to recognize situations in which a given technique is appropriate.  
Recommended background: knowledge of calculus.  
Students may receive credit for only one of the following: MG 2500, IE 2500, or OIE 2500.

OIE 2850. ENGINEERING ECONOMICS.  
(formerly MG/IE 2850)  
Cat. I  
To aid all engineering students in understanding economics and business constraints on engineering decision making. Topics include evaluation of alternative; the six time-value-of-money factors; present worth, annual cash flow and rate of return analysis; incremental analysis; depreciation and income tax; replacement analysis; inflation; handling probabilistic events; public economy; break-even and minimum cost points; and foreign exchange.  
Students may receive credit for only one of the following: MG 2850, IE 2850, or OIE 2850. Students may not receive credit for both OIE 2850 and FIN 2200.

OIE 3400. PRODUCTION SYSTEM DESIGN.  
(formerly MG/IE 3400)  
Cat. I  
This course is an introduction to the planning, analysis and design of production systems. It is designed for students in engineering or management who may wish to assume responsibilities in the production of goods or services. Topics to be covered will include: operations strategy, project management, quality management, process analysis, capacity management, and just-in-time and lean systems.  
Recommended background: Differential and integral calculus.  
Students may receive credit for only one of the following: MG 3400, IE 3400, or OIE 3400.

OIE 3401. PRODUCTION PLANNING AND CONTROL.  
(formerly MG/IE 3401)  
Cat. I  
This course is an introduction to the planning and control of production systems. Topics include: forecasting, scheduling, material management, and statistical process control.  
Recommended background: OIE 3400, MA 2611, and differential and integral calculus.  
Students may receive credit for only one of the following: MG 3401, IE 3401, or OIE 3401.

OIE 3405. WORK SYSTEMS AND FACILITIES PLANNING.  
(formerly MG/IE 3405)  
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: OIE 2500 and OIE 3400.

OIE 3420. QUALITY PLANNING, DESIGN AND CONTROL.  
(formerly MG/IE 3420)  
Cat. I  
This course focuses on the quality aspects of product design and manufacturing. Topics include: the quality/cost relationship, statistical process control, process capability studies, and design of experiments.  
Recommended background: OIE 3400 and MA 2612 or consent of the instructor.  
Students may receive credit for only one of the following: MG 3420, IE 3420, or OIE 3420.

OIE 3450. HUMAN FACTORS ENGINEERING.  
(formerly MG/IE 3450)  
Cat. I  
This course examines the human-machine interface in the workplace, concentrating on how workplace design can influence effectiveness and enhance human safety and satisfaction. Human sensory, motor, and decision systems are studied, as well as principles for designing visual and auditory displays, control devices and tools, and work spaces. Problems with repetitive and high physical effort tasks, illumination, noise, and atmospheric conditions, along with relevant governmental regulations, are also considered.  
Students may receive credit for only one of the following: MG 3450, IE 3450, or OIE 3450.

OIE 3460. SIMULATION MODELING AND ANALYSIS.  
(formerly MG/IE 3460)  
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 queueing 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: CS 1101, or CS 1102, and MA 2612.  
Students may receive credit for only one of the following: MG 3460, IE 3460, MG 3760, or OIE 3460.

OIE 3501. MANAGEMENT SCIENCE II: RISK ANALYSIS.  
(formerly MG/IE 3501)  
Cat. I  
This course provides coverage in decision analysis. Decision analysis is a technology that assists decision makers in quantifying consideration of complexity and uncertainty in problems of choice. The course applies decision analysis to problems in risk assessment and risk evaluation. Decision making in risk analysis is examined across a wide set of management engineering problems including case studies in environmental risk, product liability, facilities design, and R and D management. The course is intended to be highly integrative with respect to risk analysis including issues such as business ethics and risk communication.  
Suggested background: knowledge of calculus and introductory probability and statistics.  
Students may receive credit for only one of the following: MG 3501, IE 3501, or OIE 3501.

OIE 4410. CASE STUDIES IN INDUSTRIAL ENGINEERING.  
(formerly MG/IE 4410)  
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: OIE 3400, OIE 3401, OIE 2500 and OIE 3501.  
Students may receive credit for only one of the following: MG 3410, IE 3410, MG 4410, IE 4410, or OIE 4410.

OIE 4460. GLOBAL PLANNING AND LOGISTICS.  
(formerly MG/IE 4460)  
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 progress 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 themes 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: OIE 3400 and either FIN 2200 or OIE 2850 or consent of professor.

Students may receive credit for only one of the following: MG 4460, IE 4460, or OIE 4460.

This course will be offered 2007-08 and in alternating years thereafter.

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**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 4364. HUMAN RESOURCE MANAGEMENT.**

(formerly MG 4364)

Cat. II

This course in applied organizational science introduces concepts and techniques of human resource management. It provides experience in the solution of a variety of human resource problems through classroom exercises and organizational cases, introducing and building upon the basic concepts and techniques of industrial and organizational psychology. The course focuses on changing labor markets, employee recruitment and selection, performance appraisal and compensation, job evaluation, training and development, job design, labor relations, diversity and gender issues in the workplace, government involvement in human resource issues, job satisfaction, and motivation to work.

