COURSE DESCRIPTIONS

Air Force Aerospace Studies 184
Biology and Biotechnology 185
Biomedical Engineering 189
Chemical Engineering 191
Chemistry and Biochemistry 193
Civil and Environmental Engineering 196
Computer Science 198
Electrical and Computer Engineering 200
Engineering Science Interdisciplinary 203
Fire Protection Engineering 204
Geosciences 205
Humanities and Arts 205
Interdisciplinary 215
Management 216
Mathematical Sciences 219
Mechanical Engineering 222
Military Science 227
Physical Education 228
Physics 229
Social Science and Policy Studies 231
COURSE CATEGORIES
For purposes of planning programs of study, courses at WPI are divided into two categories.

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

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

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

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

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

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

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

2 — Basic level courses.

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

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

5 — Graduate courses.

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

COURSE CREDIT
Unless otherwise indicated, WPI courses usually carry credit of 1/3 unit. This level of activity suggests at least 17 hours of work per week, including class and laboratory time. The usual workload per term is 1 unit.

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 States 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 2000. THE EVOLUTION OF USAF AIR AND SPACE POWER.
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 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 includes a study of Air Force customs and courtesies, drill and ceremonies, and 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, and military commands, and preparation for Field Training.

AS 2003. THE EVOLUTION OF USAF AIR AND SPACE POWER III.
Cat. I (1/9 unit)
The AS 2000 sequence of courses are designed to examine general aspects of air and space power through a historical perspective. The third course in the series begins with a study of air power in the Vietnam war through the Gulf war. Oral and written communications skills will be practiced.
The course includes one hour of class work and two hours of mandatory leadership laboratory per week. The AS 2003 Leadership Laboratory continues a study of Air Force customs and courtesies, drill and ceremonies, military commands, and preparation for field training.

AS 4004. THE EVOLUTION OF USAF AIR AND SPACE POWER IV.
Cat. I (1/6 unit)
The AS 4000 sequence of courses are designed to examine general aspects of air and space power through a historical perspective. The course examines several fundamental truths associated with war in the third dimension: e.g., Principles of War and Tenets of Air and Space Power. As a whole, this course provides the students with a knowledge level understanding for the general element and employment of air and space power, from an institutional doctrinal and historical perspective. In addition, the students will continue to discuss the importance of the Air Force Core Values with the use of operational examples and historical Air Force leaders and will continue to develop their communication skills. The final course in the series explores the future role of the Air Force through 2005.

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. Special topics of interest focus the military as a profession, officership, military justice, civilian control of the military, operation for active duty and current issues affecting military professionalism. Throughout the AS 4000 sequence of courses, briefing and writing exercises will be accomplished with emphasis on refining communication skills.

The first course examines in depth the national security process, principles of war and the Air Force major commands.

The course includes three hours of class work and three hours of mandatory leadership laboratory per week. The AS 4101 Leadership Laboratory complements the classroom work by providing advanced leadership experiences in officer-like activities and giving the students the opportunity to apply leadership and management principles.

AS 4102. NATIONAL SECURITY AFFAIRS II.
Cat. I (1/6 unit)
The AS 4000 sequence of courses examines the national security process, regional studies, advanced leadership ethics, and Air Force doctrine. The second course provides a detailed examination of Air Force doctrine including a study of the joint doctrine and the roles of the other military services.

The course includes three hours of class work and three hours of mandatory leadership laboratory each week. The AS 4102 Leadership Laboratory complements the classroom work by providing advanced leadership experiences in officer-like activities and giving the students the opportunity to apply leadership and management principles.

AS 4103. NATIONAL SECURITY AFFAIRS III.
Cat. I (1/6 unit)
The AS 4000 sequence of courses examines the national security process, regional studies, advanced leadership ethics, and Air Force doctrine. The third course provides an extensive study of alliances and regional security issues, including international peacekeeping and terrorism. Continued attention is given to developing the research and communications skills required by junior officers.

The course includes three hours of class work and three hours of mandatory leadership laboratory each week. The AS 4103 Leadership Laboratory complements the classroom work by providing advanced leadership experiences in officer-like activities and giving the students the opportunity to apply leadership and management principles.

AS 4104. PREPARATION FOR ACTIVE DUTY.
Cat. I (1/6 unit)
The AS 4000 sequence of courses examines the national security process, regional studies, advanced leadership ethics, and Air Force doctrine. The final course in the series examines officership, the military justice system, social responsibilities, current issues affecting the military profession, and various factors that will facilitate a smooth transition from civilian to military life.

The course includes three hours of class work and three hours of mandatory leadership laboratory each week. The AS 4104 Leadership Laboratory complements the classroom work by providing advanced leadership experiences in officer-like activities and giving the students the opportunity to apply leadership and management principles.

**BIOLOGY AND BIOTECHNOLOGY COURSES**

**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 using a problem solving approach. Some examples of topics which may be investigated in detail include: cloning, DNA fingerprinting and molecular forensics, transgenic organisms, “green” engineering and bioremediation, bioprocess 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 2901. MOLECULAR BIOLOGY, MICROBIOLOGY, AND GENETICS
Cat. I (1/6 unit)
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 in public health will be presented. This course is designed for all biology majors and other students who seek a good general education in modern biology.
Recommended background: A basic understanding of cell biology and elementary biochemical processes is desired.

BB 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 1030 or equivalent.

BB 3020. MODELING OF BIOLOGICAL SYSTEMS.
Cat. II
This course will cover the use of mathematical and computational models to understand biological systems. Examples will be chosen from a number of different areas, including ecology, neurobiology, molecular biology and fermentation. In each topic area, we will address the assumptions of the model, how the model can be used to determine optimum behavior of the system, and the sensitivity of the model parameters. No programming experience is necessary; students will use available computer software to explore these questions.
Recommended background: MA 1021 and 1022, and any 3000 or 4000 level BB course.
Offered in 2004-05 and in alternating years thereafter.

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 2005-06 and in alternating years thereafter.

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 2550, BB 2920, CH 4110 and CH 4120.
Students who have taken BB 4050 for credit will not receive credit for BB 3055.

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

BB 3101. HUMAN ANATOMY & PHYSIOLOGY: MOVEMENT AND COMMUNICATION.
Cat. I
The form and function of the systems that are responsible for the support, movement, internal communication, and interaction of the human body with its environment will be presented and discussed: Integumentary, Skeletal, Muscular, Nervous (including the senses), and Endocrine.
Recommended background: BB 2550 Cell Biology or BB 1001, Introduction to Biology. Suggested background: Concurrent Laboratory Module: BB 3511 (Nerve and Muscle Physiology). Students who have received credit for BB 2130 (Human Anatomy) may not take BB 3101 for credit.
BIOLOGY AND BIOTECHNOLOGY COURSES

BB 3102. HUMAN ANATOMY & PHYSIOLOGY: TRANSPORT AND MAINTENANCE.
Cat. I
The form and function of the systems of the human body that provide for the intake, distribution, and processing of nutrients, water, and oxygen, and the systems that safeguard health by elimination of wastes, regulation of metabolism, and surveillance against disease will be presented and discussed. Digestive, Respiratory, Circulatory, Lymphatic, Endocrine, Urinary, and Reproductive.
Recommended Background: BB 2550 (Cell Biology); either BB 1001 (Introduction to Biology) or BB 1030 (Introduction to Biological Macromolecules); CH 1010 and CH 1020 (General Chemistry). Suggested background: Concurrent Laboratory Module: BB 3514 (Circulatory and Respiratory Physiology). Students who have received credit for BB3110 (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/organisms, and environmental responses.
Recommended background: BB 1040, BB 2550, 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 2550, BB 2920, at least one of (BB 1040, BB 2040), BB 1050.
This course will be offered in 2005-06 and in alternating years thereafter.

BB 3160. BEHAVIORAL ECOLOGY.
Cat. II
This course is an overview of the biological basis of animal behavior. Topics for the course include animal cognition and communication, foraging and orientation, and evolutionary issues of mate selection, territoriality, and group living. Format for the course is largely test readings and lecture with associated video support materials.
Recommended background: BB 1050, BB 2040.
This course will be offered in 2004-05 and in alternating years thereafter.

BB 3170. PLANT MORPHOLOGY AND DEVELOPMENT.
Cat. II
This course will focus on the form and function of developing plant structures. Beginning with the unique aspects of plant cells, 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 1040 or equivalent, and BB 2550.
This course will be offered in 2005-06 and in alternating years thereafter.

BB 3151. NERVE AND MUSCLE PHYSIOLOGY.
Cat. I (1/6 unit)
Computer and laboratory studies of nerve and muscle function.
Recommended background: BB 2940.
Concurrent or prior registration in BB 3101 is recommended.

BB 3152. 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 3153. 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, BB 2550 and knowledge of aseptic techniques.
Concurrent or prior registration in BB 4008 is recommended.

BB 3154. CIRCULATORY AND RESPIRATORY PHYSIOLOGY.
Cat. I (1/6 unit)
Computer and laboratory studies of circulatory and respiratory physiology.
Recommended background: BB 2940.
Concurrent or prior registration in BB 3102 is recommended.

BB 3156. 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.
BB 4065. VIROLOGY.  
Cat. I  
This advanced-level course uses a seminar format based on research articles to discuss current topics related to the molecular/cell biology of viral structure, function, and evolution. Particular emphasis is placed on pathological mechanisms of various human disorders, especially emerging diseases, and the use of viruses in research.  
Recommended background: BB 2550.

BB 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 4140. ECOLOGICAL MANAGEMENT.  
Cat. II  
We will take an in-depth look at the development of a management scheme for a natural area. The course focuses on the biological issues of ecological management rather than socio-economic ones. Format will vary from week to week and will include lectures, group discussions, workshops and field trips to a wildlife sanctuary with an established ecological management plan. Basic concepts of population ecology and field techniques of ecological research will be explored to give the student a working knowledge of the biological basis for ecological management.  
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.  
This course will be offered in 2005-06 and in alternating years thereafter.

BB 4150. POPULATION AND COMMUNITY ECOLOGY.  
Cat. II  
This course presents a detailed exploration of problems in population change and the interaction between populations and the environment. Topics covered will include single-and multiple-species population models, age/stage structured population growth, metapopulation growth, island bio-geography, community diversity and stability and the evolution of life history strategies. Format will include lectures and group discussion.  
Offered in 2004-05 and in alternating years thereafter.

BB 4250. ECOLOGICAL SIMULATION MODELING.  
Cat. II  
This course will cover computer simulation models of populations, biogeochemistry, 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.  
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.  
This course will be offered in 2005-06 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/cell biology of viral structure, function, and evolution. Particular emphasis is placed on biological mechanisms of autoimmune disorders, cancer, Alzheimer’s disease, thrombosis, haemostasis, neurotrophic factors, and gene therapy.  
Recommended background: BB 2550.

BB 4910. ADVANCED MOLECULAR BIOLOGY.  
Cat. I  
This advanced level course explores the molecular mechanisms by which cells use genetic information to produce RNA 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.

Graduate Biology and Biotechnology Courses of Interest to Undergraduates

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

BB 501. SEMINAR.  

BB 509. SCALE-UP OF BIOPROCESSING.  
Strategies for optimization of bioprocesses for scale-up applications. In addition to the theory of scaling up unit operations in bioprocessing, students will scale-up a bench scale bioprocess (5 liters) including fermentation and downstream processing to 55 liters. Specific topics include the effects of scaling-up on: mass transfer and bioreactor design, harvesting techniques including tangential flow filtration and centrifugation, and chromatography (open column and HPLC).  
Recommended courses include BB 3055 Microbial Physiology and BB 4070/560 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, biogeochemistry, 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 and 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 BIO SCIENCE  
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 BIO SCIENCE  
This course will explore the organization of individuals into communities, and the evolution of individual traits and behaviors. Problems discussed will range from those of population harvesting and the effect humans have on the environment to the evolution of disadvantageous traits. Required background: Students should be familiar with fundamentals of population interactions, evolution and animal behavior.

BB 579 ADVANCED APPLIED BIOTECHNOLOGY  
This course examines the use of biotechnological advances towards solving real world problems. Students will discuss problem-solving strategies from the current literature in the areas of medicine, agriculture, environmental protection/restoration and industrial biotechnology. Required background: Students should be familiar with biochemistry, microbiology, and plant and animal physiology.
BIOMEDICAL ENGINEERING
The second digit for Biomedical Engineering course numbers is coded as follows:

0 — Bioinstrumentation, Biosignals, Introduction
1 — Physiology
2 — Bioelectric, Bioimaging
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 2204. BIOELECTRIC 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 biologic electric signals (EMG, EKG, EEG, EDC, 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 2500 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 2500 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 2604. 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, rheology of Newtonian and non-Newtonian fluids, diffusion in reacting systems and homogeneous vs. heterogeneous reaction systems.
Recommended background: BB 2500 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 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 3110. EXPERIMENTAL PHYSIOLOGY FOR ENGINEERS.
Cat. I
A laboratory-based course providing an introduction to experimental physiology for engineers interested in a hands-on exploration of physiologic principles. Emphasis is placed on developing the student’s ability to make measurements on and interpret data from living systems. This is achieved with laboratory projects and computer-based physiology simulators. Students are expected to apply relevant mathematical equations, models, and statistics when interpreting data collected in the laboratories. Laboratory projects include: animal care and anesthesia, muscle and nerve physiology, electrophysiology, circulatory physiology, respiratory physiology, and acid-base physiology. The principles of writing and maintaining a laboratory notebook are also developed and used.
Recommended background: BME 2204 and BB 2550 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 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 2004-05, and in alternating years thereafter.

BME 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 bio sensor/biostimulation systems for the measurement of physiological parameters.
Recommended background: BME 2204, and BME 3011.
This course will be offered in the 2004-05 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 BME 3011. 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 2005-06 academic year and in alternating years thereafter.

BME 4201. BIOMEDICAL IMAGING.
Cat. II
This course is a practical introduction to biomedical image processing using examples from various branches of medical imaging. Topics include: image filtering, reconstruction, enhancement, X-ray radiography, and magnetic resonance imaging. A working knowledge of image formation and analysis techniques is desirable. Facility with a high-level programming language is recommended.
The course will be offered in 2004-05, and in alternating years thereafter.

BME/ME 4504. BIOMATERIALS.
Cat. II
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 on the interrelationship between biomechanics and physiology in medicine, surgery, body injury and prosthesis.
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 2005-06, and in alternating years thereafter.
BME 4541. BIOLOGICAL SYSTEMS.
Cat. II
Review of control theory with applications to biological control systems. Analysis and modeling of physiological systems. Physiological systems identification. Formulation of mathematical models of biological systems and the application of computer techniques in the simulation of these systems. Recommended background: Laplace transforms, transient response, frequency response and system stability analysis.
This course will be offered in 2005-06, and in alternating years thereafter.

BME/ME 4606. BIOFLUIDS.
Cat. II
This course emphasizes the applications of fluid mechanics to biological problems. The course concentrates primarily on the human circulatory and respiratory systems. Topics covered include: blood flow in the heart, arteries, veins and microcirculation and air flow in the lungs and airways. Mass transfer across the walls of these systems is also presented.
Recommended background: ME 3501 and fluid mechanics equivalent to ES 3004.
This course will be offered in 2004-05, and in alternating years thereafter.

BME/ME 4814. BIOMATERIALS.
Cat. I
A course discusses various aspects pertaining to the selection, processing, testing (in vitro and in vivo) and performance of biomedical materials. The biocompatibility and surgical applicability of metallic, polymeric and ceramic implants and prosthetic devices are discussed. The physical-chemical interactions between the implant material and the physiological environment will be described. The use of biomaterials in maxillofacial, orthopedic, dental, ophthalmic and neuroradiological applications is presented.
Recommended background: BB 3310 or equivalent introduction to Human Anatomy, ES 2001 or equivalent introduction to Materials Science and Engineering.

BME 4828. BIOMATERIALS-TISSUE INTERACTIONS.
Cat. I
This course examines the principles of materials science and cell biology underlying the design of medical devices, artificial organs and scaffolds for tissue engineering. Molecular and cellular interactions with biomaterials are analyzed in terms of cellular processes such as matrix synthesis, degradation and contraction. Principles of wound healing and tissue remodeling are studied. Topics covered include: biological responses to implanted materials and devices. Case studies will be analyzed to compare tissue responses to intact, bioreorbable and bioactive biomaterials. Additionally, this course will examine criteria for restoring physiological function of tissue and organs and investigate strategies to design implants and prostheses based on control of biomaterial-tissue interactions.
Recommended background: BME 2604, BB 2550 or equivalent, ES 2001 or equivalent, PH 1110 or PH 1111.

BME 551. BIOLOGICAL SIGNAL PROCESSING.
Basic principles of digital processing of biological signals, and its application on PC-compatible computers. The theoretical fundamentals and practical examples of signal processing. The major emphasis is on linking the theoretical knowledge with easy to comprehend practical examples. (Prerequisites: Basic signal analysis.)

BME/ME 552. TISSUE MECHANICS.
This biomechanical course focuses on advanced techniques for the characterization of the structure and function of hard and soft tissues and their relationship to physiologic processes. Applications include: tissue injury, wound healing, the effect of pathological conditions upon tissue properties and design of medical devices and prosthetics. (Recommended preparation: A first course in biomechanics equivalent to BME/ME 4904.)

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

BME/ME 556. BIOFLUIDS AND BIOTRANSPORT.
The emphasis of this course is on modeling flow fluid within the cardiovascular and pulmonary systems and the transport processes that take place in these systems. Applications include artificial heart valves, atherosclerosis, arterial impedance matching, clinical diagnosis, respiration, aerosol and particle deposition. Applications to other transport systems. Additional topics may include: rheologic fluids, animal propulsion in air and water and viscoelastic testing. (Recommended preparation: A first course in biofluids equivalent to BME/ME 4606.)

