

# CHEMICAL ENGINEERING

## Courses

### **CME 101. Introduction to Chemical Engineering. 0-1 Hours**

Introduction to the chemical engineering faculty, facilities, and curriculum; survey of career opportunities in chemical engineering. Introduction to the University first-year experience.

### **CME 198. Research & Innovation Laboratory. 1-6 Hours**

Students participate in (1) selection and design, (2) investigation and data collection, (3) analysis and (4) presentation of a research project. Research can include, but is not limited to, developing an experiment, collecting and analysing data, surveying and evaluating literature, developing new tools and techniques including software, and surveying, brainstorming and evaluating engineering solutions and engineering designs. Proposals from teams of students will be considered.

### **CME 200. Professional Development Seminar. 0-1 Hours**

Presentations on contemporary and professional engineering subjects by students, faculty, and engineers in active practice. The seminar addresses topics in key areas that complement traditional courses and prepare distinctive graduates, ready for life and work. Registration required for all sophomore students.

### **CME 203. Material & Energy Balances. 3 Hours**

Introductory course on the application of mass and energy conservation laws to solve problems typically encountered in chemical process industries. Prerequisite(s): CHM 123; MTH 138 or 168. Corequisite(s): CME 211.

### **CME 211. Introduction to Thermodynamics for Chemical Engineers. 3 Hours**

First law of thermodynamics, states of matter, equations of state, open and closed system energy balances, reactive energy balances, entropy, 2nd law of thermodynamics, introduction to power cycles and refrigeration. Prerequisite(s): PHY 206; CHM 123; MTH 138 or 168.

### **CME 281. Chemical Engineering Computations. 3 Hours**

Development of computational skills with an emphasis on algorithm development and problem solving. Computational skills are applied to typical problems in chemical engineering, data analysis, numerical methods. Corequisite(s): CME 203, MTH 169.

### **CME 298. Research & Innovation Laboratory. 1-6 Hours**

Students participate in (1) selection and design, (2) investigation and data collection, (3) analysis and (4) presentation of a research project. Research can include, but is not limited to, developing an experiment, collecting and analyzing data, surveying and evaluating literature, developing new tools and techniques including software, and surveying, brainstorming and evaluating engineering solutions and engineering designs. Proposals from teams of students will be considered.

### **CME 306. Chemical Reaction Kinetics & Engineering. 3 Hours**

Chemical reaction kinetics, ideal reactor analysis and design, multiple reactor/reaction systems, and heterogeneous catalysis. Prerequisite(s): CME 311. Corequisite(s): CME 324.

### **CME 311. Chemical Engineering Thermodynamics. 3 Hours**

Development and application of the fundamental principles of chemical thermodynamics: Vapor/liquid equilibrium, solution thermodynamics, chemical reaction equilibria, and thermodynamic analysis of chemical engineering processes. Prerequisite(s): CME 203; CME 211; MTH 218.

### **CME 324. Transport Phenomena I. 3 Hours**

Viscosity, shell momentum balances, isothermal equations of change, thermal conductivity, shell energy balances, non-isothermal equations of change, mass diffusivity, shell species mass balances, equations of change for multicomponent systems. Prerequisite(s): CME 203, CME 281; MTH 219. Corequisite(s): CME 381.

### **CME 325. Transport Phenomena II. 3 Hours**

Multidimensional momentum, energy, and mass transport, dimensionless parameters, turbulence and numerical solution methods. Prerequisite(s): CME 324, CME 381.

### **CME 326L. Transport Phenomena Laboratory. 1-2 Hours**

Viscosity, conductivity, diffusion coefficient measurements, velocity, temperature, concentration profiles, engineering instrumentation, and experimental error analysis. Prerequisite(s): CHM 124L; CME 324. Corequisite(s): CME 325.

### **CME 365. Separation Techniques. 3 Hours**

Equilibrium staged separations: distillation, extraction and absorption, with an emphasis on distillation. Prerequisite(s): CME 311, CME 324.