Recommended background: OBC 2300 or agreement of the professor. Students may not receive credit for both MG 4364 and OBC 4364. This course will be offered in 2008-09 and in alternating years thereafter.

**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 # IS/P.

*Initials of instructors in charge will appear in Undergraduate Catalog web site in addition to a description of seminar to be offered.

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**MATHEMATICAL SCIENCES**

The second digit in mathematical sciences course numbers is coded as follows:

0 — Basic
1 — Applied mathematics (general)
2 — Applied mathematics (differential equations)
3 — Statistics and probability
4 — Mathematics (general)

**MA 1020. CALCULUS I WITH PRELIMINARY TOPICS.**

Cat. I (14-week course)

This course includes the topics of MA 1021 and also presents selected topics from algebra, trigonometry, and analytic geometry.

This course, which extends for 14 weeks and offers 1/3 unit of credit, is designed for students whose precalculus mathematics is not adequate for MA 1021. Although the course will make use of computers, no programming experience is assumed.

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

**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.

Although the course will make use of computers, no programming experience is assumed.

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

**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.

**MA 1032. INTRODUCTION TO ANALYSIS II.**

Cat. I

This course uses the tools developed in MA 1031 to explore the theory of differentiability and introduces the Riemann integral. Topics covered include limits and continuity of functions, the intermediate value theorem, differentiation, mean value theorems, l’Hôpital’s-rule, antiderivatives, the Riemann integral, Riemann integrability.

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
This course is designed primarily for Mathematical Science majors and those interested in the deeper mathematical issues underlying combinatorics. Undergraduate credit may not be earned both for this course and for MA 2731. Recommended background: MA 2701.

This course will be offered in 2008-09 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 2731. Recommended background: MA 2701.

This course will be offered in 2007-08 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 2611. APPLIED STATISTICS I.
Cat. I
This course is designed to introduce the student to data analytic and applied statistical methods currently 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, discrete and continuous probability models, the central limit theorem, and one and two sample point and interval estimation. Recommended background: MA 1022.

MA 2612. APPLIED STATISTICS II.
Cat. I
This course is a continuation of MA 2611. Topics covered include tests of hypotheses, simple and multiple regression, one and two-way tables for categorical data, and design and analysis of one factor experiments. 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 2024.

MA 2631. PROBABILITY.
Cat. I
The purpose of this course is twofold:

- To introduce the student to probability. Topics to be covered will be chosen from: axiomatic development of probability; independence; Bayes theorem; discrete and continuous random variables; expectation; special distributions including the binomial and normal; moment generating functions; multivariate distributions; conditional and marginal distributions; independence; expectation; transformations of univariate random variables.

Recommended background: MA 2024.

MA 2701. 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 electrostatics, theory of heat, electromagnetics, elasticity and fluid mechanics. Recommended background: MA 2024.

MA 2731. COMBINATORICS.
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 Sciences majors and those interested in the deeper mathematical issues underlying probability theory. Recommended background: MA 1024.
Undergraduate credit may not be earned both for this course and for MA 2621.

MA 3211. THEORY OF INTEREST.
Cat. I
An introduction to actuarial mathematics is provided for those who may be interested in the actuarial profession.
Topics usually included are: measurement of interest, including accumulated and present value factors; annuities certain; amortization schedules and sinking funds; and bonds.
Recommended background: MA 1024 and the ability to write computer programs.

MA 3212. LIFE CONTINGENCIES.
Cat. I
A continuation of a study of actuarial mathematics with emphasis on the theory and application of contingency mathematics in the areas of life insurance and annuities.
Topics usually included are: survival functions and life tables; life insurance; life annuities; net premiums; and premium reserves.
Recommended background: MA 3211 and either MA 2621 or MA 2631.

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 2008-09 and in alternating years thereafter.

MA 3257/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 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
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 2007-08 and in alternating years thereafter.

MA 3475. CALCULUS OF VARIATIONS.
Cat. II
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 2651.
This course will be offered in 2008-09 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 will be chosen from distribution-free methods, 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 2007-08, and in alternating years thereafter.

MA 3631. MATHEMATICAL STATISTICS.
Cat. I
This course introduces students to the mathematical principles of statistics. Topics will be chosen from: Sampling distributions, limit theorems, point and interval estimation, sufficiency, completeness, efficiency, consistency; the Rao-Blackwell theorem and the Cramer-Rao bound; minimum variance unbiased estimators and maximum likelihood estimators; tests of hypotheses including the Neyman-Pearson lemma, uniformly most powerful and likelihood ratio tests.
Recommended background: MA 2631.

MA 3823. GROUP THEORY.
Cat. II
This course provides an introduction to one of the major areas of modern algebra. Topics covered include: groups, subgroups, permutation groups, normal subgroups, factor groups, homomorphisms, isomorphisms and the fundamental homomorphism theorem. Recommended background: MA 2073.
This course will be offered in 2006-07 and in alternating years thereafter.

