

## Descriptions — Biological Science

### of Courses

**800. Problems in Biological Science**  
Fall, Winter, Spring, Summer. 1 to 4 credits. May reenroll for a maximum of 18 credits. B.S. degree in biological science.

**805. Outdoor Environmental Studies**  
Fall, Winter, Spring, Summer. 1 to 4 credits. May reenroll for a maximum of 9 credits if different topics are taken. B S 418 or ZOL 460 or approval of department.

Emphasis on environmental understanding. Development of educational materials through team research and testing. Trials of materials with elementary, middle, secondary school or college students.

**899. Master's Thesis Research**  
Fall, Winter, Spring. Variable credit. Approval of department.

## BIOMECHANICS

## BIM

### College of Osteopathic Medicine

**500. Basic Concepts in Biomechanics**  
Winter. 2(2-0) Admission to a college of medicine or approval of department. Interdepartmental with the College of Osteopathic Medicine.

Basic concepts of biomechanics and their relationship to functional anatomy and osteopathic manipulative therapy.

**590. Special Problems in Biomechanics**  
Fall, Winter, Spring, Summer. 1 to 3 credits. May reenroll for a maximum of 32 credits. Approval of department.

Each student will work under direction of a faculty member on an experimental, theoretical or applied problem.

**601. Osteopathic Manipulative Medicine Clerkship**  
Fall, Winter, Spring, Summer. 6 credits. May reenroll for a maximum of 12 credits. Grade P in all courses offered in terms 1 through 8.

Advanced training in the diagnosis of musculoskeletal dysfunctions and application of osteopathic manipulative techniques in patient care.

**620. Directed Studies**  
Fall, Winter, Spring, Summer. 1 to 6 credits. May reenroll for a maximum of 24 credits. Approval of department.

Individual or group work on special problems related to biomechanics, neuromusculoskeletal system primarily.

**800. Special Topics**  
Fall, Winter, Spring, Summer. 1 to 4 credits. May reenroll for a maximum of 9 credits. Approval of department.  
Independent study in topics of biomechanics.

**805. Biomechanical Analysis**  
Fall. 3(3-0) Approval of department.  
Methods for analysis of biokinematic and biokinetic data.

**810. Biokinematics**  
Winter. 3(3-0) BIM 805 or approval of department.

Size, position and mobility of the human body as a mechanical linkage system. Detailed study of body joints and kinematic models.

**811. Biokinetics**  
Spring. 3(3-0) BIM 810 or approval of department.

Application of Newtonian mechanics to problems of force transmission and related motions in the muscular-skeletal system.

**812. Theory of Tissue Mechanics**  
Fall. 3(3-0) Approval of department.

Introduces the concepts of stress and strain in tissue and the dependency of mechanical parameters on biological factors.

**850. Research Seminar**  
Fall, Winter, Spring. 1(1-0) May reenroll for a maximum of 3 credits. Approval of department.

Discussion of current research topics in biomechanics with strong clinical application.

**871. Research Methods in Biomechanics I**  
Fall. 2(1-3) BIM 812 or concurrently or approval of department.

Measurement of responses of biological tissues to internal and external demands. Techniques include visual, palpatory, electrophysiological, and mechanical assessment methods.

**872. Research Methods in Biomechanics II**  
Winter. 2(1-3) BIM 810 or concurrently or approval of department.

Measurement of body geometry and mass distribution. Measurements include anthropometry, goniometry, volume and inertial properties of the human body.

**873. Research Methods in Biomechanics III**  
Spring. 2(1-3) BIM 811 or concurrently or approval of department.

Measurements of dynamics of human motion. Measurements include force plate and photogrammetric kinematic assessment methods.

**890. Independent Study**  
Fall, Winter, Spring, Summer. 1 to 8 credits. May reenroll for a maximum of 32 credits. Approval of department.

Individual or group work related to biomechanics and/or neuromusculoskeletal system.

**899. Master's Thesis Research**  
Fall, Winter, Spring, Summer. Variable credit. May reenroll for a maximum of 12 credits. Approval of department.  
Conduct research for master's thesis.