### **CME 381. Advanced Mathematics for Chemical Engineers. 3 Hours**

Study of analytical and numerical techniques applied to engineering topics to support upper-level chemical engineering classes. Topics include matrices, numerical differentiation, solving ordinary and partial differential equations numerically, curve fitting, probability and statistics, and optimization. Prerequisite(s): CME 281; MTH 219.

### **CME 398. Research & Innovation Laboratory. 1-6 Hours**

Students participate in (1) selection and design, (2) investigation and data collection, (3) analysis and (4) presentation of a research project. Research can include, but is not limited to, developing an experiment, collecting and analyzing data, surveying and evaluating literature, developing new tools and techniques including software, and surveying, brainstorming and evaluating engineering solutions and engineering designs. Proposals from teams of students will be considered.

### **CME 408. Seminar. 0-1 Hours**

Presentation of lectures on contemporary chemical engineering subjects by students, faculty, and engineers in active practice. Registration required of senior students only. Corequisite(s): CME 430.

### **CME 409. Introduction to Polymer Science - Thermoplastics. 3 Hours**

Broad technical overview of the nature of synthetic macromolecules, including the formation of polymers and their structure, structure-property relationships, polymer characterization and processing, and applications of polymers. Fundamental topics such as viscoelasticity, the glassy state, time-temperature superposition, polymer transitions, and free volume will also be reviewed. The course focuses on thermoplastic polymers. Prerequisite(s): CHM 313, PHY 206, MTH 219.

### **CME 410. High Performance Thermoset Polymers. 3 Hours**

Survey of high performance thermoset resins, focusing on chemistry, processing and properties of six general resin families; vinyl ester, epoxy, phenolic, cyanate ester, bismaleimide, and polyimides. The course will include fundamental discussions of polymerization mechanisms, network structure development, rheology and time-temperature transformation, resin toughening, and structure-processing-property relationships. Characterization techniques will also be reviewed. Prerequisite(s): CHM 313.

**CME 412. Advanced Composites. 3 Hours**

Materials and processing. Comprehensive introduction to advanced fiber reinforced polymeric matrix composites. Constituent materials and composite processing will be emphasized with special emphasis placed on structure-property relationships, the role of matrix in composite processing, mechanical behavior, and laminate processing. Specific topics will include starting materials, material forms, processing, quality assurance, test, methods, and mechanical behavior. Prerequisite(s): (CME 409 or CME 509 or MAT 501) or permission of instructor.

**CME 429. Computational Chemistry. 3 Hours**

Introduction to computational chemistry including a discussion of ab initio, semiempirical, and DFT methods and an overview of molecular mechanics and molecular simulation methods. Lectures are supplemented by simulation exercises using commercial programs such as Gaussian and Molecular Studio. Prerequisite(s): CHM 124 or permission of instructor.

**CME 430. Chemical Engineering Design I. 3 Hours**

Study of basic design concepts, safety and health issues, capital cost estimation, manufacturing cost estimation, basic economics and profitability analysis, materials of construction, materials selection and process vessel design. Prerequisite(s): CME 203; CME 306. Corequisite(s): CME 465.

**CME 431. Chemical Engineering Design II. 3 Hours**

Project-based study of principles of process design and economics, use of process flowsheet simulators, short-cut design procedures, process optimization, and plant layout. Prerequisite(s): CME 306, CME 365, CME 430, CME 465.

**CME 432. Chemical Product Design. 3 Hours**

Application of the design process to products based on chemical technology. Coverage of the entire design process from initial identification of product needs, to the generation and selection of product ideas, and culminating in the manufacture of a new product.

**CME 452. Process Control. 3 Hours**

Mathematical models, Laplace transform techniques, and process dynamics. Feedback control systems, hardware, and instrumentation. Introduction to frequency response, advanced techniques, and digital control systems. Prerequisite(s): CME 381. Corequisite(s): CME 306.

**CME 453L. Process Control Laboratory. 2 Hours**

Team-based, project oriented study of process dynamics and digital control using computer-based data acquisition and control systems with a focus on real time process monitoring and control. Prerequisite(s): (CME 452, CME 466L) or permission of instructor.

