

03/18/2002

Michigan Technological University

Student Records and Registration

Graduate Courses

AF 4001 National Security Affairs I Examines national security process, regional studies, advanced leadership ethics, and Air Force doctrine. This course is designed to develop an understanding of the nature of conflict and how the United States military forces are developed, organized, and employed. Topics include the need for national security, the evolution and formulation of American defense policy and strategy, the origins of regional security issues, and joint doctrine.

AF 4002 National Security Affairs II Examines national security process, regional studies, advanced leadership ethics, and Air Force doctrine. This course examines selected roles of the military in society, unconventional warfare, current issues affecting the military profession, and the military justice system. Special topics of interest focus on information warfare, the law of armed conflict, the military as a profession, and officership.

AR 4001 Jr Officer Dev Seminar Introduces the military justice system, including disciplinary measures, rights of soldiers, separations, and searches. Includes critical reasoning and decision making, in the application of solving ethical dilemmas. Army briefing techniques and writing style is discussed and practiced. Introduction to the Army training management system, the military justice system, and logistics. Includes critical reasoning and decision making, in the application of solving ethical dilemmas. Briefing techniques and the Army writing style are also discussed and practiced.

AR 4002 Seminar in Leadership Leadership topics confronting a newly appointed second lieutenant, includes counseling of subordinates, evaluation systems, personnel management, training management, supply operations and maintenance functions. Advanced writing and briefing techniques are utilized throughout the term.

AR 4003 Seminar in Leadership Covers leadership topics confronting a newly appointed second lieutenant, including counseling of subordinates, evaluation systems, personnel management, training management, supply operations, and maintenance functions.

AR 4010 Battalion Staff Operations Develops personal confidence and advanced leadership ability using basic and advanced military skills. Students are given responsibility for planning and controlling the activities of large groups.

AR 4011 Battalion Staff Operations I Develops personal confidence and advanced leadership ability using basic and advanced military skills. Students are given responsibility for planning and controlling the activities

of the cadet battalion. Applied creativity, problem solving, decision making, and leadership are the cornerstones of this course.

AR 4012 Battalion Staff Operations II Develops personal confidence and advanced leadership ability using basic and advanced military skills. Students are given responsibility for planning and controlling the activities of the cadet battalion. Applied creativity, problem solving, decision making, and leadership are the cornerstones of this course. Develops personal confidence and advanced leadership ability using basic and advanced military skills. Students are given responsibility for planning and controlling the activities of the cadet battalion. Applied creativity, problem solving, decision making, and leadership are the cornerstones of this course.

BA 4200 Data Communications/Networking Studies the theory and practice of development and implementation of distributed systems in organizations at both the hardware and software levels. Addresses network implementation and administration, telecommunications, client/server information systems, distributed database, graphical user interface development, and the managerial implications of globally distributed communications and information systems. Introduces students to telecommunications concepts, architectures and protocols, commercial offerings, hardware, software, network design, and telecommunications management, regulations, and business applications (e-commerce).

BA 4210 Strategic IT for Org'l Change Focuses on understanding IT's impact and enabling role in transforming organizations, case analysis to develop a framework for innovative IT use, and understanding IT as a tool for sustainable competitive advantage. Focuses on understanding IT for competitive advantage and as an agent of transformation. Topics include managing IT infrastructure and architecture, its impact and enabling role in transforming the enterprise, case analysis to develop a framework for innovative ES use, and understanding ES as a tool for sustainable competitive advantage.

BA 4250 Information Systems Projects MIS capstone course. Previous completion of MIS electives and BSBA technology core requirement required. Applies IS concepts as solutions to business problems using project teams and faculty project manager supervision. Emphasizes the latter portion of the systems development life cycle project management within an IS context. MIS capstone course. Previous completion of MIS electives and BSBA technology core requirement required. Applies IS concepts as solutions to business problems using project teams and faculty project manager supervision. Emphasizes the latter portion of the systems development life cycle project management within an IS context.

BA 4300 Attestation and Assurance Auditing procedures and techniques associated with public accounting and with internal auditing for business entities. Topics include auditor's responsibilities, professional ethics, generally accepted auditing standards, purpose and types of audits, objectives, internal control, evidence, organization within the public accounting profession, the audit program, and auditing procedures and techniques. Auditing procedures and techniques associated with public accounting and with internal auditing for business entities. Topics include

auditor's responsibilities, professional ethics, generally accepted auditing standards, purpose and types of audits, objectives, internal control, evidence, organization within the public accounting profession, the audit program, and auditing procedures and techniques.

BA 4310 Foundations of Taxation Introduction to basic principles, concepts, and theoretical framework of taxation systems, emphasizing income taxation and its impact on decision making. Topics include tax planning and compliance for individuals, corporations, and partnerships.

BA 4320 Cost/Management Accounting II Emphasizes information requirements of contemporary management decision-making and strategic-planning processes. Covers contemporary control and evaluation practices (such as activity-based management), determining the costs of quality, and productivity analysis in the context of accounting information systems.

BA 4350 Advanced Tax Topics Continuation of BA4310. Introduction to advanced principles and concepts of taxation, emphasizing income taxation and its impact on decision making. Topics include tax planning and compliance for estates and trusts, gratuitous transfers, multijurisdictional operations, and entity formations, liquidations, and reorganizations. Continuation of BA4310. Introduction to advanced principles and concepts of taxation, emphasizing income taxation and its impact on decision making. Topics include tax planning and compliance for estates and trusts, gratuitous transfers, multi-jurisdictional operations, and entity formations, liquidations, and reorganizations.

BA 4360 Accounting Systems Introduction to the basic principles, concepts, and theoretical framework for the design and operation of accounting information systems, emphasizing its use to enhance decision making. Topics include system design, internal controls, the use of databases, and electronic commerce.

BA 4370 Advanced & Govt Accounting Advanced measurement and financial reporting problems encountered by accountants. Topics include the Statement of Cash Flows, consolidations and mergers, partnerships, governmental and not-for-profit organizations, and foreign operations. Advanced measurement and financial reporting problems encountered by accountants. Topics include the Statement of Cash Flows, consolidations and mergers, partnerships, governmental and not-for-profit organizations, and foreign operations.

BA 4380 Accounting Theory Analysis and evaluation of contemporary accounting thought. Explores current topics through readings, independent research, and discussions. Emphasizes concepts rather than procedures.

BA 4390 Contemporary Cost Management Emphasizes information requirements of contemporary management decision-making and strategic-planning processes. Covers contemporary control and evaluation practices (such as activity-based management), determining the costs of quality, and productivity analysis in the context of accounting information systems.

BA 4400 Investment Analysis Operations of the stock market, bond market, and other financial markets. Stock and bond valuation techniques, financial markets and institutions, and investment opportunities.

BA 4410 Advanced Financial Management Advanced topics in managerial finance: working capital management, capital budgeting, investment analysis, portfolio theory, and other topics. Includes case studies, class discussion, use of the computer in financial modeling, and other financial applications.

BA 4460 Derivatives and Financial Engg Covers the pricing and use of options, financial futures, swaps, and other derivative securities.

BA 4470 Applied Portfolio Management Covers issues in the management and administration of investments in an institutional setting. Students manage a real portfolio of financial assets. Covers issues in the management and administration of investments in an institutional setting. Students manage a real portfolio of financial assets.

BA 4480 Global Finance Studies international financial systems and markets. Covers the principle of comparative advantage, balance of payments, exchange rate systems, theories of international finance, identification of international risk exposures, the management and treatment of risk, and special topics of international finance.

BA 4490 Personal Financial Planning Provides students with an overview of personal financial issues and services and instruments offered by economic and financial institutions. Topics include the personal financial environment, employee compensation, personal investments and asset management, tax planning, the development of an adequate but cost-effective insurance program, and retirement planning Provides students with an overview of personal financial issues and services and instruments offered by economic and financial institutions. Topics include the personal financial environment, employee compensation, personal investments and asset management, tax planning, the development of an adequate but cost-effective insurance program, and retirement planning

BA 4570 Employment Law Provides an understanding of the statutory environment of organized labor and employment discrimination, along with labor-management processes for work agreements and dispute settlement.

BA 4580 Law of Technology Provides an understanding of the statutory requirements for protection of intellectual property, including patent, copyright, trademark, and trade secrets, along with derivative statutes, and obligations imposed by licensing of rights.

BA 4590 Environmental Law Provides an understanding of the structure and terminology of environmental protection statutes, the regulatory approach to implementing their coverage, and the deployment and terminology of international environmental relations.

BA 4600 Management of Technology Studies technology development, methods of technological forecasting and R&D management, implementation of new technology, technology transfer, strategic technology management and international technology management issues. Two credits with no research report; three credits with a report on a company's technology strategy or the competitive technology development in a selected product/service group.

BA 4610 Project Management Focuses on application of systems analysis to

project definition and selection. Covers project teams, their structures, and interactions; cross-functional communication in technological project management; project management planning, scheduling, and control tools; project monitoring, evaluation, and termination; multiple project management and interproject relations. Case study of new product process development. Requires case study reports. Focuses on application of systems analysis to project definition and selection. Covers project teams, their structures, and interactions; cross-functional communication in technological project management; project management planning, scheduling, and control tools; project monitoring, evaluation, and termination; multiple project management and inter-project relations. Case study of new product process development. Requires case study reports.

BA 4620 Supply Chain Management Designing and managing channels of distribution, purchase and movement of goods, and transportation systems. Emphasizes design of appropriate marketing channels, advanced topics in inventory control, facility location, routing of physical flows among facilities, and design and evaluation of transportation systems

BA 4630 Manufacturing Strategy Addresses issues in operations management, quality, finance/accounting, marketing, supply chain, and technology to provide an interdisciplinary focus on strategic planning for manufacturing. Also addresses issues associated with global initiatives and changing technology.

BA 4660 Systems Quality Management Stresses concepts and tools used to manage interrelationships among several functional units. Emphasizes quality function deployment and related tools, such as experimental designs, failure mode analysis, etc. Stresses concepts and tools used to manage interrelationships among several functional units. Emphasizes quality function deployment and related tools, such as experimental designs, failure mode analysis, etc.

BA 4670 Discrete Event Simulation Introduction to discrete-event digital simulation to solve management problems with the use of special-purpose software. Computer-based modeling used for problem solving, analysis, and generating recommendations.

BA 4680 International Tech Management Comparative international studies of economic and managerial aspects of technological innovation. Analyzes conditions, forms, and structures of management for international technological projects. Case studies of international transfer of technology. Two credits without a research report; three credits with a research report.

BA 4690 Systems Thinking Systems thinking concepts are applied to understand the complex feedback relationships that exist within a dynamic system. Uses computer-based simulators and a laboratory for experimentation to understand the side effects of proposed policies and trade-offs between short-term and long-term impacts. Systems thinking concepts are applied to understand the complex feedback relationships that exist within a dynamic system. Uses computer-based simulators and a laboratory for experimentation to understand the side effects of proposed policies and trade-offs between short-term and long-term impacts.

BA 4700 Business Policy Focuses on the interrelationship of the various functions of the business organization as it relates to strategic planning.

BA 4710 International Management Study of managing work in a global context. Assesses impact of culture and the international environment (economic, social, legal, technological) on management, personnel, marketing, accounting, and finance strategies. Examines international business structures from licensing to joint ventures. Develops attitudes and skills leading to increased international effectiveness.

BA 4750 Managing Change Requires a study of organizational change management. Emphasizes leadership in envisioning, implementing, and managing resistance to change. Focuses on leadership and change management within the framework of transformational leadership, empowerment, commitment, teamwork, and culture change, and on mastering tools and techniques to facilitate large-scale organizational change. Studies the role of leadership in envisioning, implementing and managing resistance to change. Uses a leadership frame- work to examine empowerment, commitment, teamwork, culture change and methods facilitating large-scale organizational change. In-depth coverage of both leadership and change theories and processes. Class objectives are evaluation, application and synthesis of these topics with discussion using a case format. Assessment instruments, experimental exercises, a high element ropes course and group activities provide additional skill development opportunities.

BA 4760 Strategic Leadership Study and practice of leadership in organizations. Topics include leadership styles, teams, task and relationship skills, personality, power, conflict management, feedback techniques, planning, decision making, and follower-situation attributes. Various leadership theories are discussed and applied to leaders. Includes significant self-evaluation of leadership traits. Study and practice of leadership in organizations. Topics include leadership theories, processes, styles, assessment, and skills, power and influence, intelligence and creativity, personality types, values, attitudes, and beliefs, group and team effectiveness, motivation, satisfaction, and performance, abuse of power, and ethics. Not appropriate for students who have previously taken BA2700 and/or BA3700. Study and practice of leadership in organizations. Topics include leadership theories, processes, styles, assessment, and skills, power and influence, intelligence and creativity, personality types, values, attitudes, and beliefs, group and team effectiveness, motivation, satisfaction, and performance, abuse of power, and ethics. Not appropriate for students who have previously taken BA2700 and/or BA3700.

BA 4770 Human Resource Management Examines methods that organizations use to meet organizational goals through influencing worker attitudes, behaviors, and performance. Topics include recruitment, selection, training, performance appraisal, and compensation.

BA 4780 International Bus Comm Studies the importance of intercultural communication competence for effective business relationships. Provides a theoretical and practical foundation for successful business communication by examining the communication processes and contextual units.

BA 4790 Ecology and Organizations Examines the problems and solutions

associated with creating and maintaining ecologically sustainable organizations (primarily businesses). Builds an ethical framework using concepts of ecological identity and place and examines the principles of ecological economics and sustainable development.

BA 4800 Business Research Focuses on research to help make better business decisions. Includes the study of qualitative and quantitative research methods, survey research methodology, potential sources of error, statistical analysis, and using SPSS. Cases or practical research are used to give experience in business research methods.

BA 4840 Industrial Marketing Focuses on marketing and purchasing of goods and services in industrial markets. Includes pricing issues, distribution, product planning and value analysis, inventory management, and legal issues. Examines the implications of these issues to industrial buyers and industrial marketers.

BA 4860 Buyer Behavior Focuses on understanding behavior of buyers as members of relevant groups, subcultures, and national and global cultures. Emphasizes converting theories of behavior into models of behavior in industries/markets of interest to the students. Focuses on understanding behavior of buyers as members of relevant groups, cultures, and nations. Examines unique characteristics of e-commerce and its strategic implications for marketing management. Investigates design and implementation of marketing mix elements both online and offline.

BA 4870 Advertising/Sales Promotion Studies how advertising and sales promotion campaigns (for both consumer and industrial goods) are created, produced, distributed, and measured. Emphasizes roles played by clients, various components of advertising agencies, and media companies. Focuses on experiential learning using group projects for real clients (often a nonprofit).

BA 4880 Sales and Sales Management Looks at the role of the selling function as an integral part of the total marketing effort. Examines the administrative functions of sales management, the dynamics of the buying-selling process, and sales strategies and tactics.

BA 4900 Research and Special Projects Under the general guidance of a faculty member, students read, conduct research, and prepare reports and papers as required. The SBE's Curriculum Committee must approve the subject of the proposed project.

BA 4990 Special Topics in Business Business topics of interest to students and faculty.

BAA 9003 Histories & Cultures

BAA 9003U Histories & Cultures Upper Div

BAA 9004 Science, Tech and Society

BAA 9004U Science/Tech/Society Upper Div

BAA 9005 Econ, Political & Social Inst

BAA 9005U Econ/Pol/Social Inst Upper Div

BE 4000 Independent Study Students undertake an independent study under the guidance of a Biomedical Engineering faculty member. The course of study may either be research or academic and is decided upon between the study and faculty member.

BE 4100 Cell and Tissue Mechanics This course focuses on the mechanical behavior and adaptation of musculoskeletal tissues. Topics include the material properties, viscoelasticity, fatigue, and failure of musculoskeletal tissues. The role of mechanical forces in the development, growth, and adaptation of musculoskeletal tissues, and cell biology and cellular mechanotransduction will also be discussed.

BE 4210 Exercise Physiology Focuses on the functional changes brought by acute and chronic exercise sessions. Topics include muscle structure and function, bioenergetics, cardiovascular and respiratory adaptations, exercise training for sport, sport nutrition, ergogenic aids, and other health and fitness topics.

BE 4300 Adv Polymeric Biomaterials A specialized study of polymers used in biomedical engineering. The course will examine processing-structure-properties relationships for polymers, polymer fibers and composites; degradation of polymers, and medical applications for polymeric biomaterials.

BE 4440 Introduction to Genetic Engg Molecular medicine and its applications in genetic engineering for the treatment of various disease will be discussed. A quick review of genetics and cell biology as well as the human disease mechanisms will be provided. In vivo, in vitro and ex vivo treatments utilizing genetically engineered products, allogeneic and autologous cell transplantation experiments will be discussed. Students will be asked to develop a hypothetical treatment of a disease using the tools covered in the class. Molecular medicine and its applications in genetic engineering for the treatment of various disease will be discussed. A quick review of genetics and cell biology as well as the human disease mechanisms will be provided. In vivo, in vitro and ex vivo treatments utilizing genetically engineered products, allogeneic and autologous cell transplantation experiments will be discussed. Students will be asked to develop a hypothetical treatment of a disease using the tools covered in the class.

BE 4550 Aerospace Physiology Focuses on the effects of space flight on human physiology. Topics include the effects of micro-gravity on skeletal muscle, bone, and the cardiovascular respiratory, vestibular, and immune systems. Discusses counter measures for long duration space travel. This course focuses on human physiological responses and adaptations to environmental extremes. Specific topics include spaceflight, simulated spaceflight, high altitude, temperature, and pollution. This course focuses on human physiological responses and adaptations to environmental extremes. Specific topics include spaceflight, simulated spaceflight, high altitude, temperature, and diving.

BE 4660 Active Implantable Devices Implantable devices which are actively



delivering therapy and acting as monitoring tools will be covered. Emphasis will be on the component level design and system level integration. Each student will design an implantable device and demonstrate its feasibility with theoretical methods learned in the class.

BE 4700 Biosensors This course introduces the student to the fundamentals of biosensor development and applications. It provides an understanding of biological components, immobilization methods, transducers, and fabrication techniques. In particular, microfabrication and nanofabrication of biosensors are discussed.

BE 4800 Biomaterials Interfaces This course introduces the students to the effects of topography and texture on the performance of biomaterials. Special emphasis is placed on tissue engineering scaffolds and microfabrication and nanofabrication techniques. Some of the topics also include: self-organization of biomembranes and supramolecular systems, bioactive materials, and the molecular basis for surface recognition and masking.

BE 4900 Biomedical Design Project I A team approach is used to resolve a defined problem in biomedical engineering. Projects are selected and undertaken with faculty and/or industrial-sponsor guidance. Requires project notebooks, oral and written proposals, progress reports, and final presentations. A team approach is used to resolve a defined problem in biomedical engineering. Projects are selected and undertaken with faculty and/or industrial-sponsor guidance. Requires project notebooks, oral and written proposals, progress reports, and final presentations. (Senior project ready as defined by major substitutes for prerequisites)

BE 4910 Biomedical Design Project II Continuation of Biomedical Design Project I (BE4900) under faculty and/or an industrial-sponsor. Emphasizes design and testing of prototypes. Requires work project notebooks, oral and written reports, and presentations. Continuation of Biomedical Design Project I (BE4900) under faculty and/or an industrial-sponsor. Emphasizes design and testing of prototypes. Requires work project notebooks, oral and written reports, and presentations. (Senior project ready as defined by major substitutes for prerequisites)

BE 4920 Professional Development This multi-topic course prepares the student for professional practice. Modules will cover professional licensing, ethics, intellectual property, regulatory requirements, and other nontechnical aspects of the biomedical engineering profession.

BE 4930 Biomedical Engineering Topics Biomedical engineering courses will be offered as professional electives dependent upon the interest of the faculty, and/or special undergraduate research on specific problems where research credits may be granted. Biomedical engineering courses will be offered on new or emerging technical subjects depending on student demand and faculty interest and expertise.

BE 5000 Graduate Research Includes the study of an acceptable biomedical engineering problem and the preparation of a report or thesis.

BE 5300 Adv Polymeric Biomaterials A specialized study of polymers used in biomedical engineering. Topics include: Processing-structure-properties

relationships for polymer fibers and composites, degradation of polymers, and medical applications for composite biomaterials.

BE 5440 Genetic Engg & Molecular Med Molecular medicine and its applications in genetic engineering for the treatment of various diseases will be discussed. A quick review of genetics and cell biology as well as the human disease mechanisms will be provided. In vivo, in vitro and ex vivo treatments utilizing genetically engineered products, allogeneic and autologous cell transplantation experiments will be discussed. Students will be asked to develop a hypothetical treatment of a disease using the tools covered in the class. In addition, students will be asked to review the work done by other investigators and reported in the scientific literature.

BE 5500 Biomedical Materials An overview of biomaterials in three basic classes: metals, ceramics, and polymers. Topics include biomaterials used in special medical applications (such as tissue replacement, absorbable and non-absorbable sutures, and soft tissue replacements) as well as discussion of tissue, body, and blood response to implants (bio-compatibility). An overview of biomaterials in three basic classes: metals, ceramics, and polymers. Topics include biomaterials used in special medical applications (such as tissue replacement, absorbable and non-absorbable sutures, and soft tissue replacements) as well as discussion of tissue, body, and blood response to implants (bio-compatibility).

BE 5660 Advanced Active Implants Implantable devices which are actively delivering therapy and acting as monitoring tools will be covered. Emphasis will be on the component level design and system level integration. Each student will design an implantable device and demonstrate its feasibility with theoretical methods learned in the class. Students will also review existing designs and will reverse engineer them from patents and product brochures for presentation.

BE 5700 Advanced Biosensors This course introduces the student to biosensor development and applications. It provides an understanding of biological components, immobilization techniques, transducers, and fabrication methods. In particular, microfabrication and nanofabrication techniques will be discussed.

BE 5800 Biomaterials Interfaces This course introduces the students to the effects of topography and texture on the performance of biomaterials. Special emphasis is placed on tissue engineering scaffolds and microfabrication and nanofabrication techniques. Some of the topics include: self-organization of biomembranes and and supramolecular systems, bioactive materials, and the molecular basis for surface recognition and masking. This course introduces the students to the effects of topography and texture on the performance of biomaterials. Special emphasis is placed on tissue engineering scaffolds and microfabrication and nanofabrication techniques. Some of the topics include: self-organization of biomembranes and supramolecular systems, bioactive materials, and the molecular basis for surface recognition and masking.

BE 5900 Biomedical Engineering Topics Biomedical engineering courses will be offered as professional electives dependent upon the interest of the faculty.

BE 6000 Doctoral Research Includes the study of an acceptable biomedical

engineering problem and the preparation of a report or thesis.

BE 6900 Biomedical Engineering Topics Biomedical engineering courses will be offered as professional electives dependent upon the interest of the faculty.

BL 4000 Special Problems in Biology A literature and laboratory research problem that culminates in a written report on the work performed.

BL 4001 Honors Research in Biology A laboratory-based research problem that culminates in a written report and a seminar presentation on the work performed. Open only to biological sciences and clinical laboratory sciences majors accepted into the Honors in Biological Sciences program. A laboratory-based research problem that culminates in a written report and a seminar presentation on the work performed. Open only to biological sciences and clinical laboratory sciences majors accepted into the Honors in Biological Sciences program.

BL 4010 Biochemistry I Structure, chemical properties, and function of important biomolecules, such as proteins, carbohydrates, and lipids. Introduces enzyme chemistry (structure, catalysis, kinetics, and inhibition). Structure, biochemical properties, and function of important biomolecules such as proteins and nucleic acids. Introduces enzyme biochemistry (structure, function, catalysis, kinetics, and inhibition).

BL 4020 Biochemistry II Dynamic aspects of living systems. Broad exposure to cellular metabolic pathways, intermediary metabolism and its regulation and bioenergetics.

BL 4030 Molecular Biology Molecular biology of gene structure, expression and regulation. Also topics covering various molecular techniques and applications of these techniques and biotechnology.

BL 4040 Environmental Biochemistry The chemistry, biochemistry and physiology of the interaction of organisms with their environment. Topics include chemistry of heavy metals, toxic organic compounds, heavy metal resistance, bioaccumulation, detoxification, bioremediation, chemistry of surfactants, catabolism of hydrocarbons, the chemistry and biochemistry of sulfur, iron and nitrogenous compounds, bioleaching and the application of biotechnology.

BL 4090 Tropical Island Biology A survey of island biology, including marine and terrestrial habitats. Topics include formation of carbonate islands, geological history of the Bahamas, island plant communities, intertidal, grass bed, mangrove and coral reef communities. Special course fees. Consult department before enrolling.

BL 4100 Special Topics in Bio Sci A study of recent developments in the biological sciences.

BL 4130 Phycology Morphology, distribution, physiology, ultrastructure, taxonomy, and economic significance of freshwater and marine algae.

BL 4140 Plant Physiology Physiology and biochemistry of plants. Emphasizes photosynthesis, plant hormones, water and nutrient relations, and light-regulated development.

BL 4220 Appl Industrial Microbiology Discussion of microbial involvement in areas such as industrial production processes, biodeterioration, and organic and inorganic waste treatment. Also reviews current literature in these areas.

BL 4230 Virology Comparison of bacterial, animal, and plant viruses, including a detailed study of viral structure and host-virus interaction in the viral replication process. Discusses important current areas of viral research, viral immune suppression, and oncogene theory.

BL 4320 Histology Basic tissue structures and organs of the vertebrate organisms with emphasis on the human.

BL 4380 Cardiopulmonary Physiology Using a problem-based learning approach, course examines the physiology of the human body. In-class case-study analyses provide in-depth learning about the cardiovascular and pulmonary systems and their relationship with other organ systems. Promotes development of problem-solving skills.

BL 4430 Bio Simulation Techniques Introduction to the use of mathematical techniques for simulation of biological phenomena, including programming techniques for computers.

BL 4450 Limnology Introductory study of interrelated physical, chemical, and biological processes of freshwater lakes. Field work on local lakes emphasized.

BL 4451 Aquatic Ecology Integrated coverage of flowing and standing fresh water environments, including physical and chemical factors and their impact on the biota. Applied aspects include biological responses to stress and fisheries management. Emphasizes fieldwork on local environments.

BL 4470 Analysis of Biological Data Methods and techniques of analyzing quantitative biological data and of designing biological experiments.

BL 4500 Discussions in Bioinformatics Critical discussions of current topics in bioinformatics. Oral and written presentations requiring synthesis of information from various sources including primary literature.

BL 4510 Senior Essay Reading, interpreting, and integrating information from the primary literature of biological sciences. Emphasizes oral and written presentation skills.

BL 4550 Clinical Chemistry Theory and technique used in the routine and experimental analysis of body fluids. Includes the study of kidney and liver functions, electrolytes, medically important enzymes, protein electrophoresis, microanalytical techniques, and the use of automated analytical equipment.

BL 4610 CLS Clinical Practicum I Practical and didactic training in clinical chemistry, immunopathology, and medical microbiology under the direction of National Accrediting Agency for the Clinical Laboratory Sciences (NAACLS)-approved/accredited hospital internship program personnel.

BL 4611 CLS Clinical Practicum II Practical and didactic training in hematology, urinalysis, and immunohematology under the direction of National Accrediting Agency for the Clinical Laboratory Sciences (NAACLS)-approved/accredited hospital internship program personnel.

BL 4620 Histotechnology Practicum I Practical and didactic training in sample processing, microtome use, staining, instrumentation, grossing, embedding, and microscopy under the direction of National Accrediting Agency for the Clinical Laboratory Sciences (NAACLS)-approved/accredited hospital internship program personnel. Acceptance by a NAACLS-approved/accredited histological technology and/or histotechnologist hospital internship program required.

BL 4621 Histotechnology Practicum II Practical and didactic training in histochemistry, DNA immunohistochemistry techniques, research methods, management, and safety under the direction of National Accrediting Agency for the Clinical Laboratory Sciences (NAACLS)-approved/accredited hospital internship program personnel.

BL 4630 Cytotechnology Practicum I Practical and didactic training in recognition of normal cells and cellular changes, particularly malignant, in the female reproductive tract, respiratory tract, and gastrointestinal tract under the direction of Committee on Accreditation of Allied Health Education Programs (CAAHEP)-approved/accredited hospital internship program personnel. Acceptance by a CAAHEP-approved/accredited cytotechnology hospital internship program required.

BL 4631 Cytotechnology Practicum II Practical and didactic training in normal cell identification and recognition of cellular changes with emphasis on the diagnosis of cancer in the urinary, excretory, and neurological systems under the direction of Committee on Accreditation of Allied Health Education Programs (CAAHEP)-approved/accredited hospital internship program personnel.

BL 4640 Clinical Immunology & Serology Integrates basic and clinical immunological principles as well as outlines the diagnosis and evaluation of immune disorders and selected infectious diseases.

BL 4660 Current Topics in CLS Recent developments in Clinical Laboratory Science.

BL 4710 Hematology & Immunohematology Study of the morphological, biochemical, and functional aspects of blood cells, blood coagulation, and blood-banking principles of donor and recipient testing, and the rationale for and hazards of blood transfusion. Lab emphasizes techniques for analyzing the cells of the peripheral blood and for determining transfusion compatibility.

BL 4740 Introduction to Mycology The taxonomy and biology of major groups of fungi, focusing on their ecology and physiology. Emphasizes organisms of interest in medicine and forest ecology.

BL 4750 Clinical Lab Instrumentation An overview of the principles, applications, and selection of instruments used in clinical laboratory. Lab work includes operation, maintenance, and trouble shooting to obtain experience working with power supplies, centrifuges, spectrophotometers, pH

meters, osmometers, radiation counters, and chemistry analyzers, blood cell counters, and other instruments commonly used in a diagnostic laboratory.