MA 3825. RINGS AND FIELDS.
Cat. II
This course provides an introduction to one of the major areas of modern algebra. Topics covered include: rings, integral domains, ideals, quotient rings, ring homomorphisms, polynomial rings, polynomial factorization, extension fields and properties of finite fields. Recommended background: MA 2073.
This course will be offered in 2007-08 and in alternating years thereafter.
Undergraduate credit may not be earned both for this course and for MA 3821.

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 in the two-course sequence include: basic set theory, elementary topology of Euclidean spaces, limits and continuity, differentiation, Riemann-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 2007-08 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.

**MA 435. 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.
Topics covered include: classical optimization techniques, Lagrange multipliers and Kuhn-Tucker theory, duality in nonlinear programming, and algorithms for constrained and unconstrained problems.
Recommended background: Vector calculus at the level of MA 2251.
This course will be offered in 2007-08 and in alternating years thereafter.

**MA 437. PROBABILISTIC METHODS IN OPERATIONS RESEARCH.**
Cat. II
This course develops probabilistic methods useful to planners and decision makers in such areas as strategic planning, service facilities design, and failure of complex systems.
Topics covered include: decisions theory, inventory theory, queuing theory, reliability theory, and simulation.
Recommended background: Probability theory at the level of MA 2621 or MA 2631.
This course will be offered in 2007-08 and in alternating years thereafter.

**MA 4291. APPLICABLE COMPLEX VARIABLES.**
Cat. I
This course provides an introduction to the ideas and techniques of complex analysis that are frequently used by scientists and engineers. The presentation will follow a middle ground between rigor and intuition.
Topics covered include: complex numbers, analytic functions, Taylor and Laurent expansions, Cauchy integral theorem, residue theory, and conformal mappings.
Recommended background: MA 1024 and MA 2051.

**MA 4411. NUMERICAL ANALYSIS OF DIFFERENTIAL EQUATIONS.**
Cat. II
This course is concerned with the development and analysis of numerical methods for differential equations.
Topics covered include: well-posedness of initial value problems, analysis of Euler’s method, local and global truncation error, Runge-Kutta methods, higher order equations and systems of equations, convergence and stability analysis of one-step methods, multistep methods, methods for stiff differential equations and absolute stability, introduction to methods for partial differential equations.
Recommended background: MA 2071 and MA 3457/CS 4003. An ability to write computer programs in a scientific language is assumed.
This course will be offered in 2008-09, and in alternating years thereafter.

**MA 4451. BOUNDARY VALUE PROBLEMS.**
Cat. I
Science and engineering majors often encounter partial differential equations in the study of heat flow, vibrations, electric circuits and similar areas. Solution techniques for these types of problems will be emphasized in this course.
Topics covered include: derivation of partial differential equations as models of prototype problems in the areas mentioned above, Fourier Series, solution of linear partial differential equations by separation of variables, Fourier integrals and a study of Bessel functions.
Recommended background: MA 1024 or MA 2051.

**MA 4473. PARTIAL DIFFERENTIAL EQUATIONS.**
Cat. II
The first part of the course will cover the following topics: classification of partial differential equations, solving single first order equations by the method of characteristics, solutions of Laplace’s and Poisson’s equations including the construction of Green’s function, solutions of the heat equation including the construction of the fundamental solution, maximum principles for elliptic and parabolic equations. For the second part of the course, the instructor may choose to expand on any one of the above topics.
Recommended background: MA 2251 and MA 3832.
This course will be offered in 2008-09 and in alternating years thereafter.

**MA 4631. PROBABILITY AND MATHEMATICAL STATISTICS I.**
Cat. I (14 week course)
Intended for advanced undergraduates and beginning graduate students in the mathematical sciences and for others intending to pursue the mathematical study of probability and statistics, this course begins by covering the material of MA 3613 at a more advanced level. Additional topics covered are: one-to-one and many-to-one transformations of random variables; sampling distributions; order statistics, limit theorems.
Recommended background: MA 2631 or MA 3613, MA 3831 - MA 3832.

**MA 4632. PROBABILITY AND MATHEMATICAL STATISTICS II.**
Cat. I (14 week course)
This course is designed to complement MA 4631 and provide background in principles of statistics.
Topics covered include: point and interval estimation; sufficiency, completeness, efficiency, consistency; the Rao-Blackwell theorem and the Cramer-Rao bound; minimum variance unbiased estimators, maximum likelihood estimators and Bayes estimators; tests of hypothesis including uniformly most powerful, likelihood ratio, minimax and bayesian tests.
Recommended background: MA 3631 or MA 4631.

**ME 1520. THE TECHNOLOGY OF ALPINE SKIING.**
Cat. II
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 stopping, 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 2008-09 and in alternating years thereafter.