**CME 465. Fluid Flow & Heat Transfer Processes. 3 Hours**

Fluid mechanics, transportation and metering of fluids, heat transfer and its applications. Prerequisite(s): CME 311, CME 324.

**CME 466L. Chemical Engineering Unit Operations Laboratory. 2 Hours**

Study of the equipment and utilization of various chemical engineering processes. Team based experimentation includes designing, and performing experiments on common chemical process unit operations apparatuses. After experimentation, students analyze data and compare with literature for experiment validation. Report writing and group presentations are emphasized. Prerequisite(s): CME 365. Corequisite(s): CME 465.

**CME 486. Introduction to Petroleum Engineering. 3 Hours**

Introduction to the fundamental concepts in petroleum engineering. Petroleum topics include overviews of areas such as petroleum geology, petroleum fluids and thermodynamics, drilling and completion, and production and multiphase flow. In addition this course will cover refinery operations.

**CME 489. Principles of Biology for Bioengineers. 3 Hours**

This course is designed for students with undergraduate majors in engineering or non-biological sciences. The focus of the course is to provide a common broad base of basic knowledge and terminology in the biological sciences required for coursework in the bioengineering emphasis tracts. Prerequisite(s): (BIO 151, BIO 152) or permission of instructor.

**CME 490. Introduction to Bioengineering. 3 Hours**

This class provides an introduction to bioengineering - a branch of engineering focusing on biological systems, biomaterials, engineering applications in living systems, and many other areas. By the end of this course, students will be able to understand bioengineering applications and processes, and properly apply engineering fundamentals, including transport phenomena and reaction kinetics, to these systems. Prerequisite(s): ((BIO 151 or BIO 152); (CME 324 or MEE 308)) or permission of instructor.

**CME 491. Biomedical Engineering I. 3 Hours**

Introduction to the fundamental concepts in biomedical engineering with a special focus on chemical engineering applications. Biomedical topics include overviews of areas such as biomaterials, tissue engineering, biosensors and biomedical engineering technology. Prerequisite(s): ((BIO 151 or BIO 152); CME 324) or permission of instructor.

**CME 492. Chemical Sensors & Biosensors. 3 Hours**

Analysis performed with chemical sensors complement laboratory analyses and offer the potential for more rapid and on-line analyses in complex sample matrices. The demand for new chemical sensors, biosensors, and sensing concepts is rapidly increasing and associated with the growing need to understand and/or control complex chemical and biochemical processes or detect the presence of toxic chemical or biological agents. Prerequisite(s): Permission of instructor.

**CME 493. Honors Thesis. 3 Hours**

Selection, design, investigation, and completion of an independent, original research study resulting in a document prepared for submission as a potential publication and a completed undergraduate thesis. Restricted to students in University Honors Program.

**CME 494. Honors Thesis. 3 Hours**

Selection, design, investigation, and completion of an independent, original research study resulting in a document prepared for submission as a potential publication and a completed undergraduate thesis. Restricted to students in University Honors Program. Prerequisite(s): CME 493.

**CME 498. Research & Innovation Laboratory. 1-6 Hours**

Students participate in (1) selection and design, (2) investigation and data collection, (3) analysis and (4) presentation of a research project. Research can include, but is not limited to, developing an experiment, collecting and analyzing data, surveying and evaluating literature, developing new tools and techniques including software, and surveying, brainstorming and evaluating engineering solutions and engineering designs. Proposals from teams of students will be considered.

**CME 499. Special Problems in Chemical Engineering. 0-6 Hours**

Particular assignments to be arranged and approved by chairperson of the department.

**CME 507. Advanced Thermodynamics. 3 Hours**

Entropy balance. Thermodynamics of energy conversion. Mixtures. Equilibria. Current applications.

**CME 508. Advanced Topics in Chemical Engineering. 3 Hours**

Advanced Topics in Chemical Engineering.

**CME 509. Introduction to Polymer Science - Thermoplastics. 3 Hours**

Broad technical overview of the nature of synthetic macromolecules, including the formation of polymers and their structure, structure-property relationships, polymer characterization and processing, and applications of polymers. Fundamental topics such as viscoelasticity, the glassy state, time-temperature superposition, polymer transitions, and free volume will also be reviewed. The course focuses on thermoplastic polymers. Prerequisite(s): Organic chemistry; College Physics, Differential Equations.

