

- BIO E 849 Tissue Engineering 3(3,0)** Principles and practices of bioartificial organ and tissue development; cellular/material interaction and translation of information from two-dimensional surfaces to three-dimensional scaffolds; selection and processing of biomaterials to form tissue scaffolds; analysis of tissue engineered devices, standards, and regulation. *Preq:* BIO E 801, 846.
- BIO E 850 Selected Topics in Biomedical Engineering 1-4(0-4,12-0)** Advanced topics in bioengineering intended to develop in-depth areas of particular student interest. Credit may be earned for more than one semester. *Preq:* Consent of instructor.
- BIO E 870 Bioinstrumentation 3(2,2)** Concepts and techniques of instrumentation in bioengineering emphasizing effects of instrumentation on the biological system under investigation; transducers and couplers; data conversion; conditioning and transmission; experimental problems in acute and chronic procedures with static and dynamic subjects.
- BIO E 882 Biomaterials Implantology 4(2,6)** All phases of experimental surgery including selection of animal models, preparation of animals for surgery, general and special surgical techniques, and basic and applied instrumentation. *Preq:* BIOSC 459 or equivalent.
- BIO E 890 Internship 1-5** Observation and assignment in a medical college, dental college, hospital, veterinary clinic, dental clinic, health service, or industrial department. *Preq:* Consent of department chair.
- BIO E 891 Master's Thesis Research 1-12**
- BIO E 892 Nonthesis Independent Study in Bioengineering 1-6** Independent study in bioengineering for work necessary to complete requirements for the Master of Science degree in Bioengineering, nonthesis option. May be repeated for additional credit. To be taken Pass/Fail only.
- BIO E 991 Doctoral Dissertation Research 1-12**
- BIOLOGICAL SCIENCES**
- BIOSC (ENT) 600 Insect Morphology 4(3,3)**
See ENT 600.
- BIOSC 601 Plant Physiology 3(3,0)** Relations and processes that pertain to maintenance, growth, and reproduction of plants, including absorption of matter and energy, water relations of the plant, utilization of reserve products, and liberation of energy. *Preq:* BIOL 104 or 111 or BIOSC 205 and CH 102. *Coreq:* BIOSC 602.
- BIOSC 602 Plant Physiology Laboratory 1(0,3)** Laboratory exercises and experiments designed to indicate the relations and processes that pertain to maintenance, growth, and reproduction of plants, including absorption of matter and energy, water relations of the plant, utilization of reserve products and liberation of energy. *Coreq:* BIOSC 601.
- BIOSC 603 Protozoology 3(3,0)** Survey of the protozoa with emphasis on organization and function. Representative types of both free-living and parasitic forms are examined for each major taxon. *Preq:* BIOL 104 or 111.
- BIOSC 604 Protozoology Laboratory 2(1,2)** Laboratory exercises reinforce the material presented in BIOSC 403/603 and introduce techniques used in collection, preservation, and examination of protozoans. *Coreq:* BIOSC 603.
- BIOSC (GEN) 605 Molecular Genetics of Eukaryotes 3(3,0)** See GEN 605.
- BIOSC 606 Introductory Plant Taxonomy 3(3,0)** Introduction to the basic principles and concepts of plant systematics with emphasis on the plants of South Carolina. *Preq:* BIOL 104 or 111 or BIOSC 205. *Coreq:* BIOSC 607.
- BIOSC 607 Plant Taxonomy Laboratory 1(0,3)** Introduction to the basic techniques of plant taxonomy with laboratory and field emphasis on the flora of South Carolina. *Coreq:* BIOSC 606.
- BIOSC 608 Comparative Vertebrate Morphology 3(3,0)** Phylogeny and diversity of vertebrates and study of their comparative morphology, leading to an understanding of the relationships and functioning of living organisms. *Preq:* BIOL 104 or 111. *Coreq:* BIOSC 609.
- BIOSC 609 Comparative Vertebrate Morphology Laboratory 2(0,5)** Comparative anatomy of representative vertebrates; methods used in preparing specimens for study and display. *Coreq:* BIOSC 608.
- BIOSC 610 Limnology 3(3,0)** Detailed introduction to the physical, chemical, and biological interrelationships that characterize inland water environments. A fundamental approach to the interactions of components of the environment is developed at a theoretical level. *Preq:* Junior standing in a life science or consent of instructor.
- BIOSC 611 Limnological Analyses 2(1,2)** Examines a broad range of topics covered with both standing and running fresh waters. About one-third of the laboratory exercises address the major physical components of lakes and streams. The remainder provides rationale and methods for quantitative analyses of biota, as well as some integrated analyses of whole ecosystems. *Preq or Coreq:* BIOSC 610 or 643.
- BIOSC (E N R) 613 Restoration Ecology 3(3,0)**
See E N R 613.
- BIOSC (AVS, MICRO) 614 Basic Immunology 4(3,3)** See MICRO 614.
- BIOSC (ENT) 615 Insect Taxonomy 3(1,6)**
See ENT 615.
- BIOSC (GEN) 616 Recombinant DNA 3(3,0)**
See GEN 616.
- BIOSC 617 Marine Biology 3(3,0)** Survey of organisms that live in the sea and their adaptations to the marine environment. Emphasizes characteristics of marine habitats, organisms, and the ecosystems. *Preq:* BIOL 104, 111, or consent of instructor.
- BIOSC (GEN, MICRO) 618 Biotechnology I: Nucleic Acids Techniques 4(2,4)** See GEN 618.
- BIOSC 620 Neurobiology 3(3,0)** Broad background in neurobiology. Topics include neuro-anatomical structure-function; conduction in the neuron; neurite growth and development; neuromuscular junction; chemistry, physiology, and pharmacology of specific neurotransmitters and receptors; visual process; axoplasmic transport; hypothalamic-pituitary regulation; theories of behavior; theories of learning and memory. *Preq:* BIOCH 301 or 305 or consent of instructor.
- BIOSC 625 Introductory Mycology 3(3,0)** Introduction to the biology of all the groups of fungi and some related organisms, with considerations of the taxonomy, morphology, development, physiology, and ecology of representative forms. *Preq:* BIOL 104 or 111 or BIOSC 205.
- BIOSC 626 Mycology Practicum 2(1,2)** Application of the principles of mycological techniques, including isolation, culture, identification, and microscopic study of fungi. Includes examples from all major groups of fungi. *Preq or Coreq:* BIOSC 625.
- BIOSC 632 Animal Histology 3(3,0)** Structural and functional study of the basic tissues of animals and tissue makeup of organs. Emphasis is on light microscopy level with selected tissue studied at the electron microscope level. *Preq:* BIOSC 303 or consent of instructor. *Coreq:* BIOSC 633.
- BIOSC 633 Animal Histology Laboratory 2(1,2)** Microscopic examination of basic animal tissue types and the tissue makeup of organs which comprise systems. *Coreq:* BIOSC 632.
- BIOSC (ENT) 636 Insect Behavior 3(2,3)** See ENT 636.
- BIOSC 640 Developmental Animal Biology 3(3,0)** Events and mechanisms responsible for the development of multicellular animals. Gametogenesis, fertilization, embryonic development, cellular differentiation, morphogenesis, larval forms and metamorphosis, asexual reproduction, regeneration, malignancy, and aging are analyzed in terms of fundamental concepts and control processes. *Preq:* BIOCH 301 or 305 or consent of instructor. *Coreq:* BIOSC 650.
- BIOSC 641 Ecology 3(3,0)** Study of basic ecological principles underlying the relationships between organisms and their biotic and abiotic environments. Includes physiological, population, and community ecology, with applications of each to human ecological concerns. *Preq:* BIOL 104, 111, BIOSC 205, or consent of instructor.
- BIOSC 642 Biogeography 3(3,0)** Study of patterns of distribution of plants and animals in space and time. *Preq:* BIOSC 302 or 303 and 304 or 305 or consent of instructor.
- BIOSC 643 Freshwater Ecology 3(3,0)** Study of basic ecological principles and concepts as they apply to freshwater environments: rivers and streams, wetlands, lakes and ponds, and reservoirs. *Preq:* Junior standing in a life science or consent of instructor.