## BIOMEDICAL ENGINEERING

## BME

### College of Engineering

**410. Electronic Instrumentation in Biology and Medicine**  
Fall. 4(4-0) MTH 112, PHY 238 or approval of instructor.

Electronic components and circuits. Physiological measurements. Transduction of physiological events to electrical signals. Detection of physiological events by electrical impedance measurements. Ultrasonic techniques in biomedical systems. Biomedical applications of lasers.

**411. Electric Theory of Nerves**  
Winter of odd-numbered years. 4(4-0) MTH 310; PHY 288.

Neurophysiology: basic organization, structure, function and electrical activity of neurons. Sub-threshold membrane phenomena: Nernst-Planck equations, constant field membrane model, electrotonus. Membrane action potentials: voltage clamp experiments, Hodgkin-Huxley equations, computer simulation.

**414. Clinical Instrumentation**  
Winter of even-numbered years. 3(3-0) BME 410.

Ultrasound theory and applications in medicine. Photoelectric, piezoelectric and temperature transducers. Detection of physiological events by impedance measurements. Radiology and x-ray techniques. Isotopes and nuclear medicine. Lasers in medicine. Field trips required.

**424. Materials in Biomedical Engineering**  
Winter. 3(3-0) PSL 240 or PSL 431 or approval of department.

Basics of materials science. Biocompatibility of metals, polymers and ceramics. Internal and external prosthetic materials.

**431. Biological Transport Mechanisms**  
Spring. 3(3-0) MTH 215.

Mechanisms which govern transport or momentum, heat and mass. Application to mathematical description of transport processes in biological systems and to solution of biomedical problems.

**481. Tissue Biomechanics**  
Fall. 3(3-0) ANT 316 or approval of department.

Fundamentals of continuum mechanics in relation to morphological classification of tissue. Mechanical properties of connective and muscle tissue.

**499. Independent Study**  
Fall, Winter, Spring, Summer. 1 to 4 credits. May reenroll for a maximum of 9 credits. Approval of instructor.

Individual reading and research under the supervision of a member of the Biomedical Engineering Committee.

## BOTANY AND

## PLANT PATHOLOGY

## BOT

### College of Agriculture and Natural Resources College of Natural Science

**201. Plants, People and the Environment (N)**  
Fall, Spring. 3(3-0)

Relevance of plants to modern society. Basic botanical concepts and socially significant groups of plants. Natural resource exploitation. Plants as they relate to human population growth, food production, and energy resource depletion.

**205. Plant Biology**  
Fall. 3(3-0) High school chemistry and high school algebra.

An introduction to plant science for students seeking a general knowledge of the principles of plant biology as well as for prospective plant science majors.

**206. Plant Biology Laboratory**

Fall. 1(0-3) BOT 205 or concurrently.

Physiological experiments and hands-on study of plant diversity at the cellular, tissue and whole plant level.

**301. Introductory Plant Physiology**

Winter, Spring. 4(2-4) CEM 141A or CEM 151; CEM 161; BOT 205 or B S 210 or LBS 141. Introductory organic chemistry recommended.

General principles of plant physiology relating plant structure to function. Topics include cell physiology, water relations, effects of light and temperature, respiration, photosynthesis, mineral nutrition, and hormone action.

**302. Introductory Morphology**

Winter. 4(2-4) BOT 205 or B S 212 or approval of department.

Structures and life cycles of representative plant groups showing progressive evolutionary developments.

**318. Introductory Plant Systematics**

Spring. 4(3-3) BOT 302 or B S 212 or approval of department.

Plant diversity with emphasis on identification, classification, nomenclature, and evolutionary relationships of vascular plants.

**320. Biology of Fungi**

Fall. 4(2-4) BOT 205 or B S 212 or LBS 140 or approval of department.

Characteristic features of the major groups with emphasis on the significance of fungi in nature and their economic aspects.

**330. Forest Protection**

Fall. 4(4-0) FOR 304, FOR 305, FOR 320. Interdepartmental with the departments of Entomology and Forestry. Administered by the Department of Forestry.

Procedures used to detect and respond to pest, fire and environmental problems in a variety of forest types.

**335. Fossil Plants, Their History and Paleocology**

Spring. 3(3-0) One course in geology or botany or biology or approval of department. Interdepartmental with and administered by the Department of Geology.