**CME 510. High Performance Thermoset Polymers. 3 Hours**

Survey of high performance thermosetting resins, focusing on chemistry, processing and properties of six general resin families; vinyl ester, epoxy phenolic, cyanate ester, bismaleimide and polyimides. The course will include fundamental discussions of polymerization mechanisms, network structure development, rheology and time-temperature transformation, resin toughening, and structure processing property relationships. Characterization techniques will also be reviewed. Prerequisite(s): Organic Chemistry.

**CME 511. Principles of Corrosion. 3 Hours**

Theoretical and practical application of electrochemical principles to the field of corrosion covering thermodynamics, kinetics, forms of corrosion and methods for characterizing and controlling corrosion in areas of biomedical engineering, aerospace, automotive, and marine environments. Prerequisite(s): MAT 501.

**CME 512. Advanced Composites. 3 Hours**

Materials and processing. Comprehensive introduction to advanced fiber reinforced polymeric matrix composites. Constituent materials and composite processing will be emphasized with special emphasis placed on structure-property relationships, the role of matrix in composite processing, mechanical behavior and laminate processing. Specific topics will include starting materials, material forms, processing, quality assurance, test methods, and mechanical behavior. Prerequisite(s): Permission of instructor.

**CME 515. Statistics in Thermodynamics. 3 Hours**

Statistics in Thermodynamics.

**CME 521. Advanced Transport Phenomena. 3 Hours**

Applications of the principles of momentum, heat and mass transfer to steady state and transient problems. Molecular concepts. Transport in turbulent flow. Boundary layer theory. Numerical applications. Prerequisite(s): CME 324, CME 381 or equivalent.

**CME 522. Advanced Topics in Transport Phenomena. 3 Hours**

The equations of change for multicomponent systems. Turbulent mass transport. Interphase transport in multicomponent systems. Combustion analysis. Macroscopic balances. Prerequisite(s): CME 325, CME 581, or equivalent.

**CME 523. Transport Phenomena in Biological Systems. 3 Hours**

An integrated interdisciplinary systems-based examination of biological transport phenomena (momentum, heat and mass) and hemodynamics through mathematical modeling and biological processes as applied to physiological systems, with a focus on the cardiovascular, respiratory, and renal systems. Prerequisite(s): (BIE 503 or BIE 505; BIO 151, BIO 152; MTH 218) or permission of instructor.

**CME 524. Electrochemical Power. 3 Hours**

The course will cover fundamental as well as engineering aspects of fuel cell technology. Specifically, the course will cover basic principles of electrochemistry, electrical conductivity (electronic and ionic) of solids, and development/design of major fuel cells (alkaline, polymer electrolyte, phosphoric acid, molten carbonate, and solid oxide). A major part of the course will focus on solid oxide fuel cells (SOFC), as it is emerging to be dominant among various fuel cell technologies. The SOFC can readily and safely use many common hydrocarbon fuels such as natural gas, diesel, gasoline, alcohol, and coal gas. Prerequisite(s): CME 311, CME 324, or permission of instructor.

**CME 527. Methods of Polymer Analysis. 3 Hours**

Modern laboratory techniques used in preparation and characterization of polymers; experimental investigations of polymer structure-property relations; measurement of molecular weight averages and distributions, thermal and mechanical properties, viscoelastic and rheological properties; transitions and crystallinity. Prerequisite(s): CME 509, CME 510 or consent of instructor.

**CME 528. Chemical Behavior of Materials. 3 Hours**

This course will address chemical behavior as a subject complementary to mechanical behavior of materials. A special emphasis will be given to structure-property relationships of the major classes of materials. Physical/chemical periodicity, bonding, processing chemistry, and chemical behavior in the application environment will be addressed. Each major class of materials will be discussed with specific case studies for each. Prerequisite(s): College chemistry or permission of the instructor.