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

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

BME 570. ENGINEERING IN THE CLINICAL ENVIRONMENT.
Examines the responsibilities and functions of the biomedical engineer in the health care complex in the solution of the technical and engineering problems associated with patient care. Topics include equipment management, monitoring systems, electrical safety, prosthetics, technical education for medical personnel, hospital systems engineering, and administrative functions.

BME 581. MEDICAL IMAGING SYSTEMS.
Overview of the physics of medical image analysis. Topics covered include: X-ray tubes, fluoroscopic screens, image intensifiers; nuclear medicine; ultrasound; computer tomography; nuclear magnetic resonance imaging. Image quality of each modality is described mathematically, using linear systems theory (Fourier transform, convolutions). (Prerequisite: Signal analysis course ECE 2312 or equivalent.)

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

BME 585. PRINCIPLES OF IN VIVO NUCLEAR MAGNETIC RESONANCE SPECTROSCOPY.
This course emphasizes the applications of Fourier transform nuclear magnetic resonance (FTNMR) spectroscopy in medicine and biology. Course topics include: Review of the basic physical concepts of NMR, review of covalent chemical binding and its relationship to the NMR chemical shift, factors in biological systems that influence the NMR chemical shift, data acquisition and processing techniques in vivo NMR spectroscopy, and the application of NMR spectroscopy to clinical studies. (Prerequisites: BME 582, organic chemistry and biochemistry are strongly recommended.)
CHEMICAL ENGINEERING COURSES

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

BME 595B. BIOMATERIALS IN THE DESIGN OF MEDICAL DEVICES.
Biomaterials are an integral part of medical devices, implants, controlled drug delivery systems, and tissue engineered constructs. Extensive research efforts have been expended on understanding how biologic systems interact with biomaterials. Meanwhile, controversy has revolved around biomaterials and their availability as a result of the backlash to the huge liability resulting from controversies related to material and processing shortcomings of medical devices. This course specifically addresses the unique role of biomaterials in medical device design and the use of emerging biomaterials technology in medical devices. The need to understand design requirements of medical devices based on safety and efficacy will be addressed. Unexpected device failure can occur if testing fails to account for synergistic interactions from chronic loading, aqueous environments, and biologic interactions. Testing methodologies are readily available to assess accelerated effects of loading in physiologic-like environments. This combined with subchronic effects of animal implants is a potential tool in assessing durability. It is difficult to predict the chronic effects of the total biologic environment. The ultimate determination of safety comes not only from following the details of regulations, but with an understanding of potential failure modes and designs that lowers the risk of these failures. This course will evaluate biomaterials and their properties are related to the design and reliability of medical devices.

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 equilibrium with ideal thermodynamics, and staged separation processes.
Recommended background: Elementary college chemistry and calculus.

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-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.

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 the monomers 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 seen on 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.

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.

CHEMICAL ENGINEERING

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

CHE 3301. 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 biology, biochemistry, physiology, and genomics; biological process engineering including fermentation, mammalian cell culture, biokatalysis, and downstream bioseparations; drug discovery, development, and delivery; environmental biotechnology; and chemical engineering aspects of biomedical devices.
Recommended background: differential equations, thermodynamics and some organic chemistry.

CHE 3601. 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.
Recommended background: 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.

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 the monomers 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 seen on 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.

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 2005-06, and in alternating years thereafter.

Students may not receive credit towards CHE distribution requirements for both CHE 3910 and CHE 3920.

Recommended background: some familiarity with the topics listed in CHE 2011, CHE 2012, and CHE 2013.

Recommended background: differential equations, thermodynamics and some organic chemistry.

Students may not receive credit towards CHE distribution requirements for both CHE 2014 and CHE 2002.

Students may not receive credit towards CHE distribution requirements for both CHE 2014 and CHE 2002.
CHE 4401. UNIT OPERATIONS OF CHEMICAL ENGINEERING I. Cat. I
Laboratory-application of fundamental theories to practical chemical engineering operations. Emphasis is on building the student’s understanding and ability to approach the problems of design and operations of large scale chemical processing equipment.

The course is a combination of lectures and laboratory projects in the area of unit operations. Laboratory projects include experiments in fluid-flow phenomena through various media such as: friction in conduits, filtration, pressure drop in packed towers, fluidization of solids, and spray drying.

Students are expected to carry out the planning and execution of experimental work as well as the analysis and reporting of experimental results in both written and oral format. Recommended background: knowledge of chemistry, mathematics and engineering principles.

CHE 4402. UNIT OPERATIONS OF CHEMICAL ENGINEERING II. Cat. I
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. Cat. I
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. Cat. I
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. Cat. I
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.

CHE 508. CATALYSIS AND SURFACE SCIENCE OF MATERIALS. 3 credits
The major factors which distinguished catalytic processes for chemicals and fuels from one another are the structure and composition of the materials used as catalysts.

This course examines the detailed structures and reactivities of solid catalysts like zeolites, solid state inorganics, supported metals and metal-support interactions, carbon catalysts, anchored catalysts and others. Several important spectroscopic techniques used in surface science such as X-ray photoelectron spectroscopy (ESCA), electron microprobe, AUGER, scanning electron microscopy, EXAFS, Mossbauer, Fourier-transform infrared, enhanced laser Raman spectroscopy and photoacoustic 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. 3 credits
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: crystalization, latex synthesis, polymer molecular weight distribution, fermentation/ecological systems and gas-solid systems.

CHE 521. BIOCHEMICAL ENGINEERING. 3 credits
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. Cat. I
The course provides an overview of the various types of fuel cells followed by a detailed discussion of the proton-exchange membrane (PEM) fuel cell fundamentals: thermodynamics relations including cell equilibrium, standard potentials, and Nernst equation; transport and adsorption in proton-exchange membranes and supported liquid electrolyte 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 561. ADVANCED THERMODYNAMICS. 3 credits
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. 3 credits
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. 3 credits
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. 3 credits
Advanced treatment of fluid kinematics and dynamics. Stress and strain rate analysis using vectors and tensors as tools. Incompressible and compressible, one-dimensional flows in channels, ducts and nozzles. Nonviscous and viscous flow fields. Boundary layers and turbulence. Flow through porous media such as fixed and fluidized beds. Two-phase flows with drops, bubbles and/or boiling. Introduction to non-Newtonian flows.

CHE 580. TRANSFORMATION AND TRANSPORT IN THE ENVIRONMENT. 3 credits
This course will focus on the transformation and transport of pollutant chemicals, nutrients and colloids in natural and engineered environmental systems. The first part of the course deals with the transfer of chemicals between different environments (water and air, water and solid phases). The second part of the course deals with processes by which a compound is chemically or biologically transformed into one or more products. Research – as arranged

CHEMICAL ENGINEERING COURSES

Graduate Chemical Engineering Courses of Interest to Undergraduates

CHE 504. MATHEMATICS ANALYSIS IN CHEMICAL ENGINEERING. 3 credits
Methods of mathematical analysis selected from topics such 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. 3 credits
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. 3 credits
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.
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 the idea of molecularity: 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 presented below.
- Concepts of Molecules (collapsing a large universe into a small number of entities)
- Concepts of Interactions (atom to atom forces and interactions)
- Concepts of Evolution (natural selection)
- Concepts of Life (biological molecules have emerged in the universe)

CH 1020. FORCES AND BONDING.

Cat. I
The theme of CH 1020 is forces and bonding. 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 presented below.
- Concepts of Structure (molecular geometry)
- Concepts of Stability (energy of chemical bonding)
- Concepts of Reactivity (energy of chemical change)

CH 1030. EQUILIBRIUM.

Cat. I
The theme of CH 1030 is equilibrium. 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 presented below.
- Concepts of Rates (forward and reverse reactions)
- Concepts of Kinetics (reaction rates and mechanisms)
- Concepts of Equilibrium (equilibrium constants)

CH 1040. DYNAMICS.

Cat. I
The theme of CH 1040 is dynamics. 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 presented below.
- Concepts of Spectroscopy (types of spectroscopy)
- Concepts of Reaction Rates (measuring rates of reactions)
- Concepts of Reaction Mechanisms (identifying reaction pathways)

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 multifunctional 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
The course will continue the coverage of aromatic chemistry. New topics to be introduced include the chemistry of heterocycles, carbohydrates, amino acids and lipids. Particular attention will be paid to naturally occurring polymers such as polysaccharides, proteins and nucleic acids, as well as to industrial polymers.

This course is concerned with the physical and chemical properties of biomolecules, but not their biochemical behavior. It is therefore a good preparation for but distinctively different from CH 4110.

Recommended background: CH 2310 and CH 2320 topics.

The course is intended for biochemists, chemists, chemical engineers and bio-science majors.

CH 2360. ORGANIC LABORATORY.

Cat. I
Laboratory experience in the preparation 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 study in organic chemistry.) Recommended for chemical engineers, pre-medical students, BM 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-bond bond formation.

Recommended background: CH2310, CH2320, and CH2330. This course is intended for students planning to take advanced courses in organic and/or medicinal chemistry and for chemists, biochemists, chemical engineers, and bio-science majors who desire a stronger background in organic chemistry.

Offered in 2004-05 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 ultraviolet-visible spectrophotometry, bioluminescence, high performance liquid chromatography, and capillary electrophoresis. Generally, after a set exercise to illustrate the capabilities and use of a particular instrument, student teams select a chemical, biochemical or environmental problem of interest to them, formulate an approach, conduct the analysis, and present their findings to the class.

Recommended background: CH 1010-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 inorganic and 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. Analytical methods applicable to all classes of matter 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 laboratory course is designed to give the student experience in a broad range of techniques.

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 organometallic 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 offers a unique approach to the descriptive chemistry of the elements. The Lewis acidity of positive centers is the starting point for the development of a series of ideas that includes Brønsted acidity, solubility, and the properties of the oxides of the elements. Redox properties are discussed in terms of Pourbaix diagrams. The often-complex structures of the oxides and halides of the elements are rationalized in terms of radius of the "cation" and "anion". The Lewis acid-base concept is extended in discussions of coordination compounds and the theory of hard and soft acids and bases. Finally, the descriptive chemistry of the compounds of the elements with halogens, sulfur, and nitrogen are discussed.

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 and the determination of reaction rates.

Cat. II
Recommended background: CH 2310, CH 2320, or their equivalents. Recommended for students in their third year.

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 Schrödinger equation is 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, rate laws and the Periodic Table of the elements.

Recommended background: CH 3410, CH 3110, and CH 3420. This course is offered in 2004-05 and in alternating years thereafter.

Recommended background: CH 4110, CH 4120, CH 4130, BB 4010

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 biological properties of carbohydrates are reviewed. Bioenergetics, the role of ATP, and its production through glycolysis and the TCA cycle are fully considered.

Recommended background: CH 2310, CH 2320.

CH 4120. BIOCHEMISTRY II.
Cat. I
This course covers the biosynthesis of lipids and steroids leads to a discussion of the structure and function of biological membranes. Finally the membrane processes in membrane transport 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) and of their biochemical precursors. 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.

Recommended background: CH 4110 or BB 4910 prior to Term A 2000 may not receive credit for the other course.

CH 4140. EXPERIMENTAL BIOCHEMISTRY.
Cat. I
The experiments in this laboratory course have been designed to acquaint the student with the basic tools necessary to perform biochemical studies. The course will cover, for instance, protein purification from different biological sources, subcellular fractionation, enzyme kinetics (Km, Vmax, Hill coefficient; specific activity, effector-protein interaction, etc.), exclusion and ion exchange chromatography, electrophoresis and immunodetection.

Recommended background: CH 4120.

CH 4160. MEMBRANE BIOPHYSICS.
Cat. I
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 following topics: Membrane Structure and Function; Channels, Carriers and Pumps; Nerve Excitation and related topics; and Molecular Biophysics of Membrane.

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

This course will be offered in 2005-06 and in alternating years thereafter.

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

Recommended background CH 4110, CH 4120, CH 4130, BB 4010

ADVANCED CHEMISTRY COURSES

CH 4330. ORGANIC SYNTHESIS.
Cat. II
A discussion of selected modern synthetic methods including additions, condensations and cyclizations. Emphasis is placed on the logic and strategy of organic synthesis. This course is intended to follow CH 2330.

Recommended background: CH 2310, CH 2320, and CH 2330.

This course will be offered in 2004-05 and in alternating years thereafter.

CH 4420. INORGANIC CHEMISTRY II.
Cat. II
The principles of protein structure are presented. Mechanisms of enzymatic catalysis, including those requiring coenzymes, are outlined in detail. The structures and biological properties of carbohydrates are reviewed. Bioenergetics, the role of ATP, and its production through glycolysis and the TCA cycle are fully considered.

Recommended background: CH 2310, CH 2320.

CH 4430. EXPERIMENTAL CHEMISTRY III.
Cat. I
The development of the principles of classical thermodynamics is covered.

Recommended background: CH 2310, CH 2320.
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 2004-05 and in alternating years thereafter.

CH 4520. CHEMICAL STATISTICAL MECHANICS.

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 2005-06 and in alternating years thereafter.

CH 4550. POLYMER CHEMISTRY.

This course will be offered in 2005-06 and in alternating years thereafter.

Graduate Chemistry Courses of Interest to Undergraduates

CH 501. CHEMISTRY OF THE MAIN GROUP ELEMENTS.

An advanced course in recent developments in selected areas if the chemistry of the elements other than transition metals. Topics covered may include electron deficient compounds and main group organometallics; the preparation, reactions and physical properties of these compounds.

CH 502. BIOINORGANIC CHEMISTRY.

This graduate course addresses current topics in bioinorganic chemistry, with emphasis on the structure and function of metalloenzymes of d-block metal ions. Activated site structures of porphyrinoid and hematin, blue copper proteins and hemocyanin, iron-sulfur cluster proteins, and the nitrogenase enzyme are discussed. The applications of a variety of physical methods (including electronic absorption spectroscopy, FTIR, multinuclear NMR, EPR, Resonance Raman spectroscopy, EPR, and electrochemical methods) to the elucidation of metalloprotein structure/function are discussed.

Recommended background: Knowledge of the fundamental concepts and theories of d-metal chemistry and of various spectroscopic methods.

CH 516. CHEMICAL SPECTROSCOPY.

Advanced topics in identification of organic species and determination of molecular structure by spectroscopic methods.

Methods covered include 1H- and 13C-NMR, mass spectrometry and infrared and UV-visible spectroscopy. This course is concerned only with interpretation of spectra and does not cover techniques obtaining them; there is no laboratory.

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 interpretation of data and interpretation.

CH 534. ORGANIC PHOTOCHEMISTRY.

Introduction to the photophysical and photochemical consequences of light absorption by molecules. Experimental techniques, excited state description, photochemical kinetics and energy transfer are among the topics discussed in relation to the primary photochemical reactions in simple and complex molecules.

CH 538. MEDICINAL CHEMISTRY.

This course will focus on the medicinal chemistry aspects of drug discovery from an industrial pharmaceutical Research and Development perspective. Topics will include Pharmaceutical Agents (such as antibacterial, antiviral and antitumor agents) and Pharmacodynamic Agents (such as antihypertensive, antiallergic, antitumor and CNS agents).

Recommended background: CH 2310, CH 2320, and CH 2330.

CH 536. THEORY AND APPLICATIONS OF NMR SPECTROSCOPY.

This course emphasizes the fundamental aspects of 1D and 2D nuclear magnetic resonance spectroscopy (NMR). The theory of pulsed Fourier transform NMR is presented through the use of vector diagrams. A conceptual nonmathematical approach is employed in discussion of NMR theory. The course is geared toward an audience which seeks an understanding of NMR theory and an appreciation of the practical applications of NMR in chemical analysis.

Students are exposed to hands-on NMR operation. Detailed instructions are provided and each student is expected to carry out his or her own NMR experiments on a Bruker AVANCE 400 MHz NMR spectrometer.

CH 539. MOLECULAR PHARMACOLOGY.

The course will begin with a review of human physiology emphasizing the endocrine, nervous, and lymphatic systems, and including a discussion of the psychoneuroimmunology controversy. Understanding communication between cells requires study of the variety of chemical messengers, their storage, release, action on their target receptors, and eventual fate. This study will include discussion of the location and nature of the variety of receptors. Understanding the effects of messengers necessitates a detailed study of the molecular structure and function of ion channels which will include an application to the nerve impulse. Intercellular and intracellular communication are brought together by a discussion of the molecular mechanisms of receptor-effector coupling. The molecular structures of the acetylcholine receptor and of rhodopsin will be used as illustrations. The concepts of agonist and antagonist will be reinforced by a disease state. The effects of receptor blocking will be studied in a study of local anesthesia. Study of the neuroactive peptides will lead to a discussion of drug addiction and alcoholism as receptor mediated pathologies. A segment of the role ion cotransport systems play in bodily regulation will include an analysis of the molecular action of the loop diuretics as another example of nonreceptor blockers. This course is designed to complement the "Medicinal Chemistry" course and will emphasize general principles and the underlying molecular structures.

Recommended background: knowledge of the material covered in one of the following is recommended: (a) CH 4110 and CH 4120, or (b) CH 538 plus an understanding of protein and membrane structures.

CH 552. STATISTICAL MECHANICS.

Application of the results of the quantum theory to achieve an atomistic physical understanding of the common thermodynamic variables. Maxwell-Boltzmann, Fermi-Dirac, and Bose-Einstein distribution functions are defined using the concepts of phase space and the exclusion principle, and the thermodynamic functions are developed in terms of the distribution functions. Application of the partition function and the theory of fluctuations to common physical systems.

CH 554. MOLECULAR MODELING.

This course is intended to train students in the area of molecular modeling using a variety of quantum mechanical and force field methods. The approach will be towards practical chemists who want to answer specific questions about molecular geometry, transition states, reaction paths, and photoreacted 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 Extended Hückel Theory, Molecular Mechanics, Semiempirical Molecular Orbital Methods, AB initio and DFT Methods, Graphical Display of Molecules.

CH 555. ADVANCED TOPICS.

A course of advanced study in selected areas whose content and format to suit the interest and needs of faculty and students.

CH 556. EXPERIMENTAL PHOTOCHEMISTRY.