BL 4810 Plant Taxonomy The classification system and the criteria for classification employed in the plant kingdom with emphasis on vascular plants. A two-week field course immediately follows spring term. The classification system and the criteria for classification employed in the plant kingdom with emphasis on identification of vascular plants. A two-week field course immediately follows spring term.

BL 4820 Biochem Techniques I Laboratory techniques fundamental to studies in the area of biochemistry, including cell growth and disruption, membrane isolation and purification using sucrose density gradients, phospholipid extraction and analysis, and determination of fatty acid compositions using gaschromatographic analysis. Laboratory techniques basic to biochemistry and molecular biology including protein and phospholipid determinations, purification of natural and recombinant enzymes, enzyme kinetics, polyacrylamide gel electrophoresis, techniques of cell disruption, membrane isolation and purification using sucrose density gradients, phospholipid and fatty acid compositional analysis.

BL 4830 Biochem Techniques II Laboratory techniques basic to biochemistry and molecular biology, including protein assays, purification of natural and recombinant enzymes, enzyme kinetics, and polyacrylamide gel electrophoresis. Advanced Biochemical Techniques is designed to provide students with a rigorous exposure to the techniques and procedures utilized in the areas of Biochemistry. Emphasis will be placed on an active role of the student in the design of experiments and the collection and interpretation of biochemical data. Students will use microbial systems to construct and characterize experimental strains, monitor and interpret growth data and evaluate microbial regulatory systems via the use of measurements of enzyme specific activity, cell growth and viability and protein and nucleic acid synthesis.

BL 4840 Molecular Biology Techniques Laboratory techniques in molecular biology, including methods of recombinant DNA technology for identification, cloning, and characterization of genes.

BL 4860 Toxicology Focuses on principles and testing methods used to describe effects of chemical agents on biological material. Includes carcinogenic, mutagenic, and teratogenic effects and target organs of toxins. Also covers harmful effects of environmental agents such as pesticides and metals on humans, animals, and ecosystems.

BL 4979 Clinical Lab Admin & Management Discusses clinical laboratory administration and management issues, including method evaluation, reference intervals, quality control, developing standard operating procedures, and compliance. The laboratory will emphasize techniques for method evaluation, establishing reference intervals, quality control, and compliance with regulatory agencies. Discusses clinical laboratory administration and management issues, including method evaluation, reference intervals, quality control, developing standard operating procedures, and compliance. The laboratory will emphasize techniques for method evaluation, establishing reference intervals, quality control, and compliance with regulatory agencies.

BL 4980 CLS Core Concept Integration CLS Program Capstone Course. Review, and subsequently learn to integrate and apply, clinical core course material. Assignments include collaborative exercises involving development, peer review, and presentation of worksheets, case studies, and instrument evaluations, as well as other interactive learning activities.

BL 5030 Molecular Biology Molecular biology of gene structure, expression and regulation. Molecular techniques and their application to biotechnology and genomes are covered.

BL 5040 Electron Optical Methods I Hands-on course focusing on use of transmission electron microscopes. Topics include sample preparation for biology, transmission electron optics, specimen-beam interactions, operating parameter choices, image formation and processing. Successful completion of course is the prerequisite to becoming a certified operator, MTU Electron Optics Facility. Hands-on course focusing on use of transmission electron microscopes. Topics include sample preparation for biology, transmission electron optics, specimen-beam interactions, operating parameter choices, image formation and processing. Successful completion of course is the prerequisite to becoming a certified operator, MTU Electron Optics Facility. (This is a half semester course.)

BL 5050 Electron Optical Methods II Topics include sample preparation for biology, scanning electron optics, specimen-beam interactions, image formation and processing, operating parameter choices, and basic X-ray microanalysis. Successful completion of this course is prerequisite to becoming a certified operator, MTU Electron Optics Facility. Hands-on focusing on the use of transmission electron microscopes. Topics: sample preparation for biology, transmission electron optics, specimen-beam interactions, operating parameter choices, image formation and processing. Successful completion of course is the prerequisite to becoming a certified operator in the MTU Electron Optics Facility. (This is a half semester course) Hands-on focusing on the use of transmission electron microscopes. Topics: sample preparation for biology, transmission electron optics, specimen-beam interactions, operating parameter choices, image formation and processing. Successful completion of course is the prerequisite to becoming a certified operator in the MTU Electron Optics Facility. (This is a half semester course)

BL 5060 Biological Ultrastructure Microscopical investigations of biological specimens with transmission and scanning electron, scanning tunneling, and atomic force. Basic laboratory techniques include fixation and embedding, ultrathin sectioning, critical point drying, sputter coating. Also includes advanced cytochemical, cryo- and high-resolution techniques.

BL 5150 Advanced Plant Physiology Comprehensive study of metabolic activities and growth processes of plants. Emphasizes water relations and growth at the submicroscopic, microscopic, and macroscopic levels. Prerequisite: a course in plant physiology.

BL 5160 Plant Biochem & Molecular Bio Biochemical principles underlying central processes unique to plants, including photosynthesis and symbiotic nitrogen fixation. Also covers fundamentals of plant molecular biology including transformation of plants and regulation of gene expression.

Background required: one year of biochemistry and a course in plant physiology.

BL 5170 Plant Cell & Development Cellular, molecular processes involved in plant development. In-depth study of the structure and function of the plant cell as related to plant development. Such topics as control of iterative growth, cellular basis of form, cell differentiation, competence, determination and coordination of development. Background required: course in biochemistry and in plant physiology.

BL 5200 Microbial Physiology Structure and function of micro-organisms, with emphasis on mechanisms for responding to changing environmental and nutritional conditions. Structure and function of microorganisms, with emphasis on mechanisms for responding to changing environmental and nutritional conditions.

BL 5250 Immunological Toxicology Covers current topics in immunology and toxicology, including lymphokines, lymphocyte interactions, immune network theory, acquired and genetic immune defects, immunization of animals, characteristics of antibodies, immunoassays, and production of monoclonal antibodies.

BL 5340 Special Topics in Biology A discussion of recent developments in the biological sciences. Recent offerings have included population genetics, taxonomy of aquatic insects, herpetology, bryology, fungi, and lichens.

BL 5350 Special Topics in Physiology A discussion of recent developments in physiology. Recent offerings have included respiratory physiology, renal physiology, clinical cardiology, and neurophysiology.

BL 5360 Special Topics in Biochemistry A discussion of recent developments in the field of biochemistry. Topics taught recently include steroid biochemistry, immunology, and metabolic control theory.

BL 5370 Special Topics in Microbiology A discussion of recent developments in the field of microbiology. Topics taught recently include bacterial genetics, industrial microbiology, and advanced microbial ecology.

BL 5380 Special Topics in Ecology A discussion of recent developments in the field of ecology. Topics taught recently include systems ecology, ecology of Great Lakes fisheries, ecology of algae, aquatic macrophytes, and world ecosystems.

BL 5390 Special Topics in CLS A discussion of recent developments in clinical laboratory science.

BL 5400 Special Topics in Plant Sci A discussion of recent developments in plant science. Topics may include biotechnology, physiology, systematics, phylogenetics, biochemistry, and molecular genetics.

BL 5431 Population Ecology The distribution and abundance of organisms, including theoretical, laboratory, and field studies of factors limiting population growth. Examines biological limitations, including competition, predation, parasitism, and disease. The distribution and abundance of



organisms, including theoretical, laboratory, and field studies of factors limiting population growth. Examines biological limitations, including competition, predation, parasitism, and disease.

BL 5450 Limnology Study of interrelated physical, chemical, and biological processes of freshwater lakes. Emphasizes fieldwork on local lakes.

BL 5451 Aquatic Ecology Integrated coverage of flowing and standing fresh water environments, including biological, physical, and chemical factors and their interactions. Applied aspects include biological responses to stress, fisheries, and the management of aquatic systems. Emphasizes the fundamentals of aquatic systems and fieldwork on local environments.

BL 5460 Advanced Ecology: Ecosystems Comparison of ecosystem structure and processes with emphasis on lakes. Stresses critical reading of recent journal literature.

BL 5500 Graduate Seminar in Bio Sci Analysis, evaluation, and synthesis of primary scientific literature on a specific topic in recitation/discussion format.

BL 5520 Satellite Limnology Provides an overview of historical, current applications of satellite remote sensing in limnologic research, including remote sensing of lake surface temperatures and ice, application of satellite image analysis for evaluating water quality variables (e.g., suspended solids and chlorophyll), development of a new lake, ocean color algorithms, and review of satellite instrument capabilities.

BL 5680 Bryology Emphasizes the broad aspects of bryology, including physiology, ecology, development, taxonomy, and evolution with an ecological theme that is fortified with laboratory examination of structures and field identification of bryophyte species, communities, and adaptations.

BL 5750 Advanced Ecology: Communities Discussion of factors that determine plant and animal species distribution, abundance, and diversity. Emphasis on theoretical concepts involves critical reading of recent literature.

BL 5990 Master's Research in Bio Sci An original investigation in biology that culminates in a thesis.

BL 6990 Doctoral Research in Bio Sci An original investigation in theoretical or experimental biology, or both, and submission of a dissertation in partial fulfillment of the requirements for the PhD degree.

BLA 9004 Science, Tech and Society

BLA 9004U Science/Tech/Society Upper Div

CE 4201 Matrix Structural Analysis Analysis of trusses and frames by the direct stiffness method. Use of a typical commercial computer code is stressed as a tool for complex structures. Introduces three-dimensional structures.

CE 4211 Reinforced Concrete Design Design of reinforced concrete two-way slab systems and elements of continuous frames, including beams for combined

torsion and shear, and short and slender columns. Isolated, combined, and continuous footings will also be considered.

CE 4221 Structural Steel Design Design of steel frame structures by the Load and Resistance Factor Design method. Covers flexural members including unbraced beams, and plate girders as well as columns under combined bending and axial loads, including basic moment magnification techniques. Studies design of selected simple and rigid beam to column connections and introduces composite members.

CE 4231 Timber and Masonry Design Introduction to timber design and wood as a structural engineering material. Includes beams, columns, and nailed and bolted connections. Introduction to masonry materials and design. Includes flexural design, pilasters, and shear wall design.

CE 4333 Estimating, Planning & Control Examination of the different types of estimates and the function of each type. Explores drawing interpretation and quantity take-off techniques leading to the development of an estimate. Shows relationship between contract specification, drawings, project control. The estimate will be illustrated.

CE 4401 Pavement Design Analysis, behavior, performance, and structural design of highway pavements. Introduces pavement types and performance concepts, highway traffic and subgrade characterization, materials employed in highway construction, and highway drainage. Presents common methods used for designing pavement structures as well as mechanistic-empirical approaches.

CE 4402 Traffic Engineering Introduction to traffic engineering, traffic characteristics, data collection techniques, capacity analysis, traffic control devices, intersection control, traffic signal systems, parking, and street operations.

CE 4501 Env Engg Chemical Processes Application of chemistry, conservation principles, and mathematics to the analysis of chemical processes occurring in natural and engineered environments. Topics include acid-base phenomena, the carbonate system, precipitation/dissolution, redox chemistry, diffusion, mass transfer, and applications to engineering design. Laboratory experiences illustrate principles and modern measurement techniques.

CE 4502 Wastewater Treatmnt & Collec'n Principles and design of physical, biological, and chemical processes employed in wastewater treatment and application of basic engineering principles and hydraulics to analysis and design of wastewater collection systems. Unit operations laboratory experience provides hands-on experience related to operation, instrumentation, and design.

CE 4503 Drinking Water Treatmnt & Dist Principles and design of physical and chemical processes employed in drinking water treatment and application of basic engineering principles and hydraulics to the analysis and design of water distribution systems. Use computer models to design and operate various unit operations such as air stripping, carbon adsorption, and ion exchange.

CE 4504 Air Quality Engg & Science Overview of air quality regulation in the

U.S. and world, including basic concepts of atmospheric chemistry and transport; fugitive, point, and area emissions; principles and tradeoffs of operation and design of air pollution control systems; and application of air quality models.

CE 4505 Surface Water Quality Engg Develops the scientific basis for water quality management in lakes and rivers. Considers the origin, behavior, and fate of nutrients and toxic substances. Introduces engineered approaches for lake management, including mass balance modeling. Presents techniques for water quality restoration and the legal framework supporting pollution control.

CE 4506 Appl of Environmental Reg Study of the federal and state regulations (CERCLA, RCRA) and policy that governs management of solid and hazardous waste and how these regulations are incorporated into engineering practice. Other topics include pollution prevention and life cycle analysis, brown field development, baseline environment assessments, risk assessment, and engineering ethics.

CE 4510 Baccalaureate Thesis Independent baccalaureate research project performed under the supervision of one or more faculty.

CE 4610 Civil/Env Eng Systems Analysis Introduction to operations research with applications to civil and environmental engineering. Decision analysis and optimization techniques, including linear programming, nonlinear programming, and dynamic programming. Computer-based solutions of design problems in various civil engineering specialty areas are considered.

CE 4620 Open Channel Flow Analysis of open channel systems, including natural channels, designed channels, flow transitions, non-uniform flow, and unsteady flow.

CE 4630 Hydraulic Structures Analysis and design of water regulating structures. Includes dams, spillways, gates, dikes, levees, stilling basins, culverts, and various minor structures.

CE 4820 Geotechnical Engineering Applies the fundamentals learned in CE3810 to problems in geotechnical engineering. Learn the procedures used to design footings, piled foundations, retaining walls, marine structures, and slopes. Computational laboratory reinforces lectures; students have direct access to the instructor as the design is being developed.

CE 4830 Geosynthetics in Engg Prac Geosynthetic materials are grouped by mechanical characteristics and engineering use. They are widely used in highway, landfill, and embankment design. Develop designs for filters, soil separators, reinforced earth, and impermeable membranes. Also learn when using a geotextile is appropriate.

CE 4900 Engineering Design Project I An engineering design project related to civil and environmental engineering. Not available to students who have taken CE4905. Students must complete both CE4900 and CE4910 to get credit for either one. An engineering design project related to civil and environmental engineering. Not available to students who have taken CE4905. Students must complete both CE4900 and CE4910 to get credit for either one. (Senior project

ready as defined by major substitutes for prerequisites)

CE 4905 Engineering Design Project An engineering design project related to civil and environmental engineering. Not available to students who have taken CE4900 or CE4910. An engineering design project related to civil and environmental engineering. Not available to students who have taken CE4900 or CE4910. (Senior project ready as defined by major substitutes for prerequisites)

CE 4910 Engineering Design Project II Continuation of CE4900. Not available to students who have taken CE4905. Students must complete both CE4900 and CE4910 to get credit for either one. Continuation of CE4900. Not available to students who have taken CE4905. Students must complete both CE4900 and CE4910 to get credit for either one. (Senior project ready as defined by major substitutes for prerequisites)

CE 4920 Civil Engg Independent Study Approved research or design project in civil engineering, originating with the student or assigned by the instructor. Approved research or design project in civil engineering, originating with an individual student or assigned by the instructor.

CE 4930 Environ Engg Independent Study Approved research or design project in environmental engineering, originating with the student or assigned by the instructor. Approved research or design project in environmental engineering, originating with an individual student or assigned by the instructor.

CE 4990 Topics Civil & Env Engg. Topics of special interest in civil or environmental engineering.

CE 5101 Advanced Bituminous Materials Applications and properties of asphalt binder, aggregates for bituminous mixtures, and analysis and design of asphalt concrete mixtures. Includes asphalt cement production, rheology, chemistry, and grading, aggregate grading and blending, and mixture design and characterization. Also discusses asphalt mixture production, construction, and recycling.

CE 5102 Advanced Concrete Materials Properties and applications of portland cement and portland cement concrete. Includes cement production, chemistry and hydration, concrete admixtures, and the properties of fresh and hardened concrete. Presents concrete microstructure and durability. Other topics include high-strength and high early-strength concrete, fiber-reinforced concrete, and advanced cement-based materials.

CE 5190 Spec topics Civil Engg Matl's Advanced study of materials related topics, including discussions of recent research developments at an advanced level.

CE 5201 Advanced Structural Analysis Energy methods in structural analysis. Elastic buckling of beams, beam-columns, and frames, including numerical methods for buckling analysis. Introduction to finite element analysis, including one- and two-dimensional elements.

CE 5202 Finite Element Analysis Introduction to the use of finite element methods in structural analysis. Covers the finite element formulation, 1- and

2-D elements, including isoparametric elements, axisymmetric analysis, plate and shell elements, dynamics, buckling, and nonlinear analysis.

CE 5211 Adv Reinforced Concrete Design Advanced topics in behavior of reinforced-concrete structures and relationships with element design. Code requirements, reasoning behind theoretical and experimental studies for understanding structural behavior, and applications to design. Other topics include deep beams, corbel design, and yield-line analysis.

CE 5212 Prestressed Concrete Design Theory of prestressed and post-tensioned members. Covers analysis and design of prestressed concrete beams, slabs, box girders, and bridge girders by elastic and ultimate strength methods. Precast and cast-in-place system construction techniques will be included.

CE 5221 Adv Structural Steel Design Critical analysis of behavior of steel and thin-walled metal structural elements. Introduction to basic concepts of structural stability. P-delta effect as used in structural design. Torsional behavior of prismatic beams, including St. Venant and warping torsion. Torsional buckling.

CE 5231 Advanced Timber Design Design of glulam members, including tapered beams, tapered and curved beams, and arches. Covers use of timber connectors as well as design of wood shear walls and diaphragms.

CE 5241 Structural Dynamics I Free and forced vibration of undamped and damped single degree of freedom systems. Generalized coordinates and Rayleigh's method. Multiple degree-of-freedom systems, including shear buildings and frames. Frequency response analysis.

CE 5242 Structural Dynamics II Earthquake engineering and advanced dynamic analysis. Includes time history response of multiple degree-of-freedom systems, seismicity, equivalent static force method, modal analysis, base isolation, soil-structure interaction, and an introduction to random vibrations.

CE 5243 Probabilistic Analy & Rel Basic probability and statistics, including random variables, moments, probability distributions, and regression analysis. Also examines time-to-failure analysis, capacity/demand reliability analysis, first-order reliability methods, Monte Carlo simulation, and system reliability in a civil and environmental engineering context.

CE 5250 Spec Topics in Structural Engg Advanced study of structural engineering topics, including discussions of recent research developments at an advanced level. Topics might include loading analysis, advanced topics in steel design, composite materials for structures, and behavior of a variety of reinforcements for concrete applications.

CE 5332 Construction Productivity Impr Analysis of current trends of construction productivity. Examines factors that affect productivity in the construction industry. Presents techniques to identify areas of low productivity and corrective action. Analysis of current trends in productivity, factors that affect productivity, and techniques to identify and improve areas of low productivity.

CE 5337 Project Delivery Systems A study of project delivery, from feasibility through design and construction, focusing on the three contemporary systems: general contracting, design-build, and construction management.

CE 5338 Project Management & Admin Exploration of the essential elements of project management and construction administration for the design and construction industry. This includes project planning, organization, budgeting, monitoring, control, life cycle, organizational structure and characteristics, and responsibilities of project managers.

CE 5390 Spec Topics in Construction Advanced study of construction engineering topics including discussion of recent research developments.

CE 5401 Advanced Pavement Design Advanced analysis, behavior, performance, and structural design of highway and airport pavements. Focuses on mechanistic characterization of pavement structures and approaches used to characterize existing structures for the purpose of rehabilitation. Subjects include advance materials characterization, mechanistic modeling, nondestructive testing, and pavement rehabilitation. Also includes airport pavement design and rehabilitation.

CE 5402 Highway Design Advanced highway design, including horizontal and vertical alignment, cross-section elements, super elevation, and other road design topics. Includes extensive use of highway design computer software with a complete roadway design project using software.

CE 5403 Pavement Management Systems Principles of pavement management, including inventory, condition assessment, needs determination, and budget analysis. Emphasis on field condition assessment techniques. Presents database design to illustrate data handling techniques and introduces several software packages.

CE 5404 Transportation Planning Introduction to urban transportation planning, travel characteristics, demand forecasting techniques, corridor studies, traffic impact studies, and public transit planning and operations.

CE 5405 Environmental Impacts of Trans Introduction to environmental legislative and regulatory history. Understanding of the basic elements of environmental impact analysis for transportation facilities. Topics include noise, air quality, wetlands, cultural, historic, community, and socioeconomic aspects, and public participation techniques.

CE 5406 Airport Planning and Design Introduction to the air transportation system, airport planning studies, demand forecasting, aircraft characteristics, runway requirements, airport layout and design. Also includes environmental impacts, airport capacity and operations, terminal and ground access planning and analysis.

CE 5490 Spec Topics in Transportation Topics of special interest in transportation engineering.

CE 5501 Environmental Process Engg Review of mass transfer, kinetics, reactor design, and mathematical modeling principles. Includes illustration by

application to several important natural systems and environmental engineering unit processes. Mathematical models of selected environmental engineering systems are developed and solved using PCs.

CE 5502 Biological Treatment Processes Application of kinetics, reactor theory, and microbiology to modeling and design of aerobic and anaerobic wastewater treatment systems. Topics include activated sludge process models and application of these models to process design and operation.

CE 5503 Physical-Chem Treatment Proc Advanced theory, fundamentals, and application of physical and chemical processes employed in design and operation of drinking water treatment systems.

CE 5504 Surface Water Quality Modeling Mathematical models are applied in the solution of water quality management problems. The spatial and temporal variation of conservative and reactive substances is simulated in lakes, rivers, and embayments. Kinetic representations of natural phenomena are developed, including mass transport, biogeochemical cycling of nutrients and toxics and food web dynamics.

CE 5505 Atmospheric Chemistry Study of the photochemical processes governing the composition of the troposphere and stratosphere, including sampling and analysis of atmospheric compounds, introduction to solar radiation and radiative transfer in the atmosphere, and introduction to mathematical modeling of atmospheric photochemistry.

CE 5506 Air Quality Modeling Mathematical tools for the analysis of air quality issues at the indoor, local, and regional scales. Introduces statistical and deterministic methods. Provides hands-on experience with state-of-the-science air quality models from U.S. EPA and engineering consulting firms.

CE 5507 Sorption and Biological Proc Fundamental principles and modeling of some important physical and biological fate processes that govern the transport, persistence, and/or degradation of organic and inorganic pollutants in natural or engineered systems. Topics include sorption to soils/sediments, biodegradation of organic chemicals, bioavailability, and engineered remediation.

CE 5508 Biogeochemical Processes To define what constitutes sustainable human activities, one must understand linkages among physical, chemical, and biological structures and processes that comprise our biosphere. Examine interactions between physical, chemical, and biological processes on earth; model these interactions; and identify areas where knowledge is insufficient for modeling.

CE 5509 Environmental Organic Chem Investigation of factors controlling the environmental fate, distribution, and transformation of organic xenobiotic molecules. Thermodynamics and kinetics of chemical partitioning among air, water, sediment, and organic phases. Transformations examined include hydrolysis, oxidation-reduction, photochemistry, and "organism-assisted" reactions. Structure-activity relationships and estimation techniques are presented with a goal of modeling environmental impacts.

CE 5510 Practical Appl Analyt Tech Develop methods and skills for laboratory work required for experimental research in environmental engineering. Topics include laboratory safety, quality control/quality assurance, purchasing, and use of analytical equipment. Students select one or more of the following topics for specialized study: GC, AA, carbon analysis, HPLC, UV/Vis spectroscopy, liquid scintillation counting.

CE 5560 Adv Topics in Air Quality Advanced study of topics related to atmospheric chemistry and/or modeling the transformation and transport of atmospheric pollutants.

CE 5561 Adv Topics in Biological Proc Advanced study of biological processes associated with natural and engineering systems.

CE 5562 Adv Topics in Phys-Chem Proc Advanced study of physical and chemical processes that occur in natural and engineered systems.

CE 5563 Adv Topics in Surface Water Advanced topics related to understanding the biogeochemistry of surface waters (lakes, rivers, wetlands) and the mathematical modeling of those systems.

CE 5590 Spec Topics in Environ Engg Advanced study of environmental engineering topics including discussion of recent research developments.

CE 5610 Civil/Env Eng Systems Analysis Operations research theory with application to civil and environmental engineering problems. Decision theory and optimization techniques, including linear programming, nonlinear programming, and dynamic programming. Computer based applications will be included.

CE 5660 Hydrology II Advanced hydrology aimed at a more thorough understanding of the individual components of the hydrologic cycle. Includes hydrologic modeling and examines impacts of basin change on the hydrologic response.

CE 5661 GIS Applications Application of a Geographical Information Systems (GIS) to hydrologic modeling. While the application centers on hydrologic modeling, the experiences gained are applicable to a wide variety of situations. Learn the processes of obtaining, manipulating, and generating data via ArcInfo and ArcView.

CE 5662 Snow Engineering Analysis of the effects of snow on engineering projects and procedures to include these effects into the design process. Topics include snow formation, transport distribution, mechanics, loading, hydrology, and melt.

CE 5663 Ice Engineering Analysis of the effects of fresh water ice on engineering projects and procedures to include these effects into the design process. Topics include ice formation, mechanic forces, bearing capacity, hydraulic effects on rivers, ice jams, and ice control.

CE 5664 Water Resources Modeling Very application-oriented course focusing on the use of models in water resources engineering. Topics include river analysis models and hydrology models.



CE 5665 Sediment Transport Basin mechanics of the transport of sediments in natural systems, including tractive forces and geomorphic functions.

CE 5666 Water Resources Plan & Mangt Economic and environmental aspects of water use. Topics include flood damage reduction, water demand and hydrologic forecasting, water supply planning, and water resource systems operation.

CE 5690 Spec Topics in Water Resources Advanced study of water resources topics including discussion of recent research developments.

CE 5810 Advanced Soil Mechanics Provides advanced studies in the topics of soil compressibility and soil strength. Develop advanced procedures for determining stress distribution and stress changes from a fundamental basis. Students are strongly advised to take CE5820 concurrently.

CE 5820 Geotechnical Engineering Lab Hands-on experimental lab course intended to develop understanding of soil behavior and the subtle variables that influence testing results. Tests studied include cyclic and monotonic triaxial drained and undrained strength, triaxial and one-dimensional compression, and as-compacted vs. long-term behavior of fill materials.

CE 5830 Advanced Geotechnical Engg Applies soil mechanics to the design of foundations and earth-retaining structures. Proper input parameters are stressed, and elements include the design of conventional retaining walls, reinforced- earth walls, caissons, piles, shallow foundations, dewatering systems, and the support of temporary excavations. Applies soil mechanics to the design of foundations and earth-retaining structures. Proper input parameters are stressed, and elements include the design of conventional retaining walls, reinforced earth walls, caissons, piles, shallow foundations, de-watering systems, and the support of temporary excavations.

CE 5840 Frozen Ground Engineering Stresses the problems and their solutions in seasonally frozen ground. Topics include definition of detrimental frost action, frost susceptibility criteria, mechanism of frost action, frost-resistant design, and the use of insulation. Studies both pavements and light building foundations. Take field trips during the spring thaw period.

CE 5850 Earthwork & Stability of Earth Studies the analysis and design of earth cuts, earth embankments, and gravity dams. Topics include field compaction of soil, compacted properties, fluid flow through the soil, and slope stability procedures. Requires a field trip to an RCC dam and an analysis of its water pressure and movement records.

CE 5860 Fundamentals of Soil Behavior Develop an understanding of the factors determining and controlling the engineering properties of a soil. Topics include crystal structure and surface characteristics, soil mineralogy, soil formation, rock weathering, soil composition, soil water, clay-water electrolyte systems, soil structure and stability, volume change behavior, and strength and deformation behavior.

CE 5890 Spec Topics in Geotechnical Individual or group study of advanced geotechnical engineering topics. Topics of current local or regional importance are encouraged. Appropriate projects include analysis of failures, installation and observation of field instrumentation, and in-depth

literature searches. Advanced study of geotechnical engineering topics including discussion of recent research developments.

CE 5920 Civil Engg Independent Study Approved research or design project in civil engineering, originating with an individual student or assigned by the instructor.

CE 5930 Environ Engg Independent Study Approved research or design project in environmental engineering, originating with an individual student or assigned by the instructor.

CE 5990 Civil Engineering Graduate Sem Detailed study and group discussions of current literature and graduate research projects related to the broad field of civil engineering. Topics will be combined to address the student's area of interest, including construction, environmental, geotechnical, structures, transportation, and water resources. External speakers discuss current related issues.

CE 5991 Environmental Engg Grad Sem 1 Presentations and discussion of current literature and research related to the broad field of environmental engineering.

CE 5992 Environmental Engg Grad Sem 2 Presentations and discussion of current literature and research related to the broad field of environmental engineering.

CE 5993 Field Engg in the Devel World Study of applying appropriate engineering solutions and technology in the developing world. Examples are drawn from several areas of civil and environmental engineering, including transportation, materials, construction, surveying, geophysical methods, watershed management and GIS, water supply and treatment, and wastewater treatment.

CE 5994 International Engg Practicum Civil and environmental engineering field work outside of the United States.

CE 5998 Engineering Design Practicum Advanced independent study for students in the Master of Engineering program. In consultation with student's advisor, develop and execute a project demonstrating capabilities in problem solving, communications, and decision making. The practicum can be done on campus or at the site of a Michigan Tech corporate partner.

CE 5999 Master's Research Study of an acceptable civil or environmental engineering problem and preparation of a report or thesis.

CE 6999 Doctoral Research Original research leading to the preparation of a dissertation in partial fulfillment of the requirements for the PhD degree.

CH 4210 Instrumental Analysis The lecture portion of CH4212; not open to undergraduate chemistry majors.

CH 4212 Instrumental Analysis Chemical instrumentation applied to organic and inorganic analysis with emphasis on chromatography and spectroscopy.

