Chemical Engineering

Kevin Gillis, Interim Chair
Department of Biomedical, Biological, & Chemical Engineering
W2033A Lafferre Hall
(573) 882-4877
gillisk@missouri.edu
https://engineering.missouri.edu/academics/bbce/

Chemical Engineering at the University of Missouri focuses on education and research involving industrial chemicals, materials, environmental, and life-science processes. We aim to be a reservoir of talent for the research, design, and management of complex process challenges. The Department strives to provide its faculty and students with an environment for research, learning, and professional growth.

The faculty of the MU Department of Chemical Engineering prepares its students for careers in a broad range of fields and to assume leadership roles in society through a well-rounded general and rigorous technical education. The technical curriculum challenges students with a broad education in Chemical Engineering theory and practice, and to improve their skills in problem solving, critical thinking, and appreciation of the relationship between technology and society. Innovative development and use of technology facilitates both research and teaching, creating a diverse, learning environment.

MU Chemical Engineering program aims to develop versatile professionals who can excel in a variety of career environments. Our curriculum is focused on the basic sciences, engineering topics, and problem solving and design. A flexible program offering environmental, material, and biochemical options allows our graduates to move into non-traditional careers as well as traditional chemical engineering.

Additionally, we build teamwork and design skills by integrating team design projects, laboratories, and reports into our curriculum.

Faculty

Professor P. J. Pinheiro**, Y. Xing**
Associate Professor R.E. Rogers**
Assistant Professor K. D. Hammond**, B. D. Ulery**, M.J. Young**, Z. Yan**
Associate Teaching Professor M. A. Myers*, J. Park*
Assistant Teaching Professor S.P. Christensen, V. K. Gupta

* Graduate Faculty Member - membership is required to teach graduate-level courses, chair master's thesis committees, and serve on doctoral examination and dissertation committees.

** Doctoral Faculty Member - membership is required to chair doctoral examination or dissertation committees. Graduate faculty membership is a prerequisite for Doctoral faculty membership.

Undergraduate

• BSChE in Chemical Engineering (http://catalog.missouri.edu/undergraduategraduate/collegeofengineering/chemicalengineering/bsche-chemical-engineering)
  • with emphasis in Biochemical (http://catalog.missouri.edu/undergraduategraduate/collegeofengineering/chemicalengineering/bsche-chemical-engineering-emphasis-biochemical)

• with emphasis in Environmental (http://catalog.missouri.edu/undergraduategraduate/collegeofengineering/chemicalengineering/bsche-chemical-engineering-emphasis-environmental)

• with emphasis in Materials (http://catalog.missouri.edu/undergraduategraduate/collegeofengineering/chemicalengineering/bsche-chemical-engineering-emphasis-materials)

Advising and Scholarship Information Contact
Mary Myers (Director of Undergraduate Studies)
W2010 Lafferre Hall
(573) 882-1332
Teresa Pinhero
W1025 Lafferre Hall
(573) 882-2684

The educational objectives of the Chemical Engineering program at the University of Missouri are:

• Graduates will meet the expectations of employers of chemical engineers.

• Graduates will pursue advanced study if desired.

• Graduates will pursue leadership positions in their profession and/or communities.

Exploratory Course

A student wanting to explore chemical engineering as a major should take CH_ENG 1000 Introduction to Chemical Engineering.

Graduate

• MS in Chemical Engineering (http://catalog.missouri.edu/undergraduategraduate/collegeofengineering/chemicalengineering/ms-chemical-engineering)

• PhD in Chemical Engineering (http://catalog.missouri.edu/undergraduategraduate/collegeofengineering/chemicalengineering/phd-chemical-engineering)

Admissions and Advising Contacts:
Department of Chemical Engineering
Reginald E. Rogers, Jr. (Director of Graduate Studies)
E2404B Lafferre Hall
(573)882-4103

Teresa Pinhero
W1006 Lafferre Hall
(573) 882-2684

About Chemical Engineering

Established in 1906, MU Chemical Engineering has a long standing commitment to provide quality undergraduate and graduate education. Our department serves the discipline well by providing state of the art research in many cutting edge fields including batteries, biochemical engineering, biomaterials, carbon, ceramics, catalysis, corrosion, electrochemistry, environmental sciences, ionic liquids, materials science, computational modeling & simulation, nanomaterials, nuclear materials, polymers, separations, solar energy, and surface science.

Faculty Research

Currently active research areas include batteries, biochemical engineering, biomaterials, carbon, ceramics, catalysis, corrosion,
Facilities and Resources

There are excellent facilities for research students, including electron microscopy, high-vacuum (UHV) surface science, atomic force microscopy, a heterogeneous catalysis and reaction kinetics laboratory, a heat and mass transport laboratory, an air pollution monitoring and control laboratory, a biochemical engineering laboratory, a computational laboratory, and a transport properties phenomena laboratory. Excellent library facilities provide the latest domestic and international journals specific to chemical engineering and physical sciences research.