- BIOSC 644 Freshwater Ecology Laboratory 2(1,2)** Laboratory-based course providing a synthesis of major components of freshwater ecosystems. Activities are hypothesis driven and relate to each other to form an overall synthesis of the field. Hands-on experience allows engagement in creative inquiry. *Preq or Coreq:* BIOSC 443 or equivalent of consent of instructor.
- BIOSC 645 Ecology Laboratory 2(1,2)** Modern and classical approaches to the study of ecological problems discussed in BIOSC 441. Students are introduced to field, laboratory, and computer-based analyses of plant and animal populations and communities. *Preq or Coreq:* BIOSC 641.
- BIOSC 646 Plant Ecology 3(3,0)** Ecology of plants in relation to their biotic and abiotic environments. Individual organisms, populations, and communities are considered with an emphasis on seed plants in terrestrial environments. *Preq:* BIOL 104, 111, or BIOSC 205, or consent of instructor.
- BIOSC 647 Plant Ecology Laboratory 2(1,2)** Experimental and observational approach to addressing principles discussed in BIOSC 646. Students are introduced to field and laboratory methods involving individual organisms, populations, and communities. *Preq or Coreq:* BIOSC 646 or consent of instructor.
- BIOSC 650 Developmental Biology Laboratory 2(1,2)** Examines a broad range of topics concerned with the development of multicellular animals such as gametogenesis, fertilization, embryonic development, cell differentiation, morphogenesis, larval metamorphosis, and regeneration. Laboratory exercises provide the rationale and methods for the descriptive and experimental analysis of development in representative invertebrates and vertebrates. *Preq or Coreq:* BIOSC 640 or equivalent.
- BIOSC 652 Plant Anatomy and Morphology 3(3,0)** Study of the anatomy, reproduction, and phylogenetic relationships of vascular plants. *Preq:* BIOL 104, 111, BIOSC 205, or consent of instructor.
- BIOSC 653 Plant Anatomy and Morphology Laboratory 2(1,2)** Laboratory focusing on the anatomy, reproduction and phylogenetic relationships of vascular plants. *Coreq:* BIOSC 652.
- BIOSC 654 Plant Virology 4(3,3)** Study of plant viruses: their morphology, biochemistry, purification, and transmission; symptoms resulting from virus infection; virus vector relationships. Serological and nucleic acid hybridization procedures. Diagnosis of viral diseases and the identification of causal agents. Replication of plant viruses, the interaction between viral host and plant genome. Control of plant viral diseases. *Preq:* BIOCH 301, MICRO 305, or consent of instructor.
- BIOSC (ENT) 655 Medical and Veterinary Entomology 3(2,3)** See ENT 655.
- BIOSC 656 Medical and Veterinary Parasitology 3(3,0)** Introduction to parasitism in the animal kingdom; emphasizes basic and applied principles related to economically and medically important diseases. Classical and experimental approaches to the study of parasitism are examined in reference to protozoa, helminths, and arthropods. *Preq:* BIOL 104 or 111. *Coreq:* BIOSC 657.
- BIOSC 657 Medical and Veterinary Parasitology Laboratory 2(1,2)** Laboratory to reinforce material presented in BIOSC 656. Introduces students to both live and preserved human/animal parasites. Also introduces techniques used in collection, preservation, and examination of animal parasites. *Coreq:* BIOSC 656.
- BIOSC 658 Cell Physiology 3(3,0)** Study of the chemical and physical principles of cell function emphasizing bioenergetics and membrane phenomena. *Preq:* BIOCH 301 or 305 or consent of instructor.
- BIOSC 659 Systems Physiology 3(3,0)** Physiological systems of vertebrates and their homeostatic controls. Function of the major physiological systems is described in terms of anatomical structure and chemical and physical principles. *Preq:* One year each of biology, chemistry, and physics or consent of instructor.
- BIOSC 660 Systems Physiology Laboratory 2(1,2)** Modern and classical experimental methods are used to demonstrate fundamental physiological principles discussed in BIOSC 659. Students are introduced to computer-aided data acquisition and computer simulations of physiological function. *Preq or Coreq:* BIOSC 659.
- BIOSC 661 Cell Biology 3(3,0)** In-depth analysis of how and where intracellular and extracellular molecules control general and specific cellular functions such as gene expression, secretion, motility, signaling, cell-cycle control and differentiation. Taught and graded at a level where students are expected to infer from and integrate cellular events. *Preq:* BIOCH 301 or consent of instructor.
- BIOSC 662 Cell Biology Laboratory 2(1,2)** Accompanies BIOSC 661; focuses on molecular and microscopic analysis of eukaryotic cells. *Coreq:* BIOSC 661.
- BIOSC 664 Mammalogy 4(3,3)** Origin, evolution, distribution, structure, and function of mammals with laboratory emphasis on mammals of the Southeast. Field trips and live trapping of mammals are required. *Preq:* BIOSC 303 or consent of instructor.
- BIOSC (GEN, HORT) 665 Plant Molecular Biology 3(3,0)** See HORT 665.
- BIOSC 668 Herpetology 3(2,3)** Systematics, life history, distribution, ecology, and current literature of amphibians and reptiles. Laboratory study of morphology and identification of world families and U.S. genera, as well as all southeastern species. Field trips are required. *Preq:* BIOSC 303 or consent of instructor.
- BIOSC (ENT, WFB) 669 Aquatic Insects 3(1,6)** See ENT 669.
- BIOSC 670 Behavioral Ecology 3(3,0)** Historical and modern developments in animal behavior emphasizing the evolutionary and ecological determinants of behavior. A synthesis of ethology and comparative psychology. *Preq:* BIOSC 302 or 303 or consent of instructor.
- BIOSC 671 Behavioral Ecology Laboratory 2(1,2)** Laboratory exercises that explore the behavior of animals. Emphasizes behavioral observation and analysis and presentation of findings in a report format. Includes a semester-long independent research project. *Preq or Coreq:* BIOSC 670 or consent of instructor.
- BIOSC 672 Ornithology 4(3,3)** Biology of birds: their origin and diversification, adaptations, phylogeny, classification, structure and function, behavior, ecology, and biogeography. Field identification is emphasized, and field trips are required. *Preq:* BIOSC 303 or consent of instructor.
- BIOSC 675 Comparative Physiology 3(3,0)** Physiological systems of invertebrates and vertebrates with emphasis on environmental adaptation. Physiological principles as they relate to metabolism, thermoregulation, osmoregulation, respiration, and neural and integrative physiology. *Preq:* One year each of biology, chemistry, and physics or consent of instructor.
- BIOSC 676 Comparative Physiology Laboratory 2(1,2)** Modern classical experimental methods demonstrate fundamental physiological principles discussed in BIOSC 475. Students are introduced to computer-aided data acquisition and manipulation as well as computer simulations of physiological function. *Preq or Coreq:* BIOSC 675.
- BIOSC 677 Ichthyology 3(2,3)** Systematics, life history, distribution, ecology, and current literature of fish. Laboratory study of morphology and identification of U.S. genera and all Southeastern species. Field trips are required. *Preq:* BIOSC 303 or consent of instructor.
- BIOSC (AVS) 680 Vertebrate Endocrinology 3(3,0)** Introduction to the basic principles of neuroendocrine integration and homeostatic maintenance in vertebrates. Comparative morphology and physiology of various endocrine tissues and hormone chemistry and modes of action are considered. *Preq:* BIOSC 303, organic chemistry or consent of instructor.
- BIOSC 730 SC Life: Topics for Teachers 3(2,2)** Topics relating to the SC Life curriculum. Lectures, laboratories, and extensive field studies focus on the natural history and biodiversity of South Carolina. Restricted to elementary and secondary school teachers. May be repeated for credit, but only if different topics are covered. *Preq:* Consent of instructor.
- BIOSC (AN PH) 801 Electron Microscopy of Biological Specimens 3(1,6)** See AN PH 801.
- BIOSC 802 Conservation Genetics 3(3,0)** Introduction to theoretical population genetics and empirical studies of evolutionary genetics. Emphasizes exploring conservation genetics issues from an applied perspective by doing exercises using real data sets and population genetics analyses programs as well as discussions of empirical studies of species of conservation concern. *Preq:* BIOSC 335, GEN 300 or 302, or consent of instructor.
- BIOSC (ENTOX) 811 Immunotoxicology 3(3,0)** See ENTOX 811.
- BIOSC 812 Seminar 1(1,0)** Review and presentation of current literature in biological sciences. May be repeated for a maximum of four credits. To be taken Pass/Fail only. *Preq:* Consent of instructor.
- BIOSC 871 Selected Topics 1-4(1-4,0)** Cellular and developmental biology, ecology, behavior, evolutionary biology, molecular biology, physiology, systematics, and other topics of interest to graduate students in the biological sciences. May be repeated for credit, but only if different topics are covered. *Preq:* Consent of instructor.

BIOSC 872 Selected Topics Laboratory 1-4(0,2-8) Specialized laboratory experiences in cellular and developmental biology, ecology, behavior, evolutionary biology, molecular biology, physiology, systematics, and other topics of interest to graduate students in the biological sciences. May be repeated for credit, but only if different topics are covered. *Preq:* Consent of instructor.

BIOSC 891 Master's Thesis Research 1-12

BIOSC 991 Doctoral Dissertation Research 1-12

BIOLOGY

BIOL 710 Selected Topics for Teachers 1-6(0-6,0-18) Consideration of one or more topics organized according to institute needs. Lecture and laboratory emphasize the incorporation of new or updated subject matter into classroom instruction. Restricted to elementary and secondary school teachers. May be repeated for credit, but only if different topics are covered.

BIOMOLECULAR ENGINEERING

BMOLE 623 Bioseparations 3(3,0) Study of principal methods of separation and purification of bioproducts, such as proteins, amino acids, and pharmaceuticals. Topics include analytical bioseparations, membrane separations, sedimentation, cell disruption, extraction, adsorption, chromatography, precipitation, crystallization, and drying. *Preq:* BIOCH 301, CH E 330, or consent of instructor.

BMOLE 810 Biosensors and Bioelectronic Devices 3(3,0) Study of methodologies in design, fabrication, and application of biosensors and bioelectronic devices for monitoring the environmental, medical, and chemical industries. Includes measurement science fundamentals applied to optical, electrochemical, mass, and thermal means of signal transduction. Also considers surface science fundamentals to interpret bioimmobilization, biofouling, and nonspecific interactions of enzymes, antibodies, and DNA at surfaces. *Preq:* Consent of instructor.

BIOSYSTEMS ENGINEERING

B E (CSENV) 608 Land Treatment of Wastewater and Sludges 3(3,0) See CSENV 608.

B E 612 Heat and Mass Transport in Biosystems Engineering 3(3,0) Fundamentals of heat and mass transport used in engineering design and analysis of biological systems; principles of steady state and transient energy and mass balances including chemical and biological generation terms. *Preq:* B E 312, MTHSC 208. *Coreq:* M E 310.

B E 614 Biosystems Engineering Unit Operation 3(2,3) Applies the basic principles of statics, dynamics, and thermodynamics to design of mechanical and electrical systems supporting biological operations and processes. *Preq:* B E 314, M E 310.

B E 615 Instrumentation and Control for Biosystems Engineers 4(3,3) Overview of modern instrumentation techniques and digital electronic components and subsystems to integrate them into digital data acquisition and control systems for biosystems. Emphasizes laboratory use of equipment is. Topics include characteristics of instruments, signal conditioning, transducer theory and applications, programmable logic controllers, and digital data acquisition and control. *Preq:* E C E 307.

B E 617 Applied Instrumentation and Control for Biosystems 2(1,3) Study of hardware and software implementation of digital data acquisition and control systems for application to agriculture, aquaculture, biotechnology, and other biosystems. Topics include digital electronic circuits and components, microcomputer architecture, interfacing, and programming. *Preq:* B E 415 or consent of instructor.

B E 622 Hydrologic Modeling of Small Watersheds 3(3,0) Design of structures and development of best management practices for runoff, flood, and sediment control from rural and urban areas, including natural and disturbed watersheds. Topics include modeling of prismatic and non-prismatic channels, culverts, and detention/retention ponds. *Preq:* B E 322 or consent of instructor.

B E (CH E) 628 Biochemical Engineering 3(3,0) Use of microorganisms and enzymes for the production of chemical feedstocks, single-cell protein, antibiotics, and other fermentation products. Topics include kinetics and energetics of microbial metabolism, design and analysis of reactors for microbial growth and enzyme-catalyzed reactions, and considerations of scale-up, mass transfer, and sterilization during reactor design. *Preq:* B E 312, MICRO 305; *Coreq:* (for Biosystems Engineering majors) BIOCH 301 or 305; (for Chemical Engineering majors) CH E 330, 450.

B E 631 Structural Design for Biosystems 2(2,0) Analysis and design of structures and statically determinant components with emphasis on wood. *Preq:* C E 206 or M E 302.

B E 635 Applications in Biotechnology Engineering 3(2,3) Bioengineering principles applied to the expanding fields of agricultural biotechnology, ecotechnology, and biomedical technology. Special applications include waste treatment and ecological engineering, bioreactor propagation of plant and animal cells and tissues, applied genomics and synthetic seed production, biosensors and biomonitoring, biological implants and materials biocompatibility. *Preq:* B E (CH E) 428.

B E 638 Bioprocess Engineering Design 3(2,2) Design and analysis of systems for processing biological materials. Topics include biotechnology, thermodynamics, transport processes, and biological properties related to bioprocess design and computational simulation. Unit operations include basic bioreactor operation, bioseparations, and preservation techniques. *Preq:* B E 428.