This course has been designed to illustrate how modern spectroscopic techniques can be used to learn more about the photo-induced chemistry of organic materials. The principles of time-resolved and steady-state spectroscopic methods will be described in lectures and then applied in the laboratory to a variety of chemical systems. The aim will be to show how it is possible to fully describe the ground and excited state photochemical behavior of a chemical system using these techniques. Aspects of the following techniques will be covered:

- Florescence emission spectroscopy, including solvent effects, quantum yields, quenching behavior, singlet lifetime determinant, excited singlet state energies and the origin of temperature dependence.
- Phosphorescence emission spectroscopy, including triplet state energies, distinguishing between nπ* and ππ* excited states.
- Laser-flash photolysis, including generation, detection and identification of transient reaction intermediates, quenching, sensitization, triplet state lifetimes, properties of free radicals and other photochemically-generated reactive species, and the consequences of multiple photon excitation.

Steady-state irradiation coupled with end product analysis and how these studies complement time-resolved measurement.

Students will gain hands-on experience with the use of UV-visible absorption and fluorescence emission spectrometers as well as the laser flash photolysis research facility. Also, as part of the course, students will submit a short research proposal based on one or more of the techniques used.

Although there is no formal requirement, some background and an interest in photochemistry would be an asset.
CIVIL AND ENVIRONMENTAL ENGINEERING

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

CE 2000. ANALYTICAL MECHANICS I.
Cat. I
This fundamental civil engineering course provides an introduction to the analysis of structures in static equilibrium. The focus of this course is a classical analysis of concurrent and non-concurrent equilibrium. A variety of engineering problems including trusses, machines, beams, rigid frames, and hydraulic structures involving concentrated and distributed loading systems are analyzed for external reactions and internal forces.

CE 2001. ANALYTICAL MECHANICS II.
Cat. I
This course provides an introduction to the relationship between analysis, design, and the behavior of materials under load. Theory and applications are developed that utilize simple and combined stress-strain behavior of members subjected to axial, torsional, and flexural loadings, with applications to beams, trusses, rigid frames, shafts, and tension and compression structures.
Recommended background: CE 2000.

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

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

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

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

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

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

CE 3021. COST ESTIMATING, SCHEDULING AND PROJECT CONTROL.
Cat. II
This course presents the fundamental concepts and processes by which the cost and time of execution of civil engineering projects are established. It emphasizes the importance of decisions made at the early stages of design on final project cost. The relationship between time and cost is examined in detail. Topics include: construction methods, quantity surveying, resource pricing, activity planning, resource allocation, financial analysis, bidding, job cost accounting and cost control with extensions to operating and maintenance costs. Commercial software for project scheduling, cost estimating, and cost control is used in this course.
Recommended background: CE 1030 and CE 3020.
Offered in 2004-05 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 2005-06 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. AutoCAD 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 2002.
Offered in 2004-05 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 service. Laboratory experimental 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 is 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 I  
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.  

CE 3050. INTRODUCTION TO TRANSPORTATION ENGINEERING.  
Cat I  
This course provides an introduction to the field of transportation engineering with particular emphasis on traffic 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 of pavement structures. 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 3054. ASPHALT TECHNOLOGY.  
Cat I  
This laboratory-based course introduces the field of asphalt technology, provides an understanding of characterization tests for hot mix asphalt, understanding of production of hot mix asphalt, illustrates typical problems of hot mix asphalt pavements, and helps in developing an interest in asphalt technology. Instruction is provided through lecture, laboratory work and field trips. Students work in groups for preparation of laboratory reports and a term project.  
Recommended background: CE 1030 and CE 2001.  

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 biochemical oxygen demand, sources and effects of pollution, physical, chemical, and biological wastewater treatment processes, and waste sludge management.  
Recommended background: CE 3059 and ES 3004.  

CE 3062. HYDRAULICS IN CIVIL ENGINEERING.  
Cat I  
This course provides a basic background for designing hydraulic systems used in water supply and wastewater transport systems. It is a basic course for students in the sanitary engineering and water resources area. Topics include open channel flow, pipe flow, pumps, sewer design and water supply network design.  
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 influence 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 centers, etc.) necessary to support present and future growth patterns may be determined.  
The information necessary in planning, which involves conscious procedures of analysis, formulation of alternative solutions, rational assessment and deliberate choice in accordance with evaluation criteria, is obtained through extensive reading. As such the course introduces a variety of topics of concern to planners 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 I  
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.  

CE 4017. PRESTRESSED CONCRETE DESIGN.  
Cat I  
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 3002 and CE 3026.  
Suggested background: CE 3008.  

CE 4046. EXPERIMENTAL SOIL MECHANICS.  
Cat II  
The standard laboratory soil testing procedures generally encountered in civil engineering are introduced in this course. It further includes a limited discussion of soil behavior primarily based on the effect of soil’s physical and chemical properties on laboratory test results. The tests which are performed include grain size analysis, Atterberg limits, specific gravity, permeability, compaction, compression and consolidation, and direct and triaxial shear. The student’s results of the various tests are integrated within an engineering problem.  
Recommended background: CE 3041.  
Offered in 2004-05 and in alternating years thereafter.  

CE 4048. EARTH STRUCTURES.  
Cat II  
This course provides in-depth study of the geotechnical principles applied to design earth structures including earth dams, waste containment facilities, soil slopes, highway cuts and embankments, and slurry trenches. It includes fundamentals of analysis of flow through porous media by graphical and digital techniques, slope stability, use of geosynthetics, soil stabilization and the design of preloads and drain installations.  
Recommended background: CE 3041.  
Offered in 2005-06 and in alternating years thereafter.  

CE 4060. ENVIRONMENTAL ENGINEERING LABORATORY.  
Cat I  
This course familiarizes students with the laboratory studies used to obtain the design parameters for water and wastewater treatment systems. The topics include laboratory experiments dealing with physical, chemical, and biological treatment systems.  
Recommended background: CE 3000 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 resource related projects. 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.  

CAT. I  
Recommended background: CE 3059 and ES 3004.  

CAT. II  
Recommended background: CE 2002.

Suggested background: CE 3008.
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 techniques which a planner may use to plan the 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. 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 (potential topics include macros, lazy programming with streams, and programming with higher-order functions). Students will be expected to design, implement, and debug programs in a functional programming language.
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 2005. DATA STRUCTURES AND PROGRAMMING TECHNIQUES.
Cat. I
This course continues the development of discipline in programming design, style, expression, debugging and testing. It provides sufficient programming background for other 2000, 3000, and 4000 level computer science courses.
Topics include object-oriented programming, abstract data types, dynamic memory allocation, elementary data structures, algorithm analysis, recursion, internal sort/search methods, and step-wise refinement of both functions and data.
Students will be expected to design and implement reasonably large and complex programs in C++. Students will learn how to use appropriate high-level tools for program development.
Intended audience: computer science majors who do not have a strong background in these topics and noncomputer science majors who desire further programming experience or who intend to pursue upper-level computer science courses.
Recommended background: CS 1005 or CS 1006 or its equivalent.

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

CS 2223. ALGORITHMS.
Cat. I
Building on a fundamental knowledge of data structures, data abstraction techniques, and mathematical tools, a number of examples of algorithm design and analysis, worst case and average case, will be developed.
Topics include greedy algorithms, divide-and-conquer, dynamic programming, heuristics, and probabilistic algorithms. Problems will be drawn from areas such as sorting, graph theory, and string processing. The influence of the computational model on algorithm design will be discussed.
Students will be expected to perform analysis on a variety of algorithms.
Intended audience: computer science and computer engineering students, and those desiring a deeper understanding of algorithm design and analysis.
Undergraduate credit may not be earned both for this course and for CS 2136.

CS 2301. SYSTEMS PROGRAMMING FOR NON-MAJORS.
Cat. I
This course helps students with prior program design experience migrate their skills to a model of programming where the programming language exposes details of how the hardware stores and executes software. Building from the design concepts covered in CS 1101/CS 1102, this course covers manual memory management, pointers, the machine stack, and input/output mechanisms. Students will be expected to design, implement, and debug programs in C.
Intended audience: non-computer science majors who wish to take upper-level courses in the systems area of the computer science curriculum.
Recommended background: CS 1101 or CS 1102. CS majors and other students wishing to prepare for upper-level CS courses in both systems and software engineering should take CS 2303 instead of CS 2301. Students who have credit for CS 2303 may not receive subsequent credit for CS 2301.
Undergraduate credit may not be earned both for this course and for CS 2005.

CS 2302. OPERATING SYSTEMS.
Cat. I
This course provides the student with an understanding of the basic components of a general-purpose operating system.
Topics include processes, process management, synchronization, input/output devices and their programming, interrupts, memory management, resource allocation, and an introduction to file systems.
Students will be expected to design and implement a large piece of system software.

CS 2303. SYSTEMS PROGRAMMING CONCEPTS.
Cat. I
This course introduces students to a model of programming where the programming language exposes details of how the hardware stores and executes software. Building from the design concepts covered in CS 2102, this course covers manual memory management, pointers, the machine stack, and input/output mechanisms. The course will involve large-scale programming exercises and will be designed to help students confront issues of safe programming with system-level constructs. The course will cover several tools that assist programmers in these tasks. Students will be expected to design, implement, and debug programs in C++ and C.
Intended audience: computer science and computer engineering students with substantial prior object-oriented programming experience.
Recommended background: CS 2102.

CS 2301. SYSTEMS PROGRAMMING FOR NON-MAJORS.
Cat. I
This course helps students with prior program design experience migrate their skills to a model of programming where the programming language exposes details of how the hardware stores and executes software. Building from the design concepts covered in CS 1101/CS 1102, this course covers manual memory management, pointers, the machine stack, and input/output mechanisms. Students will be expected to design, implement, and debug programs in C.
Intended audience: non-computer science majors who wish to take upper-level courses in the systems area of the computer science curriculum.
Recommended background: CS 1101 or CS 1102. CS majors and other students wishing to prepare for upper-level CS courses in both systems and software engineering should take CS 2303 instead of CS 2301. Students who have credit for CS 2303 may not receive subsequent credit for CS 2301.
Undergraduate credit may not be earned both for this course and for CS 2005.

CS 2303. SYSTEMS PROGRAMMING CONCEPTS.
Cat. I
This course introduces students to a model of programming where the programming language exposes details of how the hardware stores and executes software. Building from the design concepts covered in CS 2102, this course covers manual memory management, pointers, the machine stack, and input/output mechanisms. The course will involve large-scale programming exercises and will be designed to help students confront issues of safe programming with system-level constructs. The course will cover several tools that assist programmers in these tasks. Students will be expected to design, implement, and debug programs in C++ and C.
Intended audience: computer science and computer engineering students with substantial prior object-oriented programming experience.
Recommended background: CS 2102.

CS 3013. OPERATING SYSTEMS.
Cat. I
This course provides the student with an understanding of the basic components of a general-purpose operating system.
Topics include processes, process management, synchronization, input/output devices and their programming, interrupts, memory management, resource allocation, and an introduction to file systems.
Students will be expected to design and implement a large piece of system software.
CS 3041. HUMAN-COMPUTER INTERACTION.  
Cat. I  
This course develops in the student an understanding of the nature and importance of problems concerning the efficiency and effectiveness of human interaction with computer-based systems.  
Topics include the design and evaluation of interactive computer systems, basic psychological considerations of interaction, interactive language design, interactive hardware design, and special input/output techniques.  
Students will be expected to complete 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.

CS 3043. SOCIAL IMPLICATIONS OF INFORMATION PROCESSING.  
Cat. I  
This course makes the student aware of the social, moral, ethical, and philosophical impact of computers and computer-based systems on society, both now and in the future.  
Topics include major computer-based applications and their impact, human-machine relationships, and the major problems of controlling the use of computers.  
Students will be expected to contribute to classroom discussions and to complete a number of 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 computer 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 understanding of the theoretical foundations of computer science.  
Undergraduate credit may not be earned both for this course and for CS 503.  
Recommended Background: CS 2022 and CS 2223.  
Students who have credit for CS 4121 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 4000-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 2102 and CS 2022.

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.
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 3431 and CS 3733.

This course will be offered in 2005-06 and in alternating years thereafter.

**CS 4514. COMPUTER NETWORKS: ARCHITECTURE AND IMPLEMENTATION.**

*Cat. I*

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

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

Students may be expected to design and implement programs that emphasize the concepts of file systems and distributed computing systems using current tools and languages.

Intended audience: computer science and computer engineering majors.

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

Recommended background: CS 3013 and a knowledge of probability, such as provided by MA 2621.

**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: CS majors and minors interested in understanding how programming languages work and how to implement their own small languages.

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

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

This course will be offered in 2004-05, 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 computer 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 2005-06 and in alternating years thereafter.
ELECTRICAL AND COMPUTER ENGINEERING COURSES

201

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 a 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 2011 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 relationship 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 these concepts leads to a host of practical devices such as transformers, motors, and generators. In addition, students will investigate the influence of stray electric and magnetic fields that 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 by high-speed digital circuit design.

Recommended background: ECE 2011, introductory physics courses such as PH 1120 or PH 1121, MA 1024, MA 2051 (concurrent).

ECE 2112. ELECTROMAGNETIC FIELDS.
Cat. I

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

The starting point will be the basic electric and magnetic field definitions of Coulomb and Biot-Savart leading to Gauss’s and Ampere’s laws. The students will then 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. The laboratory exercises are provided to reinforce the theory of operation of these devices. Numerous circuit applications are considered, including power supplies, transistor amplifiers, and FET switches.

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

Recommended background: ECE2011.

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

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


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

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

Recommended background: ECE 2311.

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

The goal of this course is to provide experience with the design of a system, component, or process. Basic sciences, mathematics, and engineering sciences are applied to convert resources to meet a stated objective. Fundamental steps of the design process are practiced, including the establishment of objectives and criteria, synthesis, analysis, manufacturability, testing, and evaluation. Student work in small teams and are encouraged to use creativity to solve specific but open-ended problems and 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 at least one of ECE 2112, ECE 2201, ECE 2312, 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 assembly language programs running on microprocessors are used to solve problems that require interactions between a computer and the physical world. Students in this course will also learn about the hardware and software structure of a modern computer system and how hardware, software, and the passage of time must be managed in an embedded system design. Other issues that will be addressed as appropriate include overall embedded system development, software maintenance, programming for reliability, and product safety.

Topics: Number systems, software flow diagrams, models for system state and state transitions, microprocessor and microcontroller architecture 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 microcontroller-based embedded systems using cross-platform development tools appropriate to the target platform.

Recommended background: ECE 2022 (for ECE students) or CS 2111.

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 include: 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 SPIE and monolithic and microwave integrated circuit analysis, and design (MMIC/MIC) modeling. Basing and matching networks for single and multistage amplifiers in the 900 to 2,000 MHz range are analyzed and optimized in terms of input/output impedance matching, insertion loss, and group delays.

Recommended background: ECE 2111, 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 detail. The course provides a comprehensive treatment of operational amplifier and operational amplifier operation and limitations. The use of Bode plots to describe the amplitude and phase performance of circuits as a function of operating frequency is also presented.

In addition, the concepts of analog signal sampling, analog-to-digital conversion and digital-to-analog conversion are presented along with techniques for interfacing analog and digital circuitry. Laboratory exercises are provided to reinforce student facility with the application of these concepts to the design of practical circuits.

Topics include: transducers; differential amplifiers, inverting/non-inverting amplifiers, summers, differentiators, integrators, passive and active filters, the Schmitt trigger, monostable and astable oscillators, timers, 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 radar systems; 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 influ-
ECE 3306. AUDIO ENGINEERING.

Cat. I

This course provides a basic introduction to the principles of audio engineering. Topics include: sound, applied acoustics, devices and systems associated with the recording and reproduction of speech and music, feedback amplifiers, measurement of sound, techniques for the control of acoustic noise. Selected laboratory exercises. Recommended background: ECE 2201, ECE 2311, ECE 3204 or equivalent.

ECE 3309. ADVANCED AUDIO SYSTEMS.

Cat. I

This course introduces students to the design of the complex logic systems underlying or supporting the operation of computer systems and interfaces. Students learn how to use advanced computer-aided design tools to develop and simulate logic systems consisting of MSI components such as adders, multiplexers, latches, and counters. The emphasis will be on understanding more complex systems. Hardware description languages are introduced and used to describe and implement combinational circuits. Students will also learn how to use programmable logic devices to implement customized designs.

Required background: ECE 2201 (for ECE students) or CS 211.

Suggested background: MA 2011/CS 211.

ECE 3311. PRINCIPLES OF COMMUNICATION SYSTEMS.

Cat. I

This course provides an introduction to communication systems. The baseband transmission of analog data is motivated and typical systems are analyzed with respect to bandwidth considerations and implementation techniques. Baseband and passband digital transmission systems are introduced and investigated. Pulse shaping and intersymbol interference criteria are developed in relation to the pulse rate transmission limits of bandwidth channels. Finally, digital carrier systems and line coding are introduced in conjunction with applications to modern modem transmission schemes.

Recommended background: MA 1024, ECE 2311 and 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. 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 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 3703. REAL-TIME DIGITAL SIGNAL PROCESSING

Cat. I

This course provides a basic introduction to the principles of real-time digital signal processing (DSP). Topics include: design of real-time DSP architectures, sampling and quantization of continuous time signals, design and implementation of FIR and IIR digital filters, and theory and application of the Fast Fourier Transform (FFT). The emphasis of the course is on the design and implementation of DSP algorithms. The algorithms are implemented on personal, portable DSP boards that the students can either program in the lab or purchase for use on their home computers. This course features an interactive studio format with mini-lectures and labs integrated into three-hour sessions. This format allows the students to try out the algorithms and methods shown in class immediately, with the instructor nearby to lend assistance and advice.

Recommended background: ECE 2312, ECE 2801, experience in C programming.

ECE 3711. INTRODUCTION TO ELECTRO-OPTICS.