**ME 1800. MATERIALS SELECTION AND MANUFACTURING PROCESSES.**
Cat. II
This course is designed to introduce the student to the engineering fundamentals of the most commonly encountered manufacturing processes. A thorough treatment of manufacturing processes including forging, rolling, drawing, EDM, PM, welding, casting, and machining are developed through a combination of class work and manufacturing laboratory experience. The laboratory experience includes an experimental component measuring and analyzing a manufacturing process and system. Each student is required to fabricate and assemble his/her own Stirling engine.
This course is recommended for all majors, for students who plan to utilize the manufacturing laboratory facilities as part of their MQP work, or for those students who wish a fundamental background in materials processing.

**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, spread sheet 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 2930).
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.

Recommended background: 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 3023. MECHANICAL BEHAVIOR AND MODELING PROPERTIES OF ENGINEERING MATERIALS.
Cat. II
This course is concerned with different types of material response to mechanical loads. The course studies the constitutive equations that are used to model the properties of engineering materials. The behavior of elastic, plastic, composite and visco-elastic materials is considered. Experiments describing material behaviors will be conducted and the behavior will be modeled.

Topics include: descriptions of material behavior, methods of determining the material parameters from experimental tests, behavior of different types of materials under simple states of loading and deformation such as tensile stress-strain response (elastic and plastic), and time-dependent behavior at room and elevated temperature (viscoelasticity and creep) are studied. Theories of failure and failure modes under monotonic and cyclic loading, fracture and fatigue mechanics, and methods of modifying material behavior are discussed. These topics will be integrated in several material selection projects.

Recommended background: statics (ES 2501), stress analysis (ES 2502), continuum mechanics (ES 3501), materials (ES 3501).

This course will be offered in 2007-08 and in alternating years thereafter.

ME 3310. KINEMATICS OF MECHANISMS.
Cat. I
An introduction to the synthesis and analysis of linkages, cams and gear 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. II
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 in linkage and cam design. Inertial and shakings forces, elementary mechanical vibrations, torque-time functions, rotational and reciprocating balance and 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 in linkage and cam design. Inertial and shakings forces, elementary mechanical vibrations, torque-time functions, rotational and reciprocating balance and force analysis.

Recommended background: Ordinary Differential Equations (MA 2051), statics (ES 2501), dynamics (ES 2503), kinematics (ME 3510), linear algebra.

This course will be offered in 2008-09 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 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 1001).

ME 3321. DYNAMIC MODELING.
Cat. II
This course introduces students to the modeling and analysis of dynamic systems. A unified treatment of mechanical, electrical, fluid and thermal systems is presented using the bond graph modeling language. The creation of dynamic models and the analysis of model response is emphasized. Lecture topics include energy storage and dissipation elements, transducers, transformers, formulas and equations for a dynamic system and time response of linear systems. Computers are used extensively for both system modeling and analysis.

Recommended background: mathematics (MA 2051, MA 2071), fluids (ES 3004), mechanics (ES 2501, ES 2503).

This course will be offered in 2007-08 and in alternating years thereafter.

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 and transonic flows, and afterburning jet engines.

Recommended background: thermodynamics (ES 3001 or CH 3510) and fluids (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.

This 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, and applying the appropriate differential equations to solve these equations. Limitations on the mathematical solutions due to assumptions made will be considered.

Recommended background: Ordinary Differential Equations (MA 2051), statics (ES 2501), dynamics (ES 2503).

This course will be offered in 2008-09 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 users, reliability and aesthetics. 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 concepts of 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 3601. PRINCIPLES OF MECHANICAL ENGINEERING.
Cat. I
Intended for students other than mechanical or manufacturing engineering students, this course is oriented towards developing competence in mechanical engineering concepts and principles at the level that the technology interfaces deeply with their own discipline. The course is designed specifically to help students meet that challenge through the development of a broad systems perspective and an understanding of the principal elements of mechanical engineering technology. The expectation is that students completing this course will be able to handle adequately the mechanical aspects of a broad range of application topics. In addition, and most important, they will be prepared to work effectively with mechanical engineers on the joint solution of complex problems.

Topics covered during the course include, but are not limited to, the fundamentals of: statics, dynamics, kinematics, kinetics, materials, heat transfer, fluid dynamics, thermodynamics, stress analysis, vibrations, error and uncertainty analysis, as well as current trends and future directions in solution methodologies, and will be illustrated with representative applications, such as, electro-thermo-mechanical and viscoelastic systems, electronic packaging, and MEMS. Selected projects are included to emphasize the direct application of the information presented in lectures.

Intended for non-Mechanical Engineering or non-Manufacturing Engineering majors.

Recommended background: MA 1021-1024, MA 2051, CH 1010, PH 1110/1111-PH1120/1121, or equivalent. Intended audience, non-mechanical and manufacturing majors.

ME 3602. INCOMPRESSIBLE FLUID DYNAMICS.
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: fluids (ES 3004) 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, and 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: Fluid Mechanics (ES 3004), Incompressible Flow 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 thinned 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.

Students who have already taken and received credit for ME 4715 will not be able to also get credit for ME 3712.