B E 642 Properties and Processing of Biological Products 2(1,3) Study of engineering properties of biological materials and their uniqueness as design restraints on systems for handling, processing, and preserving biological products. *Preq:* B E 333, C E 341, M E 302, 310.

B E (EE&S, FOR) 651 Newman Seminar and Lecture Series in Natural Resources Engineering 1(0,2) Topics dealing with development and protection of land, air, water, and related resources are covered by seminar with instructor and invited lecturers. Current environmental and/or resource conservation issues are addressed. *Preq:* Senior standing, consent of instructor.

B E 664 Non-Point Source Management in Engineered Ecosystems 3(2,3) Fundamentals of non-point source pollution including quantification of environmental impact and ecosystem management related to contaminants and nutrients and to planning and design of ecological systems. *Preq:* MICRO 305, senior standing in engineering, or consent of instructor.

B E (EE&S, I E) 684 Municipal Solid Waste Management 3(3,0) See EE&S 684.

B E 781 Special Problems 1-3(1-3,0) Students select subjects and conduct library, laboratory, and/or field research. A technical report documenting the study is required. May be repeated for a maximum of six credits. *Preq:* Master's degree candidate in Engineering.

B E 835 Industrial Biotechnology Techniques 4(3,3) Introduces industrial biotechnology techniques with emphasis on bioproduction, pilot bioprocessing equipment operation, biopharmaceutical storage, process simulation and economics, project management, good laboratory practice (GLP), and current good manufacturing practice (cGMP) geared toward the biotechnology industry. *Preq:* B E 638 or BIOCH 633, GEN (BIOSC) 616, or consent of instructor.

B E 838 Advanced Bioprocess Engineering 3(3,0) Advanced bioprocessing techniques with emphasis on processing and modeling aspects of eukaryotic systems and associated bioproducts. Modules include thermal processing, supercritical fluid extraction, and advanced biological thermodynamics, chromatography, and spectroscopy. *Preq:* B E 438/638 or consent of instructor.

B E 865 Advanced Biological Transport Processes 3(3,0) Study of transient transport processes in biological materials and systems. Incorporates mathematics describing active and passive cellular transport. Emphasizes numerical solution techniques for coupled transport relationships in nonideal, heterogeneous systems, including biological kinetic and thermodynamic considerations. *Preq:* BIOCH 305, CH E 601, MTHSC 634, or consent of instructor.

B E 871 Selected Topics in Biosystems Engineering 1-3(1-3,0) Supervised, in-depth study of an area related to biosystems engineering not covered in other courses. May be repeated for a maximum of six credits.

B E 882 Systems Engineering 3(3,0) Systems analysis methods applied to engineering of biological and agricultural operations; development of equations of motion, system analogs, and computer models and simulations; linear control analysis and stability. *Preq:* Consent of instructor.

B E 891 Master's Thesis Research 1-12

B E 901 Special Problems in Agricultural Engineering 3(3,0) Library and/or laboratory research on one of the following subjects, depending on student's field of study or interests: power and machinery, soil and water resources, farm structures, electric power and processing, food engineering, forest engineering or waste management. A technical report is required.

B E 991 Doctoral Dissertation Research 1-12

BOTANY

BOT 821 Inorganic Plant Metabolism 3(3,0) Study of plant, soil, water, and nutrient relations. Topics include permeability, uptake and translocation, transpiration, and mineral nutrition. Offered fall semester of odd-numbered years only. *Preq:* BIOSC 601 and 602 or consent of instructor.

BOT 822 Organic Plant Metabolism 3(3,0) Discusses respiration and photosynthesis; synthesis, translocation, storage, transformation, and degradation of organic materials, fats, carbohydrates, proteins, pigments, and nucleic acids. Offered spring semester of even-numbered years only. *Preq:* BIOSC 601 and 602 and BIOCH 623 or consent of instructor.

BOT 823 Plant Growth and Development 3(3,0) Considers vegetative and reproductive growth and development from seed to maturity, flowering, fruiting and senescence; natural and synthetic growth regulators; and morphogenesis. Offered fall semester of even-numbered years only. *Preq:* BIOSC 601, 602, and organic chemistry; or consent of instructor.

BOT 824 Mode of Action of Growth Substances 4(3,3) Study of the physiology and biochemistry of both natural and synthetic growth regulators, hormones, growth retardants, herbicides, and other inhibitors. Considers methodology and mechanism of action. Offered spring semester of odd-numbered years only. *Preq:* BIOSC 601 and 602 and general biochemistry or BOT 822 or consent of instructor.

BOT 831 Advanced Plant Taxonomy 4(3,3) Study of the principles of plant classification including relationships and characteristics of major groups of vascular plants. Students collect and identify spring flora of the area. Offered spring semester of odd-numbered years only. *Preq:* BIOSC 606 or consent of instructor.

BOT 850 Plant Tissue and Cell Culture 3(2,3) Methods and principles of plant tissue and cell culture: cloning, embryogenesis, protoplast fusion, plant regeneration, potential of plant genetic engineering. Offered fall semester of odd-numbered years only. *Preq:* Introductory plant physiology or consent of instructor.

BOT 860 Plant Anatomy and Cell Biology 4(3,3) Covers the subcellular structure and the comparative organization and function of plant cell-types, tissues, and organs. Emphasizes the interplay between the environment and the plant body and among genomes, membrane compartments, and the cytoplasm as these relate to the highly orchestrated stages in development. Offered spring semester of even-numbered years only.

BOT (HORT) 921 Plant Physiology Colloquium 1(1,0) Topics from current plant physiology literature provide a forum for criticizing research, conceiving new research ideas, developing research outlines and proposals, and integrating knowledge from various subdisciplines of plant physiology. May be repeated for credit. *Preq:* BIOSC 401/601 and 402/602 or consent of instructor.

BUSINESS ADMINISTRATION

M B A 802 Managerial Economics 3(3,0) Functioning of the market economy emphasizing the role of prices in determining the allocation of resources; the functioning of the firm in the economy and forces governing the production of economic goods. Emphasis is on using economic analysis in managerial decision making. *Preq:* M B A 803 or equivalent or consent of instructor.

M B A 803 Statistical Analysis of Business Operations 3(3,0) Provides breadth and depth in the application of statistical techniques building on basic statistical knowledge gained in M B A 818. Topics include analysis of variance, simple and multiple regression analysis, forecasting, and nonparametric statistics. *Preq:* M B A 818 or equivalent or consent of instructor.

M B A 804 Managerial Accounting and Information Systems 3(3,0) Preparation, analysis, interpretation, and use of accounting information in the guidance and control of a business enterprise. Case material and problems are used. *Preq:* M B A 819 or equivalent or consent of instructor.

M B A 805 Enterprise, Government, and the Public 3(3,0) Regulatory environment of business and how it evolves. Through use of economic logic and business cases, students are equipped to understand the all-pervading nature and importance of government regulation in the economy.

M B A 806 Operations Management 3(3,0) How firms create value and how decisions in the areas of capacity, facilities, technology, vertical integration, workforce, quality, production planning/materials control, and organization influence a firm's ability to add value; decisions and analysis tools used for these decisions. *Preq:* M B A 818 and 830, or equivalent, or consent of instructor.

M B A (FIN) 807 Financial Management 3(3,0) Theory of financial management as it relates to the financial problems faced by business concerns. Concepts developed are used to assess the validity of emerging formalized techniques for improving decision making in the financial area. Topics include financial planning, short- and long-term fund raising, capital budgeting, the administration of working capital, recapitalization, listing of securities, and reorganization. Case material and problems are used. *Preq:* M B A 804 or 854 or equivalent, and M B A 803 or 853 or equivalent.

M B A 808 Managerial Problems in Marketing 3(3,0) Major decisions facing marketing executives and top management in their attempt to harmonize the objectives and resources of the organization with the opportunities found in the marketplace; recent theoretical developments in marketing and related disciplines and their application in management. Readings, case analysis, and discussions are used. *Preq:* M B A 829 or equivalent and M B A 803, 804, 807; or consent of instructor.

M B A (MGT) 809 Organizational Behavior and Human Resources Management 3(3,0) See MGT 809.

M B A 810 Managerial Policy 3(3,0) Decisions involved in the establishment of managerial policy. Includes analysis and discussion of problems, resources, and alternative courses of action relative to the selection of company objectives and the most feasible means for achieving company goals. Integrates material and treats the coordination of the affairs of the firm as a whole. Case studies are emphasized. Should be completed as the final course in the program. *Preq:* M B A 806, 807, 808, 809.

M B A 811 International Business Management 3(3,0) Survey and analysis of managerial theory and the practice of international business, including the influence of cultural, economic, political, and financial factors affecting the management of the firm. Case studies of companies engaged in international business are discussed.

M B A (FIN) 812 Financial Markets and Institutions 3(3,0) Topics critical to the proper management of financial institutions including financial regulations, financial security types and their yields, interest rate theories, interest rate risk management, foreign currency risk management, stock index futures, and numerous operating functions in banking. *Preq:* M B A (FIN) 807 or consent of instructor.

M B A 814 Directed Research in Quantitative Analysis 3(3,0)

M B A 815 Directed Research in Qualitative Analysis 3(3,0)

M B A 817 Business Forecasting Techniques and Applications 3(3,0) Study of forecasting techniques and their application for developing and assessing forecasts. Topics include economic data sources, multiple regression and time series analysis, and interpretation of forecasts for management and other clients. *Preq:* M B A 802 and 803, or equivalent.

M B A 818 Introduction to Business Statistics 2(2,0) Introduction to probability concepts and distributions, sampling, estimation, and hypothesis testing involving one and two populations. May not be taken for credit toward any graduate degree. *Preq:* Consent of MBA director.

M B A 819 Introduction to Accounting and Finance 3(3,0) Basic concepts of accounting and finance with emphasis on using financial data for decision making; measuring, processing, reporting, and analysis of financial information; use of discounted cash flow analysis in valuation and the measurement of risk and return. Designed for MBA students lacking background in accounting and finance. *Preq:* Consent of MBA director.

M B A (MKT) 824 Management of Sales Operations 3(3,0) The sales function as an element of marketing strategy; the field of professional sales management; concepts and tools useful to managers at different levels of the sales organization. *Preq:* Principles of marketing or equivalent or consent of instructor.