Internal Funding

Research and teaching assistantships are available to qualified students for the entire year. The yearly stipend for graduate students ranges from $17,500 to $20,000, depending on the student’s terminal degree. Assistantships also include a tuition waiver and health insurance. Academically qualified students may receive additional scholarship awards. Grant research assistantships and some industrial and Graduate School fellowships may also be available. Extremely well-qualified students may be eligible for the Robert and Dorcas Holtzsmith Graduate Fellowship.

RA and TA appointments allow for 12 credit hours of advanced study each semester. The applicant’s academic record and research potential determine the financial assistance offered. Students who receive financial assistance are expected to continue their appointment during the summer session as well, as these appointments are year-long positions.

CH_ENG 1000: Introduction to Chemical Engineering
Orientation course for freshmen-level students. Introduction to careers and opportunities in chemical engineering, basic engineering principles, simple calculations.

Credit Hours: 2
Prerequisites or Corequisites: MATH 1500, CHEM 1320

CH_ENG 1000H: Introduction to Chemical Engineering - Honors
Orientation course for freshmen-level students. Introduction to careers and opportunities in chemical engineering, basic engineering principles, simple calculations.

Credit Hours: 2
Prerequisites or Corequisites: MATH 1500, CHEM 1320. Honors eligibility required

CH_ENG 2225: Mass and Energy Balance
Industrial stoichiometry, material and energy balances, thermophysics, thermochemistry; related topics. Graded on A-F basis only.

Credit Hours: 3
Prerequisites or Corequisites: PHYSCS 2750, CHEM 1330

CH_ENG 2225H: Mass and Energy Balance - Honors
Industrial stoichiometry, material and energy balances, thermophysics, thermochemistry; related topics. Graded on A-F basis only.

Credit Hours: 3
Prerequisites or Corequisites: PHYSCS 2750, CHEM 1330
Prerequisites: Honors eligibility required

CH_ENG 2226: Engineering Process Computations
Introduction to the effective use of computer software with emphasis on chemical engineering applications, which include solutions for systems of algebraic equations using matrix methods; solutions of ordinary differential equations and partial differential equations and visualization of those solutions; linear, multilinear, and nonlinear regression for data analysis; 2D and 3D plotting, symbolic calculations, process control simulations, and text processing.

Credit Hours: 3
Prerequisites or Corequisites: CH_ENG 2225, MATH 2300
Prerequisites: MATH 1700

CH_ENG 3075: Introduction to Materials Engineering
(same as BIOL_EN 3075, BME 3075). Course covers concepts and techniques in materials engineering from an engineering design perspective, materials requirements for design, and fundamentals; intended for undergraduate engineering students. Graded on A-F basis only. Prerequisites or Corequisites: One of the following: BIOL_EN 3180, BME 3180, CH_ENG 3234, MAE 4231, MAE 4300, or instructor’s consent.

Credit Hours: 3
Prerequisites or Corequisites: MATH 2300, ENGINR 1200 (or instructor’s consent)

CH_ENG 3233: Chemical Engineering Fluid Dynamics
Introductory-level continuum mechanics of fluid flow (first in a two-course series on transport phenomena). Topics emphasized include buoyancy; stress; integral and differential conservation of mass, momentum, and energy; the viscous stress equations of motion; Newtonian fluids, viscosity, creeping flow, and the Navier-Stokes equations; turbulence; dimensionless parameters and correlations; and solutions to partial differential equations. Graded on A-F basis only.

Credit Hours: 3
Prerequisites or Corequisites: MATH 4100
Prerequisites: PHYSCS 2750, MATH 2300, and a grade of C- or better in CH_ENG 2225

CH_ENG 3234: Momentum, Heat, and Mass Transfer
Fluid flow, heat and mass transfer. A comprehensive treatment of the transport processes related to chemical engineering operations, with focus on both theory and applications.

Credit Hours: 4
Prerequisites or Corequisites: MATH 4100
Prerequisites: grade of C- or better in CH_ENG 2225; PHYSCS 2750, MATH 2300

CH_ENG 3235: Separation Processes
Separation processes in chemical engineering, including: Evaporation, absorption, distillation, extraction, leaching, membrane separation, and drying.