Cat. I

The aim 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 display. A review of the concept 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 types and operation as well as critical aspects of fiber optical communication systems. Additional applications may be covered in student projects.

Recommended background: PH 1140, ECE 2311, ECE 2201.

ECE 3801. ADVANCED DIGITAL SYSTEM DESIGN.

Cat. I

This 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 devices, design, 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 chip (SOC) integration, methodologies, design for performance, and design for testability.

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. 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.

Students may not receive credit for ECE 3810 if they have received credit for either ECE 3815 or ECE 3902.
ECE 4901. SEMICONDUCTOR DEVICES.

Cat. I

The purpose of this course is to introduce students to the physics of semiconductors 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.

ECE 4304. COMMUNICATION SYSTEMS ENGINEERING.

Cat. I

This course introduces the theory and performance analysis of communication in noise. The mathematical treatment of noise as a random process is developed in the context of baseband and passband transmission systems. The performance of analog transmission systems is developed and the tradeoff between bandwidth and performance is exposed. The optimum PCM receiver is derived and introduces the general concept of decision theory and signal space representation of decision systems. A treatment of coding theory for error detection, correction and compression leads to the development of Shannon's information theory and the ultimate performance of digital transmission systems. Finally, concepts that underly modern digital data computer network systems are introduced.

Recommended background: ECE 3311 and MA 2621.

ECE 4502. ANALYSIS OF LARGE SCALE ELECTRIC POWER SYSTEMS.

ISP

This course is designed to provide an introduction to network analysis and optimization techniques that are used in operation and planning for electric power systems.


Students may not receive credit for both ECE 4502 and ECE 4502.

Recommended background: ECE 3501.

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.


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.
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 1120/1122). 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 mechanical design, engineering analysis and manufacturing is emphasized. Topics may include mechanical design, solid and feature based modeling, variational and parametric design, physical properties, assembly modeling, numerical control, mechanisms, and other analytical methods in engineering design.
Recommended background: familiarity with drafting standards (ES 1310), mechanical systems (ES 2501 or CE 2000, ES 2503) and kinematics (ME 3310) is assumed. Additional background in strength of materials (ES 2502 or CE 2001), machine design (ME 2300, ME 3320), machining and manufacturing methods (ME 1800) and higher level programming capability (CS 1101 or CS 1102) is helpful.

FIRE PROTECTION ENGINEERING

FF 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 510. FLAMMABILITY TESTS, CODES AND STANDARDS.
Cat. I
Code-related fire test standards will be presented at a level appropriate for fire protection engineers in a format which includes background on perceived need to regulate, analysis of the value and limitation of test methodology and effectiveness of code requirements to control combustible materials and mitigate particular fire hazards.
Fire test standards selected for discussion provide data and results which relate to surface flame spread, fire penetration, smoke obscuration, toxic potency of combustion products and rate of heat release for products and systems including interior finish, wall and floor assemblies, thermal insulation, furniture, bedding and draperies.

FPE 520. FIRE MODELING.
Cat. I
(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 2005-06 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 fundamentals of fire and combustion and is intended to serve as the first exposure to fire dynamics phenomena. The course includes fundamental topics in fire and combustion such as thermodynamics, chemical kinetics, pre-flashover and diffision 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 2004-05 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
FPE 563 (OIE 541). 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 fire safety performance of a variety of facilities of the built environment and to produce management plans for decision making. The framework for this course is a fire safety engineering method which decomposes the fire safety system into discrete elements that can be used for quantitative evaluation using a variety of fire protection engineering and fire science materials. Offered 2004-05 and alternating years thereafter.

FPE 570. BUILDING FIRESAFETY I.
Cat. I
This course focuses on the presentation of qualitative and quantitative means for fire safety analysis in buildings. Fire test methods, fire and building codes and standards of practice are reviewed in the context of a systematic review of fire safety 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, 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 fire safety 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 laws, 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 class 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; thermal chemical 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 2005-06 and alternating years thereafter.
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 identity, 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 1251. INTRODUCTION TO LITERATURE.
Cat. I
This course introduces the student to a variety of critical perspectives necessary to an understanding and appreciation of the major forms, or genres, of literary expression (e.g., novel, short story, poetry, drama, and essay). Writing and class discussion will be integral parts of this course.
EN 2233. AMERICAN LITERATURE: MODERNISM TO THE PRESENT.
Cat. I
This final survey course in American literature covers the modern and contemporaneous 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 the 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 and philosophical assumptions of the novels will be studied as well as their form and technique.
This course will be offered in 2005-06 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 benefit sought or 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. I
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 2004-05 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 Civil War. Authors may include Mark Twain, Stephen Crane, W. D. Howells, Edith Wharton, Kate Chopin, and Theodore Dreiser.
(Formerly EN 3236. Students who have received credit for this course may not receive credit for EN 2238.)

EN 2241. ENGLISH LITERATURE AFTER SHAKESPEARE.
Cat. II
Participants in this course will examine outstanding works of eighteenth- and nineteenth-century English literature as these works raise the question: Who is man, and what is his relationship to God, nature, and to his fellow creatures? Writers covered may include Swift, Pope, Keats, Brownrigg, and Dickens.
This course will be offered in 2004-05 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 2005-06 and in alternating years thereafter.

EN 2251. MORAL ISSUES IN THE MODERN NOVEL.
Cat. I
This course focuses on the problem of how to live in the modern world. Emphasis will be placed on the way moral issues evolve within the complications of individual lives, as depicted in fiction. Such authors as Conrad, Kesey, Camus, and Ellison show characters struggling with the questions of moral responsibility raised by love, religion, death, money, conformity.
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 Gothicism and its literary conventions. Authors studied may include Hawthorne, Longfellow, Whittier, Freeman, Wharton, Jackson, Lovecraft, and King. This course will be offered in 2005-06 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 shall 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 2005-06 and in alternating years thereafter. Students who have received credit for EN 2236 (New England Writers: Concord) may not receive credit for EN 3232.

**EN 3233. WORCESTER BETWEEN THE COVERS: LOCAL WRITERS AND THEIR WORKS.**

*Cat. II*

Worcester has had a rich and varied literary history from Isaiah Thomas’s founding of the American Antiquarian Society in the early 1800s to the works of S. N. Behrman, Robert Benchley, Elizabeth Bishop, Esther Forbes, Stanley Kurtzit, 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, nonfictional 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 2004-05 and in alternating years thereafter. Students who have received credit for EN 2236 (New England Writers: Worcester) may not receive credit for EN 3233.

**EN 3234. MODERN AMERICAN POETRY.**

*Cat. II*

This course 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 2004-05 and in alternating years thereafter.

**EN 3237. PURSUING MOBY-DICK.**

*Cat. II*

Since 1851, readers of Herman Melville’s masterpiece have joined in the chase for the “meaning” of the White Whale. After briefly examining the philosophical context of Emersonian idealism and the literary example of Hawthorne, the course is devoted solely to a close reading of Moby-Dick—one of the most innovative and mysterious novels in the English language. “Whose” book is it, anyway? Captain Ahab’s? Ishmael’s? The Whale’s? The reader’s? We conclude by surveying major critical approaches to the novel. This course will be offered in 2004-05 and in alternating years thereafter.

**EN 3248. THE ENGLISH NOVEL.**

*Cat. I*

Participants in this seminar will examine the English novel from its origins in the eighteenth century to its twentieth-century forms, exploring the rich variety of ways a writer may communicate a personal and social vision. The novels treat love, travel, humor, work, adventure, madness, and self-discovery; the novelist may include Fielding, Austen, Dickens, Eliot, Conrad, and Woolf.

**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 1511. ELEMENTARY GERMAN I.**

*Cat. I*

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

**GN 1512. ELEMENTARY GERMAN II.**

*Cat. I*

A continuation of Elementary German I. Recommended background: GN 1511.

**GN 2511. INTERMEDIATE GERMAN I.**

*Cat. I*

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

**GN 2512. INTERMEDIATE GERMAN II.**

*Cat. I*

A continuation of Intermediate German I. Recommended background: GN 2511.

**GN 3511. ADVANCED GERMAN I.**

*Cat. I*

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

**GN 3512. ADVANCED GERMAN II.**

*Cat. I*

A continuation of Advanced German I. Recommended background: GN 3511.

**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 2004-05 and in alternating years thereafter. Recommended background: GN 3511 (Advanced German I) and GN 3512 (Advanced German II) or equivalent.

**GN 3514. SEMINAR ON SELECTED TOPICS IN GERMAN LITERATURE.**

*Cat. II*

The content of the seminar will change from time to time. The course will focus either on an author (e.g., Goethe, Heine, Kafka, Gunter Grass, Christa Wolf), a genre (e.g., lyric poetry, drama, narrative prose), a literary movement (e.g., Romanticism, expressionism), or a particular literary problem (e.g., literature and technology, writing and the Holocaust, writing and the city). The seminar will be conducted entirely in German.

This course will be offered in 2005-06 and in alternating years thereafter. Recommended background: GN 3511 (Advanced German I) and GN 3512 (Advanced German II) or equivalent.
HUMANITIES AND ARTS COURSES

GN/ID 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 to be conducted entirely in German, knowledge of German sufficient for advanced conversations and detailed writing (such as students acquire in GN 3512, Advanced German II, or equivalent) is strongly recommended.
This course will be offered in 2004-05, and in alternating years thereafter.

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

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

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

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

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

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

HI 1331. INTRODUCTION TO THE HISTORY OF SCIENCE.
Cat. I
An introduction to the methods and source material historians use to study science. Topics covered will range from early Greek science to Newton and the Scientific Revolution in the 17th-century.
Suggested background: elementary knowledge of science.

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

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

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

HI 2313. AMERICAN HISTORY, 1789-1877.
Cat. I
This course surveys American history from the Presidency of George Washington to the Civil War and its aftermath. Topics include the rise of American democracy, the emergence of middle-class culture, and the forces that pulled apart the Union and struggled to put it back together.

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

HI 2315. THE SHAPING OF POST-1920 AMERICA.
Cat. 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.

HI 2316. AMERICAN FOREIGN POLICY FROM WOODROW WILSON TO THE PRESENT.
Cat. I
This survey of American diplomatic history 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, the early and later Cold War periods, and concludes with an overview of the current global involvement of the United States.

HI 2317. LAW AND SOCIETY IN AMERICA, 1865-1910.
Cat. I
This survey course explores the dramatic expansion of government’s role in American life between the Civil War and World War I. It does so by examining the response of constitutional, common, and statutory law to the social, economic, and political change associated with this pivotal period in the nation’s history.

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

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

HI 2324. INDUSTRY AND EMPIRE IN BRITISH HISTORY.
Cat. I
A survey of modern Britain from the 18th century to the present. Topics include the British state and national identity, the industrial revolution, political and social reform, the status of women, sport and society, Ireland, the British Empire, the World Wars, the welfare state, economic decline. Especially appropriate as background for students planning 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 distin-
guishing features of French society and culture. Some of the topics covered
include: Bourbon absolutism; the cause and effects of the French Revolution; the
struggle for democratic liberalism in the 19th century; class and ideological
conflict in the Third Republic; Vichy fascism, and present-day politics in the
Fifth Republic.
No prior knowledge of French history is required.
This course will be offered in 2004-05 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 twenti-
eighth century. We may consider topics such as racial, nationalist, feminist and
non-violent revolutionary ideologies, communist revolution, the “green” revolu-
tion and cultural revolution. No prior knowledge of the history of revolutions is
expected.
This course will be offered in 2005-06 and in alternate years thereafter.

HI 2331. AMERICAN SCIENCE AND TECHNOLOGY TO 1859.
Cat. I
A survey, stressing the development of a scientific community, of the content
and character of American science (and, to some degree, American technology)
from the founding of the colonies until just before the publication of The
Origin of Species. Topics include: medieval science in the new world; the Sci-
entific Revolution and its influence in America; the American Industrial Revolu-
tion; the rise of science as a profession; the interplay of science and technology
with the state and federal governments.

HI 2332. AMERICAN SCIENCE AND TECHNOLOGY FROM 1859.
Cat. I
A survey of the content and character of American science (and, to some degree,
American technology and medicine) from the publication of The Origin of Species
through the present. Topics include: Darwinism and Social Darwinism in America;
scientific agriculture and the federal government; scientific technology and
the rise of an industrial society; scientific education; and the new universi-
ty positivism and the growth of the physical sciences; the new biology and medi-
cine; conservation, scientific management, the gospel of efficiency and progres-
sivism; science, World War I and the 1920’s; the intellectual migration and its
influence; science, technology and World War II; Big Science and the Military-
Industrial-Scientific Complex; attacks on Big Science.

HI 2333. HISTORY OF SCIENCE FROM 1700.
Cat. I
A survey of major developments in science since Newton. Topics may include:
18th century physical science within the context of the Enlightenment; the
revolution in biological thought in the 19th century; relativity and the quantum
theory; key concepts such as the conservation of energy and the electromagnetic
field; the changing structure of the scientific community.
A knowledge of advanced science is not required but would be advantageous.

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 figures 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 techno-
logical conflict.

HI 2341. CONTEMPORARY WORLD ISSUES IN
HISTORICAL PERSPECTIVE.
Cat. II
This course examines the historical origins of contemporary global crises and
political transformations. Students keep abreast of 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 European Union, The
Israeli-Palestinian Crisis, Democratization in Africa, The Developing World and
Debt Relief. No prior knowledge of world history is required.
This course will be offered in 2005-06 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
stage of global colonialism, focusing on major and informative instances of
intercultural contact. The course is organized around cases that may include:
the agricultural revolution; the diffusion of religious traditions; Rome as
multicultural empire; the silk road; exchanges around the Indian Ocean; the
expansion of Islam; The Crusades; European encounters with the New World;
and Japanese contact with the West.
This course will be offered in 2004-05 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 interna-
tional 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 experi-
ence in the early development of international relations; bureaucratycultural
interactions; the changing economic, and political developments. Typical topics
include: communities, families, minorities, and women.
Suggested background: HI 2314, American History, 1877-1920; or HI 2315, The
Shaping of Post-1920 America.

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 disturb-
bances; 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 an analysis of selected aspects of social organization in Ameri-
an 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 foundation of new political structures that led
to the Constitution.

HI 3321. TOPICS IN MODERN EUROPEAN HISTORY.
Cat. II
This course seminar 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 2005-06 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 Phi-
losophy; The Social History of Ideas; The Enlightenment and the French Revo-
lution; 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 2005-06 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 gov-
ernment; the military-industrial complex in Nazi Germany; the political views
and activities of major scientists such as Einstein. Students will use current
theories and critiques of “autonomous technology” to analyze the case studies.
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
scientific management. Anthropology: 20th-century behavioral technologies; the
evolution of the military-industrial complex; the Manhattan Project; the explo-
tation of space; computers and post-World-War-II technology; and the emer-
gence 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 3341. TOPICS IN IMPERIAL AND POSTCOLONIAL HISTORY.**  
Cat. II  
This seminar course examines topics in the history of European imperialism, colonialism, and the postcolonial aftermath. Topics vary each year among the following: culture and imperialism, the expansion of Europe, the economics of empire, travel and exploration narratives, imperialist literature in anthropology, decolonization in Asia and Africa, postcolonial studies. Readings will include primary and secondary sources.  
This course will be offered in 2004-05 and in alternating years thereafter.

**HI 3342. TOPICS IN COMPARATIVE CIVILIZATIONS.**  
Cat. II  
This seminar course compares and contrasts major religious, philosophical, social, and political themes in different civilizations. Comparisons will vary each year but may be drawn from Asia, the Indian subcontinent, the Middle East, Africa, and indigenous cultures of the Americas. It examines the historical foundations of these civilizational differences and draws comparisons with common features of Western civilization. One important goal of the course is to enhance student appreciation of non-Western values and traditions.  
This course will be offered in 2004-05 and in alternating years thereafter.

**HI 3343. TOPICS IN ASIAN HISTORY.**  
Cat. I  
This seminar course examines topics in the cultural, socioeconomic, 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. Written and oral assignments will also help these students gain a more effective command of the English language.

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**Humanities**

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 and is a continuation of HU 1400. 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 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 that cross the boundaries 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 entangled 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 interest in American history and American expression.  
This course will be offered in 2005-06 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 democratization, or African literature and art.  
Suggested background: HI 1341 Introduction to Global History.  
This course will be offered in 2005-06 and in alternating years thereafter.

**HU 3411. PRO-SEMINAR IN GLOBAL PERSPECTIVES.**  
Cat. II  
This course examines the fundamentals of intercultural communication to prepare students to live and work with people from other cultures. It explores how different patterns of thinking and behavior, assumptions and values, have arisen from different cultural traditions and divergent histories in the world. Racism, prejudice, and bigotry—often the result of cultural, social, and technological differences in human experience—are among the concerns of the class. This course cannot teach students how to behave and think in all parts of the world, but it raises questions about ethnocentric assumptions often taken for granted by those working or studying in another culture. It is excellent preparation for an international IOP or educational exchange.  
Suggested background: Previous courses in Humanities.  
This course will be offered in 2005-06 and in alternating years thereafter.

**HU 3421. TOPICS IN MEDIEVAL AND RENAISSANCE STUDIES.**  
Cat. II  
This seminar course examines interdisciplinary topics in the study of the medieval 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.  
This course will be offered in 2005-06 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. Students will reflect on what they have learned in their previous courses and international experiences. They will assess what happened to them overseas, why it happened, and how it might be understood. They will also prepare a paper with an instructor in their area of international studies that integrates their previous academic courses. Students will also explore how they might translate their courses and experiences into future personal and professional opportunities.  
Recommended background: previous courses in international studies, such as HI 1341 and HU 3411, and completion of an international IOP or an international educational exchange.