- M B A (MKT) 825 Advertising and Promotional Management 3(3,0)** Role of promotion in the marketing mix emphasizing the types of decisions and decision areas affiliated with promotional planning. Students are exposed to and apply topics such as objective setting, budgeting, media planning and scheduling, and societal/economic impact of promotion. *Preq:* Principles of marketing or equivalent or consent of instructor.
- M B A (MKT) 826 Business Marketing 3(3,0)** Strategic marketing as it applies to industrial, organizational, and institutional markets; consumer marketing versus business-to-business marketing; current business marketing literature and practices. *Preq:* Principles of marketing or equivalent or consent of instructor.
- M B A (MKT) 828 Services Marketing 3(3,0)** Nature of services marketing and the special requisites that distinguish successful services marketing from goods marketing. Topics include promoting and making the service tangible, designing optimal service operations, the ideal service worker, pricing of services and critical points of services delivery. *Preq:* Principles of marketing or equivalent or consent of instructor.
- M B A 829 Marketing Foundations 2(2,0)** Principles and concepts involved in planning, pricing, promoting, and distributing goods and services. *Preq:* Consent of MBA director.
- M B A 830 Managerial Decision Modeling 2(2,0)** Introduction to basic decision modeling techniques useful in managerial decision making, including linear programming, project management, and Monte Carlo simulation. May not be taken for credit toward any graduate degree. *Preq:* Consent of MBA director.
- M B A (FIN) 832 International Financial Management 3(3,0)** Factors that influence the financial management of multinational corporations. Topics include international parity conditions, currency exposure management, capital budgeting of international projects and political risks. *Preq:* M B A (FIN) 807 or 857 or consent of instructor.
- M B A 833 Real Estate Investments 3(3,0)** Study of real estate investment analysis and decision making featuring the use of the discounted cash flow model and other tools to evaluate investment alternatives from the perspective of an equity real estate investor. Emphasizes market analysis, ownership alternatives, and financing considerations. *Preq:* M B A (FIN) 836.
- M B A (FIN) 835 Investment Management 3(3,0)** Discusses current techniques and strategies in the analysis of various investment alternatives. Includes portfolio management with an introduction to options and futures markets. *Preq:* Principles of accounting and a demonstrated proficiency in basic finance.
- M B A (FIN) 836 Real Estate Principles 3(3,0)** Advanced survey course to acquaint students with the theories, practices, and principles of real estate. Topics include urban economics, real estate law, brokerage, real estate valuation, financial institutions, tax issues, investment analysis, and development. *Preq:* M B A (FIN) 807 or 819 or consent of instructor.
- M B A 837 Legal Environment of Business 2(2,0)** Legal and case analysis of court systems and dispute resolution, contracts, business torts, EEOC, Age Discrimination in Employment Act, Americans with Disabilities Act, Employment-at-Will compared to union participation; international legal considerations as these topics relate to business concerns. May not be used for credit toward a graduate degree. *Preq:* Consent of MBA director.
- M B A 838 Law in the Business Environment 1(1,0)** Legal analysis of contracts, business torts, EEOC, American Discrimination in Employment Act, Americans with Disabilities Act, Employment-at-Will as compared to union participation and an overview of international legal considerations as these topics relate to business concerns. *Preq:* Consent of MBA director.
- M B A 839 Business Negotiations and Legal Dispute Resolution 3(3,0)** Negotiation and dispute resolution in the business environment. Negotiation techniques and practices, negotiation team building, international negotiation issues, as well as alternative dispute resolutions as applied to legal issues within the business environment. *Preq:* M B A 837, 838 or consent of instructor.
- M B A 841 Real Estate Finance 3(3,0)** The application of financial analysis and theory to real estate, mortgage credit analysis, and current financing techniques for residential and commercial properties is emphasized. Topics include financial institutions, mortgage financing techniques, financial decisions, and construction financing. *Preq:* M B A (FIN) 836.
- M B A 842 Real Estate Valuation 3(3,0)** Study of real estate appraisal with primary emphasis on two student projects: a house appraisal and a commercial property appraisal. Topics include highest and best use analysis, the three approaches to value, advanced capitalization techniques, discounted cash flow analysis, and the standards of professional practice. *Preq:* M B A (FIN) 836.
- M B A (MGT) 845 Technology and Innovation Management 3(3,0)** Interdisciplinary examination of problems and issues in integrating technology and innovation into processes and products; evaluating tangible and intangible aspects of new technology adoption; management research and development; and functional integration of marketing and operations.
- M B A 846 Use of Derivatives in Financial Engineering 3(3,0)** The valuation and use of basic derivative securities such as futures and options; the financial engineering of securities combinations such as swaps, spreads, and straddles; applications of derivatives and financial engineering in managing financial risks. *Preq:* M B A 807 or 867 or consent of instructor.
- M B A 850 Business Communications 1(1,1)** Techniques, skills, problems, and approaches for effective business communications; strengths and weaknesses of various communications forms with concentration on informative and persuasive models. Includes practical experience in written work and presentations, video and verbal feedback, teamwork, problem solving, and situational presentations. *Preq:* Consent of MBA director.
- M B A 853 Statistical Analysis for Business 3(3,0)** Application of modern statistical inference in business operations. Topics include testing statistical hypotheses, consequences of making decisions with incomplete information, univariate and multivariate regression with emphasis on business applications and design of experiments and analysis of variance. Special attention is given to efficient and relevant data collection and interpretation. Offered fall semester only. *Preq:* Consent of MBA director.
- M B A 854 Managerial Accounting 3(3,0)** Analysis, interpretation, and use of accounting information for planning and control in business and nonbusiness organizations. Includes profit planning, budgeting and standards; product and segment costing and evaluation; and case studies and computer-based assignments. Offered spring semester only. *Preq:* M B A 819 or equivalent or consent of instructor.
- M B A 856 Operations Management 3(3,0)** Strategic and tactical issues involved in the design, planning, and control of the operating system in service and manufacturing organizations. Topics include operations strategy, process choice, facility design, planning and scheduling, and methods for continuous improvement. Offered spring semester only. *Preq:* M B A 853 or consent of instructor.
- M B A 858 Managerial Marketing 3(3,0)** Key marketing concepts and theories with extensive application to a broad range of business and not-for-profit situations; analysis of marketing opportunities and threats, researching and selecting target markets, and developing and comparing marketing strategies to prepare students to develop advanced marketing strategies. Offered fall semester only. *Preq:* M B A 853 or consent of instructor.
- M B A 859 Management Science Applications 3(3,0)** Management science techniques and their application to a wide range of managerial decisions. Topics include queuing models, linear programming, transportation problems, and simulation. *Preq:* Consent of MBA director.
- M B A (MKT) 860 Advanced Marketing Strategy 3(3,0)** Advanced marketing theory and critical thinking skills applied to support strategic decision making. Data analysis and advanced marketing models are employed with emphasis on building analytic and assessment skills. Offered spring semester only. *Preq:* M B A 858 or MKT 865 or consent of instructor.
- M B A (MGT) 861 Information Systems 3(3,0)** See MGT 861.
- M B A 862 Managerial Economics 3(3,0)** Use of economic analysis in managerial decision making. Topics include the theory of cost, production, industrial organization, coordination, and control of the firm, from theoretical concepts to actual decision making. Offered fall semester only. *Preq:* Consent of MBA director.
- M B A 863 Advanced Managerial Economics 3(3,0)** Advanced economic analysis for managerial decision making. Topics include advanced price theory, theory of firm, internal organization of the firm, the economics of strategic behavior in the market, and the empirical estimation of demand and cost functions. *Preq:* M B A 862 or consent of instructor.

M B A 870 Strategic Management 3(3,0) Investigation of the ongoing process of positioning a firm for competitive advantage in its changing business environment focusing on the role of general managers in formulating and implementing strategies for single and multibusiness firms. Business cases, class discussions, and group projects are used to integrate content from previous business courses. Offered spring semester and summer session only. *Prq:* M B A 807, 809, 838, 854, 856, 861, 862; or consent of instructor.

M B A 871 Programming and System Development 3(3,0) Programming concepts and structures in developing information systems applications. Specific techniques and tools covered are updated to incorporate the newest technologies. *Prq:* Consent of instructor.

M B A 872 Entrepreneurial Finance 3(3,0) Topics include business valuation, financial forecasting, financing strategies, and business harvesting. Includes case studies and computer modeling. *Prq:* ECON 855 or M B A 807.

M B A (MGT) 874 Managing Continuous Improvement 3(3,0) See MGT 874.

M B A 875 Enterprise Development 3(3,0) Studies the entrepreneurial process from conception to birth of new venture emphasizing discovery, searching for opportunities, and gathering resources to convert opportunities to businesses. Students learn how to evaluate entrepreneurs and their plans by working in teams to write a business plan for a new venture.

M B A 876 Electronic Marketing 3(3,0) Application of the concepts and theories of marketing to E-commerce, challenges facing marketing in business-to-business and business-to-consumer contexts, strategic application of marketing mix variables in E-business environment. *Prq:* Consent of instructor.

M B A 880 MBA Seminar 1(1,0) Exposure to various career fields for MBA students through a mix of outside speakers, workshops, field trips, and other activities related to career development. May be repeated for a maximum of four credits. To be taken Pass/Fail only. *Prq:* Consent of instructor.

M B A 888 Internship in Business Administration 1-3 Preplanned, preapproved, faculty-supervised internship designed to give students on-the-job learning in support of classroom education. Internships must be no less than ten full-time, consecutive weeks with the same internship provider. May be repeated for a maximum of three credits. *Prq:* Thirty semester hours of graduate credit and consent of MBA director.

M B A 899 Selected Topics in Business Administration 3(3,0) Current topics in business administration as they relate to the manager. Topics may come from a single functional area or may integrate two or more functional areas (accounting, economics, finance, management, or marketing). May be repeated for a maximum of nine credits.

CAREER AND TECHNOLOGY EDUCATION

CTE (ED) 700 Supervising the Student Teacher in the Public School 2-3(2-3,0) See ED 700.

CTE 815 Seminar in Industrial Education 1(1,0) Students and faculty discuss and study new technological and professional advances. May be repeated for a maximum of three credits. To be taken Pass/Fail only.

CTE 820 Recent Process Developments 3(3,0) Study of recent technological innovations, inventions, processes, and products and their impact on our industrial, labor, educational, and social institutions.

CTE (H R D) 845 Needs Assessment for Education and Industry 3(3,0) See H R D 845.

CTE (H R D) 846 Applied Public Relations 3(3,0) See H R D 846.

CTE (H R D) 847 Instructional Systems Design 3(3,0) See H R D 847.

CTE 851 Current Topics in Communication Technology 1-3(1-3,0) Recent technological processes in the communication industry such as CAD, desktop publishing, and interactive video for teachers and industrial personnel.

CTE 852 Current Topics in Manufacturing Technology 1-3(1-3,0) Contemporary manufacturing practices for public school teachers and industry personnel.

CTE 853 Current Topics in Construction Technology 1-3(1-3,0) Update for teachers in industrial technology education programs at the secondary level, instructors in construction-related programs at the postsecondary level, and industrial trainers in the private sector; contemporary technological processes in construction industries.