ME 3801. EXPERIMENTAL METHODS IN MATERIALS SCIENCE AND ENGINEERING.
Cat. I
This course is designed to meet the experimental design requirement for ME students. 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 materials engineering experiments. Lecture topics include: review of materials and mechanical engineering fundamentals, and, among others, discussions of standards, measurement, and sensing devices, experiment planning, data acquisition, analysis of experimental data, and report writing. Laboratory experiments address both mechanical and thermal systems and instrumentation in materials engineering. Temperature and pressure measurements in materials processing, measurement of strain and position in mechanical testing of materials.

Recommended background: mathematics (MA 2051), thermo-fluids (ES 3001, ES 3003, ES 3004), mechanics (ME 2501, ME 2502, ME 2503), materials (ES 2001).

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.

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/trajectory 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 4220. ADVANCED ENGINEERING DESIGN.
Cat. I
This course integrates students’ background in ME in 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 modeling, CAD modeling, 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 3320), thermo-fluids (ES 3001, ES 3003, ES 3004), materials (ES 2001), manufacturing (ME 1800).

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 THERMOMECHANICAL DESIGN AND ANALYSIS.
Cat. II
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. Students will prepare a technical report and present their results. Topics will include, but not be limited to, thermomechanics of fiber optic telecommunication cables, high-energy beam interactions with materials, shape memory alloys, microelectronics, MEMS and mechatronics.

Recommended background: mathematics (MA 2051, ES 2501, ES 2502, ES 3003, ECE 3601, ME 3901), and an introduction to design.

This course will be offered in 2008-09 and in alternating years thereafter.

ME/BME 4504. BIOMECHANICS.
Cat. I
This course emphasizes the applications of mechanics to describe the material properties of living tissues. It is concerned with the description and measurement of these properties as related to their physiological functions. Emphasis is placed 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 2007-08 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, equations of motion, 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 2008-09 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 force approaches used to solve simple and represe.
Element types considered include spring, truss, beam, two-dimensional (plane stress/stretch and axiymmetric 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 covers primarily or the 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 2008-09 and in alternating years thereafter.

ME 4711. AIRBREATHING AND ROCKET PROPULSION.
Cat. I
This course provides the fundamental analysis of airbreathing and rocket propulsion engines, and components. The course addresses the associated thermofluid dynamics and performance. Topics covered include: thermofluid dynamics of airbreathing and rocket propulsion engines; ideal and ramjets; ideal nozzle flow and performance; combustion and expansion in chemical rockets; performance of engine components.
Recommended background: thermodynamics (ES 3001 or CH 3510), fluid mechanics (ES 3004 or ME 3602), compressible fluids (ME 3410 or ME 3711) or equivalent.
Students who have taken and received credit for ME 4717 or ME4716 will not be able to receive credit for ME4711.

ME 4713. SPACECRAFT DYNAMICS AND CONTROL.
Cat. I
The 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). Suggested background includes concepts of control theory as covered in Control Engineering I (ES 3011), and concepts of particle dynamics as covered in Intermediate Mechanics (PH 2201) or Introduction to Dynamic Systems (ES 2503).

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 4723. AIRCRAFT DYNAMICS AND CONTROL.
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 must establish design specifications, develop and analyze alternative designs, and justify their design in a written report. The design project incorporates fundamentals of aerodynamics, structures, aircraft performance, aircraft stability, and propulsion into a capstone design experience. The design project culminates in a Conceptual Design Review with oral presentations and a written final report. Design teams, software tools, and technical communication are emphasized.
Recommended background: intermediate fluid mechanics (ME 3602), subsonic aerodynamics (ME 3711), air breathing propulsion (ME 3716), aerospace structures (ME 4715).
This course will be offered in 2007-08 and in alternating years thereafter.

ME 4770. AIRCRAFT DESIGN.
Cat. II
This course introduces students to design of aircraft systems. Students complete a conceptual design of an aircraft in a term-long project. Students must establish design specifications, develop and analyze alternative designs, and justify their design in a written report. The design project incorporates fundamentals of aerodynamics, structures, aircraft performance, aircraft stability, and propulsion into a capstone design experience. The design project culminates in a Conceptual Design Review with oral presentations and a written final report. Design teams, software tools, and technical communication are emphasized.
Recommended background: fluid mechanics (ES 3004), heat transfer (ES 3005), control engineering (ES 3011), aeronautics (ME 2713), rocket and spacecraft propulsion (ME 3715), aerospace structures (ME 4715).
This course will be offered in 2008-09 and in alternating years thereafter.

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 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 2008-09 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 will be covered.
Recommended Background: ES 2001 or equivalent.
This course will be offered in 2008-09 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/RBE 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 V.A.L. 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 conformation, molecular weight and distributions, amorphous and crystalline states and glass-rubber transition. The principles of various processing techniques including injection molding, extrusion, blow molding, thermofoming 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 2007-08 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 2007-08 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 3811).

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 2008-09 and in alternating years thereafter.