**CME 529. Computational Chemistry. 3 Hours**

Introduction to computational chemistry including a discussion of ab initio, semiempirical, and DFT methods and an overview of molecular mechanics and molecular simulation methods. Lectures are supplemented by simulation exercises using commercial programs such as Gaussiari and Molecular Studio. Prerequisite(s): CHM124, or consent of instructor.

**CME 530. Biomaterials. 3 Hours**

The course introduces students with engineering materials used in dentistry, manufacture of surgical devices, prosthetics, and repair of tissues. Topics include bonding and atomic arrangement in materials, material selection, testing, and characterization, biocompatibility, tissue response to materials, and failure analysis. A spectrum of materials including metals, polymers, ceramics, and composites used in biomedical applications will be considered.

**CME 532. Chemical Product Design. 3 Hours**

Application of the design process to products based on chemical technology. Coverage of the entire design process from initial identification of product ideas, and culminating in the manufacture of a new product. Prerequisite(s): CME 311 and CME 324 or consent of instructor.

**CME 533. Biofuel. 3 Hours**

The course will provide an overview of the range of fuels derived from biological materials and processes, with a focus on anaerobic digestion, bioethanol and biodiesel, and production of synthetic fuel from biological materials. The course will include an overview of the biochemistry of energy production in biological systems, discussions of the economics and environmental sustainability of biofuels, and a review of reactor and separation systems concepts relevant to biofuel production. Prerequisite(s) EGR 202, CHM 123, or consent of instructor.

**CME 541. Process Dynamics. 3 Hours**

Mathematical modeling and computer simulation of process dynamics and control for chemical engineering processes.

**CME 542. Chemical Engineering Kinetics. 3 Hours**

Reaction kinetics. Heterogeneous catalytic reactions. Transport processes with fluid-solid heterogeneous reactions. Noncatalytic gas-solid reactions. Catalyst deactivation. Gas-liquid reactions. Prerequisite(s): CME 381, CME 306, or equivalent.

**CME 543. Chemical Reactor Analysis & Design. 3 Hours**

Design for optimum selectivity. Stability and transient behavior of the mixed flow reactor. Nonideal flow and balance models. Fixed and fluidized bed reactors. Multiphase flow reactors. Prerequisite(s): CME 381, CME 306, or equivalent.

**CME 550. Agitation. 3 Hours**

Agitator design and scaleup for blending and motion, solids suspension, gas dispersion, and viscous operations; experimental, computational, and design tools of agitation; static mixing; and mixing with chemical reaction. Prerequisite(s): CME 465 or permission of instructor.

**CME 560. Biological Processing of Wastewater. 3 Hours**

Measuring the characteristics of wastewater produced from domestic and industrial sources. Principles of designing and operating microbiological processes for the treatment of wastewater. Mechanisms and kinetics of biological reactions emphasized. Prerequisite(s): CHM 124.

**CME 562. Physical & Chemical Wastewater Treatment Processes. 3 Hours**

Designing of physical and chemical unit processes to treat wastewater originating primarily from industrial sources. Industry pretreatment technologies and the basis for their development. Prerequisite(s): CHM 123; CME 465, or permission of instructor.

**CME 563. Hazardous Waste Engineering. 3 Hours**

The fundamental principles of the design and operation of hazardous waste remediation processes. Characterizing contaminated sites and conducting treatability studies to select remediation strategies. Prerequisite(s): CHM 123; CME 465, or permission of instructor.

**CME 564. Solid Waste Engineering. 3 Hours**

Solid Waste Engineering.

**CME 565. Fundamentals of Combustion. 3 Hours**

Flames and combustion waves, detonation waves in gases, the chemistry of combustion, combustion of hydrocarbons, special aspects of gaseous combustion, combustion in mixed and condensed phases, explosions in closed vessels, and combustion and the environment. Prerequisite(s): CME 311, CME 306, or permission of instructor.

**CME 566. Advanced Separations. 3 Hours**

Azeotropic separations, complex column design, batch distillation, introduction to surface science, adsorptive separations, membrane separations, introduction to biological separations.

**CME 574. Fundamentals of Air Pollution I. 3 Hours**

Air pollution; combustion fundamentals; pollutant formation and control in combustion; pollutant formation and control methods in internal combustion engines; particle formation in combustion. Prerequisite(s): (CME 311 or MEE 301, MEE 302); (CME 324 or MEE 410), or permission of instructor.

