

- 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.

**Descriptions — Chemical Engineering
of
Courses**

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.

451. Process Systems Control
Fall. 3(3-0) CHE 343, CHE 428 or concurrently.

Foundation of control theory for chemical processes. Integration of present and developing practice with modern theory.

460. Problems and Reports
Fall, Winter, Spring, Summer. 1 to 9 credits. Seniors, approval of department.
Library and laboratory investigations of problems relating to departmental research.

461. Process Selection and Optimization
Winter. 5(5-0) CHE 343, CHE 428.

Application of chemical engineering principles in design calculations. Selection of the optimum design for equipment, functional units, and for the overall process. Influence of design on capital investment, operating cost, product loss, and product quality.

462. Process Design
Spring. 3(1-6) CHE 461.

Integrated design of the complete chemical engineering process. Process engineering, project engineering, instrumentation, and layout.

465. Process Optimization Methods
Spring. 3(3-0) MTH 310. *Interdepartmental with Systems Science.*

Methods for determining optimum design and operating policies of systems of varying complexity. Includes classical methods, mathematical programming and modern methods. Flowsheet optimization with process simulation packages.

470. Theory of Nuclear Reactors
Winter. 3(3-0) PHY 289, MTH 310 or approval of department.

Theory and design of nuclear research and power reactors. Nuclear transformation, fission, and energy conversion. Derivation of chain reaction design criteria, and calculation of flux-power distribution. Analysis of reactor safety, reliability and economics.

481. Transport Phenomena
Spring. 3(3-0) CHE 342, CHE 381.

Fundamental treatment of momentum, energy and mass transport. Use of partial differential equations and equations of change for chemical engineering applications. Analogies among the phenomena, dimensional analysis, and boundary layer theory.

801. Advanced Chemical Engineering Calculations I
Fall. 3(3-0) CHE 381.

Chemical engineering applications of advanced mathematical methods. Formulation and solution of mathematical equations which describe physical problems. Computer solutions.

802. Advanced Chemical Engineering Calculations II
Winter. 3(3-0) CHE 801.

Continuation of CHE 801.

806. Thermodynamics and Kinetics in Chemical Engineering

Summer. 5(7-0) B.S. with a major in chemistry, biochemistry, or a closely allied area. *Mathematics through calculus. College level physics. General physical, and organic chemistry. Not open to students with B.S. in chemical engineering for graduate credit.*

Mass and energy balances in batch continuous and open systems. Process thermodynamics. Cryogenics. Properties of substances and mixtures. Phase equilibria. Chemical reaction equilibrium. Chemical reactor kinetics. Process design orientation.

807. Transfer and Separation Processes

Summer. 5(7-0) B.S. with a major in chemistry, biochemistry, or a closely allied area. *Mathematics through calculus. College level physics. General physical, and organic chemistry. Not open to students with B.S. in chemical engineering for graduate credit.*

Momentum, energy, and mass transfer. Laminar and turbulent flow. Fluid friction. Dimensional analysis. Heat through stationary and flowing materials. Interchangers. Condensation. Boiling. Binary and multicomponent distillation, absorption, extraction.

811. Advanced Chemical Engineering Thermodynamics I

Fall. 3(3-0) CHE 311, CHE 411. CEM 361.

Advanced treatment of the laws of thermodynamics. Cryogenic processes. Corresponding state and higher parameters in computing properties of chemical compounds and solutions.

817. Advanced Chemical Reaction Engineering I

Spring. 3(3-0) CHE 428.

Treatment of absorption and catalysis and their application to catalytic reactors. Heat, momentum, and mass-transfer in fixed-bed and fluidized-bed reactors. Noncatalytic heterogeneous reactions. Homogeneous chain reactions and free radical mechanisms. Computer applications to solution of complex kinetic problems.

826. Flow of Heat I

Spring. 3(3-0) CHE 343.

Steady and unsteady state heat transfer. Conduction and convection in flow and non-flow systems.

831. Advanced Distillation

Winter. 3(3-0) CHE 343.

Stagewise calculation in distillation processes. Computer techniques. Batch, continuous, binary and multi-component calculations. Tray hydrodynamics and efficiency. Process control and energy integration.

832. Advanced Absorption and Extraction

Spring. 3(3-0) CHE 343.

Mass transfer in absorption and extraction processes. Continuous and stagewise phase contactors. Column hydrodynamics and plate efficiency. Design and control principles.

850. Fluid Flow and Rheology

Fall. 3(3-0) CHE 481 or approval of department.

Application of fluid dynamics to chemical engineering systems. Balance principles for fluids; Newtonian and non-Newtonian behavior; theory and practice of laminar and turbulent flows; stability.

851. Mass Transfer
Winter. 3(3-0) CHE 850.

Formulation of component material balances; Fick's first and second laws; convective mass transfer; multicomponent fluxes; boundary layer theory and interfacial mass transfer for laminar and turbulent flows.

881. Seminar

Fall, Winter, Spring. 1(0-2) May reenroll for a maximum of 6 credits.

Detailed library investigation of one or more specialized aspects of chemical engineering, such as recent theoretical developments in one of the unit operations; presentations of these studies to a seminar group. Participation generally required each term of residence.

886. Selected Topics in Chemical Engineering

Fall, Winter, Spring, Summer. 3(3-0) May reenroll for a maximum of 9 credits if a different topic is taken.

A newly developing area of chemical engineering selected by the department for offering each term. Information on the specific topic to be covered should be obtained from the department office before registration.

893. Special Problems

Fall, Winter, Spring, Summer. 3(3-0) May reenroll for a maximum of 9 credits. Approval of department.

899. Master's Thesis Research

Fall, Winter, Spring, Summer. Variable credit. Approval of department.

912. Advanced Chemical Engineering Thermodynamics II

Spring of even-numbered years. 3(3-0) Approval of department.

Relation of thermodynamics to quantum theory and statistical mechanics. Computation of chemical engineering thermodynamic data from spectral measurements. Irreversible thermodynamics.

918. Advanced Chemical Reaction Engineering II

Fall of odd-numbered years. 3(3-0) Approval of department.

Quantitative treatment of current literature in chemical kinetics and reaction engineering.

999. Doctoral Dissertation Research

Fall, Winter, Spring, Summer. Variable credit. Approval of department.

CHEMISTRY

CEM

College of Natural Science

Credit cannot be earned in more than one course of each of the following groups: 141A and 141B and 151; 143, 241, and 351; 142 and 153; 242 and 352; 243 and 354; 244 and 355; 245 and 353; 361 and 383; 363 and 385; 384 and 461.

With department approval, students with advanced placement credit in CEM 151 and 161 may enroll in CEM 181H and 184H. Those with advanced placement credit in CEM 152 may enroll in CEM 182H, and those with advanced placement credit in CEM 153 may enroll in CEM 183H. CEM 181H-182H-183H is a more advanced treatment of material in CEM 151-152-153. CEM 184H-185H-186H is a more advanced treatment of material in CEM 161-162-163. Students with credit in an honors chemistry course may not enroll in the corresponding nonhonors course.