**HU—AAS-50. AMERICAN ANTIQUARIAN SEMINAR.**  
ISP  
Each fall the American Antiquarian Society and five Worcester colleges sponsor a research seminar at the Antiquarian Society library. The seminar is conducted by a scholar familiar with the Society’s holdings in early American history, and
the seminar topic is related to his or her field of research.
Selection is highly competitive. The ten participating students are chosen by a
screening committee made up of representatives of the five participating 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 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.
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 2612. MUSIC OF THE MEDIEVAL AND RENAISSANCE PERIODS.
Music of the medieval church and secular troubadours is studied with special
attention given to composers such as Machaut, DesPres, Palestrina, Byrd and
Gabrieli.
This course will be offered in 2004-05 and in alternating years thereafter.

MU 2613. MUSIC OF THE BAROQUE PERIOD.
Music is examined from the operas of Monteverdi through the cantatas of
Buxtehude, culminating in the works of Bach and Handel.
This course will be offered in 2005-06 and in alternating years thereafter.

MU 2614. MUSIC OF THE CLASSIC PERIOD.
Music of the classic period concentrates on works by C.P.E. Bach, Haydn,
Mozart, and Beethoven.
This course will be offered in 2004-05 and in alternating years thereafter.

MU 2615. MUSIC OF THE ROMANTIC PERIOD.
Emphasis is on the grandeur and madness of the romantic composers of Europe:
Beethoven, Schubert, Berlioz, von Weber, Liszt, Chopin, Brahms, Wagner and
Tchaikovsky.
This course will be offered in 2005-06 and in alternating years thereafter.

MU 2616. COMPUTER TECHNIQUES IN MUSIC.
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 2612. COMPUTERS AND SYNTHESISERS IN MUSIC.
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.
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.
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 acknowled-
ged ed on the WPI transcript but will carry no WPI credit. Private lessons: voice,
piano, organ, winds, brass, strings, and percussion.

MU—. SEMINARS.
IS/P
Seminars (taken as #4 type IS/P only) are available in a variety of areas such as the
following:
MU 4623. Introduction to Jazz History
Cat. II. This seminar will be offered in 2004-05.
MU 4624. Introduction to Jazz Theory
Cat. II. This seminar will be offered in 2005-06.
MU 4625. Survey of American Popular Music (Formerly DGW 2444.)
MU 4626. Counterpoint: An Introduction (Formerly DPM 3341.)
Cat. II. This seminar will be offered in 2004-05.
MU 4629. Music of the Twentieth-Century
Cat. II. This seminar will be offered in 2005-06.

MU 4628. PERFORMANCE SUFFICIENCY.
A final (sixth term) Sufficiency in music may be fulfilled by a recital perfor-
amance 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

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 encour-
aged 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 performing on campus. Rehearsals are held weekly.
Prior singing or music experience is encouraged but not required. Open to all
women.

MU 2633. BRASS ENSEMBLE.
Cat. I
The Brass Ensemble performs frequently on campus and on tour and is open to
students who perform on trumpet, trombone, euphonium, French horn, tuba, or
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 improvisa-
tion. Rehearsals are held weekly. Students are expected to perform with the ensemble and to
know how to read music. Permission of the instructor is neces-
sary 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 prac-
tice. 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/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. I
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, Aristotle, Bacon, Locke, Rousseau and Marx, as well as numerous contemporary philosophers.

Suggested background: familiarity with basic concepts in philosophy (as in PY/RE 1731).

PY 2713. BIOETHICS.
Cat. II
This course will examine in depth selected problems in ethical theory 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 2004-05 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 apolitical 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.

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 2004-05 and in alternating years thereafter.

PY 2717. PHILOSOPHY AND THE ENVIRONMENT.
Cat. I
This course will focus on the following questions:

What is the scope of the current environmental crisis? What does this crisis reveal about the philosophical presuppositions and dominant values of our intellectual worldviews and social institutions? How can existing social theories help explain the environmental crisis? What implications does the crisis have for our sense of personal identity? What moral and spiritual resources can help us respond to it?

Readings will be taken from contemporary and historical philosophers and naturalists.

Suggested background: familiarity with basic concepts in philosophy (as in PY/RE 1731).

PY/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. II
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; interpretations 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).

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.

PY 2713.
## Religion

**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 kinds and relations of goods and evils from different religious and philosophical perspectives. This study takes into account notions of error, ignorance, wrong-doing, freedom and responsibility evident in contemporary religious and philosophical debate.

## Spanish

**SP 1524. ELEMENTARY SPANISH II.**  
*Cat. I*  
A continuation of Elementary Spanish I.  
Recommended background: SP 1523.

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

**SP 2522. INTERMEDIATE SPANISH II.**  
*Cat. I*  
A continuation of Intermediate Spanish I.  
Recommended background: SP 2521.

**SP 3521. ADVANCED SPANISH I.**  
*Cat. I*  
A course that continues to improve student’s language skills while deepening their understanding of Hispanic cultures. Some of the topics studied are: the origins of Hispanic cultures in Spain and Spanish America; family; men and women in Hispanic societies; education; religion.  
Recommended background: Intermediate Spanish II.

**SP 3522. ADVANCED SPANISH II.**  
*Cat. I*  
A continuation of Advanced Spanish I.  
Recommended background: SP 3521.

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

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

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

**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. ID3052 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 2004-05 and in alternating years thereafter.
Writing and Rhetoric

RH 3111. THE STUDY OF WRITING.
Cat. I
This course introduces students to issues in the study of writing such as the history and uses of literacy, the relationship of thought to language, the role of writing in producing knowledge, and research on composing. The focus of the course will be on professional and academic writing. The course will be organized around a series of interrelated research questions: How do writers in professional and academic settings know when they have something to write about? How do they define a problem to investigate? How do they define or construct an audience to address? How do they locate their work in relation to others’ work? How do they know which forms of writing to use? Why do they write in the first place? What functions does writing perform?

RH 3112. RHETORICAL THEORY.
Cat. I
Rhetoric concerns both the art of mastering the available means of persuasion and the study of how oral, written, and visual communication projects the intentions of individuals and groups, makes meanings, and affects audiences. The purpose of this course therefore is twofold. It is intended to help students become more effective communicators by learning about the rhetorical situation and various rhetorical techniques. And it is designed to help them understand how various forms of communication work by learning some of the strategies of rhetorical analysis.

RH 3211. RHETORIC OF VISUAL DESIGN.
Cat. I
This course explores how visual design is used for purposes of identification, information, and persuasion. It looks at many modes of visual communication, such as icons, logos, trademarks, signs, product packaging, infographics, posters, billboards, ads, exhibits, graffiti, page layout, films, television, videogames, and web sites. The course provides an overview of the history of graphic design movements, as well as analytical tools to understand how visual design encodes messages and the role visual communication plays in contemporary culture.

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

Recommended background: EN 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.

WR/EN 3217. CREATIVE WRITING.
Cat. I
The purpose of this course is to help students develop or improve the skills of written expression. Small groups are formed in which participants present and discuss their original work in either fiction or poetry.

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. These methods take into account diverse learning styles as well as various technological resources. Topics to be covered include: a brief history of education; curriculum and course guidelines (Massachusetts Education Reform and regulations 603 CMR 7.00, state curricular frameworks, national standards); legal issues; developing a course syllabus; and overview of breadth versus depth in course planning and delivery. The course also covers practical questions of organizing, delivering and assessing a course. This course is intended primarily for students interested in completing the Massachusetts requirements for teacher licensing. (See www.wpi.edu/~goulet/teacher_prep). This program is aimed primarily at majors in mathematics, physics, chemistry and biology wishing to be licensed to teach in middle or high school in one of those disciplines. A portion of the course requires the observation of master teachers at the Massachusetts Academy of Mathematics and Science, who will work with all students in the course to assist them in beginning to acquire the appropriate skills to conduct their own classes in mathematics or science at the secondary school level.

Recommended background: SS 2401, Psychology of Education.
The goal of the course is to put cost accounting in focus as a highly useful and important tool, but the course stresses the first two as they relate to project activity. Cost accounting provides data for three major purposes: 1) decision-making, and 3) inventory valuation and income determination. All three are essential in managing activities or projects. Cost accounting 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 2005-06 and in alternating years thereafter.

MANAGEMENT

ACCOUNTING (ACC)

ACC 1100. FINANCIAL ACCOUNTING. (formerly MG 1100)
Cat. 1
This course provides a tool for business communication, as accounting is an important language of business. Students are introduced to the accounting process, its underlying concepts, and the techniques of preparing and analyzing financial statements. Students are also introduced to issues in accounting for assets, liabilities, and stockholders' equity. The course demonstrates the employment of accounting data by users outside the firm, and the application of accounting numbers in financial analyses and market decisions.

Students may not receive credit for both MG 1100 and ACC 1100.

ACC 2101. MANAGEMENT ACCOUNTING. (formerly MG 2101)
Cat. 1
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

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 a major.

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

BUS 2950. BUSINESS LAW AND ETHICS. (formerly MG 2950)
Cat. 1
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 (torts, 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 issues 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, OBE 2300, OIE 2850, OIE 3400. Students may receive credit for only one of the following: MG 3960, MG 4930, or ETR 4930.
FINANCE (FIN)

FIN 1250. PERSONAL FINANCE. (formerly MG 1250)
Cat. I
This course is designed to help the student make well-informed judgments when faced with personal financial decisions. Such decisions are growing in number and complexity, and both individuals and families need a considerable degree of financial expertise in order to utilize optimally their limited incomes. Principal topics include: insurance (medical, life, automobile and disability), consumer credit, estate planning, taxation, personal investments (real estate, securities, etc.), social security legislation and personal financial planning.
Students may not receive credit for both MG 1250 and FIN 1250.

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 2101 and MA 2613.
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 2720. BUSINESS APPLICATION DEVELOPMENT TOOLS. (formerly MG 2720)
Cat. I
This course introduces students to the concepts and principles of visual, object-oriented techniques for the development of business applications. Students will use commercial, computer-based development tools and rapid development and prototyping techniques for the design of small business applications for such areas as customer tracking, order processing, and financial analysis.
Recommended background: CS 1101 or CS 1102, or ability to program in a higher level programming language.
Students may not receive credit for both MG 2720 and MIS 2720.

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: MIS 2720 or equivalent knowledge.
Students may receive credit for only one of the following: MG 4700, MG 3720, or MIS 3720.

MIS 3740. ORGANIZATIONAL APPLICATIONS OF TELECOMMUNICATIONS. (formerly MG 3740)
Cat. I
Students taking this course will develop an understanding of how organizations can effectively use telecommunications technology to enhance business functionality. Students will analyze the development of organizational communications infrastructures and their use for the development of “virtual” organizational structures and to support globally-distributed organizations. The course will begin with a survey of the concepts and technologies which form the basis of a business telecommunications system and which allow the merging of voice, data and video in an integrated multimedia communications structures.
Recommended background: MIS 3700.
Students may receive credit for only one of the following: MG 4701, MG 3740, MG/IE 3740, or MIS 3740.

MIS 4720. SYSTEMS ANALYSIS AND DESIGN. (formerly MG/IE 4720)
Cat. I
This course integrates students’ background in MIS in a one-term project focusing on development of creative solutions to open-ended business and manufacturing problems. The project will utilize systems analysis and design tools such as systems development life cycle, feasibility study, cost-benefit analysis, structured analysis and design. Students will acquire the skills necessary to analyze, develop, implement, and document real-life information systems. Students must be able to organize themselves and the project to complete their work within a seven week term. It is recommended that MIS majors take this course in preparation for their MQP.
Recommended background: MIS 3720.
Students may receive credit for only one of the following: MG 3750, MG 4720, or MIS 4720.

MIS 4740. E-BUSINESS STRATEGY, ARCHITECTURE AND DESIGN. (formerly MG/IE 4740)
Cat. II
The course focuses on the linkage between organizational strategy and networked information technologies to implement a rich variety of business models in the national and global contexts connecting individuals, businesses, governments, and other organizations to each other. It provides an introduction to e-business strategy and the development and architecture of e-business solutions and their technical components. The course will cover how businesses and consumers use the Internet to exchange information and initiate transactions. Both theoretical concepts and practical skills with appropriate development tools will be addressed within the scope of the class. Students will develop a business plan and put that plan into action through development of an e-business website using commercially available development tools.
Recommended background: CS 1101, CS 1102 or MIS 2720 or ability to program in a higher level programming language.
This course will be offered 2004-05 and in alternating years thereafter.
MIS 4750. MANAGEMENT OF THE IS FUNCTION.  
(formerly MG 4750)  
Cat. II  
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.

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, Marketing, Market Segmentation, New Product Development, Channels, Marketing Communications, Personal Selling, and Pricing.  
Students may not receive credit for both MG 3600 and MKT 3600.

MKT 3640. MANAGEMENT OF PROCESS AND PRODUCT INNOVATION.  
(formerly MG/IE 3640)  
Cat. I  
This course is based on the hypothesis that high performance firms depend on a sustainable pattern of new and innovative processes and products. Successful companies are examined in regard to their strategies for innovation and technology transfer. Technology alliances among industry, universities, and government are considered in order to increase the leverage of the individual firm. Benchmarking and commercialization from research to actualization is discussed through cases and examples.  
Recommended background: FIN 2220 or OIE 2850.  
Students may receive credit for only one of the following: MG 3440, MG 3640, or MKT 3640.

MKT 3651. INDUSTRIAL MARKETING.  
(formerly MG/IE 3651)  
Cat. II  
Provides an understanding of the industrial marketing process and practices. It presents the latest concepts, tools and techniques for marketing complex products and services to industrial and institutional users. Topics include: product innovation strategies; purchasing management and buyer behavior; major intelligence; pricing strategies and tactics; developing markets for new industrial products; bid proposals; industrial distribution; managing the industrial sales force; marketing controls.  
Students may not receive credit for both MG 3651 and MKT 3651.  
This course will be offered in 2004-05 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 taxes; 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.

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 health, 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 3500. 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 MGIE 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 process to the distribution of the finished product. Strategies that will be discussed include the design of international distribution networks, the use of third-party logistics providers, and the creation of links between logistic systems and marketing to create competitive advantage. The course will also explore tactical issues that must be managed to pursue a logistics strategy successfully, including choices regarding means of transportation, packaging, and inventory policies. Underlying 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.

ORGANIZATIONAL BEHAVIOR AND CHANGE (OBC)

OBC 2300. ORGANIZATIONAL SCIENCE—FOUNDATION.
(formerly MGIE 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 MGIE 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 sciences 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 organizational cases, introducing and building upon the basic concepts and techniques of industrial and organizational psychology. The course includes the topics of MA 1021. Although the course will make use of computers, no programming experience is assumed.

Students may not receive credit for both MG 4364 and OBC 4364. This course will be offered in 2004-05 and in alternating years thereafter.

OBC 4365. LEADERSHIP IN GROUPS AND ORGANIZATIONS. (formerly MG 4365)
Cat. II
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. No more than 1/3 unit credit will be available for this type #4 IS/P.

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

MATHEMATICAL SCIENCES

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

0 — Basic
2 — Applied mathematics (general)
4 — Applied mathematics (differential equations)
6 — Statistics and probability
8 — 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 differential equations and introduces the Riemann integral. Topics covered include limits and continuity of functions, the intermediate value theorem, differentiation, mean value theorems, 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 1031.

MA 1033. MATRICES AND LINEAR ALGEBRA II.
Cat. I
This course provides a rigorous introduction to multivariable analysis. Topics covered include vector algebra, functions of several variables, partial derivatives, gradient, multiple integrals, Green’s theorem, Stokes’ theorem, divergence theorem. Recommended background: MA 1032.

MA 2251. VECTOR AND TENSOR CALCULUS.
Cat. I
This course provides an introduction to vector and tensor calculus, an essential tool for applied mathematicians, scientists, as well as those in such interdisciplinary areas as environmental studies. It emphasizes quantitative, analytic approaches to decision making using the tools of applied mathematics, operations research, probability and computations. Topics covered include: the systems approach, mathematical modeling, optimization and decision analyses. Case studies from various areas of engineering or actuarial mathematics are used to illustrate applications of the materials covered in this course.
Recommended background: MA 1024. Suggested background: Familiarity with vectors and matrices. Although the course makes use of computers, no programming experience is assumed. Students who have received credit for CE 2010 may not receive credit for MA 2210.

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

MA 2271. GRAPH THEORY.
Cat. II
This course introduces the concepts and techniques of graph theory—a part of mathematics finding increasing application to diverse areas such as management, computer science and electrical engineering. Topics covered include: graphs and digraphs, paths and circuits, graph and digraph algorithms, trees, cliques, planarity, duality and colorability. This course is designed primarily for Mathematical Science majors and those interested in the deeper mathematical issues underlying graph theory. Undergraduate credit may not be earned both for this course and for MA 3271. Recommended background: MA 2071. This course will be offered in 2004-05 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, exclusion-inclusion principle, generating functions, recurrence relations, systems of distinct representatives, combinatorial designs, combinatorial algorithms and applications of combinatorics. This course is designed primarily for Mathematical Sciences majors and those interested in the deeper mathematical issues underlying combinatorics. Undergraduate credit may not be earned both for this course and for MA 3273. Recommended background: MA 2071. This course will be offered in 2005-06 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 Science 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 2024, 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 commonly used in industrial and scientific applications as well as in course and project work at WPI. Emphasis will be on the practical aspects of statistics with students analyzing real data sets on an interactive computer package.
Topics covered include analytic and graphical representation of data, exploratory data analysis, basic issues in the design and conduct of experimental and observational studies, 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 1024.
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 of random variables; transformations of random variables; limit theorems.
• To introduce fundamental ideas and methods of mathematics using the study of probability as the vehicle. These ideas and methods may include systematic theorem-proof development starting with basic axioms; mathematical induction; set theory; applications of univariate and multivariate calculus.
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 2311. 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 2311 and MA 2621, or MA 2631.

MA 2321. 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.
Undergraduate credit may not be earned both for this course and for MA 4231.
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 2004-05 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.
Undergraduate credit may not be earned both for this course and for MA 4471.
Recommended background: MA 2431 and MA 3832.
This course will be offered in 2005-06 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 or maximum of 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.
Undergraduate credit may not be earned both for this course and for MA 4475.
Recommended background: MA 2051.
This course will be offered in 2004-05 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 2003-04, 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 2004-05 and in alternating years thereafter.
Undergraduate credit may not be earned both for this course and for MA 3821.