**CME 575. Fundamentals of Air Pollution Engineering II. 3 Hours**

Review of the concepts of air pollution engineering; aerosols; removal of particles from gas streams; removal of gaseous pollutants from effluent streams; optimal air pollution control strategies. Prerequisite(s): CME 574 or permission of instructor.

**CME 576. Environmental Engineering Separation Processes. 3 Hours**

No description available.

**CME 579. Materials for Advanced Energy Applications. 3 Hours**

Successful long-term application of many advanced energy technologies is ultimately based on the utilization of materials in 'real world' environmental conditions. The physical/mechanical properties and application of various materials (i.e. superalloys, refractory metal alloys, ceramics) being employed in advanced energy applications are discussed. Several advanced energy technologies (i.e. fuel cells, nuclear energy, and others) are covered with emphasis on how the selection of advanced materials enhances their commercial application. Prerequisite(s): (MAT 501, MAT 502) or permission of instructor.

**CME 580. Polymer Decomposition, Degradation & Durability. 3 Hours**

An in-depth study of the mechanisms leading to polymer decomposition and degradation, as well as methods for analyzing and preventing or minimizing these processes and thereby improving polymer durability. Topics include thermal/pyrolytic, thermo-oxidative, hydrolysis, photo/UV/weathering, flammability, mechanical, and degradation in earth orbit. Prerequisite(s): CME 509 / MAT 509 or CME 510 / MAT 510.

**CME 581. Advanced Chemical Engineering Calculations I. 3 Hours**

Applications of ordinary and partial differential equations to engineering problems. Classical methods of solution. Prerequisite(s): MTH 219 or permission of instructor.

**CME 582. Advanced Chemical Engineering Calculations II. 3 Hours**

Analyses and solutions of engineering problems described by differential equations. Numerical methods of solution.

**CME 583. Process Modeling. 3 Hours**

No description available.

**CME 586. Introduction to Petroleum Engineering. 3 Hours**

Introduction to the fundamental concepts in petroleum engineering. Petroleum topics include overviews of areas such as petroleum geology, petroleum fluids and thermodynamics, drilling and completion, and production and multiphase flow. In addition this course will cover refinery operations. Second term, each year. Prerequisite(s): Permission of instructor.

**CME 590. Introduction to Bioengineering. 3 Hours**

This class provides an introduction to bioengineering - a branch of engineering focusing on biological systems, biomaterials, engineering applications in living systems, and many other areas. By the end of this course, students will be able to understand bioengineering applications and processes, and properly apply engineering fundamentals, including transport phenomena and reaction kinetics, to these systems. Prerequisite(s): BIO 151, CME 324 or MEE 308 or permission of instructor.

**CME 591. Biomedical Engineering I. 3 Hours**

Introduction to the fundamental concepts in biomedical engineering with a special focus on chemical engineering applications. Biomedical topics include overviews of areas such as biomaterials, tissue engineering, biosensors and biomedical engineering technology. Second term, each year. Prerequisite(s): BIO 151 and CME 324, or BIE 501 or permission of instructor.

**CME 592. Chemical Sensors & Biosensors. 3 Hours**

Analysis performed with chemical sensors complement laboratory analysis and offer the potential of more rapid and on-line analysis in complex sample matrices. The demand for new chemical sensors, biosensors and sensing concepts is rapidly increasing and associated with the growing need to understand and/or control complex chemical and biochemical processes or detect the presence of toxic chemical or biological agents. Prerequisite(s): Permission of instructor.

**CME 595. Special Problems in Chemical Engineering. 1-6 Hours**

Special assignments in Chemical Engineering to be arranged and approved by the advisor and the program director.

**CME 597. Research Methods. 3 Hours**

This course will provide students the ability to apply research methods and problem solving skills to identify and define a research problem, develop hypotheses and research plans to test those hypotheses.

Students will write and present an original research proposal.

**CME 599. Thesis. 3-6 Hours**

Chemical Engineering Thesis.