CTE 854 Current Topics in Power Technology 1-3(1-3,0) Contemporary applications of power and energy for public school teachers and industry personnel.

CTE (H R D) 860 Instructional Materials Development 3(3,0) See H R D 860.

CTE 865 American Industries 3(3,0) Concepts and principles of American industry and technology. Industrial plant visits supplement study of industrial organization, economics, management, production, and products.

CTE (H R D) 870 Consulting for Education and Industry 3(3,0) See H R D 870.

CTE (AG ED, ED) 889 Research in Education 3(3,0) See AG ED 889.

CTE 894 Project Research 1-6(1-6,0) Research related to departmental projects. Open only to students planning to pursue advanced graduate study. Joint use with CTE 895, 896 is not permitted for degree.

CTE 895 Special Problems I 3(3,0) Special problems in industrial education varying with interests, experiences, and needs of students. *Prq:* Submission of a written proposal, completion of nine hours in the major, and consent of advisor.

CTE 896 Special Problems II 3(3,0) Continuation of CTE 895. *Prq:* CTE 895, written proposal, and consent of advisor.

CERAMIC AND MATERIALS ENGINEERING

C M E 602 Solid State Materials 3(3,0) Discussion of the properties of solids as related to structure and bonding with an emphasis on electronic materials. Band structure theory, electronic and optical properties are treated. *Prq:* C M E 326, MTHSC 208, PHYS 221.

C M E 616 Electrical Properties of Materials 3(3,0) Covers a range of topics dealing with electrical and magnetic materials. Topics include metal and polymer conductors, insulators, ceramic and polymer materials for dielectric applications, and ferroelectric, piezoelectric, pyroelectric, and electrooptic materials. Metal and ceramic magnetic materials are also discussed.

C M E 624 Optical Materials and Their Applications 3(3,0) Introduces the interaction of materials with light. Specific topics include fundamental optical properties, materials synthesis, optical fiber and planar waveguides, and the componentry and systems-level aspects of optical communication systems. *Prq:* C M E 402, 413.

C M E (BIO E) 680 Research Principles and Concepts 1(1,0) See BIO E 680.

C M E 690 Special Topics in Ceramic Engineering 1-3(1-3,0) Study of topics not ordinarily covered in other courses. Taught as the need arises. Typical topics could include current research in a specific area or technological advances. May be repeated for a maximum of six credits, but only if different topics are covered. *Prq:* Consent of instructor.

C M E 701 Special Problems 1-3(1-3,0) Practical problems in ceramic engineering analysis or design. Students are assigned individual problems with topics varying from year to year in keeping with developments, interests, and experience of students and instructor. May be repeated for credit.

C M E 800 Ceramic and Materials Engineering Seminar 1(1,0) Discussions and presentations of current topics of ceramic science and engineering by students, faculty members, and guest speakers. Required of all graduate students. To be taken Pass/Fail only.

C M E 809 High-Temperature Materials 3(3,0) Properties of oxides, carbides, nitrides, borides, and silicides; obtainment and measurement of high temperatures; measurement of properties at high temperatures.

C M E 815 Colloidal and Surface Science 3(3,0) Theory and application of colloidal and surface chemistry to ceramic materials and processes.

C M E 816 Constitution and Structure of Glasses 3(3,0) Modern concepts of glass structure and properties.

C M E 821 X-Ray Diffractometry 3(2,3) Theory and application of powder X-ray diffractometry to ceramic and materials problems.

C M E 822 Scanning Electron Microscopy 3(2,3) Theory and application of scanning electron microscopy to ceramic and materials problems.

C M E 823 Transmission Electron Microscopy 3(2,3) Advanced course in electron microscopy for materials science incorporating all aspects of transmission techniques: basics, diffraction, imaging, and spectrometry. *Prq:* C M E 821 and 822 or consent of instructor.

CME 825 Magnetic and Electrical Ceramic Materials 3(3,0) Application of magnetic and electrical theory to ceramic insulators, semiconductors, and ferroelectric and ferromagnetic products.

CME 890 Selected Topics 1-3(1-3,0) Topics not covered in other courses emphasizing current literature and results of current research. Topics vary from year to year to keep pace with developments. May be repeated for a maximum of six credits. *Preq:* Consent of instructor.

CME 891 Master's Thesis Research 1-12

CME 991 Doctoral Dissertation Research 1-12

CHEMICAL ENGINEERING

CH E 601 Transport Phenomena 3(3,0) Mathematical analysis of single and multidimensional steady-state and transient problems in momentum, energy, and mass transfer. Both the similarities and differences in these mechanisms are stressed. *Preq:* CH E 312, MTHSC 208.

CH E 612 Polymer Engineering 3(3,0) Design-oriented course in synthetic polymers. Topics include reactor design used in polymer production, effect of step versus addition kinetics on reactor design, epoxy curing reactions, polymer solubility, influence of polymerization and processing conditions on polymer crystallinity. *Preq:* CH 224 and 332 or consent of instructor.

CH E (B E) 628 Biochemical Engineering 3(3,0)
See B E 628.

CH E 645 Selected Topics in Chemical Engineering 3(3,0) Topics not covered in other courses, emphasizing current literature, research, and practice of chemical engineering. Topics vary from year to year. May be repeated, but only if different topics are covered. *Preq:* Consent of instructor.

CH E 650 Chemical Reaction Engineering 3(3,0) Review of kinetics of chemical reactions and an introduction to the analysis and design of chemical reactors. Topics include homogeneous and heterogeneous reactions, batch and continuous flow reaction systems, catalysis, and design of industrial reactors. *Preq:* CH E 312, 321, CH 332.

CH E 803 Advanced Transport Phenomena 3(3,0) Analysis of heat, mass, and momentum transfer; derivation and application of the governing equations; solution of steady and unsteady-state multidimensional problems in fluid flow, heat transfer, and mass transfer.

CH E 804 Chemical Engineering Thermodynamics 3(3,0) First and second laws for multicomponent, unsteady-state processes; thermodynamic mixture properties from volumetric data and equations of state; excess property models; phase-equilibrium thermodynamics, including vapor-liquid, liquid-liquid, and solid-liquid equilibrium calculations for conventional systems; associating fluids, polymers, and electrolytes and reaction-equilibrium thermodynamics for multiple-reaction heterogeneous systems.

CH E 805 Chemical Engineering Kinetics 3(3,0) Kinetics of chemical reactions, particularly in design and operation of chemical reactors.

CH E (EE&S) 814 Applied Numerical Methods in Process Simulation 3(3,0) Numerical solution techniques as applied to chemical process systems; finite difference techniques for partial differential equations stressing applied numerical methods rather than theoretical numerical analysis. Standard methods for ordinary differential equations are reviewed. *Preq:* Consent of instructor.

CH E 818 Polymer Processing 3(3,0) Processing of polymeric materials; polymer flow characterization; extrusion; mixing; filtration; injection molding; fiber and film formation; physical science principles such as fluid flow, heat transfer, crystallization, and rheology applied to polymer processing operations.

CH E 819 Viscoelastic Properties of Polymers and Polymeric Composites 3(3,0) Time- and frequency-dependent behavior of structural polymers and their composites; interrelationship between various viscoelastic properties; influence of aging; prediction of composite viscoelastic response by application of the Viscoelastic Correspondence Principle. *Preq:* Consent of instructor.

CH E 823 Mass Transfer and Stagewise Contact Operations 3(3,0) Stagewise contact operations emphasizing distillation; vapor-liquid equilibria; integral and differential distillation; binary and multicomponent rectification; analytical methods; batch rectification; azeotropic and extractive distillation.

CH E 834 Advanced Chemical Engineering Thermodynamics 3(3,0) Classical and statistical thermodynamics applied to problems in chemical engineering emphasizing modern methods of predicting thermophysical properties of gases and liquids. Students' and instructor's interests influence course content but usually include fundamentals of applied statistical mechanics, molecular theory of dense fluids, descriptions of intermolecular forces, gas-liquid and liquid-liquid critical phenomena, theories of interfacial phenomena and adsorption, statistical mechanics of polymeric systems, statistical mechanics of polydispersed systems, computer simulation of fluids by Monte Carlo, molecular dynamics, and stochastic dynamics methods. *Preq:* CH E 804 or equivalent.

CH E 845 Selected Topics in Chemical Engineering 3(3,0) Topics not covered in other courses emphasizing current literature and results of current research. Topics vary from year to year to keep pace with developments. May be repeated for credit.

CH E 890 Special Projects 1-6 Comprehensive analytical and/or experimental treatment of phenomena of current interest in chemical engineering emphasizing modern technological problems. May be repeated for maximum of six credits. To be taken Pass/Fail only. *Preq:* Consent of instructor and department chair.

CH E 891 Master's Thesis Research 1-12

CH E 895 Chemical Engineering Graduate Seminar 1(1,0) Series of weekly, one-hour seminars given by students, faculty, and guests on topics of current interest. Credits earned in this course do not apply to nor alter the required minimum of six research hours for the MS degree or the required 30 research credit hours for the PhD degree. To be taken Pass/Fail only.

CH E 945 Selected Topics in Chemical Engineering 3(3,0) More comprehensive study of topics first covered in CH E 845.

CH E 991 Doctoral Dissertation Research 1-12

CHEMISTRY

CH 602 Inorganic Chemistry 3(3,0) Basic principles of inorganic chemistry are discussed with special emphasis on atomic structure, chemical bonding, solid state, coordination chemistry, organometallic chemistry, and acid-base theories. The chemistry of certain selected elements is treated. Offered fall semester only. *Preq:* CH 331, 332.

CH 604 Bioinorganic Chemistry 3(3,0) Covers fundamentals of bioinorganic chemistry with review of necessary inorganic and biochemical concepts. Topics include metal uptake, transport, and storage in biological systems; functions of metals in proteins; metal ion interactions with nucleic acids; physical methods used in bioinorganic chemistry; heavy element toxicity, radiopharmaceuticals and other metallodrugs. *Preq:* BIOCH 301 or CH 205.

CH 611 Instrumental Analysis 3(3,0) Principles of operation and application of modern chemical instrumentation in the field of analytical chemistry. Topics include basic electronics, statistics, optical, mass, magnetic resonance, electron and x-ray spectroscopies, radiochemistry, and separation science. *Preq:* CH 331, 332.

CH 614 Bioanalytical Chemistry 3(3,0) Survey of selected areas of importance in bioanalytical chemistry. Includes fundamental principles, advanced topics, and applications of analytical measurements of biomolecules, bioassays, immunoassays, separations, mass spectrometry, method validation, macromolecular crystallography, microscopy, and imaging. *Preq:* CH 313, 411, or consent of instructor.

CH 621 Advanced Organic Chemistry 3(3,0) Survey of modern organic chemistry with an emphasis on synthesis and mechanisms. *Preq:* CH 224, 332 or equivalent.