CH 4272 Process Analytical Chemistry Hands-on introduction to the application

of modern analytical chemistry in the process industries. Presents the fundamentals, use, and limitations of instruments used for process analytical measurements as well as safety regulations and hazard classifications. Emphasizes theory and practical aspects of process sampling.

CH 4292 Independent Study in Analy Chem An undergraduate research experience in analytical chemistry. Students select a literature and/or laboratory problem and write a summary report.

CH 4310 Inorganic Chemistry I Study of the bonding, physical and chemical properties, structure and reactions of the chemical elements and their compounds. Examples will include both transition metals and main group elements.

CH 4311 Inorganic Chemistry Laboratory Laboratory preparations (selected inorganic and organometallic compounds) that illustrate appropriate experimental techniques for syntheses, manipulations, and methods of analyses.

CH 4320 Inorganic Chemistry II Continuation of CH4310. A survey course that continues the study of the general principles of inorganic chemistry and the chemistry of the elements and their compounds.

CH 4412 Spectroscopy of Organic Chem Emphasizes use of spectral data interpretation to determine structures of organic compounds. Discusses proton and carbon nuclear magnetic resonance (including two dimensional techniques—COSY, HETCOR, etc.), mass spectrometry, infrared spectrophotometry. Includes use of modern software, including NMR spectramodelling, data handling and presentation, and spectral database packages. Emphasizes use of spectral data interpretation to determine structures of organic compounds. Discusses proton and carbon nuclear magnetic resonance (including two-dimensional techniques, COSY, HETCOR, etc.), mass spectrometry, infrared spectrophotometry. Includes use of modern software, including NMR spectramodelling, data handling and presentation, and spectral database packages.

CH 4430 Intermediate Organic Chemistry Develop the chemical intuition necessary for advanced work in organic chemistry. Emphasizes reaction mechanisms and why reactions occur. Topics include heteroaromatic chemistry, curved-arrow formalism and multi-step reactions, molecular orbitals and symmetry-controlled reactions, Hammett equation and structure-activity relationships, substitution reactions and carbonyl reactions.

CH 4510 Intermediate Physical Chem Discussion of selected topics in molecular orbital theory, atomic and molecular spectroscopy, group theory, thermodynamics, statistical mechanics, the solid state, and other topics for students with previous coursework in physical chemistry.

CH 4610 Intro to Polymer Science Introductory study of the properties of polymers. Includes structure and characterization of polymers in the solid state, in solution, and as melts. Topics include viscoelasticity, rubbery elasticity, rheology and polymer processing. Applications discussed include coatings, adhesives, and composites.

CH 4620 Polymer Chemistry Study of polymer chemistry dealing with the mechanisms of polymerization and copolymerization. Study of the chemistry of polymers, including polymer modification and degradation. Topics include methods for measuring and predicting the path of degradation and stabilization.

CH 4631 Polymer Science Laboratory Students undertake experiments covering aspects of polymer characterization, processing, and recycling. Also included are experiments in applications such as coatings, adhesives, and composites.

CH 4641 Polymer Chemistry Laboratory Students undertake experiments covering polymer synthesis, identification, and modification. Also includes degradation processes, and formulation of polymer systems.

CH 4710 Chemical Principles in Biology Studies biochemistry with emphasis on understanding the interconnections between biology and chemistry and the underlying chemical logic of biomolecules and metabolic pathways.

CH 4800 Curr Topics in Undergrad Chem Covers chemistry topics not included in regular courses. Topics may include designing organic syntheses, heterogeneous catalysis, homogeneous catalysis, solid-state chemistry, and heterocyclic chemistry.

CH 4900 Senior Seminar in Chemistry I Discussion of various topics relevant for professional development. Includes teamwork skills, preparation of abstracts and reports, and scientific ethics. Present results of undergraduate research project or assigned library topic in written and oral form.

CH 4910 Senior Seminar in Chemistry II Continuation of CH4900. All students must complete a comprehensive examination.

CH 4990 Undergrad Research in Chem An undergraduate research experience in which students select a literature and laboratory research problem and write a report on the work performed. The student typically signs up for 1 to 3 credits per semester; most problems require more than one semester to complete. Requires GPA of 2.50 or better.

CH 5210 Analytical Separations Covers theory and applications of modern gas chromatography, high performance liquid chromatography, and ion chromatography as well as instrumentation for these techniques. Studies trace organic analysis and environmental problems.

CH 5220 Physical Methods of Analysis Electrochemical methods, including potentiometry, voltammetry, chronopotentiometry, and electrolysis; electrochemistry in nonaqueous media; mechanisms of electrode processes. Analytical applications of atomic spectroscopy, nuclear magnetic resonance, and mass spectrometry.

CH 5310 Advanced Inorganic Chemistry Covers the organometallic chemistry of the transition elements, beginning with a historical overview of the subject, as well as basic ideas in complex and transition metal chemistry.

CH 5410 Advanced Organic Chem I Advanced study of mechanistic organic and

physical organic chemistry intended to bring the student to the level of current research activity. Topics may include methods for determining organic reaction mechanisms, chemical bonding as it applies to organic compounds, structure-reactivity relationships, molecular rearrangements, and molecular orbital theory.

CH 5420 Advanced Organic Chem II Advanced study of organic reactions and synthetic organic chemistry intended to bring the student to the level of current research activity. Topics may include retrosynthetic analysis and synthesis design, synthons, protecting groups, and analysis of syntheses from recent literature.

CH 5509 Environmental Organic Chem Investigation of factors controlling the environmental fate, distribution, and transformation of organic xenobiotic molecules. Covers thermodynamics and kinetics of chemical partitioning among air, water, sediment, and organic phases. Transformations examined include hydrolysis, oxidation reduction, photochemistry, and "organism-assisted" reactions. Structure-activity relationships and estimation techniques are presented with a goal of modeling environmental impacts.

CH 5510 Classical & Statistical Thermo Principles of classical chemical thermodynamics from the viewpoint of Gibbs and DeDonder; principles of applications of statistical mechanics to thermodynamics, including the properties of gases, liquids, electrolytic solutions, solutions of high polymers, and other systems of chemical interest.

CH 5520 Chemical Kinetics An advanced study of chemical reaction rates, including methods of analysis of reaction rate data and the theory of rate processes.

CH 5530 Molecular Spectroscopy An introduction to molecular spectroscopy and molecular structure. Topics include infrared and Raman spectroscopy, electronic spectroscopy, fluorescence, phosphorescence, and resonance techniques.

CH 5540 Appl of Group Theory in Chem The predictive power of group theory in chemistry is developed through theory and detailed applications. Emphasizes group theoretical applications to molecular orbital theory, orbital symmetry, ligand field theory, and vibrational spectroscopy.

CH 5550 Solid State Chemistry Introduces principles of solid state chemistry and the application to produce compounds with the desired physical and chemical properties. Discusses reactivity, preparation techniques, structure, impurity or dopant effects, phase transformations, electric and magnetic properties, and point defect chemistry.

CH 5560 Computational Chemistry Focuses on the theory and method of modern computational techniques applied to the study of molecular properties and reactivity through lecture and computer projects. Covers classical mechanical as well as quantum mechanical approaches.

CH 5570 Biophysical Chemistry A discussion of experimental techniques and applications of physical chemistry principles to the study of the structure, dynamics, and chemical reactions of proteins, nucleic acids, and other

biopolymers.

CH 5810 Mag Resonance Spectroscopy Considers the physical interactions of importance to magnetic resonance spectroscopy. Illustrates these principles by selected, modern experimental techniques. Emphasizes on spin 1/2 particles.

CH 5900 Chemistry Seminar Graduate seminar in chemistry.

CH 5990 Graduate Research in Chemistry An original investigation in chemistry for students seeking an MS degree.

CH 6290 Special Topics in Analy Chem Discussion of current research developments at an advanced level. A list of possible topics might include chromatography, magnetic resonance, surface analysis, mass spectrometry, or environmental analysis.

CH 6390 Spec Topics in Inorganic Chem Discussion of recent developments in inorganic chemistry.

CH 6490 Special Topics in Org Chem Advanced study in special areas of organic chemistry. Topics could include organic synthetic methods, production and reactions of enolate ions, heterocyclic, carbohydrate, bioorganic, or free-radical chemistry.

CH 6510 Curr Topics Sem - Phys Chem A weekly discussion between graduate students and faculty of current research and literature topics in physical chemistry. Required for all graduate students in physical chemistry.

CH 6590 Special Topics in Phys Chem A discussion of recent research developments at an advanced level. Topics could include atomic and molecular structure, kinetic theory of gases, solid-state chemistry, thermodynamics, electrochemistry, and molecular spectroscopy.

CH 6690 Special Topics in Polymer Sci Advanced study in special areas of polymer science. Topics could include thermal analysis, polymer surface science, advanced polymerization processes, scaling laws, etc. Some topics may include a laboratory component.

CH 6990 Chemistry Doctoral Research Laboratory research in preparation of the PhD thesis. Requires permission of the student's advisory committee and the graduate faculty.

CM 4000 Chemical Engineering Research Student undertakes a problem in some phase of chemical engineering, reviews the literature, obtains experimental data, and submits a report.

CM 4110 Unit Operations Laboratory Provides a rigorous introduction to experiments focused in the unit operations of fluid mechanics, heat transfer, mass transfer, and chemical reaction engineering.

CM 4120 Chemical Plant Operations Lab A capstone laboratory course focused on chemical manufacturing processes from the perspective of manufacturing excellence. Lecture material includes equality management, the application of statistical process control, and current trends in quality manufacturing.

Experimental reinforcement of these concepts occurs in the department's pilot plants.

CM 4310 Chemical Process Safety/Env A study of the technical fundamentals of chemical process safety and designing for the environment. Includes toxicology, industrial hygiene, source models, fires and explosions, relief systems, hazard identification, risk assessment, environmental fate and transport, hazardous waste generation, pollution prevention, and regulatory requirements.

CM 4500 Particle Technology Course reviews traditional particulate characterization and integrates recent research in particle technology.

CM 4610 Intro to Polymer Science Introductory study of the properties of polymers. Includes structure and characterization of polymers in the solid state, in solution, and as melts. Topics include viscoelasticity, rubbery elasticity, rheology and polymer processing. Applications discussed include coatings, adhesives, and composites. Introductory study of the properties of polymers. Includes structure and characterization of polymers in the solid state, in solution, and as melts. Topics include viscoelasticity, rubbery elasticity, rheology and polymer processing. Applications discussed include coatings, adhesives, and composites.

CM 4620 Polymer Chemistry Study of polymer chemistry dealing with the mechanisms of polymerization and copolymerization. Study of the chemistry of polymers, including polymer modification and degradation. Topics include methods of measuring and predicting the path of degradation and stabilization.

CM 4631 Polymer Science Laboratory Students undertake experiments covering aspects of polymer characterization, processing, and recycling. Also included are experiments in applications such as coatings, adhesives, and composites.

CM 4641 Polymer Chemistry Laboratory Students undertake experiments covering polymer synthesis, identification, and modification. Also includes degradation processes, and formulation of polymer systems.

CM 4650 Polymer Rheology A systematic development of the principles and applications of the science of rheology. Reviews vector and tensor mathematics and Newtonian fluid dynamics. Develops the physical and mathematical nature of stress and deformations in materials. Covers the use of theory and application of rheological equations of state.

CM 4660 Polymer Chemical Engineering Provides an introduction to polymer processes for chemical engineering students.

CM 4710 Biochemical Processes Presents an introduction to fundamental and applied aspects of industrial biochemical processing. Topics include cell structure and composition, enzymes and their use in industry, metabolism, bioreactor analysis and design, bioseparations for product recovery, and industrial application.

CM 4720 Design for Environment Covers fundamental principles of pollution prevention for chemical processes. Topics include hazardous waste generation

in the chemical industry, waste and pertinent environmental regulations, risk assessment, environmental impacts of chemical process designs using case studies. Introduces various tools for designing more environmentally friendly chemicals and processes.

CM 4730 Subsurface Remediation Covers the scientific and engineering principles of in-situ subsurface remediation. Topics include subsurface fate and transport processes, remediation site characterization, remediation process design, and related policy issues. Covers the scientific and engineering principles of in situ subsurface remediation. Topics include subsurface fate and transport processes, remediation site characterization, remediation process design, and related policy issues.

CM 4850 CM Process Analysis & Design 1 Technical and economic evaluation of chemical processes and operations. Applies material and energy balances, flowsheets, energy utilization, and optimization to process systems. Requires use of cost estimating and economic evaluation techniques. The optimization project requires a series of memoranda progress reports, a formal final report, and an oral presentation.

CM 4851 CM Design Laboratory 1 Discuss open-ended problems in chemical engineering design.

CM 4860 CM Process Analysis & Design 2 Applies technical and economical techniques to the development of a chemical process into an optimized design. Uses process synthesis techniques and market research to develop a conceptual design for a proposed new venture. The AIChE National Design Problem is required of each student as a capstone experience. Applies technical and economical techniques to the development of a chemical process into an optimized design. Uses process synthesis techniques and market research to develop a conceptual design for a proposed new venture. The AIChE National Design Problem is required of each student as a capstone experience.

CM 4861 CM Design Laboratory 2 Discusses open-ended problems in chemical engineering design.

CM 4900 Interdisciplinary Design 1 Focuses on an interdisciplinary chemical engineering design project. Focuses on an interdisciplinary chemical engineering design project. (Senior project ready as defined by major substitutes for prerequisites)

CM 4910 Interdisciplinary Design 2 Focuses on an interdisciplinary chemical engineering design project. Focuses on an interdisciplinary chemical engineering design project. (Senior project ready as defined by major substitutes for prerequisites)

CM 4955 Process Control Laboratory Material discussed in CM3310 applied to laboratory experiments to illustrate, by actual practice, the principles of feedback control systems using digital computers. Discusses advanced control concepts: model predictive control and statistical process control. Laboratory experiments involve signal processing, development of a proportional-integral-derivative controller, and tuning of direct digital controllers. Material discussed in CM3310 applied to laboratory experiments to illustrate, by actual practice, the principles of feedback control systems



using digital computers. Discusses advanced control concepts: model predictive control and statistical process control. Laboratory experiments involve signal processing, development of a proportional-integral-derivative controller, and tuning of direct digital controllers.

CM 4960 Microsystem Engineering Focuses on developing and demonstrating capabilities for fabrication, simulation, and testing of engineering microcomponents. Focuses on developing and demonstrating capabilities for fabrication, simulation, and testing of engineering microcomponents.

CM 4990 Current Topics in CM Covers chemical engineering topics not included in regular courses, which may include biochemical engineering, design of biochemical reactions, composite materials, and numerical analysis of transport processes.

CM 5100 Appl Mathematics for CM The solution to basic equations for momentum, mass, and heat transfer by use of separation of variables, numerical methods, and other mathematical techniques.

CM 5200 Advanced CM Thermodynamics Applications of linear nonequilibrium thermodynamics. Discussion of principles underlying energy conversion processes and the energetic analysis of complex systems. Covers topics such as thermoelectricity, gas interdiffusion, reverse osmosis, and other coupled transport processes from a macroscopic viewpoint.

CM 5300 Advanced Transport Phenomena Single- and multi-component mass, energy, and momentum transport. Derivation and use of the general transport equations for Newtonian and non-Newtonian flows, convective flows, and mass transport in flowing systems. Applications to complex systems.

CM 5310 Laboratory Safety Provides the technical and cultural background necessary to operate and manage a safe Laboratory.

CM 5400 Adv Reactive Systems Analysis An analytical study of various aspects of chemical reactor behavior, such as multiple steady-states, dynamics, stability, and control. Also covers transport phenomena in packed beds of solids and mathematical modeling of packed-bed reactors.

CM 5500 Theory and Methods of Research Discusses modern methods of research. Topics could include statistical analysis, presentation of data, modern experimental methods, or oral presentation skills.

CM 5610 Molecular Thermodynamics Thermodynamics from a molecular perspective. Discusses aspects of statistical mechanics as applied to thermodynamics.

CM 5620 Advanced Biochemical Engg Discussion of recent developments in biochemical engineering.

CM 5630 Advanced Chemical Engg Safety Discussion of advanced topics in chemical process safety.

CM 5640 Advanced Polymer Engineering Advanced study of a special area of polymer science and engineering, including current developments. Advanced study of a special area of polymer science and engineering, including current

developments.

CM 5650 Heterogeneous Catalysis A survey of theories of catalytic activity of solids with examples drawn from reactions of industrial importance.

CM 5660 Polymer Composite Materials Introduces the basic concepts of the macromechanical behavior of composite materials, and gives an overview of topics of engineering interest. The mechanics of laminated continuous fiber-reinforced composites will be developed and applied to analysis of simple composite structures.

CM 5670 Advanced Process Design Problems and lectures in plant design. Course content will vary according to particular needs of the students involved.

CM 5680 Adv Chemical Process Control Analysis and design of digital and sampled control systems; use of z-transform and time-domain methods. Study of nonlinear feedback systems, stability criteria, and state-space methods. Design using optimal control. Multivariable and adaptive control system concepts as applied to chemical processes.

CM 5690 Particle Technology A discussion of advanced topics in theory and practice of particle technology.

CM 5700 Advanced Polymer Rheology A survey of non-Newtonian fluid phenomena and study of material functions. Discusses an in-depth analysis of rheological constitutive equations and their application. A survey of non-Newtonian fluid phenomena and study of material functions. Discusses an in-depth analysis of rheological constitutive equations and their application.

CM 5900 Current Topics in CM A discussion of chemical engineering topics of current interest not included in regular graduate courses.

CM 5950 Advanced Special Projects This is a course for graduate students who wish to do extensive work on projects or topics not directly related to their thesis topic and not covered in one of the graduate courses.

CM 5990 MS Research An original investigation of a chemical engineering problem.

CM 6990 Doctoral Research An original investigation in theoretical or applied chemical engineering or both, and submission of a dissertation in partial fulfillment of the requirements for the PhD degree.

CS 4000 Senior Seminar Topics include ethical models, legal issues, privacy and security, social responsibility, professional responsibility and service, and the future of computing. Students will complete the ETS MFT assessment exam.

CS 4090 Special Topics in Computer Sci Special topics in computer science offered on occasion based on student and faculty demand and interest. Special topics in computer science offered on occasion based on student and faculty demand and interest.

CS 4099 Directed Study in Computer Sci Students study one or more special

topics in computer science under the direction of one or more faculty members.

CS 4121 Programming Languages A discussion of the concepts underlying programming languages. Topics include programming paradigms; language criteria (including syntax, semantics, run-time behavior, and implementation issues); data, procedure, functional, and control abstraction; functional programming; and logic programming.

CS 4131 Compiler Construction Introduction to compilation techniques, including parsing, syntax-directed translation, run-time storage management, error recovery, code generation and optimization. Requires a significant project.

CS 4311 Intro to Computation Theory Covers languages, automata, and grammars in some depth. Topics include deterministic and non-deterministic machines, push-down automata, Turing machines, the halting problem, the Chomsky hierarchy of languages, closure properties for language classes, and unsolvable problems. Provides deeper insight into the power of computing using various models of computation. Topics reviewed include proof techniques, finite automata, regular languages, pushdown automata, and context-free languages. Topics covered include Turing machines and their variants, the Halting Problem and decidability, computability, time complexity, space complexity, circuit model, and parallel computation.

CS 4321 Introduction to Algorithms Techniques for design and analysis of computer algorithms. Topics include asymptotic notation, methods for solving recurrences, divide-and-conquer algorithms, dynamic programming, greedy algorithms, graph algorithms, and NP-completeness. Fundamental topics in algorithm design, analysis, and implementation. Analysis fundamentals include asymptotic notation, analysis of control structures, solving recurrences, and amortized analysis. Design and implementation topics include sorting, searching, and graph algorithms. Design paradigms include greedy algorithms, divide-and-conquer algorithms, and dynamic programming.

CS 4331 Intro to Parallel Programming This class is a practical introduction to designing and building parallel programs. This involves solving problems using multiple processes. Both the shared memory and the message passing paradigms will be studied. Students will be given an abstract conceptual model of parallel programming as well as practical experience programming with HPF and the MPI parallel library. Topics covered include parallel computer architecture, message-passing computing, shared-memory computing, partitioning strategies, pipelined computation, synchronous computation, and load balancing. Both traditional computer science applications like sorting and numerical applications like matrix multiplication are discussed. Practical introduction to designing and building parallel programs. This involves solving problems using multiple processes. Both the shared memory and the message passing paradigms will be studied. Students will be given an abstract conceptual model of parallel programming as well as practical experience programming with HPF and the MPI parallel library. Topics covered include parallel computer architecture, message-passing computing, shared-memory computing, partitioning strategies, pipelined computation, synchronous computation, and load balancing. Traditional computer science applications,

such as sorting, as well as numerical applications, such as matrix multiplication, are discussed.

CS 4411 Intro to Operating Systems Presents topics on program representation and execution, operating systems, process and threads, process scheduling, memory management, file systems, network programming, and security and privacy. Presents topics on program representation and execution, operating systems, process and threads, process scheduling, memory management, and file systems. Programming homework is required.

CS 4421 Database Systems Topics include goals of database management; data definition; data models; data normalization; data retrieval and manipulation; security, integrity, and privacy measures; file, data, and storage organization; object-database systems; and parallel and distributed databases. Surveys a number of general database systems and examines in detail at least one database system.

CS 4431 Advanced Computer Architecture Architecture of high-performance parallel computer systems. Introduces various forms of parallelism, such as multiple functional units, pipelining, multiprocessors, and processor arrays. Also covers interleaved memory, caching, and interconnection networks. Includes analytic and simulation models of architectural features that implement or support parallel processing.

CS 4441 Operating Systems Continuation of CS4411. Topics include file systems, I/O, distributed systems, security, and symmetric multiprocessing. Requires a significant programming project.

CS 4451 Systems Administration Introduction to fundamental systems-administration concepts. Topics include an introduction to systems administration process model as well as the building blocks for the process model. Emphasizes technical issues, but economic affects will also be addressed. Introduction to fundamental systems-administration concepts. Topics include an introduction to systems administration process model as well as the building blocks for the process model. Emphasizes technical issues, but economic affects will also be addressed.

CS 4461 Computer Networks Computer network architectures and protocols; design and implementation of datalink, network, and transport layer functions. Introduction to the Internet protocol suite and to network tools and programming.

CS 4611 Intro to Computer Graphics Introduction to interactive computer graphics. Topics include graphics terminology, 3D viewing, 3D transformation, interactive techniques, use of graphics input devices, projections, modeling, lighting, texturing, evaluators, and graphics algorithms. Requires substantial programming homework.

CS 4711 Software Engineering A survey of software engineering concepts. Topics include an introduction to current process models as well as various specification, analysis, design, and testing techniques. Considers both technical and economic issues. This course covers the basic software process models and examines approaches to requirement analysis, formal specification, design and testing. Introduction to software engineering, the study of

principled approaches to developing and maintaining software. Topics include software process models, project management, requirements modeling/analysis, design, and testing.

CS 4712 Software Engineering II This course builds on the student's previous exposure to fundamental aspects of the software process. Topics include formal verification, measurement, quality assurance and maintenance. Building on previous exposure in CS 4711 to the fundamentals of the software process, this course focuses on techniques for ensuring software quality. Topics include formal specification, testing, proof-based verification, reliability models, and metrics for defect prediction. Projects will involve the use of online tools.

CS 4790 Senior Design Project This course allows students to apply the principles and techniques of software engineering covered in CS4711 and CS4712. Each student will be part of a team responsible for developing a production-quality software product.

CS 4811 Artificial Intelligence Fundamental ideas and techniques that are used in the construction of AI problem solvers. Topics include knowledge representation, problem solving, heuristics, search heuristics, inference mechanisms, expert systems, and language understanding.

CS 5090 Special Topics in CS Special topics in computer science offered on occasion based on student and faculty demand and interest.

CS 5091 Graduate Seminar in CS From time to time, depending on student demand, a seminar will be offered on advanced topics in current computer science research.

CS 5131 Compiler Optimization Emphasizes the design and implementation of compiler optimizations. Topics include control- and data-flow analysis, traditional compiler optimization, intermediate forms, register allocation, local and global instruction scheduling, software pipelining, dependence analysis, and memory-reuse analysis. Emphasizes the design and implementation of compiler optimizations. Topics include control- and data-flow analysis, traditional compiler optimization, intermediate forms, register allocation, local and global instruction scheduling, software pipelining, dependence analysis, and memory-reuse analysis.

CS 5311 Computation Theory Tuning machines, recursive functions, register machines, parallel computational models, bounds of complexity, NP-completeness, and P-Space completeness.

CS 5321 Advanced Algorithms A continuation of CS4321. Covers advanced techniques for design and analysis of computer algorithms. Topics include amortized analysis, divide-and-conquer algorithms, dynamic programming, greedy algorithms, graph algorithms, NP-completeness, and approximation algorithms. After a brief review of CS4321, advanced techniques for design and analysis of algorithms are covered. Topics include algorithms for complex data structures, amortized analysis, and NP-completeness. Application areas include approximation algorithms, network flow, combinatorics, string matching, and parallel algorithms. Additional topics as time permits.

CS 5331 Parallel Algorithms Emphasizes the principles used in the development of algorithms for parallel computers, including programming paradigms, implementation, analysis, and performance evaluation. Considers algorithms in the areas of scientific computation and nonnumeric processing as well as software tools for performance visualization and debugging.

CS 5431 Advanced Computer Architecture An in-depth study of various aspects of parallel processing, with an emphasis on parallel architectures. The course has an analytical focus and investigates models of various aspects of the design and analysis of parallel systems. Topics include simple uniprocessor/multiprocessor performance models, pipelining, instruction-level parallelism, and multiprocessor design issues.

CS 5441 Distributed Systems Covers time and order in distributed systems; mutual exclusion, agreement, elections, and atomic transactions; Distributed File Systems, Distributed Shared Memory, Distributed System Security; and issues in programming distributed systems. Uses selected case studies.

CS 5611 Advanced Computer Graphics Topics include polygonal objects, parametric curves and surfaces, lighting models, shadows and textures, ray-tracing techniques, radiosity methods, volume rendering, and animation.

CS 5711 Advanced Software Engineering Current issues related to the development of large-scale software. Topics include formal approaches to requirements definition, software specifications and design, language issues, testing criterion, and management and organizational issues. Building on the foundation developed in CS4711 and CS4712, this course surveys current research in software engineering. Topics include both the technical aspects of software development (e.g. requirements modeling/analysis, design, verification) and issues pertaining to software process and project management (e.g. measurement, risk analysis, team organization).

CS 5811 Adv Artificial Intelligence Course topics include current topics in artificial intelligence including agent-based systems, learning, planning, use of uncertainty in problem solving, reasoning, and belief systems.

CS 5911 Advanced Numerical Analysis Topics include linear and nonlinear systems, interpolation, function approximation, numerical integration and differentiation, fast fourier transform, ODEs and PDEs, eigenvalue calculation, and unconstrained optimization.

CS 5990 Grad Research in Computer Sci The study of an acceptable computer science problem and the preparation of a thesis

CS 5999 Reading and Research Individual reading and research on current topics in computer science.

CS 6090 Special Topics in CS Special topics in Computer Science offered on occasion based on student and faculty demand and interest.

CS 6091 Doctoral Seminar in CS Seminar covers advanced topics in current Computer Science research for doctoral degree candidates. Offered according to student demand.

CS 6131 Special Topics in CS An in-depth study of current research in compilers and compiler optimization. This course covers the use of high-level program analysis to transform code for architectures with deep memory hierarchies and vector and parallel features. Topics include dependence analysis, memory-hierarchy analysis, loop transformations and code generation strategies for high-performance computer architectures.

CS 6621 Surface Surgery & Compression An in-depth study of recent developments in computer graphics, geometric modeling and visualization, with an emphasis on polyhedron simplification, refinement, surgery, multiresolution representations and geometric compression. In addition, this course will also cover the blossoming principle, scatter data interpolation and approximation d surface subdivision schemes.

CS 6990 Doctoral Research in CS The study of an acceptable computer science problem and the preparation of a dissertation.

CS 6999 Doctoral Reading and Research Individual reading and research on current topics in Computer Science for doctoral degree candidates.

CSE 5091 CS&E Seminar From time to time, depending on student demand, a seminar will be offered on current topics in computational science and engineering.

CSE 5200 Computational Genomics Topics include introduction to molecular biology, DNA sequence assembly, fast database searching, sequence alignment, and gene recognition.

CSE 5600 Science and Data Visualization Covers the fundamental concepts in the field of scientific, engineering, biomedical, and information visualization. Emphasizes the representation of scalar, vector, and tensor fields; data sampling and resampling; reconstruction using multivariate, multivalued finite elements, surfaces, volumes, and functions on surfaces; and volumetric rendering techniques.

CSE 5610 Geometric Modeling Discusses concepts in geometric modeling. Topics include representation of shapes for solids and surfaces; shape modeling, including parametric curves and surfaces such as Bezier, B-spline, and NURBS curves and surfaces; implicit curves and surfaces; surface intersection, blending, and offsetting; applied computational geometry; and the design of robust geometric algorithms. Discusses concepts in geometric modeling. Topics include representation of shapes for solids and surfaces; shape modeling, including parametric curves and surfaces such as Bezier, B-spline, and NURBS curves and surfaces; implicit curves and surfaces; surface intersection, blending, and offsetting; applied computational geometry; and the design of robust geometric algorithms.

CSE 5900 Computational Linear Algebra Computational methods for solving systems of linear equations. Presents background in linear algebra theory and computational techniques. Typical topics include finite element methods, conjugate gradient methods, other iterative methods, and direct methods. Emphasizes modern computational approaches.

CSE 6090 Special Topics in CSE Special topics in Computational Science and

Engineering offered on occasion based on student and faculty demand and interest.