ME 4922. THEORY AND PRACTICE OF LASER INSTRUMENTATION.
Cat. II
This course introduces and analyzes the fundamentals of optical and image processing techniques applicable to engineering measurements. Optical instrumentation is widely used in high precision position, vibration, and inspection applications in the industrial environment. The goal of this course is to provide a rigorous background in the basic principles preparing the student for the more advanced courses on laser instrumentation. The course will include both in-class lectures and laboratories. Topics to be covered include: accelerated review of light, waves, and polarization; basic building blocks including lenses, detectors, optical components, and fiber optics; interferometry and coherence; basic holography and speckle; infrared temperature measurement; stress birefringence; basic video, imaging, and digital image processing.
Recommended background: mathematics (MA 2051), experimentation (ME 3910).
Suggested background: physics (PH 1140).
This course will be offered in 2008-09 and in alternating years thereafter.

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 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 (10 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 (1/3 unit 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 (10 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 (1/3 unit 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 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 decisions, and creative problem-solving.
Participation in leadership laboratories and participation in off-campus training session (field training exercise) is also required.
Recommended background: ML1022.
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.
Individual Tactical Training.

Building skills in individual subjects like the Army Physical Fitness Test, basic Army values, among others. Instruction and evaluation at LDAC is progressive, technical competence, delegation, decisiveness, problem analysis and the several platoon-level training to assess his/her leadership potential. Each cadet is Cat. I (1/6 unit) ML 3023. LEADERSHIP DEVELOPMENT AND ASSESSMENT COURSE.

Fellow students. The last module of the term contains lessons that focus on communications. The main thrust of the communication module is the opportunity for cadets to develop oral communication skills through military briefings and presentations. 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.

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.

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.

Three lab exercises and participation in the military staff ride is required.

This course is a continuation of ML 4022.

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.

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 2022.

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 PROBLEM SOLVING 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 II.
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 I.
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.
students developing the knowledge to create workouts 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. BEGINNING 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 to intermediate swimmer. Instruction in the basic stroke techniques to learn to swim, improve skills and develop survival skills.

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 1021. BOWLING.
Cat. I (1/12 unit)
Introductory course designed to acquaint students with the basic skills, knowledge and practical experience.

PE 1024. INTERMEDIATE TENNIS.
Cat. I (1/12 unit)
Designed for the student with basic skills in tennis. In-depth instruction in skill development and strategy with game competition.

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 (Lifeguard 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 (Lifeguard 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.

PH 1110. SERIES.
Cat. I (3/12 unit)
Credit for activity in one of five categories: 1) WPI athletic team participation, 2) club sports, 3) approved courses not offered at WPI, 4) individualized program at WPI, 5) Proficiency testing. Approval in advance by the Physical Education Department is necessary.

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, magnetostrictive 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 many 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 many 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 many 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.
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 and MA 1022.

PH 2201. INTERMEDIATE MECHANICS I.
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 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 2008-09 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 experimental 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 Schroedinger equation to the simple harmonic oscillator, barrier penetration and potential wells.
Recommended 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.
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 2008-09 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 2008-09 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 deuterium 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 2007-08 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 2201.
This course will be offered in 2007-08 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.
Schrödinger 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). Suggested background: electricity and magnetism (PH 1120/PH 1121), may be taken concurrently.

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 2202.

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 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 of 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 2223, MA 2051
This course will be offered starting in 2008-09.

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 of 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 2223, MA 2051
This course will be offered starting in 2008-09.

RBE 3002. UNIFIED ROBOTICS IV.
Cat. I
Fourth 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 navigation, position estimation and communication. Concepts of dead reckoning, landmark updates, inertial sensors, vision and radio location will be explored. Control systems as applied to navigation will be presented. Communication, remote control and remote sensing for mobile robots and tele-robotic systems will be introduced. Wireless communications including wireless networks and typical local and wide area networking protocols will be discussed. Considerations will be discussed regarding operation in difficult environments such as underwater, aerospace, hazardous, etc. Laboratory sessions will be directed towards the solution of an open-ended problem over the course of the entire term.
Recommended background: RBE 3001. Suggested background: ES 3011
This course will be offered starting in 2008-09.
RBE/ME 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 be also built and tested. Recommended background: mathematics (MA 2051, MA 2071), fluids (ES 3004), thermodynamics (ES 3001), mechanics (ES 2501, ES 2503)

RBE/ME 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.

SOCIAL SCIENCE AND POLICY STUDIES

ECON Economics
GOV Political Science, Government and Law
PSY Psychology
SD System Dynamics
SOC Sociology
SS General Social Science
SIT Society/Technology Studies

ECONOMICS (ECON)

ECON 1110. INTRODUCTORY MICROECONOMICS.
Cat. I
The 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. Of 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 1120. INTRODUCTORY MACROECONOMICS.
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 latter half of the course stresses economic issues in public policy and international trade.

ECON 1130. INTRODUCTION TO ECONOMETRIC MODELING.
Cat. II
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. This course will be offered in 2007-08 and in alternating years thereafter.

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 2007-08 and in alternating years thereafter.

