

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.

810. Biokinematics
Fall. 3(3-0) Approval of department.
Motion of the human body including detailed studies of body joint and linkage motion.

811. Biokinetics
Winter. 3(3-0) BIM 810.
Application of Newtonian mechanics to problems of force transmission and related motions in the muscular-skeletal system.

812. Theory of Tissue Mechanics
Spring. 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.

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.

BIOPHYSICS BPY

**College of Human Medicine
College of Natural Science**

899. Master's Thesis Research
Fall, Winter, Spring, Summer. Variable credit. Approval of department.
Approved through Summer 1985.

990. Biophysics Seminar
Fall, Winter, Spring, Summer. 1 credit. May reenroll for a maximum of 3 credits. Approval of department.
Approved through Summer 1985.

999. Doctoral Dissertation Research
Fall, Winter, Spring, Summer. Variable credit. Approval of department.
Approved through Summer 1985.

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.

301. Introductory Plant Physiology
Winter, Spring. 4(2-4) CEM 141 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
Fall, Winter. 4(2-4) 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(2-3) BOT 302 or B S 212 or approval of department.
Plant diversity with emphasis on identification, classification, nomenclature, and evolutionary relationships of vascular plants.

335. Fossil Plants, Their History and Paleoecology
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
Spring. 3(3-0)
Histories, characteristics, and origins of plants used in industrial processes, drug manufacture, and agriculture. Nontechnical to broaden student's cultural interest in plants.

400. Aquatic Plants
Fall. 3(2-3) BOT 318 or BOT 302. Students may not receive credit in both BOT 400 and BOT 423.
Aquatic plants, their classification, ecology and economic importance. Relationships to problems in fisheries, in wildlife management, and to role in limnology. Experience for student in plant ecology, aquatic biology, and water sanitation.

Descriptions — Botany and Plant Pathology

of

Courses

400H. Honors Work

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

401. Special Problems

Fall, Winter, Spring, Summer. 1 to 4 credits. May reenroll for a maximum of 16 credits. BOT 302, Seniors, approval of department.

Students with special ability may carry on laboratory research or study of published literature on a selected topic.

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.

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.

408. Freshwater Ecology

Summer. 6 credits. B S 212 or approval of department. Given at W. K. Kellogg Biological Station. Interdepartmental with Biological Science and the Department of Zoology. Administered by Biological Science.

The ecology of freshwater ecosystems, their biotic structure, and the functional interrelationships of environmental variables regulating population dynamics, productivity and community structure. Extensive field investigations.

Approved through Spring 1985.

409. Plant Disease Control

(883.) Winter of odd-numbered years. 3(3-0) BOT 405.

Principals and methods in controlling plant diseases. Considerable emphasis is placed on the chemistry of fungicides, and their role in controlling plant diseases. Other factors affecting disease epidemiology are covered.

410. Terrestrial Ecology

Summer. 6 credits. B S 212 or approval of department. Given at W. K. Kellogg Biological Station. Interdepartmental with Biological Science and the Department of Zoology and administered by Biological Science.

Extensive field investigations of several types of terrestrial communities. Interrelationship of plants, animals, and environment. Factors determining distribution and abundance.

Approved through Spring 1985.

411. Systematic Botany

Summer. 4(2-6) B S 212 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

Fall. 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. 5(3-4) CEM 241; B S 210 or LBS 141 or BOT 205; BOT 301.

General principles underlying plant metabolic processes. Nutrient requirements, photosynthesis, translocation, respiration, nitrogen metabolism, and structures associated with these processes.

415. Plant Physiology: Growth and Development

Spring. Summer of even-numbered years. 5(3-4) BOT 414 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 biological clocks.

421. Field Studies of Freshwater Algae

Summer. 3 credits. Students may not receive credit in both BOT 421 and BOT 447. One year of botany or zoology or approval of department. Given at W. K. Kellogg Biological Station.

An ecological approach to the study of freshwater algae. Algal taxonomy, morphology, life histories and distribution. Emphasis on 'ecological indicator' groups. Extensive field collections. Methods of collection, preservation, and enumeration.

423. Introduction to Aquatic and Wetland Plants

Summer. 3 credits. Students may not receive credit in both BOT 423 and BOT 400. One year of botany 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. 6 credits. Students may not receive credit in both BOT 425 and BOT 411. One year of botany or approval of department. Given at W. K. Kellogg Biological Station.

Classification, evolution, distribution and biology of vascular plants. Emphasis on field-recognition, identification, collection, and research techniques. Numerous field trips to diverse habitats for common, rare, native, and introduced plants; 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.

434. Plant Anatomy

Fall. Summer of even-numbered years. 4(2-4) BOT 302.

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.

447. Fresh Water Algae

Spring. 4(2-4) One year botany or zoology. Primarily for students in Fisheries Biology, Wildlife Management and Sanitary Engineering. 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) BOT 318; BOT 301 or BOT 414.

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

470. Nematode Diseases of Economic Plants

Spring. 4(3-3) B S 212 or BOT 205. 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.

490. Special Topics in Plant Pathology

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 the following areas: genetics, parasitism, virology, disease control, phytobacteriology, nematology, epidemiology, physiology, soil microbiology, and others.

491. 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.