History of plants through geologic time; their form and evolution; how and where found, identified and reconstructed; their use in determining ancient geographic patterns, paleoenvironments, paleoclimates and community structure. Field trip.

**336. Economic Plants**

Winter. 3(3-0) BOT 205 or B S 212 or approval of department.

Plants used by humans viewed from economic, historical, cultural, and botanical perspectives. Emphasis on food, fiber and medicinal plants. Includes plants used for herbs, dyes, perfumes, alcohol, stimulants, ornamentals, energy.

**400II. Honors Work**

Fall, Winter, Spring. 3(0-6) Approval of department; Seniors.

**401. Directed Studies**

Fall, Winter, Spring, Summer. 1 to 4 credits. May re-enroll for a maximum of 16 credits. Approval of instructor.

Directed research or study of published literature. Areas of study include (but are not limited to) plant morphology, taxonomy, anatomy, ecology, paleobotany, cell biology, genetics, mycology, physiology, and various areas of plant pathology.

**402. Introductory Mycology**

Fall. 4(2-6) B S 212 or LBS 140 or approval of department.

Survey of the fungi including characteristics, habits and diversity. Background course for biology students or those expecting to specialize in microbiology, mycology, plant pathology, or other fields involving fungi.

Approved through Fall 1988.

**403. Elements of Cell Function and Structure**

Spring. 4(4-0) MPH 407, BCH 453 concurrently. Interdepartmental with the Department of Microbiology and Public Health. Administered by the Department of Microbiology and Public Health.

Cell biology of eukaryotic cells, with an emphasis on the molecular mechanisms that underlie cellular processes.

**405. Introductory Plant Pathology**

Fall. 4(2-4) BOT 302 or B S 212 or approval of department. Students may not receive credit in both BOT 405 and BOT 407.

General principles of plant pathology including detailed study of selected diseases as examples of important groups.

**406. Medical Mycology**

Fall, Spring. 4(2-6) BOT 402 or approval of department. Interdepartmental with the Department of Microbiology and Public Health.

Characteristics, habits, and laboratory identification of fungus diseases infecting humans. Emphasis on laboratory techniques and morphological characteristics of the various mycoses.

**407. Diseases of Forest and Shade Trees**

Spring. 4(3-2) BOT 301; BOT 302; BOT 318 or FOR 204. Students may not receive credit in both BOT 405 and BOT 407.

Diseases which affect trees in forests, parks, suburbs and nurseries, and methods of control.

**411. Summer Flora**

Summer. 4(2-6). B S 212, BOT 302 or approval of department. Students may not receive credit in both BOT 411 and BOT 425.

Taxonomy, identification, and evolutionary relationships of vascular plants, illustrated by the local flora; extensive field studies.

**413. Environmental Plant Physiology**

Winter. 3(3-0) B S 210 or LBS 141 or BOT 205.

Major topics include plant-soil-water relationships, gas exchange, and stress physiology. Minor topics include mineral nutrition and energy budgets.

**414. Plant Physiology: Metabolism**

Fall. 3(3-0) CEM 241; B S 210 or LBS 141 or BOT 205; BOT 301.

General principles underlying metabolic processes characteristic of plants. Photosynthesis, translocation, nitrogen metabolism, cell wall biosynthesis, and structures associated with these processes.

**415. Plant Physiology: Growth and Development**

Spring. 3(3-0) BOT 301 or approval of department.

Growth and development in plants. Topics include the chemistry and effects of hormones, tropisms, thermoperiodicity, reproduction, vernalization and photoperiodism, photomorphogenesis, dormancy and bioengineering in plants.

**416. Plant Physiology and Molecular Biology**

Spring. 4(0-8) BOT 414 or BOT 415 or concurrently or approval of department.

Classical and modern techniques used in plant research. Demonstration of principles discussed in BOT 414 and BOT 415. New research methods utilizing antibodies and recombinant DNA.

**423. Aquatic and Wetland Plants**

Summer of odd-numbered years. 4 credits. Students may not receive credit in both BOT 423 and BOT 400. BOT 302, B S 212 or approval of department. Given at W. K. Kellogg Biological Station.