ECON 2117. ENVIRONMENTAL ECONOMICS.
Cat. II
This course investigates the effect 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 where markets are combined with government intervention to manage pollution and scarcity. The course reviews efforts to measure the costs and benefits of improving environmental conditions and evaluates current and potential policies in terms of the costs of the environment 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 2008-09 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 2008-09 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 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 sectoral 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 IPO or MQP in a developing nation. Recommended background: ECON 1120.
This course will be offered in 2007-08 and in alternating years thereafter.
GOV 1301. U.S. GOVERNMENT.

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 58.

GOV 1303. AMERICAN PUBLIC POLICY.

American Public Policy focuses on the outcomes or products of political institutions and political controversy. The course first addresses the dynamics of policy formation and stalemate, the identification of policy goals, success and failure in implementation, and techniques of policy analysis. Students are then encouraged to apply these concepts in the study of a specific policy area of their choosing, such as foreign, social, urban, energy or environmental policy. This course is an important first step for students wishing to complete IQPs in public policy research. Students are encouraged to complete GOV 1303 prior to enrolling in upper level policy courses such as GOV 2303, GOV 2304 or GOV 2311. There is no specific preparation for this course, but a basic understanding of American political institutions is assumed.

GOV 1310. LAW, COURTS, AND POLITICS.

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 status 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 2007-08 and in alternating years thereafter.

GOV 1320. TOPICS IN INTERNATIONAL POLITICS.

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 background materials for students who wish to complete IQPs on topics that involve international relations or comparative political systems.

This course will be offered in 2008-09 and in alternating years thereafter.

GOV 2302. SCIENCE-TECHNOLOGY POLICY.

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 tension between government demand 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 2008-09 and in alternating years thereafter.

GOV 2304. GOVERNMENTAL DECISION MAKING AND ADMINISTRATIVE LAW.

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 2008-09 and in alternating years thereafter.

GOV 2310. CONSTITUTIONAL LAW: FOUNDATIONS OF GOVERNMENT.

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 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 2008-09 and in alternating years thereafter.

GOV 2311. ENVIRONMENTAL POLICY AND LAW.

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.

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 environment, with irreversible consequences for humanity. Global environmental 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 essence of the course. Topically, the material begins with the nature 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 2007-08 and in alternating years thereafter.
GOV 2313. INTELLECTUAL PROPERTY LAW.
Cat. II

Intellectual property includes ideas, and the works of inventors, authors, com-
posers 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 appropriat-
ing 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 patents,
trademarks and copyrights; requirements of originality and, for patents, utility;
INFRINGEMENT issues; and the problems posed by international trade and efforts
to address them through the World Intellectual Property Organization.
Recommended background: GOV 1310 or GOV 2210.
This course will be offered in 2007-08 and in alternating years thereafter.

GOV ID 2314. CYBERLAW AND POLICY.
Cat. II

Rapidly developing technologies for computing, information management and
communications have been quickly adopted in schools, businesses and homes.
The growth of the Internet and of e-commerce, in particular, have given rise to
an entirely new set of legal issues as the courts, Congress and international
bodies struggle to keep pace with changing technology. This course addresses
the government’s role in the development of these technologies and the legal
issues that result including questions regarding privacy rights, speech and
DEFAMATION, and the application of patent and copyright law. Policy questions
such as surveillance of e-mail, regulation of content, mandates on the use of
filters, and 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
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 2008-09 and in alternating years thereafter.

GOV 2520. 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 Amend-
ment. These court decisions elaborate 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 fundamen-
tals.”
This course will be offered in 2007-08 and in alternating years thereafter.

PSY (PSY)

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 behav-
ior to the most mundane, from the behavior of neurons to the actions of na-
tions. 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, evolutionary psychology, behavioral
genetics, the anatomy and function of the brain and nervous system, 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 pro-
cesses and strategies underlying human behavior. The ways in which sensory
input is transformed, reduced, elaborated, stored, and recovered will be exam-
ined in order to develop a picture of the human mind as an active processor of
information. Topics will include perception, memory, problem-solving, judge-
ment and decision making, human-computer interaction, and artificial intelli-
genence. 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
Hgerätwist, people who interact by focusing on the individual (not society as a whole) as the unit of analysis, by emphasizing
the effects 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 prob-
lems? 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 58.
Suggested background: PSY 1400.

PSY 1403. THE PSYCHOLOGY OF WORK
Cat. I

This course examines 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 prob-
lems? 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 58.
Suggested background: PSY 1400.

PSY 1504. STRATEGIES FOR IMPROVING COGNITIVE SKILLS.
Cat. I

Life experience provides us with little insight into the basic workings of our own
minds. As a result, we tend to approach many of the important problems and
decisions of our professional and personal lives with only a dim awareness of
the limitations and capabilities of the human cognitive system and how its
performance can be improved. The purpose of this course is (1) to provide
students with the basic psychological knowledge needed to understand and
evaluate such important cognitive skills as memory, problem solving, decision
making, and reasoning and (2) to provide students the practical skills and
experience necessary to improve and assess their cognitive performance. Topics
will include but not be limited to memory improvement, study skills, effective
problem solving techniques, creativity, numeracy, making effective choices,
risky decision making, dynamic decision making, intelligent criticism of as-
sumptions and arguments, and evaluating claims about the mind.
Suggested background: PSY 1400.