CSE 6091 CS&E Seminar From time to time, depending on student demand, a seminar will be offered on current topics in computational science and engineering.

CSE 6990 Doctoral Research By arrangement with the instructor directing the PhD dissertation.

CSE 6999 Doctoral Reading and Research Individual reading and research on current topics in computational science and engineering.

EC 4000 Senior Seminar in Economics A senior capstone seminar in which students discuss and conduct research under the guidance of several faculty members.

EC 4200 Econometrics Introduces techniques and procedures to estimate and test economic and financial relationships developed in business, economics, social and physical sciences.

EC 4400 Banking & Finan Institutions Analysis of asset and liability management of financial institutions and the role of financial institutions in the U.S. and international economy.

EC 4600 Nat Resource/Environ Econ Examines economic and policy issues related to the supply and use of natural resources and to the environmental problems related to their use. Resources studied include minerals, energy, agriculture, forests, fisheries, wildlife, and water. Policy issues include efficiency, benefit cost analysis, U.S. environmental policy, and international concerns.

EC 4610 Mineral Industry Economics Studies the role of minerals and metals in society and the economics of their use. Applies economic principles to examine the supply, demand, markets, and foreign trade for important minerals and metals. Examines the effect of government policies on the minerals industries. Requires a technical report.

EC 4620 Energy Economics Introduction to the institutional, technical, and economic issues of the production and use of energy resources, including petroleum, natural gas, coal, nuclear, electric utilities, and alternative energy sources. Applies economic analysis to industrial and policy problems of the supply, distribution, and use of energy resources, including environmental and social consequences.

EC 4700 Economics of Health Care Economic analysis of the health care sector: organization, demand and supply factors, pricing practices, financing mechanism, public vs private, impact of third party, medical school funding and admission policy, insurance and prepayment, and health and economic development.

EC 4800 Economics of Tech Change Economic issues related to technological change: role of technological change in economic growth, economics of research and development, processes of invention and innovation and their



relation to market structure, diffusion of new technology and its impact on markets, economic aspects of intellectual property, and public policy toward technological change.

EC 4900 Research Under the general guidance of a faculty member, students read, conduct research, and prepare reports and papers as required.

EC 4990 Special Topics in Economics Economic topics of interest to students and faculty.

EC 5000 Microeconomics The study of consumer demand theory of the firm, market structure, and industrial performance. Emphasizes establishment of an analytic framework for evaluating public policy.

EC 5010 Macroeconomics The study of the determinants of the level of income, employment, the rate of inflation, economic growth, and cyclical variations in the economy, including considerations of the rationale for monetary and fiscal policy and their impact on the business community.

EC 5400 Advanced Engineering Economics Presents and demonstrates procedures and quantitative techniques used in capital budgeting and project evaluation and selection for industry. Topics include cashflow analysis, decision methods, risk and uncertainty, cost of capital, taxes and depreciation, and forecasting market variables. Topics presented with study problems, applying spreadsheet programs. Presents and demonstrates procedures and quantitative techniques used in capital budgeting and project evaluation and selection for industry. Topics include cash flow analysis, decision methods, risk and uncertainty, cost of capital, taxes and depreciation, and forecasting market variables. Topics presented with study problems, applying spreadsheet programs.

EC 5600 Nat Resource/Environ Econ Supply and use of renewable and depletable natural resources, including minerals, energy, agriculture, forests, fisheries, wildlife, and water. Efficient management of private and common property resources and environmental issues and concerns. Efficiency, market failures, benefit-cost analysis, and policy analysis. No credit if a student has previous credit for EC4610.

EC 5610 Economics of Nonfuel Minerals Economics of the nonfuel minerals industries: market analysis, market structure, international trade issues, policy analysis, role of minerals in society, supply, demand, markets, and foreign trade for important minerals, effects of government policies on the minerals industries. No credit if a student has previous credit for EC4600.

EC 5620 Energy Economics Examines social and private problems in the supply, distribution, and use of energy resources and the energy industries. Studies production, allocation, and environmental and social problems of petroleum, natural gas, coal, nuclear, electricity, and various alternative energy sources. No credit if a student has previous credit for EC4620.

EC 5900 Special Topics Economic topics of interest to students or independent study in economics under the guidance of a faculty member.

EC 5999 Graduate Research Under the guidance of a faculty member, students

will read, conduct research, and prepare a report, paper, or thesis.

ECA 9003 Histories & Cultures

ECA 9003U Histories & Cultures Upper Div

ECA 9004 Science, Tech and Society

ECA 9004U Science/Tech/Society Upper Div

ECA 9005 Econ, Political & Social Inst

ECA 9005U Econ/Pol/Social Inst Upper Div

ED 4500 Special Problems in Education Literature, laboratory, or field investigation under the supervision of authorized University faculty/staff with a required report of work performed and results obtained. Literature, laboratory, or field investigation under the supervision of authorized University faculty/staff with a required report of work performed and results obtained.

ED 4510 Special Topics in Education Students identify and develop an in-depth examination of current topics in education for further research and study. Working in consultation and agreement with select faculty, students engage in active inquiry on leading educational issues.

ED 4600 Independent Study in Education Through independent study, gain additional insights to relevant topics in education and research. Students must work directly with select faculty to develop a structured line of study on select educational topics.

ED 4810 Meth of Tchng Sci, Math, & CS Application of learning and instructional theories to the teaching of science, mathematics, and computer science. Emphasizes methods and materials used to teach early adolescents and adolescents. Taught from the perspective of science/mathematics/computer science teachers. Lab offer opportunities to refine instructional techniques.

ED 4820 Meth of Tchng Social Studies Application of learning and instructional theories to the teaching of social studies and English. Emphasizes methods and materials used to teach early adolescents and adolescents. Taught from the perspective of social studies teachers. Lab offers opportunities to refine instructional techniques.

ED 4830 Gen Meth of Secondary Tchng This course deals with 4 major areas of knowledge. 1. Teaching strategies 2. Classroom Management 3. Development of lesson plans 4. Test development and evaluation This course deals with 4 major areas of knowledge: Teaching Strategies, Classroom Management, Development of Lesson Plans, and Test Development and Evaluation. Requires admission to the Teacher Education program by the Department of Education.

ED 4831 Science Methods Application of learning and instructional theories to the teaching of science. Content specific to the students major or minor will be utilized in all course work. Application of learning and instructional theories to the teaching of science. Content specific to the students major or minor will be utilized in all course work. Requires admission to teacher

education program by the Department of Education.

ED 4910 Directed Teaching Knowledge of human growth and learning theories, methods and materials, and individual differences applied to classroom settings conducted under the supervision of an experienced middle or secondary school teacher. Requires admission to teacher education program.

ED 5100 College Teaching Covers course preparation, educational testing and evaluation, understanding theories and processes of student learning, developing assignments, instructional strategies (discussions, lecturing, collaborative learning, cases/simulations, etc.), using instructional technologies, motivating students, the roles of the teaching assistant, and using institutional resources for student development.

ED 5110 Educational Psychology Review of psychological principles as they relate to human learning. Covers factors in school that contribute to the emotional, psychological stability of the developing child: assessing students' capabilities, setting educational objectives for the child, classroom practices, procedures, teachers' behavior and their relationship to different types of students. Review of psychological principles as they relate to human learning. Covers factors in school that contribute to the emotional, psychological stability of the developing child: assessing students' capabilities, setting educational objectives for the child, classroom practices, procedures, teachers' behavior and their relationship to different types of students. All four components of the Early Block must be taken concurrently.

ED 5210 Principles of Education Contemporary issues in education from historical, philosophical, sociological, and legal perspectives. Emphasizes the structure/function of U.S. education as well as exceptional children, especially the handicapped and culturally different. This course is one component of the Teacher Education Early Block. Requires admission to teacher education program. Contemporary issues in education from historical, philosophical, sociological, and legal perspectives. Emphasizes the structure/function of U.S. education as well as exceptional children, especially the handicapped and culturally different. This course is one component of the Teacher Education Early Block. Requires admission to teacher education program. All four components of the Early Block must be taken concurrently.

ED 5310 Graduate Seminar in Education Introduction to contemporary issues in teacher education. Synthesis of clinical experiences with the psychological foundations of learning and foundations of education courses. Requires a term project. This course is one component of the Teacher Education Early Block. Requires admission to teacher education program. Introduction to contemporary issues in teacher education. Synthesis of clinical experiences with the psychological foundations of learning and foundations of education courses. Requires a term project. This course is one component of the Teacher Education Early Block. Requires admission to teacher education program. All four components of the Early Block must be taken concurrently.

ED 5410 Educational Field Experience Observation, tutoring, and classroom teaching in an area elementary school classroom. This course is one component of the Teacher Education Early Block. Requires admission to teacher education

program. Observation, tutoring and classroom teaching in an area elementary school classroom. This course is one component of the Teacher Education Early Block. Requires admission to teacher education program. All four components of the Early Block need to be taken concurrently.

ED 5500 Special Studies in Ed Psych Individual or group studies of specially selected issues or problems in educational psychology. Credit may be granted for scholarly work under the supervision of departmental-approved, authorized University faculty members that results in an acceptable scholarly product-research reports, curricula, computer program, or other.

ED 5510 Spec Studies in Educ Tech Individual or group studies of specially selected issues or problems in educational technology. Credit may be granted for scholarly work under the supervision of departmental-approved, authorized University faculty members that results in an acceptable scholarly product-research reports, curricula, computer program, or other.

ED 5520 Spec Std in Midl & Sec Sch Individual or group studies of specially selected issues or problems in middle and secondary school methods. Credit may be granted for scholarly work under the supervision of departmental-approved, authorized University faculty members that results in an acceptable scholarly product-research reports, curricula, computer program, or other.

ED 5530 Spec Std in Elem & Midl Method Individual or group studies of specially selected issues or problems in elementary and middle schools methods. Credit may be granted for scholarly work under the supervision of departmental-approved, authorized University faculty members that results in an acceptable scholarly product-research reports, curricula, computer program, or other.

ED 5540 Special Studies in Education 1 Individual or group studies of specially selected issues or problems in education. Credit may be granted for scholarly work under the supervision of departmental-approved, authorized University faculty members that results in an acceptable scholarly product-research reports, curricula, computer program, or other.

ED 5550 Special Studies in Education 2 Individual or group studies of specially selected issues or problems in education. Credit may be granted for scholarly work, under the supervision of departmental-approved, authorized University faculty members that results in an acceptable scholarly product-research reports, curricula, computer program, or other.

ED 5600 Independent Study in Education Through an independent study, gain additional insights to relevant topics in education and research. Students must work directly with select faculty to develop a structured line of study on select educational topics.

ED 5601 Spec Content Studies in Ed Educators' Science and Mathematics Institute Series Courses. Intensive institutes designed to help elementary, middle and high school educators integrate important concepts in math and science into classroom teaching units. New content areas are designed each year to address the needs of participating teachers.

ED 5602 Special Appl in Education Educators' Science and Mathematics Institute Series Practicums. Practical application following special content studies during which elementary, middle and high school teachers implement and evaluate a teaching unit that they designed for their own classroom inspired by the previous content course. A mandatory teachers' forum provides opportunity to share ideas with other participating teachers

ED 5603 Special Topics in Education Teachers' Earth Science Institute Courses. Utilizes mineral science and mineral processing to enhance the teaching of science in middle and high school. Teachers will be involved in hands-on, discovery-based activities that integrate concepts in math, physics, and chemistry with elements of social sciences.

ED 5610 Ecol of the Grt Lks Ecosystem Fundamental theory and application of selected concepts basic to understanding the Great Lakes Ecosystem, modeling effective teaching methods that the participants can implement in their classrooms. Helps elementary and secondary science and math teachers integrate ecological concepts into classroom teaching units.

ED 5611 Ecol of Grt Lks Practicum After taking ED5610, participants implement a teaching unit appropriate for their level in a topic of interest that meets the guidelines of the Michigan Curriculum Framework Standards. Participants present their curriculum implementation and evaluation, and submit a written summary of their experience.

ED 5612 Investigating Bio, Chem, & Bio Fundamental theory and application of selected concepts basic to understanding biology, chemistry, and biochemistry for the purpose of modeling effective teaching methods that participants implement in their classrooms. Helps elementary and secondary science and math teachers integrate selected concepts in biology, chemistry, and biochemistry into classroom teaching units.

ED 5613 Invest Bio, Chem, & Biochem Pr After taking ED5612, participants implement a teaching unit in a topic of interest that meets the guidelines of the Michigan Curriculum Framework Standards. Participants present their curriculum implementation and evaluation, and submit a written summary of their experience.

ED 5614 Exploring Math and Engineering Fundamental theory and application of selected concepts basic to understanding mathematics and engineering for the purpose of modeling effective teaching methods that the participants can implement in their classrooms. Helps elementary and secondary science and math teachers integrate concepts in mathematics and engineering into classroom units.

ED 5615 Exploring Math & Engg Practicu After taking ED 5614, participants implement a teaching unit appropriate for their level in a topic of interest that meets guidelines of the Michigan Curriculum Framework Standards. Participants present their curriculum implementation and evaluation, and submit a written summary of their experience.

ED 5616 Space and Planetary Sciences Fundamental theory and application of selected concepts basic to understanding space and planetary sciences for the purpose of modeling effective teaching methods that the participants can

implement in their classrooms. Helps elementary and secondary science and math teachers integrate concepts in space and planetary sciences into the classroom.

ED 5617 Space & Planetary Sci Prac After taking ED 5616, participants implement a teaching unit appropriate for their teaching level in a topic of interest that meets the guidelines of the Michigan Curriculum Framework Standards. Participants present their curriculum implementation and evaluation, and submit a written summary of their experience.

ED 5700 Iss & Research in Science Ed The study in depth of issues and research in science education including curricular standards, models, and designs for science education as well as modes of assessing student performance in science education using the Michigan Mathematics and Science Content Standards and the Michigan Teaching and Learning Standards. The course will include the changing models for understanding cognition and learning as related to science education, e.g., contextualized/distributed cognition and learning.

ED 5710 Measurement & Evaluation in Ed Survey of measurement and evaluation techniques as they apply to K-12 curriculum. Reviews teacher-made tests and standardized tests. Emphasizes designing and use of quality measurement tools in the classroom.

ED 5730 Connecting Sci Framewrk toPrac The course will examine the implications of using engineering applications in the physical, earth, and biological sciences as a "medium" for connecting science education research, the Michigan Mathematics and Science Frameworks, and the teaching of the sciences in secondary education, especially for evaluating and designing curricular materials and resources for science education.

ED 5740 Developing Applied Materials The student will be expected to design and develop materials and methodologies for using engineering concepts and processes in the classrooms and for demonstrating the student's understanding of engineering concepts and processes as "mediums" for teaching the sciences, particularly with the focus on applied materials and methodologies (e.g., developing computer software programs) for advancing the student's achievement in the physical, earth, and biological sciences in accord with the Michigan Science and Mathematics Education Standards.

ED 5810 Adv Mthds Tchng Sci, Math, CS Application of learning and instructional theories to the teaching of science, mathematics, and computer science. Emphasizes methods of materials used to teach early adolescents and adolscents. Taught from the perspective of science/math/computer science teachers. Lab offers opportunities to refine instructional techniques. Admission to teacher education required. Application of learning and instructional theories to the teaching of science, mathematics, and computer science. Emphasizes methods of materials used to teach early adolescents. Taught from the perspective of science/math/computer science teachers. Lab offers opportunities to refine instructional techniques. Admission to teacher education required.

ED 5900 Graduate Research in Education Students will conduct a research project/report as a capstone to an approved plan of study. The student should

present a project plan to their education advisor for approval, conduct whatever work is necessary for the project, prepare a final report at the conclusion of the project, and defend the project/report in an oral presentation.

ED 5910 Teaching Internship Knowledge of human growth and learning theories, methods and materials, and individual differences applied to classroom settings, conducted under the supervision of an experienced middle or secondary school teacher. Completion of MTTC Basic Skills Test. See department for application deadlines.

EDA 9000 Language, Thought & Values

EDA 9000U Lang/Thought/Values Upper Div

EDA 9004 Science, Tech and Society

EDA 9004U Science/Tech/Society Upper Div

EE 4211 Computer-Aided Circuit Design Basic techniques in computer aided analysis and design of networks. Includes automatic formulation of equations and fundamental programming techniques pertinent to computer-aided network analysis and modeling. Special topics may include sensitivity calculation, system analogies, and/or design optimization.

EE 4221 Power System Analysis 1 Covers power transmission line parameters and applications, symmetrical components, transformer and load representations, systems faults and protection, and the per unit system.

EE 4222 Power System Analysis 2 Covers power flow, economic dispatch, power system operation, and power system stability.

EE 4231 Physical Electronics Device physics and physical models of the most basic solid-state device structures. Major topics include the terminal characteristics and their physical origin, device design, and device applications.

EE 4232 Electronic Applications Study of electronic circuits under small- and large-signal conditions. Typical topics include analysis and design of power and RF amplifiers, feedback circuits, oscillators, timing circuits, Schmitt triggers, non-linear models of semiconductor devices, the factors that limit switching speed, the switching of reactive elements, and DC-DC converters.

EE 4241 Microwave Engineering A study of basic building blocks used in microwave systems. Includes microstrip lines, power dividers, directional couplers, filters, amplifiers, and matching networks. Accompanied by a microwave measurements laboratory.

EE 4242 Electromagnetic Systems Engg The fundamentals of electromagnetics within the context of systems engineering, integrating issues of communications, microwave sources, transmission lines, antennas, propagation, and the reception and processing of signals.

EE 4243 Physics of Microwave Devices Covers solid-state microwave devices, microwave tubes, and microwave components. Describes the basic physical

mechanisms involved in device operation at microwave frequencies. Can include device design and device applications.

EE 4244 Electromagnetic Systems Engg Systems applications of transmissions lines, RF and microwave filters and amplifiers, antennas, radiowave propagation, and the reception and processing of signals for Communications and Navigation Systems. Design software tools will be used.

EE 4251 Wireless Communications Principles of wireless communication systems. Applications include cell phones, computer networks, paging systems, satellite communications, radio, television, and telemetry.

EE 4252 Digital Signal Processing Digital signal processing techniques. Includes sampling, the Z-transform, digital filters, and discrete Fourier transforms. Emphasizes techniques for design and analysis of digital filters. Special topics may include the FFT, windowing techniques, quantization effects, and physical limitations. Digital signal processing techniques with emphasis on two dimensional problems and image processing. Includes sampling, the Z-transform, digital filters and discrete Fourier transforms. Emphasizes techniques for design and analysis of digital filters. Special topics may include the FFT, windowing techniques, quantization effects, physical limitations, image processing basics, image enhancement, image restoration and image coding.

EE 4253 Real Time Signal Processing Practical implementation of digital signal processing concepts as developed in EE4252. Emphasis on applications of DSP to communications, filter design, speech processing, and radar. Laboratory provides practical experience in the design and implementation of DSP solutions.

EE 4254 Image Processing Theory and applications of digital image processing. Topics include image transforms and filtering, image contrast and edge enhancement, image compression and encoding, and image segmentation and representation.

EE 4255 Wireless Communications Principles of wireless communication systems. Applications include cell phones, computer networks, paging systems, satellite communications, radio, television and telemetry.

EE 4261 Classical Control Systems Mathematical formulation of control problems (both transfer function and state-variable descriptions); analysis of feedback control systems (stability, transient performance, steady-state error, sensitivity, etc.); design using frequency response, root locus, state-variable methods; analog and digital simulation and computation; and experiments with physical systems.

EE 4262 Digital and Non-linear Control Digital control system design and analysis (Z-transforms, difference equations, and the discrete-time state model); introduction to nonlinear systems (equilibrium states, linearization, phase plane analysis, and describing function analysis); discrete-event controller design (state-transition techniques, relay ladder logic, and Petri nets); introduction to hierarchic systems; and experiments with physical systems.



EE 4271 VLSI Design Design of VLSI circuits using CAD tools. Analysis of physical factors affecting performance.

EE 4272 Computer Networks Communications architecture, transmission media, network topologies, protocols, and design issues. Computer networks focusing on layers 1-4 of the ISO OSI model. Includes case studies of wired and wireless networks.

EE 4273 Embed Sys and MicroP Interface Microprocessor architecture and interfacing real-time operating systems. Embedded microprocessors.

EE 4411 Engineering Electromagnetics A mathematically rigorous study of dynamic electromagnetic fields, beginning with Maxwell's equations. Topics include scalar and vector potentials, waves, and radiation.

EE 4441 The Laser Survey of laser types and analysis of the common physical and engineering principles, including energy states, inversion, gain, and broadening mechanisms. Design issues include resonators, packaging, cooling, pulsed power, and safety. Students will construct a computational model that predicts laser performance. Nonlinear optics and selected applications also covered.

EE 4800 Special Topics in Elec Engg Covers specific topics in electrical engineering.

EE 4805 Electrical Engineering Project A project in electrical engineering. An individual student or a group of students complete a mutually- agreed-upon project in consultation with a faculty member.

EE 4870 Special Topics in Comp Engg Covers special topics in computer engineering.

EE 4875 Computer Engineering Project A project in computer engineering. An individual student or a group of students complete a mutually- agreed-upon project in consultation with a faculty member.

EE 4900 Design Fundamentals The design process. Includes team design activities and studies project management.

EE 4901 EE Design Project 1 The first quarter of a program of study in which a group of students work on an engineering design project in consultation with a faculty member. The first semester of a program of study in which a group of students work on an engineering design project in consultation with a faculty member. (Senior project ready as defined by major substitutes for prerequisites)

EE 4910 EE Design Project 2 The second semester of a program of study in which a group of students work on an engineering design project in consultation with a faculty member. The second semester of a program of study in which a group of students work on an engineering design project in consultation with a faculty member. (Senior project ready as defined by major substitutes for prerequisites)

EE 4921 Power Engg Design Project 1 The first semester of a program of study

in which a group of students work on an electric power engineering design project in consultation with a faculty member. The first semester of a program of study in which a group of students work on an electric power engineering design project in consultation with a faculty member. (Senior project ready as defined by major substitutes for prerequisites)

EE 4922 Power Engg Design Project 2 The second semester of a program of study in which a group of students work on an electric power engineering design project in consultation with a faculty member. The second semester of a program of study in which a group of students work on an electric power engineering design project in consultation with a faculty member. (Senior project ready as defined by major substitutes for prerequisites)

EE 4951 Comm Systems Design Project 1 The first semester of a program of study in which a group of students work on a communication systems engineering design project in consultation with a faculty member. The first semester of a program of study in which a group of students work on a communication systems engineering design project in consultation with a faculty member. (Senior project ready as defined by major substitutes for prerequisites)

EE 4952 Comm Systems Design Project 2 The second semester of a program of study in which a group of students work on a communications system engineering design project in consultation with a faculty member. The second semester of a program of study in which a group of students work on a communications system engineering design project in consultation with a faculty member. (Senior project ready as defined by major substitutes for prerequisites)

EE 4971 Computer Design Project 1 The first semester of a program of study in which a group of students work on a computer engineering design project in consultation with a faculty member. The first semester of a program of study in which a group of students work on a computer engineering design project in consultation with a faculty member. (Senior project ready as defined by major substitutes for prerequisites)

EE 4972 Computer Design Project 2 The second semester of a program of study in which a group of students work on a computer engineering design project in consultation with a faculty member. The second semester of a program of study in which a group of students work on a computer engineering design project in consultation with a faculty member. (Senior project ready as defined by major substitutes for prerequisites)

EE 5200 Advanced Methods in Power Sys Advanced analysis and simulation methods for load flow, symmetrical components, short circuit studies, optimal system operation, stability, and transient analysis. Application of commonly used software reinforces concepts and provides practical insights. Advanced analysis and simulation methods for load flow, symmetrical components, short circuit studies, optimal system operation, stability, and transient analysis. Application of commonly used software reinforces concepts and provides practical insights.

EE 5210 Power System Protection A theoretical study of the protection of modern power systems. Addresses radial and grid systems as well as

generators, transformers, motors, and other equipment. Provides practical application experience in the laboratory.

EE 5220 Transient Analysis Methods A study of transient behaviors and their analysis and prediction. Addresses analytical methods and their numerical implementation, switching and lightning surges, short circuits, and non-linear effects. Includes computer simulations.

EE 5230 Power System Operations Study of advanced engineering and economic algorithms and analysis techniques for the planning, operation, and control of the electric power system from generation through transmission to distribution.

EE 5240 Computer Model of Power System Topics include modeling and computer methods applied to electrical power systems, matrix formulations, network topology and sparse matrix data structures, loadflow, short-circuit and stability formulations, constrained optimization methods for loadflow and state estimation, and time-domain simulation methods for transient analysis.

EE 5250 Distribution Engineering Modeling and analysis of electrical distribution systems; load characteristics, load modeling, unbalanced three-phase overhead and underground line models, and distribution transformers. Analysis of over current protection, voltage drop, and power quality.

EE 5290 Selected Topics in Power Sys 1 Selected topics of current interest.

EE 5310 Theoretical Techniques of EE 1 A study of random processes and methodology and linear systems appropriate to the electrical engineering discipline. Emphasizes both formal proofs and computational modeling. A study of random processes and methodology and linear systems appropriate to the electrical engineering discipline. Emphasizes both formal proofs and computational modeling.

EE 5320 Theoretical Techniques of EE 2 A study of non-linear and linear problems, associated with electrical engineering. Applies complex variables, partial differential equations, and Green's Functions to specific current problems. Includes formal proofs and computational modeling.

EE 5340 Statistical Optics Study of the effects of randomness in optical systems. Coverage includes coherence theory, photon statistics, wave propagation, and imaging through random media. Presents analytic and computational approaches.

EE 5410 Engineering Electromagnetics A mathematically rigorous study of dynamic electromagnetic fields, beginning with Maxwell's equations. Topics include scalar and vector potentials, waves, and radiation.

EE 5420 Electromagnetic Systems Engg Theory and application of microwave circuits such as filters, couplers, and transmission lines. Includes use of numerical modeling and applications to radar systems.

EE 5430 Electronic Materials A study of the physical principles, operational characteristics, models, and basic applications of selected solid-state

devices.

EE 5440 The Laser An in-depth survey of laser types, laser design, and laser applications, concentrating on electromagnetic and materials considerations. Survey of laser types and analysis of the common physical and engineering principles, including energy states, inversion, gain, and broadening mechanisms. Design issues include resonators, packaging, cooling, pulsed power, and safety. Students will construct computational model that predicts laser performance. Nonlinear optics and selected applications also covered.

EE 5450 Modeling of IC Interconnects Techniques of modeling phenomena associated with metallic integrated circuit interconnections will be presented. These include parasite elements, propagation delays, crosstalk and electromigration induced failure. Optical and superconducting interconnections will also be reviewed.

EE 5460 Solid State Devices A study of the physical principles, operational characteristics and models and basic applications of solid state devices such as p-n junctions, metal- semiconductor junctions and transistors.

EE 5500 Statistical Signal Processing Focuses on the application of statistical techniques to the study of random signals and noise. Includes random processes in continuous and discrete time and space, second-order properties of random processes, the interaction of random processes with linear systems, parameter estimation, and the design and implementation of statistical signal-processing algorithms.

EE 5510 Information Theory & Coding Definition of information and a study of its properties. Channel capacity and error-free communication over noisy channels. Covers encoding, decoding, and encrypting systems.

EE 5520 Fourier Optics Analysis and modeling of diffraction effects on optical systems, emphasizing frequency-domain analytic and computational approaches. Presents wave propagation, imaging, and optical information processing applications. Analysis and modeling of diffraction effects on optical systems, emphasizing frequency-domain analytic and computational approaches. Presents wave propagation, imaging, and optical information processing applications.

EE 5521 Detection & Estimation Theory Detecting and estimating signals in the presence of noise. Optimal receiver design. Applications in communications, signal processing, and radar.

EE 5522 Digital Image Processing Image formation, enhancement, and reconstruction. Applications in medical imaging, computer vision, and pattern recognition.

EE 5530 Wireless Digital Communication Detailed study of modulation, transmission, detection and demodulation in wireless digital networks. Emphasizes doppler shift, multipath, beamsteering and current topics.

EE 5540 Statistical Optics Study of the effects of randomness in optical systems. Covers coherence theory, photon statistics, wave propagation, and imaging through random media. Presents analytic and computational approaches.

EE 5550 Optical Information Processing Geometric and wave optics. Optical devices with applications in imaging, beamforming, and optical communication systems.

EE 5560 Multi-user Detection Demodulation of mutually interfering digital streams of information that occur in areas such as wireless communications and high-speed data transmission. Design and analysis of receivers for multi-access channels, with focus on fundamental models and algorithms. Topics include optimal multiuser detection and the optimal attainable performance in Gaussian multiuser channels, suboptimal linear multiuser detection, blind and adaptive methods, multiuser receiver for multiple-antenna reception, and the performance measure of asymptotic multiuser efficiency.

EE 5570 Communication Networks System architectures. Data link control, error correction, and protocol analysis. Message delay, Markov processes, queuing, delays in statistical multiplexing, multiple users with reservations, limited service, priorities. Network delay, traffic flows, throughput analysis. Multiple access networks.

EE 5580 Wavelet and Spectral Analysis Fourier analysis, wavelet transforms and time-frequency analysis. Applications in signal and image processing.

EE 5610 Linear Optimal Control I Performance analysis in multi-input, multi-output (MIMO) linear feedback systems including internal stability, principle gains and cost functions. Analysis of MIMO systems with random inputs. Stability and performance robustness analysis using singular values and structured singular values. Introduction to the calculus of variations and optimal control. The linear quadratic regulator, the stochastic regulator and their properties.