CH 625 Medicinal Chemistry 3(3,0) Survey of the pharmaceutical drug discovery process. Covers discovery of candidate compounds; bioassay methods; associated regulatory and commercial issues. Case studies are selected from the current literature. *Preq:* CH 224 or equivalent or consent of instructor.

CH 627 Organic Spectroscopy 3(2,3) Survey of modern spectroscopic techniques used in the determination of molecular structure. Emphasis is on the interpretation of spectra: nuclear magnetic resonance, ultraviolet, infrared, mass spectroscopy, optical rotatory dispersion and circular dichroism. *Preq:* One year each of organic chemistry and physical chemistry.

CH 635 Atomic and Molecular Structure 3(3,0) Introduction to quantum theory and its application to atomic and molecular systems. Topics include harmonic oscillator, hydrogen atom, atomic and molecular orbital methods, vector model of the atom, atomic spectroscopy, and molecular spectroscopy. Offered spring semester only. *Preq:* CH 332 or consent of instructor.

- CH 651 Frontiers in Polymer Chemistry 3(3,0)** Survey of selected areas of current research in polymer science with particular emphasis on polymer synthesis. Although a text is required for review and reference, course is primarily literature based and focused on areas of high impact to multidisciplinary technology. *Preq:* CH 223, 224, PFC 415 or consent of instructor.
- CH 671 Teaching Chemistry 3(3,0)** Topics in chemistry addressed in the context of constructivist methodologies. Also considers laboratory work and management, laboratory safety, and the use of technology in the chemistry classroom. *Preq:* 300-level chemistry course or high school teaching experience or consent of instructor.
- CH 704 Selected Topics for Chemistry Teachers 1-6(1-6,1-6)** Directed individual study in designing experiments and teaching materials or an in-depth study of one or more advanced topics. For graduate students in Elementary and Secondary Education. May be repeated, but only if different topics are covered. Offered spring semester of odd-numbered years only.
- CH 800 Professional Development Issues in Chemistry 1(1,0)** Covers development of professional behavior for graduate students in chemistry, including communication skills, teaching techniques, research ethics, career management, "grantsmanship," and intellectual property issues in science. *Preq:* Graduate standing in Chemistry.
- CH 805 Theoretical Inorganic Chemistry 3(3,0)** Application of group theory to structure and properties of inorganic molecules. Offered spring semester of odd-numbered years only. *Preq:* CH 435 and 804 or consent of instructor.
- CH 806 Physical Methods in Inorganic Chemistry 3(3,0)** Theory and application of infrared, Raman, visible, ultraviolet, NMR, ESR, NQR, Mössbauer, and mass spectrometry to inorganic chemistry. Offered spring semester of odd-numbered years only. *Preq:* CH 804 or consent of instructor.
- CH 807 Chemistry of the Transition Elements 3(3,0)** Structure, spectroscopy, and reactivity of transition metals and their compounds. Offered fall semester only. *Preq:* CH 804 or consent of instructor.
- CH 808 Chemistry of the Nonmetallic Elements 3(3,0)** Development and application of a bonding model for descriptive inorganic chemistry of boron, carbon, silicon, nitrogen, phosphorus, oxygen, and sulfur. Offered spring semester of odd-numbered years only. *Preq:* CH 804 or consent of instructor.
- CH 809 Chemical Applications of X-Ray Crystallography 3(2,2)** Physical description of the crystalline state, symmetry in crystals, X-ray diffraction, modern methods of structure determination, and chemical interpretation of structural results. Offered spring semester of odd-numbered years only. *Preq:* CH 331 and 332 or consent of instructor.
- CH 811 Analytical Chemistry 3(3,0)** Graduate-level review of modern analytical chemistry; literature, sampling, quality control/assurance, chemometrics, and the use of modern analytical methods; team taught by the analytical faculty. Offered fall semester only.
- CH 812 Chemical Spectroscopic Methods 3(2,3)** Emission and absorption spectroscopy, chemical microscopy, X-ray diffraction, and fluorescence techniques in analytical chemistry; theory and operation of instruments.
- CH 813 Electrochemical Science 3(3,0)** Theory and experimental study of electrochemical thermodynamics, electrified interfaces, interfacial charge transfer, electrolyte solutions, electrode processes, and membrane electrochemistry; amperometric, voltammetric, electrolytic, and potentiometric methods; practical applications of electrochemistry in analysis, materials synthesis and energy technology. *Preq:* Graduate standing in Chemistry or Chemical Engineering or consent of instructor.
- CH 816 Separation Science 3(3,0)** Fundamental thermodynamic and kinetic concepts of separation and practical aspects of current separation techniques used in analytical chemistry. Offered spring semester of odd-numbered years only.
- CH 818 Surface and Thin Film Analysis 3(2,2)** Fundamental principles underlying the most commonly employed techniques for surface and thin films analysis. Representative techniques include atomic force microscopy, scanning electron microscopy, secondary ion mass spectrometry, Auger electron spectroscopy, and Rutherford backscattering. Laboratory exercises give insights into analytical methods.
- CH 820 Fundamentals of Organic Synthesis 3(3,0)** Modern aspects of organic chemistry emphasizing the mechanisms of reactions and synthesis of molecules of current interest. Offered fall semester only. *Preq:* CH 224 or equivalent plus satisfactory performance in the organic placement examination or consent of instructor.
- CH 821 Organic Chemistry I 3(3,0)** Theoretical concepts of organic chemistry, stereochemistry, and mechanisms of organic reactions. Offered fall semester only. *Preq:* CH 421 or satisfactory performance on the organic chemistry placement examination.
- CH 822 Organic Chemistry II 3(3,0)** Continuation of CH 821; mechanisms of organic reactions including photochemistry and Woodward-Hoffman rules; modern synthetic organic chemistry. Offered spring semester only. *Preq:* CH 821 or consent of instructor.
- CH 825 Chemistry of Heterocyclic Compounds 3(3,0)** Chemistry of heterocyclic compounds of nitrogen, oxygen, sulfur, and other elements. Offered spring semester of odd-numbered years only. *Preq:* CH 821, 822, or consent of instructor.
- CH 830 Fundamentals of Physical Chemistry 3(3,0)** Principles of classical thermodynamics, chemical kinetics, and quantum chemistry. Offered fall semester only. *Preq:* CH 331 or equivalent.
- CH 831 Chemical Thermodynamics 3(3,0)** Classical thermodynamics emphasizing theory and significance of energetics and systems of variable composition. Offered fall semester of odd-numbered years only. *Preq:* CH 331 or equivalent.
- CH 834 Statistical Thermodynamics 3(3,0)** Study of statistical thermodynamics including ensemble method, ideal gases, internal degrees of freedom, solid state, imperfect gases, distribution function method in fluids, and time-dependent fluctuations. *Preq:* CH 831.
- CH 835 Chemical Kinetics 3(3,0)** Rate processes and reaction mechanisms; order of reaction; theory of rate processes; relation of reaction rates to mechanism; homogeneous and heterogeneous catalysis; experimental methods; chain reactions; diffusion; effects of solvent, temperature, and pressure on reaction rates and mechanisms. Lectures are supplemented by assigned problems, paper, and oral examination of topic of special interest to the student. Offered spring semester of odd-numbered years only.
- CH 837 Quantum Chemistry 3(3,0)** Mathematical and conceptual formulation of quantum theory of electronic structure of atoms and molecules; eigenvalue solution of one-dimensional Schrödinger equation and application of this method to chemical problems. Offered fall semester of odd-numbered years only.
- CH 838 Computational Chemistry 3(3,0)** Theoretical methods and software used in computational chemistry; quantum chemical methods including molecular orbital methods and density functional theory; classical simulation techniques including potential energy functions, molecular mechanics, molecular dynamics, and Monte Carlo. Advanced topics vary with interests of students. *Preq:* CH 331 and 332 or equivalent.
- CH 840 Techniques of Experimental Chemistry 3(1,6)** Theory and practice in major experimental techniques used in chemical research; chromatography; NMR, IR, visible, UV, and ORD/CD spectrophotometry; glassblowing and high vacuum techniques; mass spectrometry; ESR; Mössbauer spectrometry and tracer analysis.
- CH 841 Chemical Applications of NMR Spectroscopy 3(2,2)** Basic concepts of NMR spectroscopy with application to organic, inorganic, physical, and analytical chemistry; design of spectroscopic experiments and interpretation of spectra; modern techniques including multipulse, multinuclear, and two-dimensional methods. Offered fall semester only. *Preq:* CH 331 and 332 or consent of instructor.
- CH 851 Graduate Student Seminar 1-2(1-2,0)** Students and faculty review current topics in chemistry. May be taken more than one semester.
- CH 852 Departmental Seminar 1-2(1-2,0)** Off-campus speakers are invited to present aspects of their research to the chemistry faculty and graduate students every week during the academic year. Some of these talks may form the basis for cumulative examination questions. Attendance is mandatory. May be taken more than one semester. *Preq:* Approved bachelor's degree.
- CH 891 Master's Thesis Research 1-12**
- CH 900 Selected Topics in Inorganic Chemistry 1-4(1-4,0)** Metal-metal bonding; homogeneous catalysis; photochemistry; bioinorganic chemistry; solid state chemistry. Topics vary with interests of students. May be repeated for credit if different topics are covered.
- CH 910 Selected Topics in Analytical Chemistry 1-4(1-4,0)** New techniques and their applications in analytical chemistry; laser methods; data acquisition processing; electronics, instrument/computer interfacing; field methods of sampling and analysis. Topics vary with interests of students. May be repeated for credit, but only if different topics are covered.

CH 920 Selected Topics in Organic Chemistry 1-4(1-4,0) Heterocyclic compounds; stereochemistry; natural products; organometallic chemistry; photochemistry. Topics vary with interests of students. May be repeated for credit, but only if different topics are covered.

CH 930 Selected Topics in Physical Chemistry 1-4(1-4,0) Special problems in molecular spectroscopy, molecular orbital treatments, applications of group theory to chemical structure, irreversible thermodynamics, and special topics in statistical mechanics. Topics vary with interests of students. May be repeated for credit, but only if different topics are covered.

CH 991 Doctoral Dissertation Research 1-12

CITY AND REGIONAL PLANNING

C R P 601 Introduction to City and Regional Planning 3(3,0) Introduces students from other disciplines to City and Regional Planning. Spatial and nonspatial areas of discipline are explored through a wide ranging lecture/seminar program. *Preq:* Consent of instructor.

C R P 602 Human Settlement 3(3,0) Overview of forces and trends affecting community growth and change—historical, ecological, economic, demographic, design, and development—pertaining to human settlement patterns and their interrelationship in the urbanization process, especially at the national, regional, townscape, and neighborhood scale. Team-taught from various perspectives. Intended as a foundation core course for Master's in Real Estate Development, City and Regional Planning, and Landscape Architecture. *Preq:* Consent of instructor.