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 2005-06 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 Réimann-Stieltjes integration, infinite sequences and series, 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 2005-06 and in alternating years thereafter.

MA 4214. SURVIVAL MODELS. Cat. II
Survival models are statistical models of times to occurrence of some event. They are widely used in areas such as the life sciences and actuarial science (where they model such events as time to death, or to the development or recurrence of a disease), and engineering (where they model the reliability or useful life of products or processes). This course introduces the nature and properties of survival models, and considers techniques for estimation and testing of such models using realistic data.
Topics covered will be chosen from: parametric and nonparametric survival models, censoring and truncation, nonparametric estimation (including confidence intervals and hypothesis testing) using right-, left-, and otherwise censored or truncated data.
Recommended background: MA 2631.
This course will be offered in 2004-05, and in alternating years thereafter.

MA 4235. MATHEMATICAL OPTIMIZATION. Cat. II
This course explores theoretical conditions for the existence of solutions and effective computational procedures to find these solutions for optimization problems involving nonlinear functions.
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 2005-06 and in alternating years thereafter.

MA 4237. 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 2251 or MA 2631.
This course will be offered in 2005-06 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 4033. An ability to write computer programs in a scientific language is assumed.
This course will be offered in 2004-05, 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 and 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 2004-05 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, 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.

MA 4658. STATISTICAL CONSULTING. Cat. I (14 week course)
After suitable preparation through readings and discussion, undergraduate students will learn about statistical practice as part of a statistical consulting team consisting of undergraduate and graduate students. The team will provide statistical expertise to clients from the WPI community under faculty supervision. There are no formal prerequisites, but knowledge of a range of statistical methodology, such as that supplied by MA 2611-12 and MA 3627, is strongly recommended.

MA 4891. TOPICS IN MATHEMATICS. Cat. I

MECHANICAL ENGINEERING

For a detailed description of each of these courses, check the video tape index at the Gordon Library.

The second digit in mechanical engineering course numbers is coded as follows:
1 — General mechanical engineering
2 —
3 — Design
4 — Thermal—fluids
5 — Engineering mechanics
6 — Fluid mechanics—hydraulics
7 — Aerospace
8 — Materials
9 — Engineering experimentation

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 stepping, selection of line in racing; equipment design, testing and performance; and ski injuries. We will also address issues in the epidemiology of skiing injuries, the calculation of the cost of ski injuries to society, the impact of ski equipment technology on litigation and the impact of litigation on equipment and trail design.
This course will be offered in 2005-06, and in alternating years thereafter.

ME 1800. MATERIALS SELECTION AND MANUFACTURING PROCESSES. Cat. I
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 MOP 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, spreadsheet calculations and programming.

Recommended background: Calculus, MA 2051, PH 1110, ES 2501, and any programming language (BASIC, Fortran, Pascal, C).

Recommended background: Ordinary Differential Equations (MA 2501), mechanics (PH 1110), statics (ES 2501), any programming language.

ME 2713. ASTRONAUTICS.

Cat. I

Topics studied: Orbital mechanics including spacecraft maneuvering and station keeping, transfer orbits, and interplanetary transfers; space environment including characteristics of low earth highly elliptical and geosynchronous orbits; ascent and reentry trajectories.

Recommended background: Dynamics (ES 2503).

ME 2820. MATERIALS PROCESSING.

Cat. I

An introduction to material processing in manufacturing. This course provides important background for anyone interested in manufacturing, design engineering, design, sales, or management.

Processing of polymers, ceramics, metals and composites is discussed. Processes covered include casting, forging, powder metallurgy and 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. I

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: description of material behavior, methods of determining the material parameters from experimental tests, behavior of different types of materials under simple statics of loading and deformation such as tensile stress-strain, creep and fatigue behavior. 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 2001).

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 2501), statics (ES 2501), dynamics (ES 2503).

ME 3311. DYNAMICS OF MECHANISMS AND MACHINES.

Cat. I.

This course provides an in-depth study of forces in dynamic systems. Dynamic force analysis is developed using matrix methods. Computer programs are used to solve the sets of simultaneous equations derived by students for realistic, unstructured design problems. Inertial and shaking forces, elementary mechan-
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 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 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, electronic, 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. INTERMEDIATE FLUID DYNAMICS.
Cat. I
A second course in fluid mechanics concerned with the application of basic principles. Applications include velocity potentials and stream functions, fluid machinery, pipe networks and unsteady flow. The equations of viscous flow are developed with applications including exact solutions, energy, dissipation and introductory boundary layer theory.

Recommended background: fluids (ES 3004).

ME 3711. AERODYNAMICS.
Cat. I
A first course in the science and engineering of heavier-than-air flight vehicles.

Topics covered include: application of fluid mechanic and thermodynamic principles to study lift and drag, the effects of viscosity and compressibility, methods of estimating performance, and the elements of stability. The theory of airfoil circulation is developed and used to examine induced drag, downwash, ground effect and vortex wake turbulence.

Methods of characterizing and presenting airflow performance data are developed and utilized to examine the performance of wings. Propulsion systems, including propellers and their effects on flight performance are discussed. Longitudinal, lateral and turning stability of aircraft are considered for both static and dynamic conditions.

Recommended background: thermodynamics (ES 3001), fluids (ES 3004).

ME 3715. ROCKET AND SPACECRAFT PROPULSION.
Cat. I
This course provides an introductory study of propulsion systems for launch vehicles and spacecraft. Rocket propulsion systems discussed include solid, liquid-biopropellant and hybrid. Spacecraft propulsion systems discussed include cold gas, solid, liquid and electric. Advanced propulsion and micropropulsion concepts are introduced. Issues associated with combustor, nozzle, and propellant storage and feed systems are discussed.

Recommended background: thermodynamics (ES 3001), fluid mechanics (ES 3004), heat transfer (ES 3003), astronautics (ME 2713), intermediate fluid mechanics (ME 3602), compressible flow (ME 3410) or supersonic aerodynamics (ME 4712).

This course will be offered in 2005-06 and in alternating years thereafter.

ME 3716. AIR BREATHING PROPULSION.
Cat. II
This course provides a study of breathing engines for aircraft and ground-based applications. Topics covered include: Thermodynamic cycles and fluid dynamics of aero engines, including gas turbines (turbojets, turbofans, turboprops), ramjets, and scramjets. Performance measures such as inlets, combustors, nozzles, as well as axial compressors and turbines will be addressed.

Recommended background: thermodynamics (ES 3001), fluid mechanics (ES 3004), aerodynamics (ME 3711), and compressible flow (ME 3410).

This course will be offered in 2004-05 and in alternating years thereafter.

ME 3811. MICROSTRUCTURE ANALYSIS AND CONTROL.
Cat. I
An in-depth study of the microstructure and properties of alloy systems in current use.

Topics covered include: interpretation of microstructure and its relationship to engineering properties, and the design of microstructures. Among the alloy systems studied are low alloy steels, alloyed steels, cast irons, copper base alloys, aluminum alloys, titanium alloys, nickel base superalloys and composites.

Recommended background: materials science (ES 2001).

ME 3820. COMPUTER-AIDED MANUFACTURING.
Cat. I
This introductory course in modern control systems will give students an understanding of key design 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 2620), 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 exercise both theoretical and instrumentation in either traditional mechanical engineering (heat transfer, flow measurement/visualization, force/torque/strain measurement, motion/vibration measurement) or materials engineering (temperature and pressure measurements in material 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.

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

ME 4010. MECHANICAL ENGINEERING SENIOR SEMINAR.
Cat. I
For students who will soon be entering the engineering profession.

Current thought on mechanical engineering and related engineering problems presented by staff members and visiting lecturers from the engineering profession. Emphasis is placed on the transition from engineering student to professional engineer.

Registration as a junior or senior is assumed; not for credit.

ME 4320. ADVANCED ENGINEERING DESIGN.
Cat. I
This course integrates students' background in ME in a one-term design project that is usually taken from a local company. Students must organize themselves and the project to successfully realize a product that meets customer needs. Activities include problem definition, design analysis, mathematical modelling, CAD modelling, manufacturing, testing, liaison to customers, vendor selection, marketing, technical management, purchasing, report writing, and oral presentations.

Recommended background: mechanisms (MA 2051), thermo-fluids (ES 3003, ES 3003, ES 3004), materials (ES 2001), manufacturing (ME 1800).

ME 4412. INTRODUCTION TO COMBUSTION.
Cat. II
This course will be an introduction to chemical and physical aspects of combustion.

Topics covered include thermodynamics of combustion, chemical kinetics, premixed flames, diffusion flames, ignition, detonation, pollutant formation, advanced and conventional combustion systems and combustion measurement techniques.

Course emphasis will be on developing basic understanding of combustion phenomena relevant to engineering applications of combustion. Computer programming and available software may be employed to solve combustion problems.

This course may be used toward a graduate degree by submission of an additional report based on a review of research literature as arranged with the instructor.

Recommended background: thermodynamics (ES 3001), fluids (ES 3004).

This course will be offered in 2005-06 and in alternating years thereafter.

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 THERMOELECTRICAL DESIGN AND ANALYSIS.
Card. II
Current state-of-the-art computer based methodologies used in the design and analysis of thermomechanical systems will be presented and illustrated by selected laboratory demonstrations, and used in projects. Projects will include thermal, mechanical, electronic, and photonic loads of steady state and dynamic nature and will integrate design, analysis, and testing. Students will prepare a technical report and present their results. Topics will include, but not be limited to, thermomechanics of fiber optic telecommunication cables, high-energy beam interactions with materials, shape memory alloys, microelectronics, MEMS and mechatronics. Recommended background: MA 2051, ES 2001, ES 2502, ES 3003, ECE 3601, ME 3901, and an introduction to design. This course will be offered in 2005-06 and in alternating years thereafter.

ME/BME 4504. BIOMECHANICS.
Card. II
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 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, ES 2503, ME 3501), mathematics (MA 2051). This course will be offered in 2005-06 and in alternating years thereafter.

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

ME 4506. MECHANICAL VIBRATIONS.
Card. 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.
Card. I
This course serves as an introduction to finite element analysis (FEA) for stress analysis problems. Finite element equations are developed for several element types from stiffness and energy approaches and used to solve simple problems. Element types considered include spring, truss, beam, two-dimensional (plane stress/strain and axisymmetric), 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 2501, MA 2701), Mechanics (ES2501 & ES 2502 or CE2000 & CE2001).

ME 4530. COMPUTATIONAL METHODS IN MECHANICAL ENGINEERING.
Card. II
This course teaches the students how to analyze and solve complicated mechanical engineering problems utilizing state-of-the-art numerical analysis methods and digital computer. Some fundamental numerical schemes such as roots of algebraic and transcendental equations; solution of simultaneous algebraic equations; matrix analysis; curve fitting and data interpolation; numerical integration and differentiation; numerical solution of differential equations; symbolic manipulation and numerical solution of linear and nonlinear differential equations; Fourier and frequency response analysis; eigenvalue problems; and other numerical analysis problems are considered. Emphasis will be on modeling, numerical formulation and numerical and symbolic solution of practical problems in mechanical engineering. Fundamentals of FORTRAN programming are also included. Recommended background: mechanics (ES 2501, ES 2502, ES 2503), mathematics (MA 2051, MA 2701).

ME 4605. COMPUTATIONAL FLUID MECHANICS.
Card. I
This course serves as an introduction to the use of finite-difference methods to solve fluid flow problems. Topics covered include: difference approximations; truncation error and consistency; the development of finite-difference equations from partial differential equations using Taylor series, polynomial fitting, integral methods, and control volumes; algebraic mapping and irregular grid generation; stability of inviscid flow solutions using Gaussian elimination, Thomas’ algorithm, Gauss-Seidel, and Successive Over-Relaxation; boundary layer solutions using Dufort-Frankel and Crank-Nicolson; Navier-Stokes solutions using the vorticity transport-stream function method and primitive variable approaches. Recommended background: fluids (ME 3602).

ME/BME 4606. BIOFLUIDS.
Card. II
This course emphasizes the applications of fluid mechanics to biological problems. The course concentrates primarily on the human circulatory and respiratory systems. Topics covered include: blood flow in the heart, arteries, veins and microcirculation and air flow in the lungs and airways. Mass transfer across the walls of these systems is also presented. Recommended background: continuum mechanics (ME 3501), fluids (ES 3004). This course will be offered in 2004-05 and in alternating years thereafter.

ME 4712. SUPERSONIC AERODYNAMICS.
Card. II
This course introduces the study of performance and dynamic behavior of vehicles moving through fluids. Topics covered include: subsonic and supersonic performance of aircraft and rockets, external flow fields, aerodynamic heating, shock and expansion patterns, control surface interaction, and real gas effects, aerodynamic stability including interaction with structural dynamics. Applications to flutter, dynamic stability, and control system performance. Recommended background: aerodynamics (ME 3711). This course will be offered in 2004-05 and in alternating years thereafter.

ME 4715. AEROSPACE STRUCTURES.
Card. I
Aircraft and space vehicle structural design including finite element analysis, modal analysis, and thermal loading along with traditional and composite material characteristics and selection for atmospheric and space environment are studied. Flutter, transient response, and large structure dynamics are typical examples used. Recommended background: mechanics (ES 2501, ES 2502, ES 2503), aerodynamics (ME 3711).

ME 4724. HIGH SPEED FLOW.
Card. II
This course will introduce the students to the physical phenomena associated with flows at supersonic/hypersonic speeds. Emphasis will be placed on the hypersonic limit and various models developed to treat the continuum flow at this limit. Topics covered include: characterization of hypersonic flow, normal shock relations, the piston analogy and shock tube equations, oblique shock waves and expansion fans at the hypersonic limit, similarity methods, the Newtonian model, Mach number independence of the inviscid equations, small disturbance theory for planar and axially symmetric bodies, lift and drag coefficients, dynamics of the viscous portion of the flow, and real gas effects. Recommended background: thermodynamics (ES 3001), compressible flow (ME 3410), fluid dynamics (ES 3004, ME 3602), aerodynamics (ME 3711). This course will be offered in 2005-06 and in alternating years thereafter.
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), aerodynamics I (ME 3711), air breathing propulsion (ME 3716), aerospace structures (ME 4715).

This course will be offered in 2005-06 and in alternating years thereafter.

**ME 4711. SPACECRAFT AND MISSION DESIGN.**

Cat. II

This course introduces students to design of spacecraft, spacecraft subsystem and space missions. Topics covered in lectures address mission classification and the space environment, the design of subsystems that include spacecraft power and propulsion, attitude dynamics and control, structural, thermal, and communication. Lectures are in parallel with a term-long conceptual design of a spacecraft, spacecraft subsystem or space mission. 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 3003), control engineering (ES 3011), astronautics (ME 2713), rocket and spacecraft propulsion (ME 3715), aerospace structures (ME 4715).

This course will be offered in 2004-05 and in alternating years thereafter.

**ME 4813. CERAMICS.**

Cat. II

A course which develops an understanding of the structure-property relationships in ceramic materials. Content of interest to individuals interested in selecting and using ceramics as engineering materials. Limited material included in theory and practice of producing the initial shape.

Topics covered include: bonding and configuration of atoms in crystalline and noncrystalline materials, phase diagrams, microstructures, and macrostructures. Mechanical, optical and thermal properties as related to structure.

Recommended background: materials (ES 2001).

This course will be offered 2004-05, 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).

This course will be offered 2004-05, and in alternating years thereafter.

**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.

**ME 4816. MATERIALS OPTIMIZATION FOR ENGINEERS.**

Cat. II

A course designed to synthesize the students' background in materials science and engineering for selecting materials and processing methods in realistic applications. Case studies will cover a wide range of applied problems encountered in materials engineering. Current literature for newer materials and processes will be used.

Recommended background: materials (ME 2820, ME 3811, ME 3823).

This course will be offered in 2004-05 and in alternating years thereafter.

**ME 4821. CHEMISTRY, PROPERTIES, AND PROCESSING OF PLASTICS.**

Cat. II

Topics covered include: polymer chemistry, physical and chemical properties, processing methods, selection of materials, comparisons of plastics with metals, design considerations, and new materials. Laboratory studies are included. Use of current literature is stressed.

Recommended background: materials (ES 2001, ME 2820).

This course will be offered 2005-06, and in alternating years thereafter.

**ME 4822. SOLIDIFICATION PROCESSES.**

Cat. II

A course designed for in-depth study of industrial processes based on liquid-solid transformation. Fundamentals are developed and applied to commercial processes.

Topics covered include: quantitative treatment of casting and processes, semi-solid forming, laser welding, rapid solidification, spray forming, compoasting and other emerging technologies, which utilize liquid-solid transformations. Library and laboratory work are included.

Suggested background: General understanding of heat flow, fluid flow, diffusion, and metallurgy.

This course will be offered in 2004-05 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 2004-05 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 4850. SOLID STATE THERMODYNAMICS.**

Cat. I

Classical and atomistic thermodynamics are developed and applied to the behavior of solids, liquids and gases. Phase equilibria and phase diagrams are discussed. Emphasis is placed on the gas phase reactions and reactions between solids and gases as well as the behavior or solutions. Applications to Materials Engineering processes and phenomena are discussed.

Recommended background: materials (ES 2001), chemistry (CH 1020).

**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 3901).

Suggested background: physics (PH 1140).

This course will be offered in 2004-05 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.

MS 1011 and MS 1021 will appear on the WPI transcript as a zero credit course with a grade. Successful completion of MS 1011 and MS 1012 earns 1/9 unit in MS 1012. Successful completion of MS 1021 and MS 1022 earns 1/9 unit in MS 1022.

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

ML 1012. FOUNDATIONS OF OFFICERSHIP II.
Cat. I (1/9 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, enhance effective communication. Students begin to develop leadership potential by instilling self-confidence and fostering teamwork through basic survival techniques (e.g., water survival). Participation in leadership laboratories and participation in off-campus training sessions (field training exercise) is also required.