EE 5620 Linear Optimal Control II Linear, mean-square estimation and Kalman filtering. Optimal estimation for colored plant and measurement noise. Linear quadratic Gaussian optimal control, loop transfer recovery and tracking system design. H-infinity optimal control  $\mu$ -synthesis. Controller order reduction via pole-zero truncation and balanced truncation.

EE 5710 Current Topic in Comp Engg I Current topics in computer engineering suitable for both computer specialists and nonspecialists. Current topics in computer engineering suitable for both computer specialists and non-specialists.

EE 5711 Math Techniques for Comp. Engg Mathematical theory and methods frequently used in computer engineering research and development. Picks up where undergraduate courses usually stop. Includes selected topics from formal logic, theorem proving, probability, statistics, modeling and simulation. Contains a significant programming component.

EE 5720 Current Topic in Comp Engg II Current topics in computer engineering suitable for both computer specialists and nonspecialists. Current topics in computer engineering suitable for both computer specialists and non-specialists.

EE 5730 Digital Design I Study of the structure and design of modern digital

systems.

EE 5731 Real-Time and Embedded Systems Theory and practice of building real-time embedded systems with sensors and actuators with real-time operating systems (RTOS) to obtain hard-real-time behavior. The lab class puts theory into practice.

EE 5740 Digital Design II Study of the structure and design of modern digital systems.

EE 5752 Digital Storage Technologies Digital Storage Technologies including solid state memory devices, magnetic and optical disks will be covered. The usage of the available technologies in a microprocessor system memory hierarchy will be explored using architectural simulation tools.

EE 5755 Fault-Tolerant Systems Covers both the theory and the practice of how to design, model, evaluate, and implement reliable systems out of unreliable components. Includes: Fault Models, Redundancy Management, Agreement, Consensus, Voting, Clock synchronization and reliable broadcast. Material is reinforced with real-world case studies.

EE 5772 Parellel Computer Organization The range of multiprocessor computer architecture (CMP & SMP to Deep Blue to Beowulf Clusters) will be examined in conjunction with the communication protocols necessary to enable operation of these machines. Focus of this course will be on the hardware implementation rather than programming techniques or algorithms.

EE 5778 Digital Arithmetic High speed implementations for common digital arithmetic and number crunching functional units will be examined and explained. A variety of SIMD ISA extensions (MMX, 3dNOW, SSE) will be covered together with their compatibility with standard floating point functional units and area impact.

EE 5805 Directed Study in Elec & Comp Directed study on a topic mutually agreed upon by the student and the instructor.

EE 5900 Special Topics in EE Special topics in electrical engineering selected by the student and approved by his/her advisor and the faculty member who will approve the study.

EE 5920 Power Systems Seminar An analytical study of any current high-level problem or series of problems associated with the advance of knowledge in power systems.

EE 5940 Electrophysics Seminar An analytical study of any current high-level problem or series of problems associated with the advance of knowledge in electrophysics.

EE 5950 Signals and Systems Seminar An analytical study of any current high-level problem or series of problems associated with the advance of knowledge in signals and systems.

EE 5970 Computer Engineering Seminar An analytical study of any current high-level problem or series of problems associated with the advance of

knowledge into computer engineering.

EE 5990 Thesis Research in EE Study of some acceptable electrical engineering problem and preparation of a thesis.

EE 5991 Project Research in EE Study of some acceptable electrical engineering problem and preparation of a report.

EE 5992 Practical Experience in EE A collaboration with industry on some acceptable electrical engineering task and preparation of a report.

EE 6210 Power Sys Dynamics & Stability A study of the dynamic behavior of power systems. A review of synchronous machine modelling, system dynamic equations, and method of analysis. Examines overall system behavior via small signal and transient stability and energy functions. Also studies voltage stability and non-linear effects. A study of the dynamic behavior of power systems. A review of synchronous machine modeling, system dynamic equations, and method of analysis. Examines overall system behavior via small signal and transient stability and energy functions. Also studies voltage stability and non-linear effects.

EE 6290 Selected Topics in Power Sys 2 Selected topics of current interest.

EE 6410 Advanced Engr Electromagnetics A continuation of EE5410. Emphasizes problems of antenna design, scattering, and relativistic effects.

EE 6420 Interact of Emag Waves & Matl Alternates with EE6440. Develops basic understanding of the interaction of radiated electromagnetic waves and materials. Topics include light-emitting diodes, heating and materials changes due to such radiation.

EE 6440 Radar Alternates with EE6420. Covers the design and use of radar systems. Includes both electromagnetic and signal processing aspects.

EE 6450 Theory of Devices Alternates with EE6470. An in-depth study of the theory of several important solid-state devices. Develops modeling methods for such devices.

EE 6460 Modeling of Devices A continuation of EE6450. Alternates with EE6480. Emphasizes the use of computers to model the operating characteristics of important devices.

EE 6470 Thin Films Alternates with EE6450. A study of the problems and theories of ohmic thin-film attachment to semiconducting materials. Develops modeling methods.

EE 6480 Modeling of Thin Films A continuation of EE6470. Alternates with EE6460. Develops the actual modeling of thin-film semiconductor interfaces.

EE 6900 Advanced Topics in EE Advanced topics in electrical engineering selected by the student and approved by his/her advisor and the faculty member who will approve the study.

EE 6920 Adv Seminar in Power Systems An in-depth study of any problem or series of problems of current importance associated with the advancement of

knowledge in power systems.

EE 6940 Adv Seminar in Electrophysics An in-depth study of any problem or series of problems of current importance associated with the advancement of knowledge in electrophysics.

EE 6950 Adv Seminar in Signals & Sys An in-depth study of any problem or series of problems of current importance associated with the advancement of knowledge in signals and systems.

EE 6990 Doctoral Research Original research leading to the preparation of a dissertation in partial fulfillment of the requirements for the PhD degree.

EET 4000 Special Topics in EET The study of a special interest topic in Electrical Engineering Technology. The class requires significant independent study and the preparation and presentation of a report. Approval by an EET faculty member is required.

EET 4141 Microcomputer Interfacing The design of systems, hardware, and software needed to perform serial and parallel data transmission between microcomputers. Data collection using analog to digital converters, and analog and digital control outputs.

EET 4311 Advanced Circuits and Controls An introduction to the modeling, analysis and design of linear circuits and linear systems. Emphasis is placed on transfer function descriptions of practical circuits and systems. Frequency response and transient response performance is investigated using LaPlace transform techniques.

EET 4341 Network Administration A study of computer network topologies and administration of networked UNIX or NT systems running TCP/IP. Investigation of networking hardware including cabling, bridges, routers, and other communications devices.

EET 4367 Wireless Communications A continuation of EET3267. Topics include transmission lines, wave propagation, antennas, fiber optics, digital communications, and applications of those ideas to mobile wireless communications systems.

EET 4373 Adv Programmable Controllers Using Allen Bradley Micro Logix, SLC500, & PLC-5 programmable controllers, course covers structured programming, Sequential Function Charts, networking, proportional integral differential control, data acquisition and interfacing. The labs will require students to write and troubleshoot complex PLC programs.

EET 4480 Senior Project A capstone course requiring the application of knowledge gained in lower division courses. Projects are normally team oriented, require weekly progress reports, and culminate with a final report and oral presentation. Six credits of Senior Project is required for graduation, normally satisfied in two three-credit semesters.

ENG 4500 Engg for the Environment The fundamentals of environmentally responsible design and manufacturing of goods. Topics include definition and measure of pollution, product life cycle, manufacturing processes and



systems, pollution control systems, pollution prevention and sustainability.

ENG 4900 Multidiscip Sr Des Proj I Introduction to engineering design, including modeling, simulation, economic decision making, and reliability. Integration of design principles in the solution of open-ended engineering problems. Projects are defined and planned with faculty and industrial guidance. Emphasizes economics and environmental constraints. Introduction to engineering design, including modeling, simulation, economic decision making, and reliability. Integration of design principles in the solution of open-ended engineering problems. Projects are defined and planned with faculty and industrial guidance. Emphasizes economics and environmental constraints. (Senior project ready as defined by major substitutes for prerequisites)

ENG 4910 Multidiscip Sr Des Proj II Continuation of ENG4900. Introduction to engineering design including modeling, simulation, economic decision making and reliability. Integration of design principles in the solution of open-ended engineering problems. Projects are defined and planned with faculty and industrial guidance. Emphasizes economics and environmental constraints. Continuation of ENG4900. Introduction to engineering design including modeling, simulation, economic decision making and reliability. Integration of design principles in the solution of open-ended engineering problems. Projects are defined and planned with faculty and industrial guidance. Emphasizes economics and environmental constraints. (Senior project ready as defined by major substitutes for prerequisites)

ENG 4950 Engg Enterprise Proj Work IV Interdisciplinary teams work as part of an engineering enterprise to address real-world engineering design projects or problems. Fourth- year students gain experience in defining project objectives, planning strategies to achieve these objectives, and leading technical teams to accomplish project goals.

ENG 4951 Budgeting-Entrepreneurial Engg Introduction to the mechanics and dynamics of the financial budgeting process. Emphasizes their use in planning and evaluating engineering projects and enterprises. Topics and activities include budget preparation, performance assessment, and emerging issues analysis.

ENG 4952 Complex Comm Practices Students apply strategies and knowledge learned in ENG2962 and ENG3962 to the achievement of more complex communication practices demanded in technical and professional settings. Emphasizes creating professional identities, management communication skills, and responsible messages within teams and organizations and for a variety of technical and nontechnical audiences.

ENG 4953 Writing Engg Societal Context Engineering projects take place within overlapping political, social, economic, and cultural contexts, and these contexts affect and are affected by engineering work. Student reflect upon the variety of cultural perspectives that could be brought to bear on present and future projects as professionals. Engineering projects take place within overlapping political, social, economic, and cultural contexts, and these contexts affect and are affected by engineering work. Students reflect upon the variety of cultural perspectives that could be brought to bear on present and future projects as professionals.

ENG 4954 Global Competition Emphasizes unique economic, market, and political risks faced by organizations as operations expand beyond domestic borders. Discusses establishing risk profiles to analyze new labor, product, capital markets on a global scale and appropriate market entry strategies. Small teams will do a risk profile and recommend market entry strategies for selected countries.

ENG 4955 Concurrent Engg and PDM The focus of this course is on concurrent engineering. Topics in project management will also be included. Concurrent engineering or "fasttracking" project delivery is when the product or project is designed while being built or manufactured. The advantages and disadvantages of concurrent engineering will be discussed.

ENG 4960 Engg Enterprise Proj Work V Interdisciplinary teams work as part of an engineering enterprise to address real-world engineering design projects or problems. Fourth- year students gain experience defining project objectives, planning strategies to achieve these objectives, and leading technical teams to accomplish project goals.

ENG 4970 Engg Enterprise Special Topics For the development of new, senior-level instructional modules in support of the engineering enterprise.

ENG 4990 Special Topics in Engineering Engineering topics of interest to students and faculty that are not normally covered in the existing courses.

ENG 5100 The Engineering Process This course introduces the engineering problem solving and design processes. Students will learn about the engineering profession and will complete a design/build/test project.

ENG 5200 Engg Apps Physical Sciences This class will show how engineers use principles from the physical sciences to solve problems and design systems. Key concepts will be linked to the Michigan Curriculum Frameworks for precollege education.

ENG 5300 Engg Apps Earth Sciences This course will show how engineers use principles from the earth sciences to solve problems and design systems. Key concepts will be linked to the Michigan Curriculum Frameworks for precollege education.

ENG 5900 Engg Intern for Educators Students will work in an industry or research internship during summer months with an engineer. At the conclusion of the internship, students will write a paper regarding how they will apply what they have learned in their pre-college classroom.

ENG 5998 Engineering Design Practicum An advanced independent study for students in the Master of Engineering program. In consultation with his/her advisor, the student develops and executes a project demonstrating capabilities in problem solving, communications, and decision making. The practicum can be completed on or off campus.

ENGA 9000 Language, Thought & Values

ENGA 9000U Lang/Thought/Values Upper Div

ENGA 9005 Econ, Political & Social Inst

ENGA 9005U Econ/Pol/Social Inst Upper Div

ETC 8888 Unassigned EETConcentrationEle

ETE 8888 Unassigned EET Electives

EX 4001 National Student Exchange

EX 4002 National Student Exchange

FA 4150 Advanced Drawing Studio Advanced independent exploration and experimentation in drawing theory and use of various drawing media. Students identify a problem or area of interest and develop an approach to it in close consultation with a faculty member, experimenting with a variety of media and methods.

FA 4200 Advanced Watermedia Studio Advanced work in watermedia painting. Reading and theory as well as advanced applications of personal expression in watermedia may be included. Emphasis on independence in approach to materials, techniques, and concepts.

FA 4250 Advanced Oil Painting Studio Advanced independent exploration and experimentation in oil painting theory and practice, supervised by a fine arts faculty member.

FA 4300 Advanced Sculpture Studio Projects course in advanced three-dimensional design. Requires a written proposal indicating the nature of the project, theory supporting it, and source and availability of materials, equipment, and funds to facilitate its completion. Completed project is presented to the instructor with a written justification and all drawings and models.

FA 4400 Chamber Music Seminar For students interested in the study and performance of instrumental chamber music. Small ensembles meet once each week for coaching, presentations, and discussion on literature and techniques of rehearsal and performance.

FA 4420 Music Performance: Jazz Jazz combos (e.g., Jaztec, Salsa Norte) are select small groups of musicians studying jazz improvisation and performing literature for the small jazz ensemble. Focuses on developing individual improvisational techniques, personal style, and unique original arrangements. Repertoire includes swing, jazz-rock, ballads, fusion, and experimental techniques. Activities can include performances and tours.

FA 4800 Jazz Improvisation Explores the elements of jazz improvisation while developing creative ideas and technical facility in the individual musician. Emphasis will be placed on learning the idiomatic use of the major scale and associated modes, the jazz melodic minor scale, the blues scale, pentatonic scales, and the 8-tone dominant scale. Development of stylistic conformity by exploring the styles of swing, bebop, cool, blues, Latin and rock/funk. Emphasis on the II-V-I progression in major and minor keys and symmetric harmony.

FA 4820 Jazz Arranging

FA 4900 Independent Study: Research Independent research directed by fine arts faculty. Projects focus on one or more of the fine arts genres (theatre, music, visual arts). Requires a written proposal setting out goals, plans for final project (e.g., research paper, research Web site), and the resources required to complete the project.

FA 4910 Independent Study: Studio Guided independent study directed by fine arts faculty member(s) involving creating and performing new work in the areas of music, theatre, and visual arts. Requires a written proposal setting out goals, plans for final project, and the resources required to complete the project.

FA 4950 Special Topics in Fine Arts Tutorial, seminar, or class study of a topic of special interest and importance in fine arts.

FA 4960 Special Topics Workshop Special workshop projects in the fine arts.

FA 4970 Fine Arts Final Project This is a capstone course for students opting for a minor in fine arts (theatre, music, or art), extending the student's knowledge and skill in a chosen fine arts discipline through independent research or other focused creative activities. A detailed proposal of the student's final project must be approved in writing by a Fine Arts faculty advisor before the student enrolls in FA4970. This is a capstone course for students opting for a minor in fine arts (theatre, music, or art), extending the student's knowledge and skill in a chosen fine arts discipline through independent research or other focused creative activities. A detailed proposal of the student's final project must be approved in writing by a Fine Arts faculty advisor before the student enrolls in FA4970.

FAA 9000 Language, Thought & Values

FAA 9000U Lang/Thought/Values Upper Div

FAA 9001 Aesthetics & Creativity

FAA 9001U Aesth/Creativity Upper Div

FAA 9002 Aesth/Creativity Activities

FAA 9002U Aesth/Creativity Act Upper Div

FAA 9003 Histories & Cultures

FAA 9003U Histories & Cultures Upper Div

FW 4024 Wood Preservation and Drying Studies microorganisms, insects, and other biological agents that can cause deterioration of wood-in-use. Covers the chemistry and nature of wood preservative systems and the manufacture of treated wood products. Discusses principles and methods of wood drying, drying defects, and commercial practices.

FW 4080 Forest Economics and Finance Financial analysis and economic theory applied to forestry project analysis and selection, focusing on prices.

Covers risk, regional economics, taxation, auctions, and non-market valuation. Use operations research and statistical methods to solve problems.

FW 4085 Wood Biotechnology Biotechnological applications in the forest and wood products industry. Includes genetic control of wood quality and wood durability, lignin and cellulose biosynthesis, growth and development, environmental stress tolerance, secondary metabolism, and phytoremediation. In-depth study of the regulatory mechanisms and strategies applied in the genetic manipulation of desired traits. Introduction to biotechnological applications in the forest products industry. Topics include genetic control of wood quality, lignin and cellulose biosynthesis, growth and development, environmental stress tolerance, secondary metabolism, phytoremediation, pharmaceutical products of trees, DNA microarray technology and regulatory issues related to field introduction of genetically modified organisms.

FW 4087 Molecular Genetics of Trees Covers tree genome organization, structure, and function relationship of genes from trees; genome mapping using various techniques, such as RFLP, RAPD, AFLP and ESTs; GeneChip and Microarray applications; and DNA finger printing. Learn marker-assisted selection and gene tagging for qualitative and quantitative traits as well as physical mapping and map-based cloning of important genes.

FW 4089 Plant Bioinformatics Computer applications in molecular biology. Hands-on experience with popular computer programs for DNA, RNA, and protein sequence analysis. Learn database management, data editing, assembly, and organization. Covers multiple-sequence comparisons, protein structural analysis, evolutionary relationships of genes, and use of internet for data retrieval, comparison, and analysis.

FW 4110 Tree Seedling Prod & GH Man Demonstrates greenhouse culture of trees from seed or vegetative cuttings. Topics include production of containerized seedlings; vegetative propagation via budding, grafting, and rooting of cuttings; and genetic manipulation. Students have hands-on roles in the routine greenhouse culture, such as media preparation, pest management, and fertilization.

FW 4120 Tree Physiology and Genetics Introduction to the genetics and physiology of forest trees. Develops a basic understanding of how trees grow and develop and why they vary from tree to tree. Covers modern methods to improve forest trees.

FW 4140 Ecosystem Modeling Introduces the principles of quantitative analysis of ecosystem, population models, and growth-yield. Emphasizes modeling philosophy, approaches (e.g., empirical models), and applications in understanding changes of forest ecosystems and alternatives in management (e.g., landscape management system, LMS).

FW 4150 Forest Management Methods of organizing forest properties for sustainability and multiple-use management using operations research methods, particularly linear programming, for selecting preferred options. Emphasizes developing an understanding of the strengths and weaknesses of the models used. Discusses single- and multiple-use land management formulations.

FW 4220 Wetlands Study of the physical, chemical, and biological

characteristics of wetlands. Describes functions and values of individual wetland types. Presents management of wetlands and laws governing wetlands. Labs concentrate on field techniques used to assess specific plant, animal, soil, and hydrological characteristics of wetlands.

FW 4240 Mammalogy Covers the classification, structure, and natural history of mammals, including physiological, behavioral, and ecological adaptations. Through laboratory and fieldwork, emphasizes field techniques and the distribution and identification of mammals, especially those species found in the western Great Lakes. Covers the classification, structure, and natural history of mammals, including physiological, behavioral, and ecological adaptations. Through laboratory and fieldwork, emphasizes field techniques and the distribution and identification of mammals, especially those species found in the western Great Lakes.

FW 4300 For Fire Ecology & Management Principles of forest fire management based on an understanding of fire behavior, with special emphasis on ecological effects.

FW 4360 For Soils and Watershed Man Principles of forest soil and watershed management based on an understanding of soil chemical, physical, and biological properties, and forest management practices.

FW 4400 Urban Forestry Urban forestry covers the planting and maintenance of trees in urban settings. Presents modern arboriculture and tree care methods and discusses administration of urban forests. Topics covered include pest management, pruning, planting, fertilization, inventories, tree selection, and line clearance. Labs include experience in tree climbing, pruning, and planting.

FW 4500 Independent Study Guided study or research on an approved forest resource topic with a chosen faculty member.

FW 4520 Tropical Forests Ecology, traditional use, current problems, and potential solutions to those problems in various types of tropical forests. Includes a broad understanding of the social and political dynamics of countries where the forests are located.

FW 4610 Wildlife Ecology Covers the ecological basis for management of wildlife, including biological and sociological factors that influence management.

FW 4630 Isle Royale Field Ecology Camp An intensive field-based course in research methods. Introduces the process of ecological science, from initial questions to devising methods to collect data to assessing the strength of conclusions drawn from the results. Course takes place on Isle Royale and nearby mainland habitats. An intensive field-based course in research methods. Introduces the process of ecological science, from initial questions to devising methods to collect data to assessing the strength of conclusions drawn from the results. Course takes place at off campus field sites.

FW 4700 Diseases and Insects of Forest Recognition, ecology, and management of important forest tree diseases and insects, and deterioration of forest products. Emphasizes human activity, importance in ecosystem function, and

forest resources. Using diseases and pests of North America as examples, develops the principles of tree and forest disease and insect diagnosis, identification, and controls,

FW 4750 Forest Diseases/Fungal Ecology This course provides an understanding of fungi as essential components of forest ecosystems by examining both their disease-causing and beneficial roles. Students will develop the principles of fungus identification and diagnosis of diseases of trees caused by fungi and other organisms by using the specimens in the field and lab.

FW 4810 Integrated Resource Assessment First of two courses on integrated resource management to form a capstone experience. Covers multiresource inventory of forested landscapes; description and evaluation of the potential for providing various natural resource outputs; and development of GIS applications, maps, and other descriptors useful in the analysis of diverse management alternatives. Provides a capstone experience by integrating techniques from many of the applied ecology and forestry core courses. Covers multi-resource inventory of forested landscapes; description and evaluation of the potential for providing various natural resource outputs; development of GIS information and applications, maps, and other descriptors useful in the analysis of diverse management alternatives.

FW 4820 Integrated Resource Management Second of two courses on resource assessment for a parcel of land. Students continue to assess natural resources on a parcel of land and develop a range of management alternatives for their parcel. They will also develop efficient land allocations in response to each alternative and evaluate landscape-level implications.

FW 5024 Advanced Wood Preservation Covers mechanisms of fungal degradation of wood; chemistry and formulation of modern wood preservatives used worldwide; and environmental aspects of wood preservation.

FW 5050 Curr Topics in Forest Biotech Current topics in forest biotechnology. Could include micropropagation of young and old trees, anther culture, genetic engineering via agrobacterium and biolistics, and environmental concerns about the commercial use of forest biotechnology. Aspen and larch are used for labs, focusing on sterile technique, micropropagation, and genetic engineering.

FW 5068 Advanced Wood Composites In-depth analysis of the influence of material and processing parameters on the physical and mechanical properties of wood composite products. Applied surface sciences. New developments and special topics.

FW 5077 Adv Wood Chem & Biochemistry The biosynthesis and structures of chemical components, such as lignin and cellulose, in woody plants. Enzymes involved in monolignol biosynthetic pathways. Genetic engineering of lignin biosynthesis in plants.

FW 5087 Plant Molecular Genetics Plant genome organization, structure and function relationship of plant genes, genome mapping, and Genomics. Gene Chip and Microarray applications. DNA fingerprinting. Marker assisted selection and gene tagging for qualitative and quantitative traits. Physical mapping and map based cloning of important genes for economical traits.

FW 5089 Tools of Bioinformatics Computer applications in molecular biology. Hands-on experience with using popular computer programs for DNA, RNA and protein sequence analysis, database management, data editing, assembly, and organization, multiple sequence comparisons, protein structural analysis, evolutionary relationships of genes, use of Internet for data retrieval, comparison and analysis. Computer applications in molecular biology. Hands-on experience with using popular computer programs for DNA, RNA and protein sequence analysis, database management, data editing, assembly, and organization, multiple sequence comparisons, protein structural analysis, evolutionary relationships of genes, use of Internet for data retrieval, comparison and analysis.

FW 5090 Biophysics & Ecosystem Process Introduces movement of energy and materials through ecosystems by examining the physical properties of ecosystems, such as microclimate and plant-atmosphere interactions. Emphasizes instrumentation for field measurements, energy budget, and linkages to various ecosystem processes.

FW 5100 Advanced Terrestrial Ecology Structure and function of terrestrial ecosystems. Roles of ecotypic variation, animals, natural disturbance, biological diversity, management, and global change on plant community dynamics and ecosystem processes.

FW 5130 Forest Vegetation Dynamics Investigation of how trees grow and interact in a variety of stand structures from a functional standpoint at both the tree- and stand-level. These principles will be used to test the use of silvicultural management tools for meeting a variety of objectives. Linkages will be made between stand development patterns and management options, with an emphasis on disturbance ecology.

FW 5160 Operations Research in Natural Forestry applications of operations research methods. Includes linear, mixed integer, separable, and dynamic programming and their application to renewable resource management and wood products manufacturing situations. Emphasizes problem formulation and case studies.

FW 5220 Advanced Wetland Ecology Advanced study of the physical, chemical, and biological characteristics of wetlands. Concentrates on recent research in wetland ecology. Labs emphasize field techniques used to assess specific plant, animal, soil, and hydrological characteristics of wetlands.

FW 5320 Soil Physical/Chem Properties Relationship of the chemical and physical properties of soil to plant growth.

FW 5350 Soil Biology Ecology of soil microorganisms and fauna and their roles in soil organic matter decomposition and nutrient cycling.

FW 5400 Advanced Conservation Biology This course examines the biology that underlies our attempts to conserve genetic, species, and community diversity. Discussion will include current issues from the primary literature and applications to student research projects.

FW 5410 Analysis of Ecological Data I Theory, application, and interpretation of quantitative methods for the analysis of ecological data, including



techniques used in developing and using quantitative management tools.

FW 5411 Analysis of Ecological Data II Expands analytical skills from FW5410 to more advanced methods, such as multivariate analysis, geostatistics, wavelet analysis, and spatial point analysis. Emphasizes selection of proper methods, data requirements, uses of software with real-world data, interpretations of results, and their applications.

FW 5420 Natural Resource Inventory Advanced topics in natural resource inventory planning, implementation, and design. Emphasizes practical applications of inventory methods to meet the information needs of land managers.

FW 5430 Advanced Landscape Ecology Focuses on understanding the heterogeneous properties of ecosystems at broader temporal and spatial scales. Reviews and discusses current literature and methods, applications in landscape management, and modern techniques during recitation.

FW 5510 Spec Topics in Nat Resources Independent study of a specific area of natural resources.

FW 5550 Geographic Information Systems Use of geographic information systems (GIS) in resource management. Studies various components of GIS in detail, as well as costs and benefits. Laboratory exercises use ERDAS Imagine, ArcView, and ArcInfo software packages to solve resource management problems.

FW 5560 Dig Image Proc: Rem Sens Pers Presents the theory and quantitative procedures of digital image processing using remotely sensed data. Emphasizes image acquisition, preprocessing, enhancement, transformation classification techniques, accuracy assessment, and outproducts. Discusses linkages to GIS. Also covers evaluating applications of the technology to current resource management problems via peer-reviewed literature. Presents the theory and quantitative procedures of digital image processing using remotely sensed data. Emphasizes image acquisition, preprocessing, enhancement, transformation classification techniques, accuracy assessment, and out-products. Discusses linkages to GIS. Also covers evaluating applications of the technology to current resource management problems via peer-reviewed literature.

FW 5600 The Ecology of Insects An advanced examination of insects as a highly successful group of organisms which are involved in a myriad of interactions in terrestrial and aquatic ecosystems. This course will include study of some of the unique mechanisms that insects have evolved to overcome challenges facing them in different environments.

FW 5700 Graduate Field Forestry For graduate students without an undergraduate degree in forestry or a closely related field. Covers field skills in mapping/GPS work, forest diseases and insects, wildlife, timber harvesting, natural resource inventory, and silviculture.

FW 5710 Trees in Agricultural Systems Farm systems analysis and the role of trees in tropical farming systems. Also covers specific material on soil conservation and tropical crops.

FW 5720 International Forestry Seminar Seminar for students who have completed FW5730. Synthesizes field work in a theoretical framework. Covers macro aspects of development theory.

FW 5730 Internat'l Forestry Practicum Field work and reporting from students in the Peace Corps Loret Miller Ruppe Masters International Program in Forestry.

FW 5740 Overseas Research An introduction to conducting research overseas. Covers scientific methods, ethics, and responsibilities in other cultures, social research, and research development.

FW 5750 Tropical Soils and Hydrology Overview of tropical soils, hydrology and watershed management. Topics include soil conservation. Examples covered in class include moist, arid and semi-arid environments.

FW 5760 Graduate Tropical Forestry Fundamental ecological processes in tropical forests, traditional use including tenure, current problems and solutions to those problems.

FW 5800 Master's Graduate Seminar Current forest resource-related problems and discussion of their solutions.

FW 5810 Res Methods in Natural Res Overview of science and scientific research, research problem selection, study plan and proposal preparation, with literature review and scientific hypothesis testing. Students prepare a proposal for their individual research and go through a peer review of their proposal.

FW 5999 For & Wood Prod MS Res An original investigation in forest science, applied ecology, or wood science that culminates in a thesis. An original investigation in forest science, applied ecology, or wood science that culminates in a Master's degree.

FW 6800 Doctoral Graduate Seminar A seminar course in which current topics in natural resources are presented and discussed.

FW 6980 Graduate Teaching Development of teaching skills through assisting in instruction. Students gain experience in course organization, lecture and laboratory instruction, and laboratory preparation.

FW 6999 For & Wood Prod Doc Res An original investigation in theoretical or experimental natural resources and submission of a dissertation in partial fulfillment of the requirements of the PhD degree.

FWA 9004 Science, Tech and Society

FWA 9004U Science/Tech/Society Upper Div

FWA 9005 Econ, Politcal & Social Inst

FWA 9005U Econ/Pol/Social Inst Upper Div

GE 4000 Earth Science Teaching Exper Development of earth science teaching skills through assisting in instruction in a geology course laboratory.