Extensive exposure to plants in aquatic environments. Emphasis on systematics, morphology, evolution and community relations. Survey of diverse wetland and aquatic habitats with numerous field trips.

**425. Field Plant Systematics**

Summer. 4 credits. B S 212 or approval of department. Students may not receive credit in both BOT 425 and BOT 411. Given at W. K. Kellogg Biological Station.

Classification, evolution, and ecology of vascular plants. Emphasis on field recognition, identification of families, research techniques. Field trips required. Research projects.

**427. Cell Biology**

Fall. 4(4-0) BCH 200 and one year of general botany or general zoology.

Organization and structure of the cell, with emphasis on eukaryotes. Structure and function of the nucleus and cytoplasmic organelles. An introduction to molecular biology.

**431. Comparative Physical-Chemical Limnology**

Summer. Given at W. K. Kellogg Biological Station. 4 credits. One general chemistry course, one college level biology course. Interdepartmental with and administered by the Department of Zoology.

Physical and chemical structure of lakes and streams; methodology and field experience; cultural acidification and eutrophication. Field trips required.

**432. Comparative Biological Limnology**

Summer. Given at W. K. Kellogg Biological Station. 4 credits. ZOL 431. Interdepartmental with and administered by the Department of Zoology.

Biological structure of lakes and streams; methodology and field experience; primary and secondary production; freshwater community ecology. Field trips required.

**434. Plant Anatomy**

Fall. 4(2-4) B S 212 or BOT 205.

Principles underlying the differentiation and growth of vegetative plant structures with special emphasis upon their functional and developmental genetic relationships.

**441. Geographical Plant Ecology**

Winter. 3(3-0) BOT 205 or BOT 302 or B S 212 or approval of department.

Distribution and ecology of plants and plant communities in Polar, temperate and tropical regions with emphasis on North America. Geological history and environmental factors which influence distribution. Island biogeography.

**Descriptions — Botany and Plant Pathology  
of  
Courses**

**447. Fresh Water Algae**

Spring. Summer of even-numbered years. Given at W. K. Kellogg Biological Station Summer of even-numbered years. Spring; 4(2-4) Summer of even-numbered years: 4 credits. B S 212, BOT 302. Students may not receive credit in both BOT 421 and BOT 447.

Identification of fresh water algae, especially those forms concerned with fish food problems, water contamination and limnology. Methods for making analyses of samples for biological survey work on lakes and streams. Economic aspects and life histories of the algae.

**450. Ecology**

Spring; 4(2-4). Given at W. K. Kellogg Biological Station Summer term: 4 credits. BOT 318; BOT 301 or BOT 414.

Interrelationship of plants and environment. Factors which govern their distribution.

**470. Nematode Diseases of Economic Plants**

Spring of odd-numbered years. 4(3-3) BOT 405. Interdepartmental with and administered by the Department of Entomology.

Major nematode diseases of economically important plants, with emphasis on diagnostic symptoms, nematode biology and principles of control.

**499. Senior Seminar**

Winter. 1(1-0) May reenroll for a maximum of 3 credits. B S 212 and 1 course in botany or approval of department.

Reports by students, faculty, and guest lecturers, with emphasis on current developments in research.

**800. Special Problems in Taxonomy**

Fall, Winter, Spring, 1 to 15 credits. Approval of department.

**801. Special Problems in Anatomy and Morphology**

Fall, Winter, Spring, 1 to 15 credits. Approval of department.

**802. Special Problems in Pathology**

Fall, Winter, Spring, Summer, 1 to 15 credits. Approval of department.

**803. Special Problems in Physiology**

Fall, Winter, Spring, Summer, 1 to 15 credits. Approval of department.

**805. Special Problems in Mycology**

Fall, Winter, Spring, Summer, 1 to 15 credits. Approval of department.

**807. Special Problems in Algae**

Fall, Winter, Spring, Summer, 1 to 15 credits. Approval of department.

**809. Special Problems in Ecology**

Fall, Winter, Spring, Summer, 1 to 15 credits. Approval of department.

**812. Ecology of Plant Pathogens**

Winter of even-numbered years. 3(3-0) BOT 402, BOT 405; or approval of department.