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.
- 806. Special Problems in Cytology and Genetics**
Fall, Winter, Spring. 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. Principles of Plant Disease Epidemiology**
Winter of even-numbered years. 3(4-0) BOT 402, BOT 405; or approval of department. Quantitative and qualitative analysis of pathogen, host, and environmental interactions at the individual and population level. Synthesis of these interactions into a quantitative description of the disease process.
- 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.
- 821. Ecology of Algae and Aquatic Plants**
Summer of odd-numbered years. 6 credits. BOT 400, BOT 447 or approval of department. Given at the W. K. Kellogg Biological Station. Physiology and ecology of freshwater phytoplankton, sessile algae, and aquatic plants. Emphasis on physiological adaptations, mineral nutrition, growth, population dynamics, community productivity, and control measures.
- 823. Plant Taxonomy I**
Fall of odd-numbered years. 4(3-3) BOT 318; ZOL 441 recommended. First course of a series on classification and relationships of vascular plants. Family characteristics, patterns, geographic distribution, and evolutionary trends are stressed. Contributions from classical taxonomy, cytotaxonomy and experimental taxonomy are discussed.
- 824. Plant Taxonomy II**
Winter of even-numbered years. 4(3-3) BOT 823. Second course of a series on classification and relationships of vascular plants.
- 825. Tropical Biology: An Ecological Approach**
Winter, Summer. 12 credits. Approval of department and acceptance by Organization for Tropical Studies. Interdepartmental with the Department of Zoology. An introduction in the field to the principles of ecology as they operate in the tropics, especially concerning the tropical environment and biota, ecologic relations, communities and evolution in the tropics. Given in Costa Rica by Organization for Tropical Studies.
- 828. Cytogenetics**
Winter of even-numbered years. 4(2-4) BOT 427 or ZOL 441 or approval of department. Detailed discussions of mitosis and meiosis; mechanisms of chromosome movement; fine structure of chromosomes and spindle apparatus; changes of chromosome number and structure and their genetic significance.
- 830. Paleobotany**
Fall. 4(3-4) Approval of department. Interdepartmental with the Department of 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.
- 835. Morphogenesis of Reproductive Structures**
Spring of even-numbered years. 4(2-4) BOT 434. Principles underlying the differentiation and growth of reproductive plant structures with special emphasis upon their functional and developmental genetic relationships.
- 836. Advanced Mycology: Biology of the Phycomyces**
Spring of even-numbered years. 3(3-0) BOT 402 and approval of department. Selected topics on the biology of phycomycetous fungi.
- 837. Advanced Mycology: Ascomycetes**
Fall of even-numbered years. 4(2-6) BOT 402. Morphological features and adaptations of the major groups of ascomycetous fungi and the imperfect fungi. Evolutionary trends and relationships with reference to recent classification schemes.
- 838. Advanced Paleobotany**
Winter. 3(2-4) Approval of department. Interdepartmental with the Department of 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 of even-numbered years. 3 credits. May reenroll for a maximum of 6 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.
- 841. Physiology of the Algae**
Fall of even-numbered years. 3(3-0) Approval of department. Physiology, chemistry, biochemistry, and aspects of the ultra-structure of the various algal divisions. Discussion of use of algae for the study of classical physiological and developmental problems.
- 844. Plant Organelle Genetics**
Winter of odd-numbered years. 3(3-0) Approval of department. Interdepartmental with Genetics and the departments of Crop and Soil Sciences, Forestry, and Horticulture. Administered by the Department of Horticulture. 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.
- 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.
- 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 of even-numbered years. 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 CO₂ 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.

Descriptions — Botany and Plant Pathology

of

Courses

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.

871. **Biology of Nematodes**
Spring. 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.

878. **Comparative Limnology**
(478.) Summer of odd-numbered years. 6 credits. Approval of department. Given at W. K. Kellogg Biological Station. Interdepartmental with and administered by the Department of Zoology.

Theoretical concepts and methods of analysis of environmental parameters influencing productivity of freshwaters. Comparative field investigations of lakes, streams, and other aquatic habitats.

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.

882. **Genetics of Host/Parasite Interactions**
Winter of even-numbered years. 3(3-0) ZOL 441, BOT 405.

Inheritance of resistance and susceptibility, virulence and avirulence; types of resistance, aggressiveness in parasites; use of genetics in studies of host/parasite interactions, practical application in disease control.

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 re-enroll 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.

920. **Advanced Plant Taxonomy**
Spring of even-numbered years. 4(4-0) BOT 824, ZOL 441.

Consideration of the recent scientific developments affecting plant classification.

930. **Advanced Plant Ecology**
Winter of odd-numbered years; Summer of even-numbered years. Given at W. K. Kellogg Biological Station summer term. 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.

342. **Transfer Processes and Separations III**
Winter. 3(2-2) CHE 340.

Design of stagewise separations. Binary and multicomponent distillation. Graphical and numerical methods of solution. Equilibrium stage design and efficiency. Control schemes. Computer aided design. Extraction.

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. 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**
Winter. 3(3-0) CEM 361, CHE 311 or concurrently.

Properties in solutions. Deviations from ideality. Liquid-vapor equilibria. Chemical equilibria in the gas, liquid, and solid states. Electrochemical and irreversible systems.

423. **Chemical Engineering Laboratory**
Fall, Summer. 3(1-6) CHE 307.

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 306.

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.

443. **Chemical Engineering of the Solid State**
Winter. 3(3-0) CEM 361.

Structure and properties of inorganic and organic solids. Relation of bond type and steric configuration to mechanical, electrical, thermal, optical properties. Macroscopic structure influence on physical properties. Surface phenomena. Applications.

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 120 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) MTH 215, CHE 300 or concurrently.

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.