Students gain experience in organizing, preparing, and presenting earth science topics and answering questions.

GE 4050 Advanced Structural Geology How rocks deform on a microstructural to hand specimen scale. Topics include dislocations, work hardening and recovery processes, annealing and recrystallization, slipsystems, preferred orientation mechanisms, and foliation development. How rocks deform on a microstructural to hand specimen scale. Topics include dislocations, work hardening and recovery processes, annealing and recrystallization, slipsystems, preferred orientation mechanisms, and foliation development.

GE 4100 Geomorph & Glacial Geology The study of the processes, including fluvial, glacial, wind, mass movement, and wave action, shaping the earth's surface by erosion and deposition of geologic materials. Emphasizes the role of past and present climate. Field trips are a major component.

GE 4150 Natural Hazards Exploration of how to develop comprehensive plans to mitigate the impact of natural hazards on humans. Includes basic scientific background, current mitigation practices, and proposed mitigation strategies. Includes group and individual student proposals for value added. Most recent natural disasters will be focal points. Exploration of how to develop comprehensive plans to mitigate the impact of natural hazards on humans. Includes scientific background, past and current mitigation practices, and proposed mitigation strategies. Basic Geographic Information System approaches are covered, and laboratories teach the development of hazards maps using standard GIS software packages.

GE 4160 Introduction to Subsurface GIS Introduction to elements of GIS, emphasizing application to subsurface from groundwater levels to gas and oil reservoirs. Students prepare maps of subsurface features using large data sets. Labs use current, popular GIS software packages.

GE 4170 Volcanic Clouds Remote sensing applied to volcanic cloud hazards. Synthesis of the recent advancements in volcanic cloud research, along with theoretical background and practical experience in the study, understanding and practical remote sensing of volcanic clouds. The techniques covered are applicable to other phenomena, although volcanic ash, gas and aerosol clouds are the main examples.

GE 4200 Applied Geochemistry Monitoring techniques, collection of field data, processing, and analysis of geochemical data to study near-surface environmental systems. Provides a link between theoretical geochemistry and practical application of monitoring and analytical techniques used in environmental consulting work. Coursework includes planning and collection of field data, analysis, and interpretation. Course projects are designed to give practical and appropriate experience in the consulting field.

GE 4300 Igneous & Metamorph Petrology Optical mineralogy taught first five weeks. Petrogenesis of igneous and metamorphic rocks, including petrographic imagery and quantitative microdescriptive techniques.

GE 4400 Near Surface Geophysics I Design of geophysical site investigations utilizing resistivity, electromagnetic, ground penetrating radar, and magnetic techniques. Emphasizes geophysical detection of contamination,

ground water supplies, and mining applications.

GE 4410 Near Surface Geophysics II Principles and design of geophysical investigations of the shallow subsurface. Emphasizes seismic refraction and reflection methods with focus on engineering and groundwater applications.

GE 4500 Plate Tec & Global Geophysics Plate tectonics and the internal structure of the earth using information from seismology, geomagnetism, gravity, and heat flow.

GE 4600 Reflection Seismology Principles of reflection seismic techniques, including theoretical background and application, and hands-on computer projects. Included are acquisition, data processing, and 2D/3D data interpretation. Students conduct projects using actual commercial-quality seismic data.

GE 4610 Formation Eval & Petrol Engg Principles and practice of formation evaluation, primarily through analysis of well logs and the principles and practice of petroleum engineering. Emphasizes reservoir engineering and simulation. Students conduct projects using actual field data. A three-day field trip is required.

GE 4640 Meteorology Essential elements of atmospheric physics and meteorology, including atmospheric composition and structure, atmospheric thermodynamics, radiative transfer, atmospheric fluid dynamics, and cloud physics. In addition to prerequisites, PH2300 and MA4515 are recommended.

GE 4750 Struct Styles in Petrol Engg Geometry and mechanics of extensional, wrench and compressional features that produce structural traps in petroleum engineering, including techniques of subsurface geological mapping.

GE 4760 Engg Eval of Mineral Deposits Design of programs to explore and evaluate various types of mineral deposits. An integrated project includes factors such as geologic characteristics, economics, regulations, and environmental impact.

GE 4800 Groundwater Engineering Application of hydrogeology principles to design groundwater supply, protection, and treatment systems for municipal and agricultural uses.

GE 4810 Groundwater Site Investigation Geologic factors affecting site investigations, investigative techniques and methods, and reports of investigation. Emphasizes quantitative techniques and methods for investigating groundwater resources and quality.

GE 4820 Subsurface Remediation Covers the scientific and engineering principles of in-situ subsurface remediation. Topics include subsurface fate and transport processes, remediation site characterization, remediation process design, and related policy issues.

GE 4900 Geological Engg Design Proj I Capstone geological engineering design course focusing on a realistic, complex, open-ended geological engineering problem. Project includes technical design, economic analysis, environmental impacts, and regulations. Report writing required. Capstone geological

engineering design course focusing on a realistic, complex, open-ended geological engineering problem. Project includes technical design, economic analysis, environmental impacts, and regulations. Report writing required. (Senior project ready as defined by major substitutes for prerequisites)

GE 4910 Geological Engg Design Proj II Continuation of GE4900. Capstone geological engineering design course focusing on a realistic, complex, open-ended geological engineering problem. Project includes technical design, economic analysis, environmental impacts, and regulations. Report writing required. Continuation of GE4900. Capstone geological engineering design course focusing on a realistic, complex, open-ended geological engineering problem. Project includes technical design, economic analysis, environmental impacts, and regulations. Report writing required. (Senior project ready as defined by major substitutes for prerequisites)

GE 4920 Geological Engineering Seminar Seminar course dealing with geological engineering subjects of current interest.

GE 4921 Geology Seminar Seminar course dealing with geology subjects of current interest.

GE 4922 Geophysics Seminar Seminar course dealing with geophysics subjects of current interest.

GE 4930 Special Topics in Geo Engg Study and discussion of geological engineering topics.

GE 4931 Special Topics in Geology Study and discussion of geology topics.

GE 4932 Special Topics in Mineralogy The study of special topics in mineralogy using the Seaman Mineral Museum.

GE 4933 Special Topics in Geophysics Study and discussion of geophysics topics.

GE 4960 Independ Geo Engg Res Proj Approved engineering design research project originated by the student or assigned by the instructor. A final report is required.

GE 4961 Independent Geology Res Proj Approved literature, laboratory, and/or field geology research problem originated by the student or assigned by the instructor. A final report is required.

GE 4962 Independent Geophysics Res Pr Approved literature, laboratory, and/or field geophysics research problem originated by the student or assigned by the instructor. A final report is required.

GE 5040 Evol of Struc in Deformed Rock How rocks deform on a microstructural to hand specimen scale. Topics include dislocations, work hardening and recovery processes, annealing and recrystallization, slipsystems, preferred orientation mechanisms, and foliation development, with independent project on selected topic.

GE 5050 Structural Analy & Interp Analysis of deformed rock structures from hand specimen to outcrop and map scales. Topics include mechanics of cleavage

development and folding, shear zones and vorticity, strain measurement, style group analysis, overprinting relationships, mapping and hemispherical projection techniques.

GE 5100 Adv Geomorph & Glacial Geo In-depth study of surficial processes that shape landforms and determine the composition and character of the earth's surface. Processes studied include glacial, fluvial, wind, mass movement, and wave action. Emphasizes the role of past and present climate. In-depth report and presentation on two separate topics required. In-depth study of surficial processes that shape landforms and determine the composition and character of the Earth's surface. Processes studied include glacial, fluvial, wind, mass movement, and wave action. Emphasizes the role of past and present climate. In-depth report and presentation on two separate topics required.

GE 5110 Sequence Stratigraphy The study of sedimentary rocks interpreted as a series of packages separated by time-significant surfaces. Also examines the processes controlling generation of the time-significant surfaces (eustasy, tectonics, and sediment supply).

GE 5120 Basin Analysis The evolution of sedimentary basins is influenced by the tectonic mechanisms that initially form the basin, the sediments that are deposited in the basins (composition and environments), and post-depositional processes (thermal, hydrologic, chemical and tectonic) that modify the basin fill. Course examines sedimentary basins as a record of past events. The evolution of sedimentary basins is influenced by the tectonic mechanisms that initially form the basin, the sediments that are deposited in the basins (composition and environments), and post-depositional processes (thermal, hydrologic, chemical and tectonic) that modify the basin fill. Course examines sedimentary basins as a record of past events.

GE 5130 Geology of Utah's Nat'l Parks A two-week, field-based course taught in the National Parks and Monuments of eastern Utah. Course requires a project and special assignments.

GE 5140 Paleoclimatology This course will investigate the geologic evidence of global climate and the mechanisms that are interpreted to produce climate change.

GE 5150 Advanced Natural Hazards Exploration of how to develop comprehensive plans to mitigate the impact of natural hazards on humans. Requires a project and report.

GE 5160 Remote Sensing of Atmosphere Studies atmospheric-based phenomena such as meteorological and volcanic clouds through a variety of satellite instruments in the infrared, visible and ultraviolet spectrums. Examines applications of these types of studies both in scientific research and hazard mitigation. Studies atmospheric-based phenomena such as meteorological and volcanic clouds through a variety of satellite instruments in the infrared, visible and ultraviolet spectrums. Examines applications of these types of studies both in scientific research and hazard mitigation.

GE 5170 Remote Sens of Earth Surface Introduces various sources of remotely sensed data (e.g., Landsat Thematic Mapper) that allow study of surficial features, such as structural (faults, topography, bedding) and

geomorphological (glacial, alluvial, erosional) features as well as unconsolidated sands, soils, shallow water, and bedrock.

GE 5180 Volcanology Volcanoes and how they work. Volcanic products, their recognition, and significance. Applies chemistry, physics, and fluid mechanics in a volcanological context.

GE 5200 Advanced Geochemistry Elements of modern geochemistry, including aqueous solutions, isotopes, age dating, etc., with an emphasis on concepts and quantitative methods. Project and report required.

GE 5210 Advanced Applied Geochem Monitoring techniques, collection of field data, processing, and analysis of geochemical data to study near-surface environmental systems. Project and report required.

GE 5220 Aqueous Geochemistry Introduction to quantitative methods in aqueous geochemistry with emphasis on calculation of aqueous equilibria relevant to natural systems such as carbonate equilibria.

GE 5300 Clay Min and X-ray Diff The identification of clay minerals using X-ray diffractometry methods. Reviews clay mineral structures, chemistry, and physical properties and demonstrates applications in diagenesis, petroleum geology, weathering/soils, and sedimentation.

GE 5400 Global Geophysics & Geotech Plate tectonics and the internal structure of the earth using information from seismology, geomagnetism gravity, and heat flow. A term project/report is required.

GE 5450 Potl Theo in Grav & Mag Appl The fundamentals of potential theory and the application to gravity and magnetic studies of the crust and lithosphere. Topics include newtonian & magnetic potential, magnetization, regional gravity fields, the geomagnetic field, forward & inverse modeling. Fourier-domain modeling and transformations. The fundamentals of potential theory and the application to gravity and magnetic studies of the crust and lithosphere. Topics include Newtonian & magnetic potential, magnetization, regional gravity fields, the geomagnetic field, forward & inverse modeling. Fourier-domain modeling and transformations.

GE 5500 Paleomagnetism & Envr Magnet Origin and interpretation of the natural remanent magnetism in rocks and its use in deciphering the geologic past. Applications studied are plate tectonic movements, environmental change, stratigraphic correlation, and the earth's magnetic field. Origin and interpretation of the natural remanent magnetism in rocks and its use in deciphering the geologic past. Applications studied are plate tectonic movements, environmental change, stratigraphic correlation, and the earth's magnetic field.

GE 5600 Adv Reflection Seismology Principles and application of reflection seismic techniques. Includes acquisition, data processing, and 2D/3D data interpretation. Project and report required.

GE 5610 Quantitative Reservoir Charact Develop and integrate several aspects of reservoir characterization using data from actual oil and gas fields. The various aspects include well logs, seismic data, production data, and

geologic/outcrop inference. Geostatistical routines and integrated software suites.

GE 5650 Topics in Petroleum Geology The study of current topics in petroleum geology. Research papers and reports are required.

GE 5760 Adv Engg Eval of Mineral Dep Analysis and design of programs to explore and evaluate various types of mineral deposits. An integrated project includes factors such as geological characteristics, economics, regulations, and environmental impact. Requires an independent project on an approved topic.

GE 5770 Mineral Deposit Explor Models Systematic study of the characteristics, distribution, and origin of economic metallic and nonmetallic mineral deposits, and the development of models for exploration with emphasis on selected deposits. Laboratory stresses the study of mining districts and development of exploration and genetic models.

GE 5780 Explor & Envir Geochemistry Application of geochemical data collection and analysis to the exploration of metallic and nonmetallic mineral deposits and evaluation of environmental consequences of extraction.

GE 5800 Math Modeling of Earth Systems Introduction to numerical techniques for mathematical modeling of various earth-system phenomena, including groundwater flow, heat transfer, and atmospheric transport. Numerical techniques covered include finite-difference, finite-element, collocation, and characteristic methods. Students write their own mathematical models. Prerequisite: experience in programming computer languages such as FORTRAN.

GE 5810 Flow & Transport Sub Sys Analysis of fluid flow in geologic materials, including groundwater flow, solute and contaminant transport, heat flow, and petroleum movement. Develops fundamental transport equations and numerical methods for solving these equations.

GE 5820 Fund of Subsurface Remediation Scientific and engineering principles of in-situ subsurface remediation. Topics include subsurface fate and transport processes, remediation site characterization, remediation process design, and related policy issues. Project and report required.

GE 5825 Subsurface Remediation Lab Apply the principles of soil and groundwater remediation in a series of laboratory experiments. Students will set up and conduct experiments that demonstrate design aspects of remediation technologies.

GE 5900 Geological Engineering Seminar Seminar course dealing with geological subjects of current interest.

GE 5910 Geology Seminar Seminar course dealing with geology subjects of current interest.

GE 5920 Geophysics Seminar Seminar course dealing with geophysics subjects of current interest.

GE 5930 Special Topics in Geo Engg Study and discussion of geological



engineering topics.

GE 5940 Special Topics in Geology Study and discussion of geology topics.

GE 5941 Special Topics in Mineralogy The study of special topics in mineralogy using the Seaman Mineral Museum.

GE 5950 Special Topics in Geophysics Study and discussion of geophysics topics.

GE 5999 Master's Graduate Research Research of an acceptable geological engineering, geology, or geophysics problem and preparation of a thesis.

GE 6999 Doctoral Graduate Research Original research of an acceptable geological engineering, geology, or geophysics problem and preparation of a PhD dissertation.

GEA 9004 Science, Tech and Society

GEA 9004U Science/Tech/Society Upper Div

HUA 9000 Language, Thought & Values

HUA 9000U Lang/Thought/Values Upper Div

HUA 9001 Aesthetics & Creativity

HUA 9001U Aesth/Creativity Upper Div

HUA 9002 Aesth/Creativity Activities

HUA 9002U Aesth/Creativity Act Upper Div

HUA 9003 Histories & Cultures

HUA 9003U Histories & Cultures Upper Div

HUA 9004 Science, Tech and Society

HUA 9004U Science/Tech/Society Upper Div

IEX 4001 International Exchange

IEX 4002 International Exchange

IEX 4003 International Exchange

IEX 5001 International Exchange

IEX 5002 International Exchange

IEX 5003 International Exchange

LBA 9000 Language, Thought & Values

LBA 9000U Lang/Thought/Values Upper Div

LBA 9004 Science, Tech and Society

LBA 9004U Science/Tech/Society Upper Div

MA 4208 Optimization/Graph Algorithms An introduction to linear and integer programming and related graph problems. Topics include simplex algorithm, duality, branch-and-bound and branch-and-cut, shortest paths, spanning trees, matchings, network flow, graph coloring, and perfect graphs.

MA 4209 Combinatorics and Graph Theory An introductory course in combinatorics and graph theory. Topics include designs, enumeration, extremal set theory, finite geometry, graph coloring, inclusion-exclusion, network algorithms, permutations, and trees.

MA 4210 Applied Wavelet Analysis Topics include review of Fourier transform, continuous wavelet transform, multiresolution analysis, discrete wavelet transform, wavelet analysis of 1-D and 2-D signals, nonparametric estimation with wavelets, data compression by wavelet shrinkage, exploratory wavelet analysis, wavelet packet analysis, cosine packet analysis, variations on wavelet analysis, boundary conditions for wavelet analysis.

MA 4211 Inform Theory/Data Compression An introduction to information theory and data compression. Topics include information and entropy, channel and channel capacity, Kraft-McMillan inequality, maximum likelihood decoding, reliability, Shannon's theorem, lossless data compression, arithmetic coding, higher order modeling, adaptive methods, dictionary methods, transform methods, and image compression.

MA 4308 Theory of Numbers Mathematical induction, Euclid's algorithm, prime and composite integers, algebra of congruences, Chinese remainder theorem, the quadratic reciprocity law, number theoretic functions, first degree Diophantine equations, Pythagorean triples, Fermat and Mersenne numbers, factoring algorithms, tests for primality, various applications.

MA 4310 Abstract Algebra Topics on groups, rings, and fields such as : group actions, the Sylow theorems, integral domains, factorization theory, Euclidean domains, principal ideal domains, splitting fields, zeros of irreducible polynomials, field extensions, and Galois theory.

MA 4330 Linear Algebra A study of fundamental ideas in linear algebra and its applications. Includes review of basic operations, block computations; eigensystems of normal matrices; canonical forms and factorizations; singular value decompositions, pseudo inverses, least-square applications; matrix exponentials and linear systems of ODEs; quadratic forms, extremal properties, and bilinear forms.

MA 4410 Complex Variables A study of complex numbers, functions of a complex variable, analytic functions, elementary functions, integrals, Taylor and Laurent series, residues and poles, and conformal mapping.

MA 4426 Differential Geometry Geometrical properties of curves and surfaces, including the Frenet formulas, natural equations of curves, first and second fundamental forms, normal and Gaussian curvature, lines of curvature, geodesics, covariant derivatives, and parallel displacement. Tensors or

differential forms with possible applications to Riemannian geometry, general relativity or other physical applications.

MA 4450 Real Analysis Real analysis on Euclidean  $n$ -space. Topics include real and vector valued functions, metric and normed linear spaces; an introduction to Lebesgue measure and convergence theorems.

MA 4490 Applied Wavelet Analysis Topics include review of Fourier transform, continuous wavelet transform, multiresolution analysis, discrete wavelet transform, wavelet analysis of 1-D and 2-D signals, nonparametric estimation with wavelets, data compression by wavelet shrinkage, exploratory wavelet analysis, wavelet packet analysis, cosine packet analysis, variations on wavelet analysis and boundary conditions for wavelet analysis.

MA 4515 Intro Partial Diff Equations An introduction to solution techniques for linear partial differential equations. Topics include: separation of variables, eigenvalue and boundary value problems, spectral methods, and Green's functions. Studies applications in heat and mass transfer (diffusion eqn.), and mechanical vibrations (wave and beam eqns.). An introduction to solution techniques for linear partial differential equations. Topics include: separation of variables, eigenvalue and boundary value problems, spectral methods, fourier series, and Green's functions. Studies applications in heat and mass transfer (diffusion eqn.), and mechanical vibrations (wave and beam eqns.).

MA 4520 Integral Trans & Series Meth Laplace, Fourier, and other integral transforms and methods; special functions; series methods to solve ordinary differential equations.

MA 4525 Applied Vector & Tensor Math Introduction to vector and tensor mathematics with applications. Topics include vectors; vector differential calculus, space curves; dyadic products and matrices; gradients, divergence, curl, Laplacians; Stokes' integral theorem, Gauss theorem, conservation laws; curvilinear coordinates; tensors, material derivatives; applications of potential theory in electricity and magnetism, heat transfer, solid and fluid mechanics.

MA 4535 Dynamic Sys: Control & Chaos Ordinary differential equations and dynamical systems via a modern geometric approach, including physical and engineering applications. May include chaotic phenomena and fractals or elements of control theory.

MA 4540 Waves and Solitons A study of linear and nonlinear waves with a brief introduction to completely integrable systems. Topics include unidirectional wave equation, Burger's equation, elementary numerical techniques, wave breaking and shock formation, dispersive waves, water waves and KdV equation, nonlinear optics, and scattering theory.

MA 4545 Aerodynamics A mathematical study of the fundamental principles of aerodynamics. Topics include elements of complex variable techniques, two-dimensional potential flow theory, vorticity and circulation, lift and drag forces, pitching moment, and analysis of two-dimensional airfoils.

MA 4550 Math Models in Biomathematics Mathematical models from biology,

biophysics, biomedical engineering, medicine, and ecology. Models may include human physiology (heart, lung, brain, bones), population models (microorganisms, cells, animals), and diagnosis and treatment of disease (heart, cancer).

MA 4555 Derivative Securities Models Mathematical models to price-derivative securities, stochastic calculus. Computational methods for computing option prices. May include study of mathematical models of risk analysis, portfolio selection theory, futures, options, and other derivative investment instruments.

MA 4610 Numerical Linear Algebra Derivation and analysis of algorithms for problems in linear algebra. Covers floating point arithmetic, condition numbers, error analysis; solution of linear systems (direct and iterative methods), eigenvalue problems, least squares, singular value decomposition. Includes a review of elementary linear algebra and the use of MATLAB or software from NETLIB.

MA 4620 Finite Difference Meth & PDEs Derivation, analysis, and implementation of finite difference methods; applications to fluid mechanics, elasticity, heat conduction, acoustics, or electromagnetism. Difference equations, Taylor series, stability, convergence; Runge-Kutta, multistep methods, etc., stiff systems. Finite difference methods for partial differential equations; alternate methods for discretizing space, such as spectral, finite element, or particle methods.

MA 4625 Finite Element Methods Theory and practical applications of finite element methods in fluid mechanics, elasticity, heat transfer, and electricity and magnetism. Topics include variational principles, elementary function space concepts, finite element methodology, convergence, errors, and element selection.

MA 4630 Comp Industrial Math I Methods for solving industrial and financial problems involving linear and nonlinear systems, eigen-analysis, discrete and numerical calculus, splines, mathematical models, well-posed problems and well-conditioned algorithms, stability and forward- and backward-error analyses, digital computer arithmetic, roundoff error, program design and development and debugging applications, simulations, efficacy, fidelity tests.

MA 4631 Comp Industrial Math II Methods for solving industrial and financial problems involving function approximation, data representation, curve fitting, constrained and unconstrained optimization, linear and nonlinear programming, ordinary and partial difference and differential equations, stability, convergence, consistency, well-posed problems and well-conditioned algorithms, finite X methods - X = cell, difference, element, first-principles, interpolations, volume.

MA 4635 Numer Meth for Integral Equat Includes quadrature and quadrature methods for solving integral equations that occur in many scientific disciplines (imaging, aerodynamics, etc.).

MA 4710 Regression Analysis Covers simple, multiple, and polynomial regression; estimation, testing, and prediction; weighted least squares,

matrix approach, dummy variables, multicollinearity, model diagnostics and variable selection. A statistical computing package is an integral part of the course.

MA 4720 Design/Analysis of Experiments Covers construction and analysis of completely randomized, randomized block, incomplete block, Latin squares, factorial, fractional factorial, nested and split-plot designs. Also examines fixed, random and mixed effects models and multiple comparisons and contrasts. The SAS statistical package is an integral part of the course.

MA 4730 Nonparametric Statistics Survey of distribution free statistical inference procedures. Topics include a review of probability and distribution theory, one sample, paired samples, multi-sample location tests, tests of independence and related measures of association, goodness-of-fit tests and tests based on the cumulative distribution function.

MA 4740 Sampling Methods Topics include survey construction, sources of error in surveys, estimation of population parameters from simple random, stratified, systematic, and multi-stage samples, effects of and remedies for non-response, hypothesis testing survey data, and other topics as time permits. Students cannot receive credit for both MA4740 and MA5740.

MA 4760 Mathematical Statistics I Covers probability set functions and distributions, multivariate distributions, special distributions, distributions of functions of random variables, and limiting distributions.

MA 4770 Mathematical Statistics II Point estimation, confidence intervals, sufficient statistics, Bayesian estimation, the Rao-Cramer inequality, hypothesis testing, including optimal tests, nonparametric methods.

MA 4810 Life Contingencies Measurement of mortality, life tables, commutation functions. Covers all basic forms of life insurance and life annuities, including gross and net premiums, reserves, cash values, and expense loadings. Advanced topics may include stationary populations, joint and multiple life functions, multiple decrement tables and dividends.

MA 4820 Loss Distrib/Credibility Theor Credibility theory addresses methods for updating statistical estimates as new data becomes available. Loss distribution studies probability distributions that are used for modeling the outcomes of insurance claims.

MA 4830 Risk Theory/Survival Models Individual and collective risk models as they apply to the economics of insurance. Nature and properties of parametric and tabular survival models, estimated from complete or incomplete data. Includes actuarial, moment and maximum likelihood estimation techniques, and applications and extension of models.

MA 4900 Mathematical Sciences Project Independent study in an area of mathematical sciences under the guidance of a faculty member.

MA 4908 Theory of Numbers with Tech Mathematical induction, Euclid's algorithm, prime and composite integers, algebra of congruences, Chinese remainder theorem, quadratic reciprocity law, number theoretic functions, first degree Diophantine equations, Pythagorean triples, Fermat and Mersenne

numbers, factoring algorithms, tests for primality and various applications. Projects use Mathematica and EXCEL software packages.

MA 4945 History of Mathematics Survey of the development of mathematics from ancient times to today. How cultural, mathematical, and technological developments have influenced one another throughout history. Course provides all necessary historical background. Survey of the development of mathematics from ancient times to today. How cultural, mathematical, and technological developments have influenced one another throughout history. Course provides all necessary historical background. Completion of MA3150 or MA3160 is recommended.

MA 4990 Topics in Mathematics Students study in greater depth a particular area of mathematics not studied in existing courses.

MA 5201 Combinatorial Algorithms Basic algorithmic and computational methods used in the solution of fundamental combinatorial problems. Topics may include but are not limited to backtracking, hill-climbing, combinatorial optimization, linear and integer programming, and network analysis.

MA 5211 Combinatorial Optimization I Optimization problems (traveling salesman, minimal spanning tree, linear programming, scheduling, etc.), simplex algorithm, primal-dual algorithms, complexity, matching, weighted matching, spanning trees, matroid theory, integer linear programming, approximation algorithms, branch-and-bound, local search, polyhedral theory.

MA 5212 Combinatorial Optimization II Continuation of MA5211.

MA 5221 Combinatorics I Counting principles, occupancy problems, recurrence relations, generating functions, applications. Review of basic graph theory followed by one or more advanced topics which may include topological graph theory, algebraic graph theory, graph decomposition or graph coloring.

MA 5222 Combinatorics II Optimization, systems of distinct representatives, Polya's counting theorem, applications. Possible special topics include combinatorial designs, graph theory, and combinatorics on words. Methods for the construction of different combinatorial structures such as difference sets, symmetric designs, projective geometries, orthogonal latin squares, transversal designs, steiner systems and tournaments.

MA 5231 Error-Correcting Codes Basic concepts, motivation from information transmission, finite fields, bounds, optimal codes, projective spaces, duality and orthogonal arrays, important families of codes, MacWilliams' identities, applications.

MA 5232 Cryptography Classical cryptography, public key systems, signature schemes, key exchange, authentication codes, secret sharing schemes, protocols.

MA 5301 Modern Algebra I Groups, rings, and fields: Galois theory, ideal theory, introduction to algebraic geometry: representations of groups and algebras: multilinear algebra. Basic theory of finite groups (subgroups, normality, homomorphisms, abelian groups, cyclic groups, commutators, order, cosets, index, conjugacy, simple groups, Sylow Theorems), basic theory of

finite fields (prime fields, irreducible polynomials, Galois groups, trace), families of groups defined over finite fields (linear groups).

MA 5302 Modern Algebra II A continuation of MA5302. Topics include rings and fields, ideal theory, polynomials, Galois theory, modules, and linear operators. A continuation of MA5301. Topics include rings and fields, ideal theory, polynomials, Galois theory, modules, and linear operators.

MA 5330 Topics in Linear Algebra A graduate-level study of fundamental ideas in linear algebra and its applications. Reviews basic operations, block computations, vector spaces and decompositions, operators, eigenvalue problems, canonical forms, generalized inverses and singular value decompositions, functions of matrices, and applications.

MA 5401 Real Analysis I A graduate-level study of the Lebesgue integral including its comparison with the Riemann integral; the Lebesgue measure, measurable functions and measurable sets. Integrable functions, the monotone convergence theorem, the dominated convergence theorem, and Fatou's lemma.

MA 5402 Real Analysis II Continuation of MA5401, including a study of  $L_p$  spaces, convergence in measure, almost uniform convergence, Egorov's and Vitali's convergence theorems. Decomposition of measures, the Radon-Nikodyn theorem and the Riesz representation theorem.

MA 5405 Complex Variables The Cauchy-Goursat theorem; the argument principle and winding numbers; the Riemann mapping theorem; conformal mappings and application in hydrodynamics; Poisson's formula and the Dirichlet problem for harmonic functions; analytic continuation; infinite products; the gamma and zeta functions, and the distribution of primes.

MA 5504 Mathematical Modelling I Construction, analysis, and testing of mathematical models (continuum, discrete, deterministic, or stochastic). Possible models include acoustical, biological, chemical, dynamical, ecological, economics, electromagnetics, financial, geological, mechanical, medical, metallurgical, optical, process, robotics, systems, thermal, material (solid, liquid, gas, plasma, multiphase) dynamics.