C R P 603 Seminar on Planning Communication 3(3,0) In-depth analysis of methods to communicate planning and policy decisions effectively. Familiarizes students with the various communication skills needed by planners, policy makers, and other professionals to become successful practitioners. *Preq:* Consent of instructor.

C R P (C E) 612 Urban Transportation Planning 3(3,0) See C E 612.

C R P 634 Geographic Information Systems for Landscape Planning 3(1,6) Develops competence in geographic information systems technology and its application to various spatial analysis problems in landscape planning. Introduces basic principles of GIS and their use in spatial analysis and information management. Topics include database development and management, spatial analysis techniques, cartography, critical review of GIS applications, and hands-on projects.

C R P 801 Planning Process and Legal Foundations 3(3,0) Introduction to the city and regional planning profession and related processes with the legal foundation for comprehensive planning and tools of implementation. *Preq:* Consent of instructor.

C R P 802 Site Planning and Infrastructure 3(2,3) Working knowledge of natural systems and infrastructure systems as they affect site planning and development. *Preq:* Consent of instructor.

C R P 803 Quantitative Analysis 4(2,6) Basic tools of quantitative analysis and planning methods in the context of analytical, procedural, and institutional needs of the planner. Students learn data collection, analysis, and interpretation of different planning problems. Emphasis is placed on understanding the logic of statistical analysis, methods of planning analysis, and policy formation. *Preq:* Consent of instructor.

C R P 804 Land Use Analysis and Assessment 4(2,6) Introduction to basic methods of land use planning including land suitability analysis, land market forecasts, and formulating alternative land use plans. Development impact assessment and project appraisal methods are introduced to evaluate land use plans. *Preq:* C R P 803.

C R P 805 Planning Theory and History 3(3,0) Development of the planning practice and theories of planning process: historical evolution of planning practice in the U.S., social issues in planning, theories of planning and critiques of those theories, and ethical issues in planning practice. *Preq:* Consent of instructor.

C R P 806 Urban Systems and Growth Management 3(3,0) Overview of basic principles of resource allocation including public finance and project appraisal techniques. Introduces infrastructure planning and capital improvement plans followed by basic concepts of growth management and an overview of growth management laws and tools. Course is team-taught to address diverse subject matter. *Preq:* Consent of instructor.

C R P 807 Professional Studio 4-6(2-3,6-9) Serves as a vehicle for synthesis and application of skills developed in other courses and includes participation in one or more real-world planning projects in addition to seminars and readings devoted to development of professional practice skills. *Preq:* Consent of instructor.

C R P 822 Urban Design 3(3,0) Analysis of the evolution of the physical patterns of cities through research in the historical development of urban form in Europe and America within the context of prevailing social, economic, and political influences; approaches to the analysis of contemporary cities through the study of modern planning theorists. *Preq:* Consent of instructor.

C R P 830 Introduction to GIS 1(1,0) Introduces participants to ArcGIS as a tool for real estate development analysis and provides the foundation for becoming a successful GIS user. Students are introduced to fundamental GIS concepts. Topics include displaying, downloading, analyzing, and printing public domain geographical data sets. *Preq:* Consent of instructor.

C R P 832 Problems in Site Planning 3(1,6) Advanced site planning and design concept studies developed through site projects; concentration on industrial, residential, and recreational facilities. Emphasis is on use-specific site analysis and generation of development alternatives. *Preq:* Consent of instructor.

C R P 834 Spatial Modeling Using GIS 3(2,3) Use of geographic information systems (GIS) in spatial analysis, information management, and synthesis of spatial patterns and processes. Emphasizes developing an operational understanding of the modeling techniques and data used in different applications such as land use allocation, corridor location, site location and market analysis, environmental assessment, and cost-benefit analysis. *Preq:* C R P 634 or 804; or consent of instructor.

C R P 835 GIS and Remote Sensing Applications for Trend Analysis 3(2,3) Principles of remote sensing and land information systems in trend analysis. Addresses aspects of change detection for monitoring natural resources and urban growth. Designed for those interested in planning, natural resources management, and environmental analysis. Lectures and hands-on laboratory work emphasize the use of imagery for database generation and analysis. *Preq:* C R P 634, 804, or 834; or consent of instructor.

C R P 840 Seminar in Coastal Planning 3(3,0) Issues relating to development and conservation of coastal environments, focusing on inherent tradeoffs between growth and environmental quality. Discusses ecology and carrying capacity of coastal areas and appropriate management approaches to balance coastal resource demand. *Preq:* Consent of instructor.

C R P 841 Seminar in Environmental Planning 3(3,0) Current and emerging environmental issues and appropriate planning options, including population dynamics and limits to growth, entropy law, waste management, and global climate change; students pursue individual research on an environmental issue of particular concern and report findings. *Preq:* Consent of instructor.

C R P (PRTM) 844 Outdoor Recreation Resource Management and Planning 3(3,0) Issues relating to planning and development of natural areas for recreational purposes. Emphasis is on the policy-making process at the federal, state, regional, and local levels. *Preq:* Consent of instructor.

C R P 858 Research Design 3(3,0) Provides opportunity for students in their final year of study in the planning program to develop a proposal for the terminal project or thesis. Students are responsible for completing the research, writing, and editing necessary for an acceptable proposal. *Preq:* Consent of faculty.

C R P 859 Planning Terminal Project 3(0,9) Students select, with approval of advisor, and conduct research on individual planning problems of suitable scope. Oral, written and, where appropriate, visual presentations of solution are required. Students must enroll during final semester. *Preq:* C R P 858.

C R P (PO ST) 870 Seminar in Sustainable Development 3(3,0) See PO ST 870.

C R P 871 Growth Management and Legal Issues 3(3,0) Basic laws and court cases relating to the comprehensive plan, implementing tools, and other aspects of the planning process in the growth management context. *Preq:* C R P 672, consent of instructor or department chair.

- C R P 872 Housing Issues in the United States 3(3,0)** Regulation, stimulation, salvage, and replacement of housing through public policy administrative procedures. Specific housing programs are analyzed in detail. *Preq:* Consent of instructor.
- C R P 873 Economic Development Planning 3(3,0)** Economic development planning process, focusing on applied programmatic techniques, especially at the state, local, and neighborhood levels. Emphasizes theoretical models, economic development process, private/public partnerships, economic development tools, political context, and economic development planning administration and organization. *Preq:* Consent of instructor.
- C R P 883 Techniques for Analyzing Development Impacts 3(3,0)** Models and techniques for analyzing development impacts in urban areas and regions; economic, fiscal, social, and environmental impact methods. Operational knowledge of these techniques is developed. *Preq:* Consent of instructor.
- C R P 889 Selected Topics in Planning 3(3,0)** Topics emphasizing current literature and results of current research. May be repeated for credit. *Preq:* Consent of instructor.
- C R P 890 Directed Studies in City and Regional Planning 1-6(0,3-18)** Students pursue individual professional interests under guidance of City and Regional Planning graduate faculty. May be repeated for credit.
- C R P 891 Planning Thesis 6(0,18)** Students, working individually, program a planning problem of appropriate scope and conduct research. Oral, written and, where appropriate, visual presentations of these are required. To be taken Pass/Fail only. *Preq:* Consent of faculty.
- C R P 893 City and Regional Planning Internship 3(0,9)** Ten weeks of supervised professional employment with an approved planning entity. To be taken Pass/Fail only. *Preq:* Two semesters of City and Regional Planning or equivalent.
- C R P 894 Planning Internship Seminar 3(3,0)** Seminar-based analysis of student internships, enabling students to compare experiences and gain greater understanding of professional practice by reflecting on planning issues. To be taken Pass/Fail only. *Preq:* C R P 893.
- ## CIVIL ENGINEERING
- C E 601 Indeterminate and Matrix Structural Analysis 3(3,0)** Analysis of indeterminate structures using moment distribution, energy methods such as virtual work and Castigliano's Theorem, and the matrix formulation of the direct stiffness method. *Preq:* C E 301 or consent of instructor.
- C E 604 Masonry Structural Design 3(3,0)** Introduction to design of structural elements for masonry buildings. Lintels, walls, shear walls, columns, pilasters, and retaining walls are included. Reinforced and unreinforced elements of concrete or clay masonry are designed by allowable stress and strength design methods. Introduction to construction techniques, materials, and terminology used in masonry. *Preq:* C E 402 or consent of instructor.
- C E 607 Wood Design 3(3,0)** Introduction to wood design and engineering; properties of wood and wood-based materials; design of beams, columns, walls, roofs, panel systems, and connections. *Preq:* C E 402 or 406, or consent of instructor.
- C E 608 Structural Loads and Systems 3(3,0)** In-depth discussion of minimum design loads and load combinations. Includes overview of various steel and concrete systems. Discusses practical selection and design issues and design of proprietary building materials and components such as steel joists, diaphragms, engineered wood products, etc. *Preq:* C E 206, 301.
- C E 610 Traffic Engineering Operations 3(3,0)** Basic characteristics of motor-vehicle traffic, highway capacity, applications of traffic control devices, traffic design of parking facilities, engineering studies, traffic safety, traffic laws and ordinances, public relations. *Preq:* C E 311 or consent of instructor.
- C E 611 Roadway Geometric Design 3(2,3)** Geometric design of roadways, at-grade intersections, and interchanges in accordance with conditions imposed by driver ability, vehicle performance, safety, and economics. *Preq:* C E 311 or consent of instructor.
- C E (C R P) 612 Urban Transportation Planning 3(3,0)** Urban travel characteristics, characteristics of transportation systems, transportation and land-use studies, trip distribution and trip assignment models, city patterns, and subdivision layout. *Preq:* C E 311 or consent of instructor.
- C E 621 Geotechnical Engineering Design 3(3,0)** Relationship of local geology to soil formations, groundwater, planning of site investigation, sampling procedures, determination of design parameters, foundation design, and settlement analysis. *Preq:* C E 321 or consent of instructor.
- C E 624 Earth Slopes and Retaining Structures 3(3,0)** Principles of geology, groundwater and seepage, soil strength, slope stability, and lateral earth pressure and their application to the design of excavations, earth fills, dams, and earth-retaining structures. *Preq:* C E 321 or GEOL 320 or consent of instructor.
- C E 633 Construction Planning and Scheduling 3(3,0)** Principles and applications of the Critical Path Method (CPM) and Project Evaluation and Review Techniques (PERT). Project breakdown and network graphics. Identification of the critical path and resulting floats. Definition and allocation of materials, equipment, and manpower resources. Resource leveling, compression, and other network adjustments. Computer applications using packaged routines. *Preq:* C E 331 or consent of instructor.
- C E 634 Construction Estimating and Project Control 3(3,0)** Study of specifications, contracts, and bidding strategies; purchasing and subcontracting policies; accounting for materials, supplies, subcontracts, and labor; procedural details for estimating earthwork, reinforced concrete, steel, and masonry; overhead and profit items. *Preq:* C E 331 or consent of instructor.
- C E 638 Construction Support Operations 3(3,0)** Describes activities necessary for the completion of a construction job although not specifically recognized as direct construction activities: general conditions, safety, security, quality assurance, value engineering; organizational support features, and typical implementation procedures. *Preq:* C E 331 and EX ST 301, or consent of instructor.
- C E 643 Water Resources Engineering 3(3,0)** Extension of the concepts of fluid mechanics to applications in water supply, water resource assessment, water transmission, water distribution networks, pump and pipe selection, pipe networks, and analysis of open channel appurtenances. *Preq:* C E 341.
- C E 646 Flood Hazards and Protective Design 3(3,0)** Study of flood hazards and methods of protective design of the built environment. Floodplain mapping and delineation. Methods for determining base flood elevations. Flood-resistant construction, flood proofing, and governmental regulations are discussed. Includes case studies and design projects. *Coreq:* C E 342 or consent of instructor.
- C E 647 Stormwater Management 3(3,0)** Evaluation of peak discharges for urban and rural basins, design of highway drainage structures such as inlets and culverts; stormwater and receiving water quality; best management practices; detention and retention ponds; and erosion and sediment control. *Preq:* C E 342. *Coreq:* EE&S 401 or consent of instructor.
- C E 648 Physical Models in Hydraulics 3(2,3)** Tools and techniques of physical modeling to aid in design of complex hydraulic systems. Students participate in construction, operation, and testing of physical models to solve hydraulic engineering design problems. Experimental design and operation are covered. *Preq:* C E 342 or consent of instructor.
- C E 649 Hydraulic Structures 3(3,0)** Design methods and procedures are taught for a variety of hydraulic structures including intake structures, complex open-channel and closed conduit control structures, transitions, spillways, small dam, and pond design. Field trips to actual hydraulic structures may be included. *Preq:* C E 342 or consent of instructor.
- C E 655 Properties of Concrete and Asphalt 3(2,3)** Properties of aggregate, concrete, and asphalt; concrete and asphalt mix designs are conducted in the laboratory. *Preq:* C E 351 and EX ST 301, or consent of instructor.
- C E 662 Coastal Engineering I 3(3,0)** Introduction to coastal and oceanographic engineering principles including wave mechanics, wave-structure interaction, coastal water-level fluctuations, coastal-zone processes, and design considerations for coastal structures and beach nourishment projects. *Preq:* C E 341 or consent of instructor.
- C E 682 Groundwater and Contaminant Transport 3(3,0)** Basic principles of groundwater hydrology and transport of contaminants in groundwater systems; groundwater system characteristics; steady and transient flow; well hydraulics, design and testing; contaminant sources, movement and transformations. *Preq:* C E 341. *Coreq:* EE&S 401.

