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.

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, entrophy, 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.

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.

139. Selected Topics in Introductory Chemistry
Fall, Winter, Spring, Summer. 1 to 3 credits. May reenroll for a maximum of 7 credits. Previous college chemistry, approval of department.
Self-instructional units from CEM 140, CEM 141A, CEM 141B (or equivalent) selected and approved by the department for individual students with special needs.

140. Introductory Chemistry
Fall, Winter, Spring, Summer. 2 credits. Self-scheduled instruction only. MTH 108 or MTH 111 or concurrently.
Chemical symbols, formulas, equations, stoichiometry, structure of atoms, bonding, states of matter, solutions.

141A. Chemical Principles
Fall, Winter, Spring, Summer. Fall 4(4-0); Winter, Spring, Summer: 4 credits. Self-scheduled instruction only. MTH 108 or MTH 111 or concurrently; CEM 140 or satisfactory chemistry placement test score.
Chemical principles for students in the physical sciences and engineering.

141B. Chemical Principles
Fall, Winter, Spring, Summer. Fall 4(4-0); Winter, Spring, Summer: 4 credits. Self-scheduled instruction only. MTH 108 or MTH 111 or concurrently; CEM 140 or satisfactory chemistry placement test score.
Chemical principles for students in biological, health-related, and agricultural disciplines.

142. Descriptive Inorganic Chemistry
Winter, Spring. 3(3-0) CEM 141A or CEM 141B or CEM 152.
Reactions and behavior of inorganic compounds illustrated in part by industrial and environmental applications.

143. Introductory Organic Chemistry
Fall, Spring, Summer. 4(3-3) CEM 141A or CEM 141B or CEM 152.
Chemistry of carbon compounds. The chemistry of the main organic functional groups is described and illustrated with applications to everyday life, industry and biology. The laboratory is designed to exemplify the lectures.

151. Principles of Chemistry I
Fall, Winter. 4(4-0) MTH 108 or MTH 111 or concurrently; CEM 140 or satisfactory chemistry placement test score.
First of a 3-term sequence for science majors, chemical engineering students, and others desiring a comprehensive general chemistry sequence. Atomic and molecular structure; stoichiometry; solids, liquids, and gases; solutions.

152. Principles of Chemistry II
Winter, Spring. 3(3-0) MTH 112 or concurrently; CEM 151 or CEM 141A or CEM 141B or CEM 181H.
Continuation of CEM 151. Chemical thermodynamics; kinetics, acids, bases, and aqueous equilibria; electrochemistry.

153. Introductory Inorganic Chemistry
Fall, Spring. 3(3-0) CEM 152 or CEM 182H.
Continuation of CEM 152. Descriptive inorganic chemistry with further discussion of bonding.

161. Introductory Chemistry Laboratory
Fall, Winter, Spring, Summer. 1(0-3) CEM 140 or CEM 141A or CEM 141B or CEM 151 or concurrently.
Laboratory work in chemistry, including quantitative physiochemical or analytical experiments and chemical synthesis.

162. Quantitative Analysis
Fall, Winter, Spring, Summer. 3(1-6) CEM 141A or CEM 141B or CEM 151 or CEM 181H; CEM 161 or CEM 184H.
Laboratory work in quantitative chemistry.

163. Introductory Inorganic Laboratory
Spring. 2(0-6) CEM 142 or CEM 153 or concurrently; CEM 161.
Qualitative analysis and inorganic preparations.

181H. Honors Chemistry I—Principles
Fall. 4(4-0) An A average in high school chemistry, physics and mathematics; MTH 112 or MTH 122 concurrently. Results of examination during orientation; approval of department.
Subatomic, atomic and molecular structure; quantum theory and bonding; experimental methods of structure determination; states of matter; nuclear chemistry.