MA 5505 Mathematical Modelling II Continuation of MA5504. Construction of mathematical models involving approximating real world objects with ideal mathematical objects. Analysis of mathematical models, including the investigation of whether or not they lead to well-posed mathematical problems. Testing of mathematical models, including comparisons against reality.

MA 5510 Ordinary Diff Equations I First order equations, general theory of linear equations, constant coefficient equations, matrix methods, singular points, infinite series methods, plane autonomous systems.

MA 5511 Ordinary Diff Equations II Asymptotic solutions, solutions in terms of integrals, boundary and eigenvalue problems, Green's functions, nonlinear equations.

MA 5524 Functional Analysis Metric spaces, Banach spaces, Hilbert spaces, fundamental convergence and mapping theorems, spectral theory, weak

topologies and weak compactness, unbounded operators and their adjoints, fixed point theorems.

MA 5531 Asymptotic & Perturbation Meth Addresses asymptotic expansions for integrals, method of steepest descent, stationary phase, etc.; asymptotic expansions for differential equations, regular perturbation methods, Linstedt-Poincare expansions, multiple scales, and averaging, singular perturbation methods, matched asymptotic expansions, composite expansions, etc.; specific applications in mechanical vibrations, boundary layer heat transfer, and fluid flows.

MA 5532 Bifurcation & Stability Theory Study of the branching of solutions to nonlinear problems and their stability. Employs asymptotic and functional and analytic techniques to study stationary (steady) and Hopf (time-periodic) bifurcations. Analyzes specific applications in elastic buckling, Benard convection, hydrodynamic stability, and chemical reaction-diffusion systems.

MA 5545 Applied Integral Equations Linear integral equations of the first and second kind, Fredholm theory with applications, Hilbert-Schmidt theory with applications, computational methods for approximate solutions of integral equations.

MA 5548 Math Continuum Mechanics Lagrangian and Eulerian coordinate systems, stress and strain in elastic, viscoelastic, and plastic materials. Constitutive equations, viscosity, balance laws of fluid and solid mechanics, elasticity, Euler equations, and Navier-Stokes equations.

MA 5560 Symbolic Comp for Res in Math An introduction to the effective use of symbolic computation in mathematical research using a computer algebra system for simulation, discovering patterns, forming conjectures, scientific visualization, and algebraic manipulation.

MA 5565 Partial Diff Equations I Theory and practice of partial differential equations. Covers classification, appropriate boundary conditions and initial conditions, PDEs of mathematical physics, characteristics, Green's functions, and variational principles. Theory of partial differential equations. Covers classification, appropriate boundary conditions and initial conditions, PDEs of mathematical physics, characteristics, Green's functions, and variational principles.

MA 5566 Partial Diff Equations II Continuation of MA5565.

MA 5626 Numerical Approximation Theory Analysis and design of algorithms (for the numerical solution of industrial and financial problems) using the following bodies of theory: difference calculus and interpolation, summation calculus and quadrature, function approximation and data representation, linear and nonlinear optimization, and mathematical programming.

MA 5627 Numerical Linear Algebra Analysis and design of algorithms for the numerical solutions of linear systems of equations using direct and iterative methods; eigenvalue problems.

MA 5628 Numerical ODEs Analysis and design of algorithms for the numerical solutions of ordinary differential equations.



MA 5629 Numerical PDEs Analysis and design of algorithms for the numerical solution of partial differential equations.

MA 5630 Numerical Optimization Numerical solution of unconstrained and constrained optimization problems and nonlinear equations. Topics include optimality conditions, local convergence of Newton and Quasi-Newton methods, line search and trust region globalization techniques, quadratic penalty and augmented Lagrangian methods for equality-constrained problems, logarithmic barrier method for inequality-constrained problems, and Sequential Quadratic Programming.

MA 5640 Computational Fluid Dynamics Topics include equations of continuum mechanics, principles and applications of numerical methods to discretize equations, stability and error analysis, linear and nonlinear solvers, boundary conditions, incompressible and compressible flows, transient and stationary flows, pre- and post-processing, and applications.

MA 5701 Statistical Methods Introduction to design, conduct, and analysis of statistical studies, with an introduction to statistical computing and preparation of statistical reports. Topics include design, descriptive, and graphical methods, probability models, parameter estimation and hypothesis testing.

MA 5711 Mathematical Statistics I Review of distribution theory and transformation theory of random variables. Topics include sufficiency; exponential and Bayesian models; estimation methods, including optimality theory; basics of confidence procedures and hypothesis testing, including the Neyman-Pearson framework.

MA 5712 Mathematical Statistics II Optimal tests and decision theory. Other topics may include regression and analysis of variance, discrete data analysis, nonparametric models.

MA 5721 Stochastic Processes Markov chains and their stationary distributions; Markov processes; second-order processes, including Gaussian processes and Brownian motion; differentiation and integration of second-order processes, white noise, and stochastic differential equations.

MA 5731 Linear Models A unified development of linear statistical models that includes the following topics: matrices and quadratic forms, normal and chi-square distribution theory, ordinary and generalized least squares modeling, estimability, estimation and tests of hypothesis.

MA 5740 Advanced Sampling Methods Runs concurrently with MA 4740 and covers the same topics as MA 4740, but students meet an additional one hour per week to prove results and discuss advanced topics. Students cannot receive credit for both MA 4740 and MA 5740.

MA 5741 Multivariate Stat Methods Survey of methods used to analyze multivariate data. Topics include graphical and descriptive analyses, inference for the multivariate normal model, multivariate linear models, classification, dimension reduction, cluster analysis, additional topics as time permits.

MA 5750 Statistical Genetics Application of statistical methods to solve problems in genetics such as locating genes. Topics include basic concepts of genetics, linkage analysis and association studies of family data, association tests based on population samples (for both qualitative and quantitative traits), gene mapping methods based on family data and population samples.

MA 5781 Time Series Analysis Analysis of data collected over time. Topics include graphical and descriptive methods, spectral analysis; identification, fitting, and implementation of Box-Jenkins ARIMA models; intervention and transfer function models; additional topics as time permits.

MA 5791 Categorical Data Analysis Structure of 2-way contingency tables. Goodness-of-fit tests and Fisher's exact test for categorical data. Fitting models, including logistic regression, logit models, probit and extreme value models for binary response variables. Building and applying log linear models for contingency tables.

MA 5980 Special Topics in Mathematics Special topics in mathematics.

MA 5999 Graduate Research in Math Original investigation in theoretical, or applied mathematics, and submission of a thesis in partial fulfillment of the requirements for the master's degree in mathematics.

MA 6200 Adv Topics in Discrete Math Reflects the current research interests of the discrete mathematics faculty. Topics may include but are not limited to finite fields, permutation groups, projective geometries, design theory, graph theory, coding theory, probabilistic methods, extremal set theory, and combinatorial matrix theory.

MA 6201 Finite Geometries Introduction to finite geometries and its links to groups and codes. Topics include projective and affine geometries over finite fields, geometric description of error-correcting codes, bilinear forms and their groups (the classical groups, geometric algebra), group geometries (Dynkin diagrams, projective planes, generalized quadrangles), coordinatization of projective planes.

MA 6301 Perm Groups and Enumeration Introduction to finite groups, permutations and their applications. Covers a review of finite group theory (Lagrange's theorem, simple groups, p-groups, Sylow theorems), permutation groups (Burnside's lemma, orbit formula, primitivity, t-fold transitivity, linear groups, the Mathieu groups). Applications include Polya theory (counting group orbits) and its use in chemistry, construction of combinatorial designs.

MA 6302 Algebraic Curves and Codes Introduction to the theory of algebraic curves, equivalent algebraic function fields (main theorems Riemann-Roch theorem and Hasse-Weil theorem) and the construction of error-correcting codes from algebraic curves with finite fields of constants.

MA 6700 Advanced Topics in Statistics Topics may include but are not limited to experimental designs, methods of quality improvement, discrete data analysis, regression analysis, sampling theory, multivariate methods, resampling methods, statistical computing, integral and measure theory,

stochastic processes, asymptotic methods, optimization, modelling, nonparametric and parametric statistics. Topics may include but are not limited to experimental designs, methods of quality improvement, discrete data analysis, regression analysis, sampling theory, multivariate methods, resampling methods, statistical computing, integral and measure theory, stochastic processes, asymptotic methods, optimization, modeling, nonparametric and parametric statistics.

MA 6701 Probability Review of discrete probability, probability measures, random variables, distribution functions, expectation as a Lebesgue-Stieltjes integral, independence, modes of convergence, laws of large numbers and iterated logarithms, characteristic functions, central limit theorems, conditional expectation, martingales, introduction to stochastic processes.

MA 6980 Special Topics in Mathematics Special topics in mathematics.

MA 6999 Math Sci Doctoral Research Taken in partial fulfillment of the doctoral thesis requirement.

MEEM 4150 Intern Mechanics of Materials Basic concepts of three-dimensional stress and strain. Inelastic behavior of axial members, circular shafts and symmetric beams. Deflections of indeterminate beams. Unsymmetrical bending, shear flow and shear center for open sections. Energy methods for structures made up of one-dimensional elements. Introduction to theories of failures for anisotropic materials.

MEEM 4160 Fund of Exp Stress Analysis Transmits basic understanding of purposes and uses of experimental stress analysis and makes students familiar with methods used in the field to give experience in either design or analysis of strain-gauged transducer.

MEEM 4170 Failure of Mat'l in Mechanics Identifies the modes of mechanical failure that are essential to prediction and prevention of mechanical failure. Discusses more important failure modes in detail. Treats the topic of fatigue failure extensively with attention to both high-cycle and low-cycle range of fatigue.

MEEM 4180 Biomechanics Mechanics applied to the human body in health and disease or injury, which includes mechanics of human biological materials and musculo-skeletal system. Also studies mechanics of posture (occupational biomechanics) and locomotion (sports biomechanics) using mathematical models of the human body. Engineering mechanics applied to the human body in health and disease or injury, which includes mechanics of human biological materials and engineering design in musculo-skeletal system. Also studies on mechanics of posture (occupational biomechanics) and locomotion (sports biomechanics) using mathematical models of the human body.

MEEM 4200 Principles of Energy Convers Introduces basic background, terminology, and fundamentals of energy conversion. Discusses current and emerging technologies for production of thermal, mechanical, and electrical energy. Main topics include fossil and nuclear fuels, solar energy, gas and steam turbine power plants, hydraulic and wind turbines, fuel and solar cells.

MEEM 4210 Comp Methods in Thermal Sci Introduces computational methods used to solve thermodynamic, fluid mechanic, and heat transfer problems. Discusses theoretical and practical aspects. Modern computational tools are used to reinforce principles and introduce advanced topics in thermodynamics, fluid mechanics, and heat transfer.

MEEM 4220 Internal Combustion Engines I Teaches the operation and design of various types of internal combustion engines through the application of applied thermodynamics, cycle analysis, combustion, mixtures of gases, fluid dynamics, and heat transfer.

MEEM 4240 Combustion & Air Pollution Introduces physico-chemical processes of combustion, including the phenomena of ignition, extinction, flame propagation, detonation, solid propellant combustion, fuel spray combustion, and pollutant formation. Also addresses analysis and design of an air pollution control system with a special focus on automotive emissions. Introduces physico-chemical processes of combustion, including the phenomena of ignition, extinction, flame propagation, detonation, solid propellant combustion, fuel spray combustion, and pollutant formation. Also addresses analysis and design of an air pollution control system with a special focus on automotive emissions.

MEEM 4250 Heating/Ventilation/Air Cond Elements of heat transfer for buildings. Thermodynamic properties of moist air, human comfort and the environment, solar energy fundamentals and applications, water vapor transmission in building structures, heating and cooling load calculations.

MEEM 4403 Computer-Aided Design Methods Students apply fundamental and intermediate geometric modeling techniques to construct solid models of mechanical components, assemble them into a system, and document the system's design. Students use shared data to function in a concurrent design environment and identify major functional features of commercially available geometric modeling software.

MEEM 4403D Computer-Aided Design Methods Students apply fundamental and intermediate geometric modeling techniques to construct solid models of mechanical components, assemble them into a system, and document the system's design. Students use shared data to function in a concurrent design environment and identify major functional features of commercially available geometric modeling software.

MEEM 4404 Mechanism Syn/Dynamic Modeling Students apply kinematic synthesis techniques in design and analysis of mechanical systems. They develop synthesis software to link to dynamic analysis packages such as ADAMS, I-DEAS, Unigraphics, etc. They investigate influences of process variation on system output and learn methods to minimize the variation influences.

MEEM 4404D Mechanism Syn/Dynamic Modeling Students apply kinematic synthesis techniques in design and analysis of mechanical systems. They develop synthesis software to link to dynamic analysis packages such as ADAMS, I-DEAS, Unigraphics, etc. They investigate influences of process variation on system output and learn methods to minimize the variation influences.

MEEM 4405 Intro to Finite Element Method Introduces the use of the finite

element method in stress analysis and heat transfer. Emphasizes the modeling assumptions associated with different elements and uses the computer to solve many different types of stress analysis problems, including thermal stress analysis and introductory nonlinear analysis.

MEEM 4610 Advanced Machining Processes Covers mechanics of machining processes, oblique cutting processes, heat transfer in machining, machining of brittle materials, dynamics of multipoint cutting, nontraditional machining processes. Credit may not be received for both MEEM4610 and MEEM5610. Covers mechanics of 2-D and 3-D cutting and their extension to commonly used conventional processes such as turning, boring, milling, and drilling. Topics include force modeling, surface generation, heat transfer, tool life and dynamics.

MEEM 4610D Advanced Machining Processes Covers mechanics of 2-D and 3-D cutting and their extension to commonly used conventional processes such as turning, boring, milling, and drilling. Topics include force modeling, surface generation, heat transfer, tool life and dynamics. Credit may not be received for more than one of the following: MEEM 4610, 4610D and 5610.

MEEM 4615 Metal Forming Processes Covers analytical and experimental study of metal forming processes, such as forging, extrusion, rolling, bending, stretch forming, and deep drawing as well as progressive die design for sheet metal stamping and design of dies for bulk forming.

MEEM 4615D Metal Forming Processes Covers analytical and experimental study of metal forming processes, such as forging, extrusion, rolling, bending, stretch forming, and deep drawing as well as progressive die design for sheet metal stamping and design of dies for bulk forming.

MEEM 4620 Metal Forming & Cutting Mach Analysis and design of metal cutting and forming machines and subsystems to estimate part throughput, power requirements, thermal load, environmental influence, and precision. Includes the characteristics and performance of actuation devices, feedback devices, and machine kinematics.

MEEM 4625 Precision Manuf and Metrology Course presents theory and practice involved in manufacturing and measuring of precision components. Topics include precision machining processes, precision machine/mechanism design, and dimensional metrology. Also discusses current manufacturing challenges in the bearings, optics, and microelectronics industries.

MEEM 4635 Design with Plastics Covers various complexities in design of plastic parts and design of molds for manufacturing of plastic parts.

MEEM 4640 Micromanufacturing Processes Introduces the processes and equipment for fabricating microsystems and the methods for measuring component size and system performance. Fabrication processes include microscale milling, drilling, diamond machining, and lithography. Measurement methods include interferometry and scanning electron microscopy.

MEEM 4650 Quality Engineering Introduction to the concepts and methods of quality and productivity improvement. Topics include principles of Shewhart, Deming, Taguchi; meaning of quality; control charts for variables,

individuals, and attributes; process capability analysis; variation of assemblies; and computer-based workshops. Credit may not be received for both MEEM4650 and MEEM5650.

MEEM 4653D Life-cycle Engineering Familiarizes students with the principles and techniques of life-cycle engineering. These techniques include design reviews, re-engineering, cost/benefit analysis, value engineering, and life-cycle design. Upon completion of this course, students should be adept at weighing the costs and benefits of product design decisions as they apply to the entire life of a product from concept to retirement. Credit may not be received for both MEEM 4653D and MEEM 5653.

MEEM 4655 Production Planning Provides current issues, such as just-in-time production and reengineering, while covering fundamental production planning topics as scheduling, job design, inventory and forecasting. Provides the fundamental essence of the firm--how its products are made and how they are delivered to customers.

MEEM 4660 Data Based Modeling & Control System modeling from observed data for computer-aided design and manufacturing, providing differential equation models. Analysis of manufacturing and dynamic systems, computer routines for modeling, forecasting with accuracy assessment, and minimum mean-squared error control. Underlying system analysis, including stability and feedback interpretation, periodic and exponential trends. Illustrative applications to real-life data.

MEEM 4665 Manufact'ng System Simulation Provides concepts and techniques for the design of manufacturing systems with computer simulation programming. Emphasizes a teamwork approach to achieve the goal. Provides basic simulation programming techniques to design various production systems.

MEEM 4675 Material Handling-Plant Layout Basic background in material handling and plant layout for manufacturing, assembly, or warehousing. Emphasis is between the formulation and application experience in system design, plant layout, methods for solving design problems, and practical design issues. Insight is gained into the application of engineering design principles, performance calculations/analysis, and management concepts.

MEEM 4685 Env Resp Design & Manuf Examines the impact of engineering and design/manufacturing, decision on the environment. Topics include sustainability; energy and material flows; risk assessment; life cycles, manufacturing process waste streams, and product design issues, including disassembly and post-use product handling and techniques for pollution. A course project may be completed for one extra credit. Examines the impact of engineering and design/manufacturing, decision on the environment. Topics include sustainability; energy and material flows; risk assessment; life cycles, manufacturing process waste streams, and product design issues, including disassembly and post-use product handling and techniques for pollution. A course project may be completed for one extra credit.

MEEM 4700 Dynamic Systems and Controls Analysis of dynamic systems, use of Laplace transforms to solve differential equations, design of control systems using classic and modern approaches, comparison of control methodologies, application and comparison of time-and-frequency domain specifications to

design, basic system identification, digital implementation issues. Emphasizes practical design and application issues.

MEEM 4700D Dynamic Systems and Controls Analysis of dynamic systems, use of Laplace transforms to solve differential equations, design of control systems using classic and modern approaches, comparison of control methodologies, application and comparison of time-and- frequency domain specifications to design, basic system identification, digital implementation issues. Emphasizes practical design and application issues.

MEEM 4701 Analy and Exp Modal Analysis Combined experimental and analytical approach to mechanical vibration issues; characterization of the dynamic behavior of a structure in terms of its modal parameters; digital data acquisition and signal processing; experimental modal analysis procedures; parameter estimation for obtaining modal parameters; model validation and correlation with analytical models; structural dynamics modification.

MEEM 4703 Intermediate Control Systems Develops classical and modern control system analysis and design techniques to apply to variety of dynamic systems. Topics include Bode, Nyquist, Nichols chart, controllability, observability, state feedback, observers, z-transform, and controller discretization. Places special emphasis on the control system process from system modeling, controller simulation and experimental implementation.

MEEM 4704 Acoustics and Noise Control Analysis and solution of practical environmental noise problems. Fundamental concepts of sound generation and propagation, the unwanted effects of noise, assessment of sound quality, and source-path-receiver concepts in noise control. Lecture, measurement laboratory, and team project directed at solving a real noise problem under a client's sponsorship.

MEEM 4705 Automation and Robotics Describes automation equipment and processes, including programmable logic controller and introduction to robotics. Covers techniques for developing embedded microprocessor based systems in addition to machine vision fundamentals and applications. Introduces cost vs functionality analysis methods. Cross-discipline system integration of sensors, actuators, and microprocessors to achieve high-level design requirements, including robotic systems. A variety of sensor and actuation types are introduced, from both a practical and a mathematical perspective. Embedded microprocessor applications are developed using the C programming language.

MEEM 4900 Senior Design I Introduces computer-aided design (CAD) methods, including the finite element method and computational fluid dynamics, as tools for engineering design. Senior projects are selected/assigned with initial concepts evaluated using CAD methods. Covers project management methods and emphasizes communications, oral and written. Introduces computer-aided design (CAD) methods, including the finite element method and computational fluid dynamics, as tools for engineering design. Senior projects are selected/assigned with initial concepts evaluated using CAD methods. Covers project management methods and emphasizes communications, oral and written. (Senior project ready as defined by major substitutes for prerequisites)

MEEM 4900D Senior Design I Introduces computer-aided design (CAD) and finite element methods as tools for engineering design. Senior projects are selected/assigned with initial concepts evaluated using CAD methods. Covers project management methods and emphasized communications, oral and written

MEEM 4910 Senior Design II Design projects started in MEEM4900 are completed and evaluated using computer-aided engineering methods, physical models, and/or prototypes as appropriate. Introduces evaluation and design optimization methods, enabling students to develop efficient and cost-effective designs. Design projects started in MEEM4900 are completed and evaluated using computer-aided engineering methods, physical models, and/or prototypes as appropriate. Introduces evaluation and design optimization methods, enabling students to develop efficient and cost-effective designs. (Senior project ready as defined by major substitutes for prerequisites)

MEEM 4990 Special Topics in Mech Engg Problems in mechanical engineering, engineering mechanics, manufacturing, or industrial engineering that are not covered in regular courses.

MEEM 4990T Senior Design Trailer Course

MEEM 4991D Solid Modeling Develops a working knowledge of parametric solid modeling techniques for building, modifying, and constraining virtual automotive components and assemblies, including the use of parametric constraints, feature creation and editing techniques, and development of freeform features.

MEEM 4992D Vehicle Packaging Explores the designer's role in vehicle packaging issues and practices, such as drive/passenger ergonomics, engine compartment serviceability, and clearance parameters; door, deck and hood requirements; suspension and exhaust system considerations; heating/cooling system provisions and limitations; and fuel system factors. Explores the designer's role in vehicle packaging issues and practices, such as drive/passenger ergonomics, engine compartment serviceability, and clearance parameters; door, deck and hood requirements; suspension and exhaust system considerations; heating/cooling system provisions and limitations; and fuel system factors.

MEEM 4993D Design for Manufacturability Provides the background and concepts needed to select and apply the various methodologies and techniques of Design for Manufacturability (DFM) to the design of automotive components and systems as a means of improving the manufacturing effectiveness, productivity, and reducing cost.

MEEM 5110 Fund of Mechanics/Elasticity Covers development of Cartesian tensors and indicial notation applied to vector analysis; analysis of stress, principal stresses, invariants, strain tensors, material derivatives, and continuity equations; basic conservation laws and constitutive relationships; the theory of elasticity, including 2-D problems in plane stress/strain, stress functions, and 3-D problems with polar symmetry.

MEEM 5120 Plasticity and Viscoplasticity Plastic stress-strain laws, yield criteria, flow rules, work hardening, flexure and torsion of bars, boundary-value problems, thick cylinders, spheres, discs, general 3-D,



residual stresses, limit analysis, plane strain, slip line theory.

MEEM 5150 Advanced Mechanics of Matls A critical study of the basic concepts of stress, strain, and constitutive laws of solids, the physical significance of principle stresses, stress deviator and octahedral stress. Covers failure theories; two-dimensional elasticity theory; torsion of prismatic bars, thick pressure vessels; special topics in beam theory; elements of elastic stability.

MEEM 5160 Experimental Stress Analysis Review of elastic stress-strain relationships. Covers theory and use of resistive strain gages, strain gage circuits, rosette analysis, static and dynamic strain measurement; discusses other current strain measuring techniques; introduces photoelasticity, Moire, and other optical techniques.

MEEM 5170 Finite Element Methods in Engg Variational concepts and Euler-Lagrange equations and the application of these concepts in formulating boundary value problems and approximate methods, including finite-element method. Development of finite element methodology for problems in engineering.

MEEM 5180 Mechanics of Composite Matls Introduces engineering properties and advantages of fibrous composites, the governing equations of mechanics of anisotropic, laminated materials. Develops micromechanics methods for predicting the elastic properties of the composite and classical lamination theory, including hygrothermal effects, and applies them to stress and failure analysis of composite structures. Introduces engineering properties and advantages of fibrous composites, the governing equations of mechanics of anisotropic, laminated materials. Develops micromechanics methods for predicting the elastic properties of the composite and classical lamination theory, including hygrothermal effects, and applies them to stress and failure analysis of composite structures.

MEEM 5200 Advanced Thermodynamics A study of the principles of thermodynamics, including fundamental concepts and introduction of the analytical treatments of the first, second and combined first and second laws of thermodynamics. Topics include irreversibility, availability, thermodynamic relations, mixtures, chemical reactions, and chemical equilibrium.

MEEM 5205D Comp Methods in Thermal Sci Introduces computational methods used to solve thermodynamic, fluid mechanic, and heat transfer problems. Discusses theoretical and practical aspects. Modern computational tools are used to reinforce principles and introduce advanced topics in thermodynamics, fluid mechanics, and heat transfer.

MEEM 5210 Advanced Fluid Mechanics Develops control volume forms of balance laws governing fluid motion and applies to problems involving rockets, pumps, sprinklers, etc. Derives and studies differential forms of governing equations for incompressible viscous flows. Covers qualitative aspects of lift and drag, loss of stability of laminar flows, turbulence, and vortex shedding. Develops control volume forms of balance laws governing fluid motion and applies to problems involving rockets, pumps, sprinklers, etc. Derives and studies differential forms of governing equations for

incompressible viscous flows. Some chemical analytical solutions are obtained and students are exposed to rationale behind computational solution in conjunction with CFD software demonstration. Covers qualitative aspects of lift and drag, loss of stability of laminar flows, turbulence, and vortex shedding. Develops control volume forms of balance laws governing fluid motion and applies to problems involving rockets, pumps, sprinklers, etc. Derives and studies differential forms of governing equations for incompressible viscous flows. Some analytical solutions are obtained and students are exposed to rationale behind computational solution in conjunction with CFD software demonstration. Also covers qualitative aspects of lift and drag, loss of stability of laminar flows, turbulence, and vortex shedding.

MEEM 5230 Advanced Heat Transfer Presents advanced topics on conduction, convection, radiation, and heat exchangers. Emphasizes the application of the principles of heat transfer to automobiles, manufacturing, etc.

MEEM 5240 Comp Fluid Dynamics for Engg Introduces finite-difference and finite-volume methods used in solving fluid dynamics and heat transfer problems. Covers numerical grid generation, turbulence modeling, and application to some selected problems.

MEEM 5250 Internal Combustion Engines II Advanced topics in internal combustion engines with emphasis on CI operation, modeling of engines, modeling of combustion processes, tribology, second law applications, and other topics of current interest.

MEEM 5260 Advanced Engine Laboratory Experimental studies of the effect of operating and design variables on the performance, efficiency, and exhaust emission of internal combustion engines.

MEEM 5270 Advanced Combustion The objective is to understand basic combustion processes through detailed analysis. Introduces both analytical and modern experimental methods. Emphasizes liquid fuel combustion, flame propagation, and critical phenomena of ignition and extinction.

MEEM 5280 Phase-Change & Two-Phase Flows Considers two-phase flow patterns for air-water, condensing, and boiling flows in context of interface conditions (surface tension, etc.) and interfacial instabilities leading to interfacial waves, droplet formation, etc. Emphasizes model equations, experimental data, pressure drop correlations, interfacial shear models, etc., along with their uses in problem solving. Considers two-phase flow patterns for air-water, condensing, and boiling flows in the context of interface conditions (surface tension, etc.) and interfacial instabilities that lead to interfacial waves, droplet formation, etc. The course emphasizes development of model equations. Relevant experimental data leading to pressure drop correlations, interfacial shear model, etc., are discussed. The model equations and empirical correlations are used to estimate solutions of problems.

MEEM 5401 Design for Reliability Emphasizes the importance of reliability in design, covering basic concepts of series, parallel, standby and mixed systems. Uses conditional probability and multimode functions as methods for problem solution. Considers derating and reliability testing.

MEEM 5404D Mechanism Syn/Dynamic Modeling Student apply kinematic synthesis techniques in design and analysis of mechanical systems. They develop synthesis software to link to dynamic analysis packages such as ADAMS, I-DEAS, Unigraphics, etc. They investigate influences of process variation on system output and learn methods to minimize the variation influences.

MEEM 5405D Intro to Finite Element Method Introduces the use of the finite element method in stress analysis and heat transfer. Emphasizes the modeling assumptions associated with different elements and uses the computer to solve many different types of stress analysis problems, including thermal stress analysis and introductory nonlinear analysis.

MEEM 5443 Kinematics Students apply kinematic synthesis techniques in the design and analysis of mechanical systems and special purpose cams. They develop synthesis software to link to commercial dynamic packages, optimizing simple mechanisms and mechanical systems.

MEEM 5602D Prod & Process Design & Improv Introduces value-engineering tools for product development and total quality management. Topics include systems engineering fundamentals, quality function deployment, experimental design, robust engineering, failure mode and effects analysis, and engineering problem-solving techniques.

MEEM 5605D Metal Forming Processes Covers analytical and experimental study of metal forming processes, such as forging, extrusion, rolling, bending, stretch forming, and deep drawing as well as progressive die design for sheet metal stamping and design of dies for bulk forming.

MEEM 5610 Advanced Machining Processes Covers mechanics of machining processes, oblique cutting processes, heat transfer in machining, machining of brittle materials, dynamics of multipoint cutting, nontraditional machining processes. Covers mechanics of 2-D and 3-D cutting and their extension to commonly used processes such as turning, boring, milling, and drilling. Topics include force modeling, surface generation, heat transfer, tool life and dynamics.

MEEM 5615 Advanced Metal Forming Introduces fundamentals of plasticity theory and applies to the analysis of deformation processes. Processes considered are forging, extrusion, wire drawing, bending, deep drawing, and stretch forming. Emphasizes sheet metal formability.

MEEM 5625 Precision Manuf and Metrology Presents theory and practice involved in the manufacturing and measuring of precision components. Topics include precision machining processes, precision machine/mechanism design, and dimensional metrology. Addresses current manufacturing challenges in the bearings, optics, and microelectronics industries.