PSY 2401. THE PSYCHOLOGY OF EDUCATION.
Cat. II

This course is concerned with the learning of persons in educational settings
from preschool through college. Material will be divided into five units covering a wide range of topics: Unit 1: Understanding Student
Characteristics: Cognitive, Personality, Social, and Moral Development; Unit 2:
Understanding the Learning Process: Behavioral, Humanistic, and Cognitive Theories of Learning; Unit 3: Understanding Motivations to Learn; Unit 4: Under-
standing Student Diversity: Cultural, Economic, and Gender Effects upon
Learning; Unit 5: Evaluating Student Learning: Standardized Tests, Intelligence,
Grades, and other Assessment Issues. Students planning IQPs in educational
settings will find this course particularly useful. Instructional methods will
include: lecture, discussion, demonstration, and project work. Course will also
focus on current issues in educational psychology and international higher
education.
Recommended background: PSY 1400 or PSY 1401.
This course will be offered in 2007-08, and in alternating years thereafter.

PSY 2405. ENVIRONMENTAL PROBLEMS AND HUMAN COGNITION.
Cat. II

This course examines how people think about the environment. Any environ-
mental problem, whether local, regional, or global, can ultimately be attributed
to the environmental decisions and actions of human beings. These behaviors can
in turn be understood as the situation or circumstances in which behavior occurs,
knowledge of the root psychological 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
psychological 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 hazard-
ous waste and (2) to help students identify and improve shortcomings in their
personal knowledge and daily life 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 personal environmental choices; strategies for promoting pro-environmental behavior; systems thinking; use of computer simulation to learn about environmental issues; and human ability to model and manage the global environmental future.

Recommended background: PSY 1400, PSY 1401 or PSY 1402.

This course will be offered in 2007-08 and in alternate years thereafter.

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 psychological 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 2008-09 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 underlying 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.

Cat. II

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.

This course will be offered in 2007-08 and in alternating years thereafter.

SD 3550. SYSTEM DYNAMICS SEMINAR.

Cat. II

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.

This course will be offered in 2007-08 and in alternating years thereafter.

SOCIOLOGY (SOC)

SOC 1202. INTRODUCTION TO SOCIOLOGY AND CULTURAL DIVERSITY.

Cat. I

This 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 bureaucracies 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 goal 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 2530. 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 2007-08 and in alternate years thereafter.

SOCIETY/TECHNOLOGY STUDIES (STS)

STS 1207. INTRODUCTION TO THE PSYCHO-SOCIOLOGY OF SCIENCE.

Cat. II

This course will describe how traditional issues addressed in the Sociology of Science dealing with science as an institution, social controversies involving science, priority disputes within science and process of scientific discovery are illuminated by studies using measures borrowed from psychology. Examples will involve measures of cognitive style, personality and openness to innovation. The scientific pipeline that runs through the science programs in the educational system and the experience of women as students and as practicing scientists will be addressed as a science and society equity issue. Problems balancing the roles of the scientist as expert and concerned citizen in a democratic but technological society will also be addressed. This course works equally well as a second course after PSY 1402, Social Psychology, or as a first course in Social Science. It is recommended background for STS 2209, Conflict and Cooperation in Research and Development Settings.

This course will be offered in 2008-09 and in alternating years thereafter.
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 model equations, 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; going to the next step that they work together well through 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 modeling 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 projects put forward by managers from a variety of companies seeking a system dynamics approach to important issues. 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 use of 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 the course toward the end of their system dynamics coursework as it provides a natural transition from coursework to system dynamics practice. Pre-requisites: SD 550 and SD 551

SD 555. PSYCHOLOGICAL FOUNDATIONS OF SYSTEM DYNAMICS MODELING
(3 credits)
This course examines the cognitive and social processes underlying the theory and practice of system dynamics. The errors and biases in dynamic decision making that provide the primary rationale for the use of system dynamics modeling will be traced to their root causes in cognitive limitations on perception, attention, and memory. Group processes that influence the outcome of modeler-client interactions and appropriate psychological techniques for eliciting and using mental data to support model building will also be addressed. Additional topics will include the reliability of alternate data sources for modeling, techniques for quantifying soft variables, design issues in group model building, the relative advantages of qualitative and quantitative modeling, and client attitudes toward modeling.
Pre-requisites: SS 550 System Dynamics Foundation: Managing Complexity or permission of the instructor

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. Pre-requisites: SD 550 or permission of the instructor

SD 561. ENVIRONMENTAL DYNAMICS.
Environmental Dynamics introduces the system dynamics students to the applications 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 and SD 551
250 SOCIAL SCIENCE AND POLICY STUDIES COURSES

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 Cross 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.