- C E 691 Selected Topics in Civil Engineering 1-6(1-6,0)** Structured study of civil engineering topics not found in other courses. May be repeated for a maximum of six credits, but only if different topics are covered. *Preq:* Consent of instructor.
- C E 801 Matrix and Finite Element Analysis 3(3,0)** Matrix and finite element methods in solution of engineering problems; stiffness matrices for triangular, rectangular, and quadrilateral elements in planer systems; plate bending, shell, and 3-D elements; applications to solutions of structural and soil mechanics problems using special and general purpose programs. *Preq:* C E 401 or consent of instructor.
- C E 802 Advanced Reinforced Concrete Design 3(3,0)** Second course in design of reinforced concrete structures; advanced concepts in analysis and design of beams, columns, and slabs; introduction to prestressed concrete. *Preq:* C E 402 or consent of instructor.
- C E 803 Advanced Steel Design 3(3,0)** Advanced design of structural steel buildings emphasizing the relationship between design and response of the structural system. Includes theoretical basis of building code provisions, limit state and plastic design, beam-columns, plate girders, and composite sections and connections. *Preq:* C E 406 or consent of instructor.
- C E 804 Prestressed Concrete 3(3,0)** Introduction to the analysis, behavior, and design of prestressed concrete members and structures. Covers allowable stress design and strength design of P/C members, shear design, loss of prestress force, design of continuous structures. *Preq:* C E 401 and 402, or consent of instructor.
- C E 805 Advanced Structural Mechanics 3(3,0)** Development and utilization of mechanics principles in solution of structural problems; unsymmetrical bending and curved beams; beams on elastic foundations; plastic structure analysis of beams and frames; eigenvalue problems; plastic stress-strain relations; strain energy; series and finite element solutions to plate and shell structures. *Preq:* C E 401 or consent of instructor.
- C E 806 Dynamic Analysis of Structures 3(3,0)** Analysis and design of structures subjected to dynamic loading; response of lumped and distributed parameter systems of one or many degrees of freedom; approximate design methods; introduction to earthquake analysis and design. *Preq:* C E 801 or consent of instructor.
- C E 807 Wind Engineering 3(2,2)** Effects of wind on buildings, bridges, and other structures; meteorological aspects of wind generation; types and characteristics of various wind events; aerodynamics of flow around structures; wind-induced loads; structural responses; design basis safety and serviceability criteria.
- C E 808 Earthquake Engineering 3(3,0)** Effects of earthquake-induced forces on buildings, bridges, and other structures; development of design codes and their application to the design of structures to resist seismic forces; fundamental structural dynamics and analysis techniques used to compute the response of structures or obtain design forces. *Preq:* C E 806 or consent of instructor.
- C E 809 Forensic Engineering 3(3,0)** Study of civil engineering failures including analyses of conditions just prior to the failure, load or event causing failure. Also covers methods of investigation and design of remedial measures, case histories of failures illustrating common errors and failures. Student projects involve design of remedial measures and alternatives.
- C E 813 Highway and Airport Pavement Design 3(3,0)** Structural design of rigid and flexible pavements; design of bases and subbases; theory of stresses and application of plate bearing, triaxial and California Bearing Ratio design methods to flexible pavements; Westergaard analysis for rigid pavements; pavement evaluation methods. *Preq:* C E 311 and 321, or consent of instructor.
- C E 815 Transportation Safety Engineering 3(3,0)** Methodology for conducting transportation accident studies; accident characteristics as related to operator, facility, and mode; statistical applications to accident data; current trends and problems in transportation safety. *Preq:* C E 311 or consent of instructor.
- C E 821 Advanced Soil Mechanics 3(3,0)** Study of stresses in soils, plastic equilibrium of soil masses, failure conditions, earth pressures, analysis of flexible retaining wall bulkheads, and solution of problem by elastic theory. *Preq:* C E 321 or consent of instructor.
- C E 822 Foundation Engineering 3(3,0)** Requirements for satisfactory foundations; theory and design of shallow foundations; pressure distribution beneath rigid and flexible shallow foundations; bearing capacity and settlement of deep foundations; foundation failures. *Preq:* C E 821 or consent of instructor.
- C E 823 Asphalt Concrete Properties 3(3,0)** Includes identification and suitability of aggregates for construction. Covers characteristics and properties of bituminous materials and materials behavior, construction, and design problems. Requires use of microcomputers and the mainframe. *Preq:* C E 351 or consent of instructor.
- C E 825 Soil Dynamics and Geotechnical Earthquake Engineering 3(3,0)** Fundamentals of soil dynamics, plate tectonics, and earthquakes; application of the concepts to seismic ground response, design ground motions, soil liquefaction, seismic slope stability, dynamic lateral earth pressures, and soil improvement. *Preq:* C E 421, 424, or consent of instructor.
- C E 826 Properties of Portland Cement Concrete 3(3,0)** Material science and engineering of Portland cement concrete. Topics include physical and chemical properties of cements; mixture proportioning; mixing; placement; curing techniques; specifications, tests, and evaluation of fresh and hardened concrete; durability issues; and considerations in specialized applications. *Preq:* C E 351 or consent of instructor.
- C E 835 Construction Project Modeling 3(3,0)** Mathematical and computer models are used to simulate construction operations. Covers linear models and optimization applications to construction materials, scheduling, and equipment allocation; typical computer models used in construction using simple modeling examples. *Preq:* C E 331 or consent of instructor.
- C E 836 Civil Engineering Quality Management 3(3,0)** Principles of total quality management (TQM) and their applications in the engineering and construction industry; TQM implementation techniques emphasizing the construction environment; concepts of quality assurance (QA) and quality control (QC) in construction.
- C E 837 Construction Specifications and Contracts 3(3,0)** Elements of specifications delineating responsibilities of all involved parties and identifying courses of action during abnormal circumstances; necessary parts of a contract dealing with governmental regulations and institutional preferences, licenses, bonds, insurance, and taxes. *Preq:* C E 331 or consent of instructor.
- C E 838 Materials Management 3(3,0)** Functions of construction materials management including design interface, purchasing, expediting, transportation, field control, and warehousing; design and application of integrated materials management computer systems; new technology that impacts materials management including bar coding, electronic data interchange, and voice recognition. *Preq:* Consent of instructor.
- C E 839 Expert Systems Applications in Civil Engineering 3(3,0)** Applications of expert systems in civil engineering design, construction, and facility management; use of expert systems shells for expert systems development; linking expert systems to external programs; knowledge acquisition and system validation.
- C E 840 Project Management Applications 3(3,0)** Quantitative tools for effective management and control of engineered projects from design through construction; cost coding and control, advanced schedule management techniques and quality management principles; extensive hands-on use of the microcomputer. *Preq:* C E 433 and 434, or consent of instructor.
- C E 846 Flow in Open Channels 3(3,0)** Free surface flow problems; applications of digital computer; concepts of boundary layer theory; uniform and varied flow; hydraulic jump; design criteria for prismatic channels and transitions; applications of unsteady flow. *Preq:* C E 342 or consent of instructor.
- C E 851 Reliability 3(3,0)** Elements of probabilistic methods; classical theory of structural reliability and reliability-based design methods. Term project required on reliability design in a relevant field of civil engineering.
- C E 853 Applications in Traffic Engineering 3(2,3)** Highway capacity analysis; design of unsignalized intersections; intelligent transportation systems; parking; traffic signal coordination; microscopic and macroscopic traffic simulation. *Preq:* C E 410 or consent of instructor.
- C E 854 Travel Demand Forecasting 3(2,3)** In-depth coverage of travel-demand forecasting theory and the four-step process; site impact analysis; disaggregate demand models. Students work in groups to develop a computer-based travel forecasting model for a small city. *Preq:* C E 412 or consent of instructor.
- C E 855 Transportation Seminar 1(1,0)** Practical discussion of the transportation profession featuring faculty and off-campus experts. Course is highlighted by a retreat where students present their transportation research.