Ecology and qualitative epidemiology of plant pathogens. Problems confronting pathogens in their environment and strategies for survival. Inoculum dispersal, inoculum potential, seasonal carry-over, influence of host exudates, influence of microbiota.

**813. Special Problems**

Fall, Winter, Spring, 1 to 4 credits. May reenroll for a maximum of 16 credits. Approval of department.

**816. Industrial Mycology**

Winter of odd-numbered years. 3(2-4) BOT 402 or approval of department.

Industrially important fungi, their uses and characteristics. Methods of commercial production, including acids, enzymes, cheeses, mushrooms, and antibiotics. Several field trips will be taken.

**823. Flowering Plant Diversity I**

Fall of odd-numbered years. 4(3-3) BOT 318; ZOL 441 recommended.

Evolutionary diversity of flowering plants. Family characteristics, patterns of geographic distribution and evolutionary trends. Contributions from classical and experimental systematics.

**824. Flowering Plant Diversity II**

Winter of even-numbered years. 4(3-3) BOT 823.

Continuation of BOT 823.

**826. Tropical Biology: An Ecological Approach**

Winter, Summer, 12 credits. Approval of department and acceptance by Organization of Tropical Studies. Interdepartmental with the Department of Zoology.

Principles of tropical ecology at the population, community and ecosystem levels. Given at various sites in Costa Rica by the Organization for Tropical Studies.

**830. Paleobotany**

Fall. 4(3-4) Approval of department. Interdepartmental with Geology.

Survey of fossil plants: their preservation, occurrence, geology, paleogeography, paleoecology, evolutionary history, classification and representative types. One weekend field trip to fossil plant locality.

**831. Palynology**

Spring. 4(3-4) Approval of department. Interdepartmental with and administered by the Department of Geology.

An introduction to the principles and techniques of spore and pollen analysis, both fossil and recent, and utilization of plant micro-fossils for stratigraphic determinations and paleoecologic interpretations of most sedimentary accumulations and rocks. Includes certain algae, protozoans, similar organisms of uncertain affinity and dissociated fragments of larger organisms.

**836. Advanced Mycology: Biology of the Phycomycetes**

Spring of even-numbered years. 3(3-0) BOT 402 and approval of department.

Selected topics on the biology of phycomycetous fungi.

Approved through Fall 1988.

**838. Advanced Paleobotany**

Winter. 3(2-4) Approval of department. Interdepartmental with Geology.

Morphology, anatomy, phylogenetic relationships and classification of fossil plants. Microscopic analysis of tissues and organs prepared by thin section, transfers, peels, polished and etched surfaces, and macerations.

**839. Population Ecology**

Summer. 4 credits. Approval of department. Given at W. K. Kellogg Biological Station. Interdepartmental with and administered by the Department of Zoology.

A field-experimental approach to the study of adaptations. Selected topics will deal with population growth, competition, predation, mutation, community structure and species abundance.

**842. Chromosome Structure and Genetics**

Winter of even-numbered years. 4(4-0) Introductory genetics course. Interdepartmental with Genetics and the department of Zoology. Administered by Genetics.

Mechanisms of mitosis and meiosis, classical and molecular genetics of chromosome structure, alterations in chromosome number and structure, transposable elements, meiotic drive.

**844. Plant Organelle Genetics**

(HRT 844.) Winter of odd-numbered years. 4(4-0) BOT 856, one introductory course in each of the following: genetics, cell biology and botany. Interdepartmental with Genetics.

Organization, structure, function, heredity, molecular biology and manipulation of chloroplasts and mitochondria. Biological interactions between the nucleus and organelles.

**846. Seminar in Plant Pathology**

Fall, Winter, Spring, 1(1-0) Approval of department.

**847. Mycology I**

Winter of odd-numbered years. 5(2-6) Approval of department.

Classification, morphology, and relationships of fungi identification.

**848. Mycology II**

Spring of odd-numbered years. 5(2-6) BOT 847 or approval of department.

Classification, morphology, and relationships of fungi. Identification techniques within selected orders.

**850. Agrostology**

Fall of even-numbered years. 3(1-4) One year of botany or approval of department.

Comprehensive treatment of the systematics, evolution, ecology, geography and economic significance of the grass family; including pertinent aspects of genetics, cytology, anatomy and physiology.