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

ML 1022. BASIC LEADERSHIP II.
Cat. I (1/9 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 team building techniques. Students build upon the basic leader principals and leadership development methodologies to refine their understanding of leadership. How to build teams, how to influence, how to communicate, how and when to make decision, and creative problem-solving. Participation in leadership laboratories and participation in off-campus training session (field training exercise) is also required
Recommended background: ML 1022

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

ML 2021. LEADERSHIP AND TEAMWORK I.
Cat. I (1/12 unit)
Students continue the study of leader principals and are introduced to formal policies such as equal opportunity, ethics, and values. Military communication skills are trained along with the principles of camouflage. Complex cases of risk management are studied. Students will submit a written information paper.
Participation in leadership laboratories and participation in off-campus training session (field training exercise) is also required.
Recommended background: ML 2012

ML 2022. LEADERSHIP AND TEAMWORK II.
Cat. I (1/12 unit)
This course covers small unit movement and military tactics. It combines previous study in weapons, movement and communications to teach the combination of firepower and maneuver to the student. This course also teaches the student the elements of how the military trains its personnel. A written decision paper and practical exercise in conducting training is included in this course.
Participation in leadership laboratories and participation in off-campus training session (field training exercise) is also required.
Recommended background: ML 2021

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

ML 3011. LEADERSHIP AND 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 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. NATIONAL ADVANCED LEADERSHIP CAMP.
Cat. I (1/6 unit)
NALC 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 NALC is progressive, building skills in individual subjects like the Army Physical Fitness Test, basic military skills and land navigation, followed by such skill-building exercises as Individual Tactical Training.
ML 4011. LEADERSHIP AND MANAGEMENT I.
Cat. I (1/6 unit)
ML 4011 begins with a series of lessons designed to enable the cadets to make informed career decisions as they prepare their accessions documents. Lessons concentrate on Army operations and training management, communications and leadership skills and support the beginning of the final transition from cadet to lieutenant. The course focuses cadets, early in the year, on attaining knowledge and proficiency in a few critical areas they will need to operate effectively as Army officers. These areas include: the Army’s training management system, coordinating activities with staffs, and counseling skills. While the proficiency attained in each of these areas will initially be at the apprentice level, cadets will continue to sharpen these skills as they perform their roles as cadet officers in the ROTC battalion and as new lieutenants after commissioning. At the end of this semester cadets should possess the fundamental skills, attributes, and abilities to operate as competent leaders in the cadet battalion and confidently shoulder the responsibilities entrusted to them.

ML 4022. LEADERSHIP AND MANAGEMENT II.
Cat. I (1/6 unit)
This course focuses on completing the transition from cadet to lieutenant. As an expansion of the Ethics instruction in ML 3021, the course starts with an examination of unit ethical climate and the commander’s role as the moral anchor of the unit. This is followed by a module addressing military law and leadership. The next module reinforces previous instruction on the organization of the Army and introduces how the Army organizes for operations from the tactical to strategic level. This is followed by instruction on administrative and logistical management that focuses on the fundamentals of soldier and unit level support. Next is a short module that focuses on preparing cadets for their forthcoming commissioning and military service. At the core of this semester is the Advance 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.

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

ML 4024. TRANSITION TO LIEUTENANT.
Cat. I (1/6 unit)
Cadets organize and lead all the junior cadets. This course covers the military legal system, personnel actions and personal finances. It certifies fundamental competencies in land navigation, tactics, counseling, and interpersonal communications.

This course requires three hours of class work and three hours of physical fitness per week. Three lab exercises and a formal military mall are required. Recommended background: ML 4023

PHYSICAL EDUCATION

PE 1001. INTRO TO GOLF & TENNIS.
Cat. I (1/2 unit)
Introduction to the sports through skill development and play.

PE 1002. INTRO TO VOLLEYBALL & SQUASH.
Cat. I (1/2 unit)
Introduction to the sports through skill development and play.

PE 1003. INTRO TO BOWLING & BADMINTON.
Cat. I (1/2 unit)
Introduction to the sports through skill development and play.

PE 1004. INTRO TO TABLE TENNIS, GOLF, & TENNIS.
Cat. I (1/2 unit)
Introduction to the sports through skill development and play.

PE 1005. INTRO TO RECREATIONAL SPORTS.
Cat. I (1/2 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 (1/2 unit)
Introductory course designed to acquaint students with knowledge and skills necessary to make choices that foster health and well-being.

PE 1007. BASIC WATER SAFETY.
Cat. I (1/2 unit)
For the beginner and intermediate swimmer. Students will learn about water recreational activities and how to remain safe while participating in them. Opportunity to learn the necessary means for safety in/near water and basic rescue techniques. Fee required.

PE 1011. TOUCH FOOTBALL.
Cat. I (1/2 unit)
Introduction to basic rules and individual/team skill development with practical application through game competition.

PE 1012. BASKETBALL.
Cat. I (1/2 unit)
Introduction to basic rules and individual/team skill development with practical application through game competition.

PE 1013. SOFTBALL.
Cat. I (1/2 unit)
Introduction to basic rules and individual/team skill development with practical application through game competition.

PE 1014. BEGINNING TENNIS.
Cat. I (1/2 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 (1/2 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 (1/2 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 (1/2 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 (1/2 unit)
Introduction to basic rules and individual/team skill development with practical application through game competition.

PE 1021. BOWLING.
Cat. I (1/2 unit)
Introductory course designed to acquaint students with the basic skills, knowledge and practical experience.

PE 1024. INTERMEDIATE TENNIS.
Cat. I (1/2 unit)
Designed for the student with basic skills in tennis. In-depth instruction in skill development and strategy with game competition.

PE 1027. INTERMEDIATE SWIMMING.
Cat. I (1/2 unit)
For the intermediate to advanced swimmer. Class will offer instruction geared toward creating efficient swimming. Swimming for Fitness will be introduced. Completion of Beginning Swimming (PE 1017) is recommended for this class; however students who pass a competency test administered by the instructor will be admitted.

PE 1055. PHYSICAL CONDITIONING.
Cat. I (1/2 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 (1/2 unit)

PE 1057. LIFEGUARDING II.
Cat. I (1/2 unit)
This class is based on the Red Cross Manual for Lifeguarding, Red Cross fee and books are required. The Lifeguard I course is the first part of a two course requirement (Lifeguarding I and II) for a student to be certified in CPR for the Professional Rescuer, First Aid, AED, Oxygen Administration and Lifeguarding. Recommended background: PE 1007

PE 1059. WEIGHT TRAINING PROGRAM FOR WOMEN.
Cat. I (1/2 unit)
This introductory course is designed to acquaint women with circuit training and free weight programs.
PH 1111. PRINCIPLES OF PHYSICS—ELECTRICITY AND MAGNETISM.
Cat. I
An introduction to electricity and magnetism, at a somewhat higher mathemati-
cal level than PH 1120.
Topics include: Coulomb’s Law, electric fields and potentials, capacitance,
electric current and resistance, magnetism, and electromagnetic induction.
Recommended background: working knowledge of material covered in PH
1111 and concurrent study of MA 1024 (or higher). Students concurrently taking
MA 1022 or MA 1023 are advised to take PH 1120.
Students may not receive credit for both PH 1121 and PH 1120.

PH 1120. INTERMEDIATE MECHANICS II.
Cat. I
This course is a continuation of the treatment of mechanics started in PH 2201.
Topics covered include: rigid-body dynamics, rotating coordinate systems,
Newton’s law of gravitation, central-force problem, driven harmonic oscillator,
and the Lagrangian and Hamiltonian formulation of mechanics.

PH 2201. INTERMEDIATE MECHANICS I.
Cat. I
This course emphasizes a systematic approach to the mathematical formulation
of mechanics problems and to the physical interpretation of the mathematical
solutions.
Topics covered include: Newton’s laws of motion, kinematics and dynamics of
a single particle, vector analysis, motion of particles, rigid body rotation about
an axis.
Recommended background: PH 1110, PH 1120, PH 1130, PH 1140, MA 1021,
MA 1022, MA 1023, MA 1024 and concurrent registration in or completion of
MA 2051.

PH 2202. INTERMEDIATE MECHANICS II.
Cat. I
This course is a continuation of the treatment of mechanics started in PH 2201.
Topics covered include: rigid-body dynamics, rotating coordinate systems,
Newton’s law of gravitation, central-force problem, driven harmonic oscillator,
and the Lagrangian and Hamiltonian formulation of mechanics.

PH 2501. ELECTROMAGNETIC FIELDS.
Cat. II
Introduction to the theory and application of electromagnetic fields, appropriate
as a basis for further study in electromagnetism, optics, and solid-state physics.
Topics: electric field produced by charge distributions, electrostatic potential,
electrostatic energy, magnetic force and field produced by currents and by
magnetic dipoles, introduction to Maxwell’s equations and electromagnetic
waves.
Recommended background: introductory electricity and magnetism, vector
algebra, integral theorems of vector calculus as covered in MA 2251.

PH 2501. PHOTONICS.
Cat. II
An introduction to the use of optics for transmission and processing of informa-
tion. The emphasis is on understanding principles underlying practical photonics
device. Topics include lasers, light emitting diodes, optical fiber communica-
tions, fiber lasers and fiber amplifiers, planar optical waveguides, light modula-
tors and photodetectors. Recommended background is PH 1110, PH 1120,
PH 1130 and PH 1140 (or their equivalents).
This course will be offered in 2004-05 and in alternating years thereafter.

PH 2502. LASERS.
Cat. II
An introduction to the physical principles underlying lasers and their applica-
tions. Topics will include the coherent nature of laser light, optical cavities,
beam optics, atomic radiation, conditions for laser oscillation, optical amplifiers
(including fiber amplifiers), pulsed lasers (Q-switching and mode locking), laser
excitation (optical and electrical), and selected laser applications. Recommended
background is PH 1110, PH 1120, PH 1130 and PH 1140 (or their equivalents).
This course will be offered in 2005-06 and in alternating years thereafter.

PH 1140. OSCILLATIONS, AND WAVES.
Cat. I
An introduction to oscillating systems and waves.
Topics include: free, damped forced, and coupled oscillations of physical
systems, traveling waves and wave packets, reflection, and interference
phenomena.
Recommended background: working knowledge of the material covered in
PH 1110 and PH 1120 (or PH 1111 and PH 1121) and completion of MA 1021,
MA 1022 and MA 1023.

PH 1121. INTERMEDIATE MECHANICS II.
Cat. I
This course is a continuation of the treatment of mechanics started in PH 2201.
Topics covered include: rigid-body dynamics, rotating coordinate systems,
Newton’s law of gravitation, central-force problem, driven harmonic oscillator,
and the Lagrangian and Hamiltonian formulation of mechanics.

PH 2201. INTERMEDIATE MECHANICS I.
Cat. I
This course emphasizes a systematic approach to the mathematical formulation
of mechanics problems and to the physical interpretation of the mathematical
solutions.
Topics covered include: Newton’s laws of motion, kinematics and dynamics of
a single particle, vector analysis, motion of particles, rigid body rotation about
an axis.
Recommended background: PH 1110, PH 1120, PH 1130, PH 1140, MA 1021,
MA 1022, MA 1023, MA 1024 and concurrent registration in or completion of
MA 2051.

PH 2202. INTERMEDIATE MECHANICS II.
Cat. I
This course is a continuation of the treatment of mechanics started in PH 2201.
Topics covered include: rigid-body dynamics, rotating coordinate systems,
Newton’s law of gravitation, central-force problem, driven harmonic oscillator,
and the Lagrangian and Hamiltonian formulation of mechanics.

PH 2501. ELECTROMAGNETIC FIELDS.
Cat. II
Introduction to the theory and application of electromagnetic fields, appropriate
as a basis for further study in electromagnetism, optics, and solid-state physics.
Topics: electric field produced by charge distributions, electrostatic potential,
electrostatic energy, magnetic force and field produced by currents and by
magnetic dipoles, introduction to Maxwell’s equations and electromagnetic
waves.
Recommended background: introductory electricity and magnetism, vector
algebra, integral theorems of vector calculus as covered in MA 2251.

PH 2501. PHOTONICS.
Cat. II
An introduction to the use of optics for transmission and processing of informa-
tion. The emphasis is on understanding principles underlying practical photonics
device. Topics include lasers, light emitting diodes, optical fiber communica-
tions, fiber lasers and fiber amplifiers, planar optical waveguides, light modula-
tors and photodetectors. Recommended background is PH 1110, PH 1120,
PH 1130 and PH 1140 (or their equivalents).
This course will be offered in 2004-05 and in alternating years thereafter.

PH 2502. LASERS.
Cat. II
An introduction to the physical principles underlying lasers and their applica-
tions. Topics will include the coherent nature of laser light, optical cavities,
beam optics, atomic radiation, conditions for laser oscillation, optical amplifiers
(including fiber amplifiers), pulsed lasers (Q-switching and mode locking), laser
excitation (optical and electrical), and selected laser applications. Recommended
background is PH 1110, PH 1120, PH 1130 and PH 1140 (or their equivalents).
This course will be offered in 2005-06 and in alternating years thereafter.
PH 2601. PHOTONICS LABORATORY.
Cat. II
This course provides an experimental approach to concepts covered in Photonics (PH 2501), Lasers (PH 2502), and Optics (PH 3504). Through a series of individually tailored experiments, students will reinforce their knowledge in one or more of these areas, while at the same time gaining exposure to modern photonics laboratory equipment. Experiments available include properties of optical fibers, optical fiber diagnostics, optical communications systems, properties of photodetectors, mode structure and threshold behavior of lasers, coherence properties of laser light, characterization of fiber amplifiers, diffraction of light, polarization of light, interferometry.
Recommended background: PH 1101/1111, 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 2004-05 and in alternating years thereafter.

PH 2651. INTERMEDIATE PHYSICS LABORATORY.
Cat. I
This course offers experience in experimentation and observation for students of the sciences and others. In a series of subject units, students learn or review the physical principles underlying the phenomena to be observed and the basis for the measurement techniques employed. Principles and uses of laboratory instruments including the cathode-ray oscilloscope, meters for frequency, time, electrical and other quantities are stressed. In addition to systematic measurement procedures and data recording, strong emphasis is placed on processing of the data, preparation and interpretation of graphical presentations, and analysis of precision and accuracy, including determination and interpretation of best value, measures of error and uncertainty, linear best fit to data, and identification of systematic and random errors. Preparation of high-quality experiment reports is also emphasized. Representative experiment subjects are: mechanical motions and vibrations; free and driven electrical oscillations; electric fields and potential; magnetic materials and fields; electron beam dynamics; optics; diffraction-grating spectroscopy; radioactive decay and nuclear energy measurements.
Recommended background: the Introductory Physics course sequence or equivalent. No prior laboratory background beyond that experience is required.
Students who have received credit for PH 2600 or PH 3600 may not receive credit for PH 2651.

PH 3117. PROBLEM SOLVING SEMINAR.
Cat. I
This course is intended to give students some experience in solving the kinds of problems that form the daily diet of a working physicist. Small groups of students will be presented with a series of problems, which they will solve under the guidance of one or more faculty members.
Topics will be selected from a wide variety of physical disciplines.
This course is intended for third- and fourth-year physics majors, after completion of intermediate-level classical mechanics, electromagnetism, and quantum mechanics.

PH 3301. ELECTROMAGNETIC THEORY.
Cat. I
A continuation of PH 2301, this course deals with more advanced subjects in electromagnetism, such as topics covered in 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: Junior standing, MA 4451, and completion of the introductory physics sequence, including the introduction to the 20th century physics.
Suggested background: knowledge of probability (or concurrent study) of linear algebra, Fourier series, and Fourier transforms.

PH 3402. QUANTUM MECHANICS II.
Cat. I
This course represents a continuation of PH 3401 and includes a study of three-dimensional systems and the application of quantum mechanics in selected fields.
Topics include: the hydrogen atom, angular momentum, spin, perturbation theory and examples of the application of quantum mechanics in fields such as atomic and molecular physics, solid state physics, optics, and nuclear physics.
Recommended background: PH 3401.

PH 3501. RELATIVITY.
Cat. II
This course is designed to help the student acquire an understanding of the formalism and concepts of relativity as well as its application to physical problems.
Topics include the Lorentz transformation, 4-vectors and tensors, covariance of the equations of physics, transformation of electromagnetic fields, particle kinematics and dynamics.
Recommended background: knowledge of mechanics and electrodynamics at the intermediate level.
This course will be offered in 2004-05 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 2004-05 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 deuteron 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 2005-06 and in alternating years thereafter.

PH 3504. OPTICS.
Cat. II
This course provides an introduction to classical optical physics, in particular interference, diffraction and polarization, and to the elementary theory of lenses.
The theory covered will be applied in the analysis of one or more modern optical instruments.
Recommended background: knowledge of introductory electricity and magnetism and of differential equations.
Suggested background: PH 2301.
This course will be offered in 2005-06 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 513/PH 4201. CLASSICAL MECHANICS.

PH 514. QUANTUM MECHANICS I.
Schroedinger wave equation. Harmonic oscillator, hydrogen atom, potential wells, approximation methods.

PH 515. QUANTUM MECHANICS II.
These issues have all been featured in one or more offerings of the course in limitations of national government, global environmental issues, the challenges of work debate, changes in unionism and advanced capitalism, the role and may include subsets of energy, welfare, environmental racism, homelessness, what a proper response to them would be.

Perspectives on the nature of each social problem, their relative importance and values, institutional structures, media interpretation and political authorities all involves an examination of both the process whereby public consensus is ing post-modern social organization and contemporary social issues. 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 to be considered to suggest economic solutions. There are no prerequisites for the course.

SS 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 are used to achieve full employment, stable prices, and economic growth.

The second digit for courses in this department has the following meaning:
1 — Economics
2 — Sociology
3 — Political Science and Law
4 — Psychology
5 — System Dynamic

SS 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.