MEEM 5645 Numerical Analy Manuf Proc Nonlinear FEM and BEM analyses, modeling of bulk forming processes, sheet forming processes, machining processes, casting processes, grinding of ceramics.

MEEM 5650 Advanced Quality Engineering Stresses the concepts and methods for quality and productivity improvement. Topics include principles of Shewhart, Deming, Taguchi; meaning of quality: control charts for variables,

individuals, and attributes; process capability analysis; variation of assemblies; Monte Carlo simulation, multi-variate situations; and computer-based workshops. No credit for both MEEM4650 and MEEM5650.

MEEM 5653 Life-cycle Engineering Familiarizes students with the principles and techniques of life-cycle engineering. These techniques include design reviews, re-engineering, cost/benefit analysis, value engineering and design for "X." Upon completion, students should be adept at weighing the costs and benefits of product design decisions as they apply to a product from concept to retirement. Credit may not be received for both MEEM 4653D and MEEM 5653.

MEEM 5660 Data Based Modeling & Control System modeling and analysis from observed data for computer-aided design and manufacturing, providing differential equation models. Computer routines for modeling, forecasting with accuracy assessment, and minimum mean-squared error control. Underlying system analysis, including stability and feedback interpretation, periodic and exponential trends. Uses illustrative applications to real-life data, including team projects.

MEEM 5670 Experimental Design in Engg Review of basic statistical concepts. Models for testing significance of one or many factors. Reducing experimental effort by incomplete blocks, Latin squares, and Youden squares. Factorial and fractional factorial designs. Response surface analysis for optimal response. Review of basic statistical concepts. Models for testing significance of one or many factors. Reducing experimental effort by incomplete blocks, and Latin squares. Factorial and fractional factorial designs. Response surface analysis for optimal response.

MEEM 5680 Optimization I Provides introductory concepts to optimization methods and theory. Covers the fundamentals of optimization, which is central to any problem involving engineering decision making. Provides the tools to select the best alternative for specific objectives.

MEEM 5685 Env Respon Design & Manuf Examines impact of engineering and, in particular, design/manufacturing decisions on the environment. Topics include sustainability; energy/material flows; risk assessment, life cycles, manufacturing process waste streams, product design issues, including disassembly/post-use product handling; techniques for pollution prevention. Requires course project. Credit may not be received for both MEEM4685 and MEEM5685.

MEEM 5700 Dynamic Meas/Signal Analysis Assessment of measurement system requirements: transducers, conditioners, and displays of dynamic measurands. Time-, frequency-, probabilistic-, and correlative-domain approaches to dynamic signal analysis: sampled data, discrete Fourier transforms, digital filtering, estimation errors, system identification, calibration, recording. Introduction to wavelet analysis. All concepts reinforced in laboratory and simulation exercises.

MEEM 5701 Intermediate Dynamics Intermediate study of several topics in engineering dynamics, including three-dimensional kinematics and kinetics, generalized coordinates, Lagrange's equation, and Hamilton's principle. Uses computer-aided dynamic simulation tools for analyzing dynamic systems.

MEEM 5702 Analytical Vibroacoustics First in a series of two courses on vibro-acoustics to provide a unified approach to study noise and vibration. Emphasizes interaction between sound waves and structures. Presents advanced vibration concepts with computational tools. Discusses wave-modal duality.

MEEM 5703 Exp Methods Vibro-Acoustics Covers operating data measurement and analysis, including multisource ODS. Includes signature analysis and order tracking; modal theory, modal scaling. FRF estimators; multiple input excitation techniques; parameter estimation methods; sound measurements and acoustic intensity; sound quality; field data acquisition, DAT; binaural recording and playback with equalization.

MEEM 5710D NVH and Sound Quality Noise Vibration and Harshness (NVH) is an important design consideration in the automotive, appliance, and machine tool industry. This course presents the fundamental concepts of noise and vibration measurement, modeling, and control. Lectures are supported with hands-on testing and analysis. Noise Vibration and Harshness (NVH) is an important design consideration in the automotive, appliance, and machine tool industry. This course presents the fundamental concepts of noise and vibration measurement, modeling, and control. Lectures are supported with hands-on testing and analysis.

MEEM 5990 Special Topics Study of selected subjects related to mechanical engineering or engineering mechanics.

MEEM 5999 Graduate Research Research/investigation on a topic related to mechanical engineering or engineering mechanics leading to the submission of a thesis or report in partial fulfillment of the requirements for the master's degree.

MEEM 6000 Graduate Seminar Presentations/seminars on issues related to mechanical engineering and engineering mechanics. May include invited speakers from industry, government labs, and academe.

MEEM 6120 Hi Strain Rate Behav of Matl Covers stress-strain response of high strain rates, constitutive models, microstructural changes, wave propagation. Uses experimental methods to obtain dynamic response, dynamic fracture, adiabatic shear banding. Covers stress-strain response of high strain rates, constitutive models, microstructural changes, wave propagation. Uses experimental methods to obtain dynamic response, dynamic fracture, adiabatic shear banding.

MEEM 6130 Engineering Fracture Mechanics Development of the stress and deformation fields present near the tips of cracks. Uses elasticity solutions, plasticity corrections, and numerical methods in modeling these fields. Introduces fracture criteria and explains the various parameters used to develop these criteria.

MEEM 6140 Theory of Plates and Shells A study of classical theory of plates and shells with applications. Includes solutions of plates and shells of various shapes; limitations and validity of classical theory; and variational methods.

MEEM 6230 Conduction Fundamental aspects of conductive heat transfer applied

to steady-state and transient conditions. Studies multidimensional conduction problems with exact and approximate solutions techniques. Fundamental aspects of conductive heat transfer applied to steady-state and transient conditions. Studies multidimensional conduction problems with exact and approximate solutions techniques.

MEEM 6240 Convective Heat Transfer An introduction to flow and boundary layer theory for forced and natural convection heat and mass transfer. Includes derivation and application of the equations for conservation of mass, energy, and momentum; dimensional analysis and correlation of experimental results.

MEEM 6250 Radiative Heat Transfer Fundamentals of thermal radiation for black, gray, nongray, diffuse, and specular surfaces. Includes radiation combined with conduction and convection at boundaries; properties for radiation in absorbing, emitting, and scattering media; and the engineering treatment of gas radiation in enclosures.

MEEM 6401 Engg Design Optimization Covers mathematical optimization methods useful for engineering design optimization. Includes classical methods as well as new techniques. Emphasizes practical applications and the selection of optimization methods for the solution of specific problems in design.

MEEM 6670 Data Dependent Systems Modeling of systems from multiple series of observed data. Includes interpretation and characteristics of vector difference-equation models; impulse response functions and modal analysis; spectrum analysis of the contribution of various system components to the measured responses; application to process control and design.

MEEM 6680 Optimization II Provides advanced concepts to optimization theory and methods with an emphasis on engineering problems. Covers design and manufacturing optimization problems in all engineering disciplines. Provides various optimization methods, including unconstrained/constrained optimization, multiobjective optimization, and stochastic optimization.

MEEM 6701 Advanced Acoustics Advanced concepts in acoustics with emphasis on modeling of sound sources, sound interaction with solid structures, transmission and radiation of sound. Discusses numerical acoustics, statistical energy analysis, and sound quality concepts. Provides beneficial background in basic vibrations and noise control.

MEEM 6702 Nonlinear Sys Analy & Contro Studies nonlinear systems from perspective of analysis/control system design. Explores fundamental properties of nonlinear differential equations in addition to describing functions, phase plane analysis, stability/instability theorems. Develops and applies control system design approaches for nonlinear systems, including feedback linearization, quantitative feedback theory, sliding mode control, and backstepping.

MEEM 6703 Advanced Vibrations Free and forced vibration of continuous systems with applications to strings, shafts, beams, plates and membranes. Problems formulated using Hamilton's principle and Lagrange's equations. Approximate methods of solution include the Rayleigh-Ritz method and Galerkin's method.

MEEM 6705 Advanced Dynamics Systematic study of principles of mechanics from

a modern perspective. Includes rates of change of position and orientation; angular velocity and acceleration; linear velocity and acceleration; generalized coordinates and velocities; properties of distributed mass; generalized active and inertia forces for holonomic and nonholonomic systems; potential energy, kinetic energy, and virtual work.

MEEM 6990 Special Topics Study of selected subjects related to mechanical engineering or engineering mechanics.

MEEM 6999 Doctoral Research Research/investigation on a topic related to mechanical engineering or engineering mechanics leading to the submission of a dissertation in partial fulfillment of the requirements for the PhD degree. Research/investigation on a topic related to mechanical engineering or engineering mechanics leading to the submission of a dissertation in partial fulfillment of the requirements for the PhD degree.

MET 4000 Special Topics in MET The study of a special interest topic in Mechanical Engineering Technology. The class requires significant independent study and the preparation and presentation of a report. Approval by an MET faculty member is required.

MET 4131 Advanced Instrumentation Continuation of concepts introduced in MET3131. Covers transducer design, circuit simulation, data collection and data reduction; fundamentals of digital signal processing, including a treatment of fast Fourier transforms, cross correlation, and auto correlation. General introduction to computer-aided testing.

MET 4200 Design of Experiments This course provides basic knowledge required to develop statistical experiments to improve quality of process and products. The student will begin designing simple experiments and expand to apply advance principles to study interaction between variables. A strong foundation will be provided allowing the student to progress to Taguchi experimental design techniques.

MET 4350 Heating, Ventilation and AC An introduction to the principles and applications of HVAC engineering for technology students. Emphasizes design and evaluation of practical engineering systems.

MET 4375 Applied Energy Systems Expands on the applications of energy systems covered in MET3361. Emphasizes practical approaches to efficient energy management using system evaluations and design projects.

MET 4390 Internal Combustion Engines Introduction to the principles of internal combustion system design, development, and testing for engineering technology students. Emphasizes design and evaluation of practical engineering systems.

MET 4400 Manufacturing Simulation An introductory course in computer integrated manufacturing. Covers computer interfaces of machine tools, post processors and overall integration of enterprise-wide manufacturing systems. Discusses group technology, economic analysis, and quality metrics.

MET 4450 Manufacturing Process An introduction to the mechanics of several manufacturing processes and nontraditional manufacturing processes and

examinations of metal forming and machining. Several plant trips will be made to local manufacturers.

MET 4460 Product Design and Development A treatment of design and development issues such as design for manufacturing, prototyping, industrial design, and customer needs. Presents integrated methodologies that examine marketing, manufacturing, and cross-functional teams. Includes concurrent engineering and projects utilizing CAD systems.

MET 4570 Senior Project I First of two courses that introduce a student to a research and design experience in which full documentation is maintained by the student. Includes written and oral reports, peer reviews, and teaming. Emphasizes the use of computers. First of two courses that introduce a student to a research and design experience in which full documentation is maintained by the student. Includes written and oral reports, peer reviews, and teaming. Emphasizes the use of computers.

MET 4670 Senior Project II A continuation of MET4570. Involves design reviews, teaming, and formal presentations that include a comprehensive assessment of the student project.

MET 4700 Applied Mechanical Vibrations An introduction to mechanical vibration with emphasis on machinery diagnostics. Covers single- and multiple-degree-of-freedom systems as well as applications of FEA. MATLAB and SDRC Master Series used in examining practical case studies. Students introduced to FFT analyzers and accelerometers.

MG 4200 Mine Environmental Engineering Topics include environmental problems and causes, regulations and practical methods to prevent or solve the environmental problems, including gas emissions and dust monitoring and control, processing and discharging water treatment and unit operations, solid wastes utilization and landfilling, and land remediation and reclamation.

MG 4350 Recycling & Matls Systems Engg Recycling for industrial applications, materials system design, equipment selection, process system controls, and economics. Case studies used.

MG 4400 Particle Technology Fundamentals of particle processing, characterization, and separation. Topics include fine particle synthesis of raw materials and feedstocks; minerals; processing of materials such as fly-ash; automobile recycling; newsprint; contaminated soils; recyclable materials such as batteries and tires; and sludges. Also covers zeta potential, particulate surface chemistry, and flocculation, and dispersion.

MG 4410 Non-Explosive Rock Fragmentation Examines mechanical methods of fragmenting and excavating rock. Topics include fragmentation theory, performance prediction, water jet technology, cutterhead layout, tunnel boring machines, roadheaders, continuous miners, and rock drilling.

MG 4420 Hydrometallurgy Interfacial properties of solid particles in water and introduction to the concepts of hydrometallurgical and their effects on wet separation processes. Special electrochemical processing of ores. Reviews the chemical, emphasis on the flotation separation of minerals (oxides,



thermodynamic, and kinetic principles that are essential silicates, sulfides, semisoluble and soluble salts) and for the field and employs plant processing examples in waste materials, illustrating the concepts. Also covers environmental concerns and processing. Offered as a half semester course.

MG 4440 Pyrometallurgy The objective of this course is to introduce the thermal processes in primary metal production. Fundamentals of unit processes used in copper, iron and aluminum manufacturing will be expanded using knowledge of thermodynamics and equilibrium reaction chemistry. Offered as a half semester course.

MG 4500 Rock Mechanics Discover and predict the behavior of rock systems, beginning with continuum mechanics and constitutive relations, including Mohr's circle. Continue with non-ideal aspects, such as groundwater, cracks, time effects, etc. Characterize rock system properties with field instrumentation, classification schemes, and computer models. Evaluate rock fragmentation and stability of excavations. Introduction to rock mechanics and its applications to the engineering design and analysis of both surface and underground mines. Includes historical review and its role in mining engineering, rock mass characterization and classification, structural stability analysis of excavations in open pits and underground mines, and infrastructures. Advanced technologies are compared with the design criteria applied in various structures to understand changes in the current engineering rock mechanics.

MG 4510 Rock Mechanics Laboratory Become familiar with the standard methods of measuring engineering properties of rock, and incorporating those properties in analyses of underground and surface excavations. Standard methods of measuring fundamental rock properties that provide the basis for geotechnical design and analysis. Includes the definition of strength and failure theorems, and other parameters. Preparation of ASTM standard samples. Requires reduction and summary of data, and an engineering report of sample tests.

MG 4520 Engineering Rock Mechanics Nature of rock mechanics problems. Includes analysis of stress-strain and elasticity; rock failure theorems and strength; surface and underground mine stability, covering pit slopes and tailings dams; room and pillar systems; functions of supports; roof control; rock mass characterization and engineering classifications.

MG 4530 Stability of Excavations Evaluation of the stability of surface and underground excavations in rock and soil. Topics include preventive excavation design and design of mitigation measures for unstable situations.

MG 4600 Geostatistics In-depth review of classical statistics and an introduction to principles of geostatistics, the theory of spatially correlated random variables and its application on the evaluation of mineral resources, strategic exploration planning, ore reserve estimation, and production planning. Examines various real case studies from the mining and petroleum industries.

MG 4610 Mineral Industry Economics Studies the role of minerals and metals in society and the economics of their use. Applies economic principles to examine the supply, demand, markets, and foreign trade for important minerals

and metals. Examines the effect of government policies on the minerals industries. Requires a technical report.

MG 4700 Ore Reserve Analysis and Eval Comparison of mining with other industrial enterprises, classifications of reserves, sampling methods and the irreliability, conventional and geostatistical methods of ore reserve analysis, and cutoff grade theory and its application. Provide the basis for economic feasibility of ore deposits and mine design. Include definition of ore and reserve classifications, sampling methods and analysis, various reserve calculation and modeling techniques. Requires engineering reports based on actual mine data.

MG 4800 Ventilation & Air Conditioning Properties and behavior of air and mine gases, and dustcontrol in mines. Pressure, velocity, and density measurement; ventilation network calculations, including airway resistances, and their precalculations. Natural ventilation, design and layout of fans, mine ventilation systems, climatic measurements and temperature precalculations. Properties and behavior of air and mine gases, and dust control in mines. Pressure, velocity, and density measurement; ventilation network calculations, including airway resistances, and their precalculations. Natural ventilation, design and layout of fans, mine ventilation systems, climatic measurements and temperature precalculations.

MG 4900 Mine Design I Capstone design course. Design a mine beginning from typical exploration data. Research, make decisions, and present conclusions in teams. Capstone design course. Design a mine beginning from typical exploration data. Research, make decisions, and present conclusions in teams. (Senior project ready as defined by major substitutes for prerequisites)

MG 4910 Mine Design II Capstone design project. Continuation of MG4900. Continuation of capstone design course. Finish project begun in MG4900, or perform second complete mine design project.

MG 4950 MPE Process Design I Fundamentals of designing process operations. Students will be responsible for characterizing the ore and designing and conducting lab-scale experiments to determine the best process-handling schemes. The ultimate goal is to have the students use the information gathered in the laboratory to design and operate a pilot-scale operation.

MG 4960 Mill Operation Practices This course is intended to be a hands-on, project-based design experience. The design, construction and operation of a pilot plant will be undertaken for solid material that is provided by the minerals or materials industry (i.e. mining, exploration or engineering company, etc.).

MG 4970 Special Topics in Mat Proc Eng Materials processing engineering topics not included in regular undergraduate courses.

MG 4980 Special Topics in Mining Engg Mining engineering topics not included in regular undergraduate courses.

MG 4990 Undergraduate Res in Mining Research in mining engineering, approved and supervised by departmental faculty.

MG 4995 Undergrad Res in Mat Proc Engg Research in materials processing engineering, approved and supervised by departmental faculty.

MG 5110 Advanced Topics in Mining Engg Individual or group study of advanced topics in mining engineering, approved and supervised by departmental faculty. Student proposals for topics of study are encouraged.

MG 5120 Adv Topics in Mat Proc Engg Individual or group study of advanced topics in materials processing engineering, approved and supervised by departmental faculty. Student proposals for topics of study are encouraged.

MG 5210 Environmental Impact Analysis An overview of extraction, construction, transportation, and processing activities and their environmental design. Includes impacts on air, water, solids, land, wildlife, and socioeconomics. Covers environmental permitting and processes. Uses case studies.

MG 5310 Adv Matl Handling & Transport Selection, design, and analysis of materials handling methods to include trucks, shovels, drag lines, belt conveyors, pneumatic and hydraulic systems. Topics in materials handling systems selected according to student's area of specialization.

MG 5410 Non-Explosive Rock Fragment Examines mechanical methods of fragmenting and excavating rock. Topics include fragmentation theory, performance prediction, water jet technology, cutterhead layout, tunnel boring machines, roadheaders, continuous miners, and rock drilling.

MG 5430 Rock Fragmentation by Blasting Thermohydrodynamic theory and mechanism of detonation of explosives. Explosion properties and the blasting action of explosives. Explosives-induced rock fracturing. Damage potential of air and ground vibrations. Evaluation of the response of structures to air and ground vibrations. Establishment of tolerable limits for the structural response to prevent damage.

MG 5510 Advanced Rock Mechanics Critical ground control problems relating to underground openings and surface mines. Review of engineering mechanics, numerical methods, and empirical methods to develop solutions and design criteria. Introducing probabilistic approaches for engineering design.

MG 5520 Keyblock Theorem & Struct Stab Study keyblock theorems and apply for both surface mines and underground openings. Finite element modeling for keyblock failures and probabilistic keyblock analysis exercised by using up-to-date professional software, including rock joint system analysis and modeling.

MG 5550 Geomechanics Instrumentation Measure rock and rock mass properties and interpret the results. Covers instrumentation for research and for geotechnical site monitoring in the laboratory and in the field. Of interest to mining engineers, geological engineers, and geotechnical/civil engineers.

MG 5560 Discontin Analy Rock Engg I Self-paced introduction to the scientific analysis of discontinuities in rock. This first course in the series explores techniques for identifying discontinuities and evaluating and measuring discontinuity orientation, frequency, and spacing.

MG 5570 Discontin Analy Rock Engg II Self-paced introduction to the scientific analysis of discontinuities in rock. This second course in the series explores techniques for evaluating and measuring discontinuity size, stresses on discontinuities, rigid-rock-block behavior, and effects of discontinuities on rock mass strength and deformability.

MG 5600 Advanced Geostatistics Presents the nature of linear and nonlinear geostatistical problems and their solutions. Introduces various techniques for global and local recovery analysis of in-situ resources. A complete case study of various kriging methods by using professional software.

MG 5620 Spec Topics in Geostatistics Studies theories and applications of selected topics extensively to provide research techniques for engineering research projects. Topics to be chosen are disjunctive Kriging, multi-Gaussian approach, indicator Kriging, probability Kriging, and conditional simulations. Potential applications to other disciplines.

MG 5700 Advanced Mineral Processing Recent advances in crushing, grinding, gravity separation and flotation. Mathematical modeling of unit operations.

MG 5710 Coal Geology, petrography, mining, and preparation of coal. Covers topics such as coal-water-fuels, transportation, economics, and environmental considerations.

MG 5720 Advanced Hydrometallurgy Fundamentals of precious metal hydrometallurgy. Applications to chemical systems, process technology, and industrial operations. Leaching, concentrating, and recovering of precious metals.

MG 5730 Control of Process Streams Sampling statistics, on-line sensors, serial and parallel interfacing, artificial intelligence, and fuzzy logic applied to minerals and materials processing operations.

MG 5900 Advanced Mine Planning Planning and design of surface and underground mines. Ore and waste production plans, machine and personnel requirements, and scheduling. Selection and comparison of different haulage and/or hoisting systems.

MG 5980 Master's Res in Mat Proc Engg Master's-level research in materials processing engineering, approved and supervised by departmental faculty advisor.

MG 5990 Master's Res in Mining Engg Master's-level research in mining engineering, approved and supervised by departmental faculty advisor.

MG 6150 Mining Graduate Seminar Focusing on graduate research problems and on related topics in the current literature as well as recent advances in mining technology. May be taken as pass/fail only. Focusing on graduate research problems and on related topics in the current literature as well as recent advances in mining and materials processing technology.

MG 6500 Adv Topics Minerals Processing Advanced concepts applied to minerals processing, hydrometallurgy, extractive metallurgy, or refining. Specific course content is tailored to the needs and interests of students and the

expertise of faculty or visitors to the department. Occasionally, visitors will offer short workshops via this course.

MG 6980 Doctoral Res in Mat Proc Engg Doctoral-level research in materials processing engineering, approved and supervised by departmental faculty advisor.

MG 6990 Doctoral Res in Mining Engg Doctoral-level research in mining engineering, approved and supervised by departmental faculty advisor.

MY 4100 Primary Metals Processing Pyrometallurgical and electrometallurgical methods of extracting nonferrous metals from their mineral sources. Covers roasting, decomposition, and reduction reactions, slag-metals reactions, and electrolysis using aqueous and fused-salt electrolytes; principles of thermochemistry and kinetics to the reactions in ironmaking and steelmaking processes; environmental regulations and their impact on the industry. Pyrometallurgical and electrometallurgical methods of extracting nonferrous metals from their mineral sources. Covers roasting, decomposition, and reduction reactions, slag-metals reactions, and electrolysis using aqueous and fused-salt electrolytes; principles of thermochemistry and kinetics to the reactions in iron-making and steel-making processes; environmental regulations and their impact on the industry.

MY 4130 Principles of Metal Casting Principles of metal casting, including melting practice, casting design, mold design, heat transfer and solidification, fluid flow and gating design. Introduction to computer simulation techniques for mold filling, solidification, and development of residual stress. Structure-property relations in cast metals. Recycling and environmental issues of the cast metals industry.

MY 4140 Ceramics & Powder Materials The structure, defect chemistry, and properties of crystalline and amorphous ceramics. Processing of metallic and ceramic powders to useful components. Design with ceramics and powder-processed metals. The structure, defect chemistry, and properties of crystalline and amorphous ceramics. Processing of metallic and ceramic powders to useful components. Design with ceramics and powder-processed metals.

MY 4150 Composite Materials Structure, processing and properties of composite materials based on combinations of metals, ceramics, and polymers. Offered first half of spring semester. Structure, processing and properties of composite materials based on combinations of metals, ceramics, and polymers. Offered first half of spring semester.

MY 4160 Corrosion and Env Effects Mechanisms of corrosion processes, electrochemical and oxidation kinetics, and fundamentals of corrosion engineering. Offered second half of spring semester.

MY 4170 Materials & Energy in Society Includes history of material flow in an industrial society; waste and pollution; energy requirements; sustainable economy; lifecycle of materials, including steel, aluminum, cement, polymers, semiconductors; product life cycle; recycling and reuse; design for the environment. Offered first half of spring semester. Includes history of material flow in an industrial society; waste and pollution; energy

requirements; sustainable economy; lifecycle of materials, including steel, aluminum, cement, polymers, semiconductors; product life cycle; recycling and reuse; design for the environment. Offered first half of spring semester.

MY 4200 Scanning Electron Microscopy Scanning electron microscopy, including theory of operation. Application to the analysis of metallic, ceramic, geological and biological materials, including chemical analysis using energy and wavelength dispersive spectroscopy, x-ray mapping, low voltage and high resolution imaging. Offered first half of fall semester.

MY 4210 Diffraction Materials characterization using x-ray, electron and neutron diffraction. Concepts of the reciprocal lattice. Offered second half of fall semester.

MY 4250 Practical TEM Practical aspects of materials characterization by transmission electron microscopy. Offered first half of spring semester.

MY 4400 Deformation & Forming of Matls Deformation, fatigue, creep, and fracture of engineering components. Stress analysis. Processing of materials by deformation. Modeling of deformation, fracture, fatigue, and metalworking by traditional mechanics methods as well as by finite element methods. Practical aspects of metalworking.

MY 4500 Particle Technology Fundamentals of particle processing, characterization, and separation. Topics include fine particle synthesis of raw materials and feedstocks; minerals; processing of materials such as fly-ash; automobile recycling; newsprint; contaminated soils; recyclable materials such as batteries and tires; and sludges. Also covers zeta potential, particulate surface chemistry, and flocculation, and dispersion. Fundamentals of particle processing, characterization, and separation. Topics include fine particle synthesis of raw materials and feedstocks; minerals; processing of materials such as fly-ash; automobile recycling; newsprint; contaminated soils; recyclable materials such as batteries and tires; and sludges. Also covers zeta potential, particulate surface chemistry, and flocculation, and dispersion.

MY 4510 Hydrometallurgy Introduction to the concepts of hydrometallurgical and electrochemical processing of ores. Reviews the chemical, thermodynamic, and kinetic principles that are essential for the field and employs plant processing examples in illustrating the concepts. Also covers environmental concerns and processing.

MY 4520 Mineral Process Engineering Interfacial properties of solid particles in water and their effects on wet separation processes. Special emphasis on the flotation separation of minerals (oxides, silicates, sulfides, semisoluble and soluble salts) and waste materials.

MY 4530 Surfaces and Interfaces Introduction to applied interfacial/surface chemistry. Discussion of the effects of interfacial phenomena on the separation processes used in material processing, waste recycling, and environmental engineering. Fabrication of new materials with surface properties designed based on the surface chemistry principles.

MY 4700 Electronic Properties of Matls Uses principles of modern physics to

rationalize the physical and electronic properties of various classes of materials, emphasizing solids. Topics include the band theory of solids; metallic materials; semiconductor physics, including the basis of elementary semiconductor devices; dielectric and optical properties of materials; magnetic materials; and superconductivity.

MY 4710 Matls Sci of Electronc Devices The use of materials science and engineering principles in the design and processing of electronic materials and devices. Topics include operating principles of solid-state electronic devices, electronic materials structure-processing-properties relationships, and materials issues in electronic device fabrication and performance. The use of materials science and engineering principles in the design and processing of electronic materials and devices. Topics include operating principles of solid-state electronic devices, electronic materials structure-processing-properties relationships, and materials issues in electronic device fabrication and performance.

MY 4800 Material & Process Selection The principles of materials selection for engineering design. Topics include selection based on strength, stiffness, thermal properties, high temperature behavior, corrosion resistance, formability, joinability, manufacturability, recyclability, etc. Considers ethics and economics. Presents numerous case studies and examples.

MY 4900 MSE Capstone Design Project I Capstone senior design project, conducted in teams of students working on a problem with an industrial partner. Open to all engineering majors interested in interdisciplinary projects. Capstone senior design project, conducted in teams of students working on a problem with an industrial partner. Open to all engineering majors interested in interdisciplinary projects. (Senior project ready as defined by major substitutes for prerequisites)

MY 4910 MSE Capstone Design Project II Capstone senior design project, conducted in teams of students working on a problem with an industrial partner. Open to all engineering majors interested in interdisciplinary projects. Capstone senior design project, conducted in teams of students working on a problem with an industrial partner. Open to all engineering majors interested in interdisciplinary projects. (Senior project ready as defined by major substitutes for prerequisites)

MY 4950 MPE Process Design I Fundamentals of designing process operations. Students will be responsible for characterizing the ore and designing and conducting lab-scale experiments to determine the best process-handling schemes. The ultimate goal is to have the students use the information gathered in the laboratory to design and operate a pilot-scale operation.

MY 4960 MPE Process Design II Fundamentals of designing process operations. Students are responsible for characterizing the ore and designing and conducting lab-scale experiments to determine the best process-handling schemes. The ultimate goal is to have the students use the information gathered in the laboratory to design and operate a pilot-scale operation.

MY 4970 Special Topics - Materials Special topics in materials science and engineering.

MY 4980 Special Topics - Minerals Special topics in minerals science and engineering.

MY 4990 Undergraduate Research Undergraduate research in materials science and engineering. Independent research conducted under the guidance of a faculty member.

MY 5000 Matls Science and Engineering Concepts of crystallography and crystal structure. Designed for students without a degree in materials science and engineering. Covers microstructural development as related to phase diagrams, kinetics of phase transformations, diffusion and materials processing. Relationship of properties to microstructure and pr