**851. Quantitative Methods in Ecology and Evolution**

Spring. 4(2-6) STT 423.

Methods for experimental and analytical study of ecological and evolutionary questions. Specific applications of quantitative techniques to field studies. Field trips required.

**852. Plant Population Ecology**

Fall of odd-numbered years. 4(4-0) BOT 450 or ZOL 389, STT 422, 1 term of calculus.

The dynamics, evolution, regulation, and distribution of plant populations; subject matter interfaces with plant genetics, plant systematics, and plant physiology.

**856. Plant Genetics and Molecular Biology**

Spring. 3(3-0) Approval of department and a course in introductory genetics. Interdepartmental with Genetics and the Department of Biochemistry.

Recent advances in genetics and molecular biology of higher plants.

**863. Advanced Environmental Physiology**

Winter. 3(3-0) BOT 413 or approval of department.

The plant in relation to its environment: energy exchange; coupling between CO<sub>2</sub> assimilation and transpiration; hydraulics in the stationary and nonstationary states; transport of ions, carbohydrates, and hormones; stress physiology.

- 864. Plant Biochemistry**  
Spring. 4(4-0) BCH 401, BOT 301 or approval of department. Interdepartmental with and administered by the Department of Biochemistry.  
Metabolism of nitrogen-compounds, carbohydrates, and lipids unique to plants' cell organelles; photosynthesis; photorespiration; dark respiration; cell walls; lectins; nitrogen cycle including nitrogen fixation; sulfur cycle.
- 865. Advanced Growth and Development**  
Fall. 3(3-0) BOT 415 or approval of department.  
Advanced treatment of the physiological processes of growth and development. The mechanism underlying these processes and the roles played by hormones, light, etc., in controlling them will be analyzed.
- 866. Cellular and Molecular Basis of Plant Development**  
Winter of even-numbered years. 3(3-0) Approval of instructor.  
Cellular and molecular basis of the control processes in differentiation of plants at the subcellular, cellular and organ levels. Development of stages in the life cycle of plants.
- 871. Biology of Nematodes**  
Spring of even-numbered years. 4(2-6) ENT 470 or approval of department. Interdepartmental with and administered by the Department of Entomology.  
Ontogeny, taxonomy, morphology, pathology and ecology of nematodes, with special reference to plant-parasitic and phytopathogenic species.
- 880. Plant Virology**  
Fall of odd-numbered years. 5(2-6) BOT 405 or approval of department.  
External and internal symptomatology, transmission, interactions, purifications, assay and serology of plant viruses.
- 881. Pathogenesis and Disease Resistance**  
Winter of odd-numbered years. 4(3-2) BOT 405 and BOT 415, or approval of department.  
Lectures, readings, and discussions on mechanisms of pathogenicity and infectivity; physiology and biochemistry of disease development; tumorigenesis; metabolic consequences of infection; nature of disease resistance; and parasitism.
- 884. Phytobacteriology**  
Spring of odd-numbered years. 5(3-4) BOT 405 or approval of instructor.  
Bacterial genera associated with plant diseases. Their description, identification, physiology, and genetics. Emphasis on laboratory techniques.
- 885. Plant Diseases in the Field**  
Spring. 4 credits. BOT 405 and approval of department.  
Diagnosis, distribution, and sequential development of plant diseases in the field. Field trips permit observation of diseases in the natural setting.
- 890. Selected Topics in Plant Pathology**  
Fall, Winter, Spring. 2 to 5 credits. Approval of department.  
Topics will be selected from the following areas: parasitism, plant viruses, ecology, genetics, nematology, fungicidal action, and soil microbiology.

- 891. Selected Topics in Botany**  
Fall, Winter, Spring. 2 to 5 credits. May reenroll for a maximum of 6 credits if different topics are taken. Approval of department.  
Topics may be selected from ecology, systematics, evolution, physiology, cytology, mycology, bryology, phycology, lichenology, anatomy, morphology, genetics, and others.
- 899. Master's Thesis Research**  
Fall, Winter, Spring, Summer. Variable credit. Approval of department.  
Research in anatomy, bryology, cytology, ecology, genetics, lichenology, morphology, mycology, paleobotany, pathology, phycology, physiology, and taxonomy.
- 930. Advanced Plant Ecology**  
Winter of odd-numbered years. 3(2-4) Approval of department.  
Fundamental theories and modern research horizons.
- 999. Doctoral Dissertation Research**  
Fall, Winter, Spring, Summer. Variable credit. Approval of department.  
Research in anatomy, bryology, cytology, ecology, genetics, lichenology, morphology, mycology, paleobotany, pathology, phycology, physiology, and taxonomy.