SS 1130. INTRODUCTION TO ECONOMETRIC MODELING. Cat. I
The purpose of this course is to provide students with an introduction to econometric modeling s it is applied in the social sciences 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.

SS 1203. SOCIAL PROBLEMS AND POLICY ISSUES. Cat. II
The goal of this course is to examine various problematic features of the emerging post-modern social organization and contemporary social issues. The course involves an examination of both the process whereby public consensus is shaped and of the “life cycle” of a social problem. Social movements, cultural values, institutional structures, media interpretation and political authorities all get attention in the study of this process whereby some objective conditions come to be considered social problems requiring public action and others do not. Attention is also given to the warring conservative, liberal and radical perspectives on the nature of each social problem, their relative importance and what a proper response to them would be.

Several specific problem areas are addressed in detail as illustrations. These may include subsets of energy, welfare, environmental racism, homelessness, the crisis in education, environmental problems, international conflict, the end of work debate, changes in unionism and advanced capitalism, the role and limitations of national government, global environmental issues, the challenges facing the American family and the relationship between drugs and crime.

These issues have all been featured in one or more offering of the course in recent years. The students in each class will be given some choice as to which topics are covered as illustrations so long as they are in text.

The course requirements generally include an individual or group (your choice) project and an oral presentation. The topics are selected by the student with the approval of the instructor. This course will be offered in 2005-06 and in alternating years thereafter.

SS 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 illustrated 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 SS 1402, Introduction to Social Psychology, or a first course in Social Science. It is recommended background for SS2209, Innovation, Teamwork and the Process of Innovation.

SS 1301. U.S. GOVERNMENT. Cat. I
This course is an introduction to the fundamental principles, institutions, and processes of the constitutional democracy of the United States. It examines the formation and structure of the Federal 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 implementation 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 Sufficiency programs. See page 54.

SS 1303. AMERICAN PUBLIC POLICY. Cat. I
American Public Policy focuses on the outcomes or products of political institutions and political controversy. The course first addresses the dynamics of policy formations 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 SS 1303 prior to enrolling in upper level policy courses such as SS 2303, SS 2304 or SS 2311. There is no specific preparation for this course, but a basic understanding of American political institutions is assumed.

SS 1310. LAW, COURTS, AND POLITICS. Cat. II
This course is an introduction to law and the role courts play in society. The course examines the structure of judicial systems, the nature of civil and criminal law, police practice in the enforcement of criminal law, and the responsibilities of judges, attorneys and prosecutors. Additional topics for discussion include the interpretation of precedent and statute in a common law system and how judicial discretion enables interest groups to use courts for social change.

The student is expected to complete the course with an understanding of how courts exercise and thereby control the power of the state. As such, courts function as political actors in a complex system of governance. It is recommended that students complete this course before enrolling in SS 2310, Constitutional Law.

This course will be offered in 2005-06 and in alternating years thereafter.

SS 1320. TOPICS IN INTERNATIONAL POLITICS. Cat. II
SS 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 2004-05, and in alternating years thereafter.
SS 1401. INTRODUCTION TO COGNITIVE PSYCHOLOGY.
Cat. I
This course is concerned with understanding and explaining the mental processes and strategies underlying human behavior. The ways in which sensory input is transformed, reduced, elaborated, stored, and recovered will be examined in order to develop a picture of the human mind as an active processor of information. Topics will include perception, memory, problem-solving, judgment and decision making, human-computer interaction, and artificial intelligence. Special attention will be paid to defining the limitations of the human cognitive system. Students will undertake a project which employs one of the experimental techniques of cognitive psychology to collect and analyze data on a topic of their own choosing.

SS 1402. INTRODUCTION TO SOCIAL PSYCHOLOGY.
Social psychology is concerned with how people think about, feel for, and act toward other people. Social psychologists study how people interact by focusing on the individual (not society as a whole) as the unit of analysis, by emphasizing the effect on the individual of the situation or circumstances in which behavior occurs, and by acquiring knowledge through empirical scientific investigation. This course will examine the cause of human behavior in a variety of domains of social life. Topics will include, but not be limited to, person perception, attitude formation and change, interpersonal attraction, stereotyping and prejudice, and small group behavior. Special attention will be given to applied topics: How can the research methods of social psychology be used to help solve social problems? Students will work together in small groups to explore in depth topics in social psychology of their own choosing. May be included in certain Humanities and Arts Sufficiency programs. See page 54.

SS 1504. STRATEGIES FOR IMPROVING COGNITIVE SKILLS.
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 assumptions and arguments, and evaluating claims about the mind.

SS 1510. INTRODUCTION TO SYSTEM DYNAMICS MODELING.
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.

SS 1520. SYSTEM DYNAMICS MODELING.
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 including the construction, testing, and assembly of sub-sectors. Students will be required to complete modeling assignments working in groups and take in-class quizzes on modeling issues. Recommended background: SS1510, or permission of instructor.

SS/ID 2050. SOCIAL SCIENCE RESEARCH FOR THE IQP.
The topics addressed in this course are similar to those covered in SS 1110 (Introductory Microeconomics) but the treatment proceeds in a more rigorous and theoretical fashion. The course is designed for the economics major who has opted for the specialty area of economic growth and development. Special attention will be paid to defining the limitations of the human cognitive system. Students will 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 2110. INTERMEDIATE MICROECONOMICS.
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.

SS 2117. ENVIRONMENTAL ECONOMICS.
This course is an advanced treatment of microeconomic theory well suited for students majoring in Economics or Management, or others with a strong interest in economics. The topics addressed in SS 2117 are similar to those covered in SS 1120, however the presentation of the material will proceed in a more rigorous and theoretical fashion.

SS 2120. INTERMEDIATE MACROECONOMICS.
This course is open to students accepted to off-campus IQP centers and programs. The course reviews the principles and applications of macroeconomic issues and the relationship between fiscal and monetary policies, the sources of economic growth and development, the impact on economic policy, and the effects of economic policies on economic growth and development. The course concludes with a consideration of international problems and policies such as import substitution and trade policies.
export promotion, foreign debt, foreign investment, and the role of international firms. In conjunction with a traditional presentation of the above topics, the course curriculum will include the use of computer simulation models and games. These materials have been formulated with a simulation technique, system dynamics, that has its origins in control engineering and the theory of servomechanisms. As a result, students will find them complementary to their work in engineering and science. In addition, the various development theories and simulation and gaming results will be related, where possible, to specific developing nations where WPI has on-going project activities (e.g., Costa Rica and Thailand). This course is recommended for those students wishing to do an IQP or MQP in a developing nation. Recommended background: SS 1120.

This course will be offered in 2005-06 and in alternating years thereafter.

SS 2208. THE SOCIETY - TECHNOLOGY DEBATE.

Cat. II

A course which considers what one means when they say that we live in a technological society, focusing on the characteristics of technology that humanistic critics find problematic or objectionable. In the course of the analysis, the nature of technology, its connection to scientific advance, as well as its relationship to the state, and the social role of scientists and technologists will be considered. Special attention is given to the behavior of experts in scientific and technological controversies, and to the debate about the “technological mentality” said to pervade western societies. Utopian, Dystopian and Marxist interpretations of how technological development is taking us will be examined in an effort to understand the major themes in the larger debate about the social impact of technology. Computer science majors can take this course in place of CS 3043 if they write a term paper on a computer-related topic. Recommended background: SS 1202.

This course will be offered in 2005-06 and in alternating years thereafter. May be included in certain Humanities and Arts Sufficiency programs. See page 54.

SS 2209. INNOVATION, TEAMWORK AND THE PROCESS OF INNOVATION.

Cat. II

This course operates on two levels. It is a study of great innovations teams and R and D organizations in the field of aerospace, and great entrepreneurs who created their own companies around their inventions. China Lake, the Navy lab that invented the Sidewinder heat seeking air to air missile, Lockheed’s “Skunkworks” which produced the U2 spy plane and Stealth technology, and Korolev, the great Russian “chief designer” who shaped the Soviet missile and space program are featured. Edwin Land was the inventor-entrepreneur who created Polaroid Corporation and worked for the US government on projects such as camera optics for spy planes and satellites. Aspects of the technological context in which Carnegie, Edison and Bell emerged to prominence and the nature of their contributions will be discussed.

On another level, the class is an R and D unit composed of teams in a startup company with two different product lines, trying to get its first contract from an established aerospace conglomerate. The client company, its mission and CEO are described in Michael Flynn’s novel, Firestart. The home company has a new information project, ISIS, the Integrated Staff/Student Information System, which it claims can improve the effectiveness of innovation and production teams through the use of psychological instruments. Your unit is to research the great R and D units of the past, show how the client’s organization can be reconfigured to approximate them, and assess the case that teams usually likely to function well in their assigned roles can actually be formed using the ISIS cognitive styles database.

This course will be offered 2004-05, and in alternating years thereafter.

SS 2302. SCIENCE-TECHNOLOGY POLICY.

Cat. II

This course is an examination of the relationship between science-technology and government. It reviews the history of public policy for science and technology, theories and opinions about the proper role of government and several current issues on the national political agenda. Examples of these issues include genetic engineering, the environment and engineering education. It also examines the formation of science policy, the politics of science and technology, the science bureaucracy, enduring controversies such as public participation in scientific debates, the most effective means for supporting research, and the regulation of technology. Throughout the course we will pay particular attention to the fundamental theme: the tension between government demands for accountability and the scientific community’s commitment to autonomy and self-regulation. Recommended background: SS 1301 or SS 1303.

This course will be offered in 2004-05 and in alternating years thereafter.

SS 2304. GOVERNMENTAL DECISION MAKING AND ADMINISTRATIVE LAW.

Cat. II

The course addresses the role of expert knowledge 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 role of expert knowledge. Policy questions will be used to provide 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: SS 1301 or SS 1303 or SS 2310.

This course will be offered in 2005-06 and in alternating years thereafter.

SS 2310. CONSTITUTIONAL LAW.

Cat. II

Constitutional Law is a study of those Supreme Court decisions which interpret the foundation of American governance, the U.S. Constitution. These decisions address a wide variety of questions of historic and contemporary significance. For example: What are the limits on the powers of the President? How are the powers of the Congress restricted? How are legislative powers to be shared with the state and local governments? Other questions focus on the rights of individuals. What is the right to privacy and where is it found in law? Does the Constitution protect women who desire abortions, prevent discrimination against homosexuals, provide support for affirmative action programs? These and many other questions of great social and political importance are answered by the Supreme Court as it interprets the words of the founders. It is only through the decisions of the Court that we can come to have a complete understanding of the “living Constitution.”

Recommended background: SS 1310. (Formerly Dynamics and Limits of Law.) This course will be offered in 2004-05 and in alternating years thereafter.

SS 2311. LEGAL REGULATION OF THE ENVIRONMENT.

Cat. I

This course deals with environmental law as it relates to people, pollution and land use in our society. A case method approach will be used to illustrate how the courts and legislators have dealt with these social-legal problems. The course is designed to have the student consider: 1) the legal framework within which environmental law operates; 2) the governmental institutions involved in the formulation, interpretation and application of environmental law; 3) the nature of the legal procedures and substantive principles currently being invoked to resolve environmental problems; 4) the types of hazards to the environment presently subject to legal constraints; 5) the impact that the mandates of environmental law have had, and will have, on personal liberties and property rights; 6) the role individuals and groups can play within the context of our legal system to protect and improve man’s terrestrial habitat and the earth’s atmosphere; and 7) some methods and sources for legal research that they may use on their own.

Recommended background: SS 1303 or SS 1310.

SS 2312. INTERNATIONAL ENVIRONMENTAL POLICY.

Cat. II

Environmental issues present some of the major international problems and opportunities facing the world today. Worst-case scenarios envision irreparable degradation of the earth’s natural systems, but virtually every analysis sees the need for major change worldwide to cope with problems such as global warming, deforestation, ozone layer depletion, loss of biodiversity, and population growth, not to mention exponential increases in “conventional” pollutants in newly industrialized countries. The global environment issues represent a “second-generation” of environmental policy in which the focus of concern has moved from national regulations to international law and institutions. In addition, the environment has emerged as a major asset 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 includes the formulation, interpretation and application of environmental law; 2) the governmental institutions involved in the course. Recommended background: SS 2312.

This course will be offered 2005-06 and in alternating years thereafter.

SS 2310. CONSTITUTIONAL LAW.

Cat. II

Constitutional Law is a study of those Supreme Court decisions which interpret the foundation of American governance, the U.S. Constitution. These decisions address a wide variety of questions of historic and contemporary significance. For example: What are the limits on the powers of the President? How are the powers of the Congress restricted? How are legislative powers to be shared with the state and local governments? Other questions focus on the rights of individuals. What is the right to privacy and where is it found in law? Does the Constitution protect women who desire abortions, prevent discrimination against homosexuals, provide support for affirmative action programs? These and many other questions of great social and political importance are answered by the Supreme Court as it interprets the words of the founders. It is only through the decisions of the Court that we can come to have a complete understanding of the “living Constitution.”

Recommended background: SS 1310. (Formerly Dynamics and Limits of Law.) This course will be offered in 2004-05 and in alternating years thereafter.

SS 2311. LEGAL REGULATION OF THE ENVIRONMENT.

Cat. I

This course deals with environmental law as it relates to people, pollution and land use in our society. A case method approach will be used to illustrate how the courts and legislators have dealt with these social-legal problems. The course is designed to have the student consider: 1) the legal framework within which environmental law operates; 2) the governmental institutions involved in the formulation, interpretation and application of environmental law; 3) the nature of the legal procedures and substantive principles currently being invoked to resolve environmental problems; 4) the types of hazards to the environment presently subject to legal constraints; 5) the impact that the mandates of environmental law have had, and will have, on personal liberties and property rights; 6) the role individuals and groups can play within the context of our legal system to protect and improve man’s terrestrial habitat and the earth’s atmosphere; and 7) some methods and sources for legal research that they may use on their own.

Recommended background: SS 1303 or SS 1310.

SS 2312. INTERNATIONAL ENVIRONMENTAL POLICY.

Cat. II

Environmental issues present some of the major international problems and opportunities facing the world today. Worst-case scenarios envision irreparable degradation of the earth’s natural systems, but virtually every analysis sees the need for major change worldwide to cope with problems such as global warming, deforestation, ozone layer depletion, loss of biodiversity, and population growth, not to mention exponential increases in “conventional” pollutants in newly industrialized countries. The global environment issues represent a “second-generation” of environmental policy in which the focus of concern has moved from national regulations to international law and institutions. In addition, the environment has emerged as a major asset 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 includes the formulation, interpretation and application of environmental law; 2) the governmental institutions involved in the course. Recommended background: SS 2312.

This course will be offered 2005-06 and in alternating years thereafter.
SS 2313. INTELLECTUAL PROPERTY LAW.
Cat. II
Intellectual property includes ideas, and the works of inventors, authors, composers and other creative minds. Patents, copyrights and trademarks establish legal rights in intellectual property. Alternatively, control over the use of an idea might be maintained by treating it as a trade secret. In these ways, the ideas of inventors and creators are protected and others are prohibited from appropriating the ideas and creative works of others. This course addresses the concept of intellectual property and the public policies that support the law of patents, 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: SS 1310 or SS 2310.
This course will be offered in 2005-06 and in alternating years thereafter.

SS/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 in creating policies regarding privacy rights and freedoms, and hazardous waste and (2) to intellectual property including patents, copyrights and trademarks.
Recommended background: SS 1401 or SS 2310.
This course will be offered in 2004-05 and in alternating years thereafter.

SS 2401. THE PSYCHOLOGY OF EDUCATION.
Cat. II
This course is concerned with the learning of persons in educational settings from pre-school through college. Material in the course will be organized 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 Motivation to Learn; Unit 4: Understanding 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 technological education and international higher education.
Recommended background: SS 1401.
This course will be offered in 2005-06, and in alternating years thereafter.

SS 2405. ENVIRONMENTAL PROBLEMS AND HUMAN COGNITION.
Cat. II
This course examines how people think about the environment. Any environmental 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 resulting from the nature and limitations of the human mind. 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 hazardous 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: SS 1401 or SS 1402.
This course will be offered in 2005-06 and in alternating years thereafter.

SS 2406. CROSS-CULTURAL PSYCHOLOGY: HUMAN BEHAVIOR IN GLOBAL PERSPECTIVE.
Cat. II
This course is an introduction to the study of the ways in which social and cultural forces shape human behavior. Cross-Cultural psychology takes a global perspective of human behavior that acknowledges both the uniqueness and interdependence of peoples of the world. Traditional topics of psychology (learning, development) as well as topics specific 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: SS 1402.
This course will be offered in 2004-05 and in alternating years thereafter.

SS 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 complex problems will be discussed. Topics will include an extended discussion of model analysis, the use of summary statistics and sensitivity measures, the moderuntation process and 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: SS 1520.
This course will be offered in 2005-06 and in alternating years thereafter.

SS 2540. GROUP MODEL BUILDING.
Cat. II
This course will review the system dynamics practice of group model building, in which a system dynamics model is created through close interaction with a team of policy makers or managers. Topics will include theories of mental models, alternate techniques for eliciting, mapping and sharing mental models for use in model building, procedures for group facilitation, individual and team learning, group communication and decision making processes, and factors that promote or impede group performance. Special attention will be paid to the rigorous assessment of learning and group performance.
Recommended background: SS 1520.
This course will be offered in 2005-06 and in alternating years thereafter.

SS 3278. TECHNOLOGY ASSESSMENT AND IMPACT ANALYSIS SEMINAR.
Cat. II
The Indicators, Impact and Assessment Seminar is a specialized concepts and methods course designed primarily for Society-Technology Majors and students presently engaged in planning projects to carry out such analyses. It is run “seminar” style with one third of the sessions being reserved for student presentations. The course includes a laboratory experience and will stress the assessment of learning and group performance. The indicators 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: SS 1520.
This course will be offered in 2005-06 and in alternating years thereafter.

SS 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: SS 1520 and SS 2530.
This course will be offered in 2005-06 and in alternating years thereafter.