## BUILDING CONSTRUCTION MANAGEMENT

See Agricultural Engineering.

## CHEMICAL ENGINEERING CHE

### College of Engineering

- 300. Material and Energy Balances**  
Fall, Winter. 4(3-2) One year general chemistry, MTH 214 or concurrently, CPS 112 or concurrently.  
Chemical engineering calculations. Synthesis of chemical process systems. Analysis of chemical process systems by material and energy balances. Behavior of gases. Enthalpy calculations for changes of temperature, phase changes, chemical reactions.
- 311. Thermodynamics for Chemical Engineering**  
Winter, Spring. 3(3-0) CHE 300 or approval of department.  
First and second laws. Energy, enthalpy, entropy, free energy, the mathematics of property relationships. Energy conversion processes. Thermodynamics of flow.
- 340. Transfer Processes and Separations I**  
Fall. 3(2-2) CHE 300 or concurrently, CHE 381 or concurrently or approval of department.  
Thermodynamics of fluid flow. Treatment of fluid flow as a momentum transfer process. Laminar and turbulent motion of compressible and incompressible fluids. Design of flow systems.
- 341. Transfer Processes and Separations II**  
Winter. 3(2-2) CHE 340.  
Design of heat exchange equipment. Heat transfer in solids and flowing fluids. Multiple effect evaporation. Radiant heat exchange. Interphase transfer.
- 342. Transfer Processes and Separations III**  
Winter. 3(2-2) CHE 340.  
Design of stagewise separation processes. Absorption, distillation, extraction, flash calculations, multicomponent separations. Graphical, analytical, and numerical methods of solution. Stage design and efficiency. Utilization of computer-aided design software.
- 343. Transfer Processes and Separations IV**  
Spring. 3(2-2) CHE 341, CHE 342.  
Diffusion. Mass transfer coefficients. Design of continuous contacting systems. Counter-current processes. Fractionation. Contacting efficiency. Simultaneous momentum, heat, and mass transfer.
- 381. Chemical Engineering Analysis**  
Fall, Spring. 3(3-0) Students may not receive credit in both CHE 381 and MTH 341. MTH 310, CPS 112. Interdepartmental with the Department of Mathematics.  
Formulation of ordinary and partial differential equations describing chemical systems. Boundary value problems, numerical methods, matrices, and applications, to chemical engineering systems.
- 411. Phase and Chemical Equilibria**  
Spring. 3(3-0) CEM 361, CHE 311.  
Properties in solutions. Deviations from ideality. Liquid-vapor equilibria. Chemical equilibria in the gas, liquid, and solid states.
- 423. Chemical Engineering Laboratory**  
Fall, Summer. 3(1-6) CHE 428 concurrently, CHE 451 concurrently.  
Assigned laboratory problems, requiring team effort. Experimental work, involving momentum, heat and mass transfer; separation processes, such as distillation, filtration, and drying; reactor kinetics; automatic process control.
- 424. Transport Phenomena and Physical Properties Laboratory**  
Winter, Spring. 3(1-6) CHE 341, CHE 342 concurrently.  
Experiments involving the transport processes and measurement of physical, chemical and thermodynamic properties of various materials. Comparison of theoretical and experimental results.
- 428. Chemical Reaction Engineering**  
Fall. 4(4-0) CEM 361, CHE 311, CHE 343.  
Quantitative treatment of mechanisms and rates of chemical reactions. Catalysis. Design and analysis of flow and non-flow reactors. Heterogeneous catalysis.
- 442. Polymer Science and Engineering**  
Spring. 3(3-0) One year organic chemistry. CEM 361.  
Structure of polymers. Polymerization reaction kinetics. Polymer characterization. Solution rheology. Polymer processing and fabrication. Commercial polymerization processes.