Credit Hours: 3
Prerequisites or Corequisites: CH_ENG 3262
Prerequisites: CH_ENG 2225, CH_ENG 2226
CH_ENG 3243: Chemical Engineering Laboratory I
Laboratory study of some principal unit operations of chemical engineering.
Credit Hours: 3
Prerequisites or Corequisites: CH_ENG 3235, CH_ENG 4363
Prerequisites: CH_ENG 2226, CH_ENG 3234, PHYSCS 2760
Recommended: CH_ENG 4370 or concurrent enrollment

CH_ENG 3243W: Chemical Engineering Laboratory I - Writing Intensive
Laboratory study of some principal unit operations of chemical engineering. Graded on A-F basis only.
Credit Hours: 3
Prerequisites or Corequisites: CH_ENG 3235, CH_ENG 4363
Prerequisites: CH_ENG 2226, CH_ENG 3234
Recommended: CH_ENG 4370 or concurrent enrollment

CH_ENG 3261: Chemical Engineering Thermodynamics I
Introduction to classical thermodynamics with chemical engineering applications. Heat, work, and energy; Application of the Laws of Thermodynamics to closed systems, open systems, and power and refrigeration cycles; Thermochemical calculations; Equations of state; Phase equilibrium properties of pure fluids.
Credit Hours: 3
Prerequisites or Corequisites: MATH 2300
Prerequisites: PHYSCS 2750; grade of C or better in CH_ENG 2225

CH_ENG 3262: Chemical Engineering Thermodynamics II
Chemical thermodynamics, with emphasis on mixtures. Multicomponent systems and phase diagrams; residual and excess properties; chemical potential, fugacity, and activity; models of non-ideal mixtures; phase and surface equilibria; chemical reaction equilibria.
Credit Hours: 3
Prerequisites: CH_ENG 3261, MATH 2300
Recommended: CHEM 2110 or concurrent enrollment

CH_ENG 3307: Chemical Process Safety and Professional Ethics
A course focused on important technical fundamentals of chemical process safety and their application including professional ethics considerations. Graded on A-F basis only.
Credit Hours: 3
Prerequisites: CH_ENG 2225

CH_ENG 4001: Topics in Chemical Engineering
Current and new technical developments in chemical engineering.
Credit Hours: 3
Prerequisites: instructor's consent

CH_ENG 4085: Problems in Chemical Engineering
Directed study of chemical engineering problems.
Credit Hours: 2-4
Prerequisites: instructor's consent

CH_ENG 4220: Hazardous Waste Management
(same as CV_ENG 4220; cross-leveled with CH_ENG 7220, CV_ENG 7220). Engineering principles involved in handling, collection, transportation, processing and disposal of hazardous waste, waste minimization, legislation on hazardous wastes and groundwater contamination.
Credit Hours: 3
Prerequisites: junior standing

CH_ENG 4232: Ceramic Materials and Processing
(same as MAE 4232; cross-leveled with MAE 7232, CH_ENG 7232). Treatment of ceramics materials, structure, and ceramic processing with hands-on demonstration/labs.
Credit Hours: 3
Prerequisites: C- or better in MAE 2200, BIOL_EN 3075, BME 3075, or CH_ENG 3075

CH_ENG 4270: Design of Experiments and Statistical Quality Control for Process Engineers
(same as BIOL_EN 4270; cross-leveled with CH_ENG 7270, BIOL_EN 7270). A practical statistical tool box for experimenters: process means, effects of variables, factorial experiments, and statistical quality control.
Credit Hours: 3
Recommended: experience with Excel or instructor's consent

CH_ENG 4285: Pollution Prevention
Identify, analyze, and solve energy, water, and raw materials inefficiencies common to industrial processes and facilities. Graded on A-F basis only.
Credit Hours: 3
Prerequisites: Thermodynamics (ENGINR 2300, MAE 2300, or CH_ENG 3261); Sophomore standing
Recommended: CHEM 1320

CH_ENG 4306: Advanced Engineering Math
(same as NU_ENG 4306). Applies ordinary and partial differential equations to engineering problems; Fourier's series; determinants and matrices; Laplace transforms; analog computer techniques.
Credit Hours: 3
Prerequisites: MATH 4100

CH_ENG 4311: Chemodynamics
(cross-leveled with CH_ENG 7311). Environmental movement of chemicals in air, water, and soil; designed to introduce students to the basic principles and techniques useful for the prediction of the movement and fate chemicals in ecosystems.
Credit Hours: 3
Prerequisites: CH_ENG 3234 or instructor's consent

CH_ENG 4312: Air Pollution Control
(cross-leveled with CH_ENG 7312). Modeling of urban air pollution and control techniques. Topics treated are plume dispersion theories, photochemistry, methods of monitoring, methods of industrial abatement and legal aspects.
Credit Hours: 3
Examples from current literature are also introduced to expose students to the frontier research in the field.

**CH_ENG 4335: Intermediate Transport Phenomena**
(cross-leveled with CH_ENG 7335). Integrated study of momentum, heat and mass transport.

**Credit Hours:** 3  
**Prerequisites:** CH_ENG 3234, and MATH 4100 or MATH 7100

**CH_ENG 4363: Chemical Reaction Engineering and Technology**
Reactor design and optimization; rate equations; thermal effects in reactor.

**Credit Hours:** 3  
**Prerequisites:** CHEM 1330, CH_ENG 2226, CH_ENG 3234  
**Recommended:** CH_ENG 3261, MATH 4140

**CH_ENG 4370: Process Control**
State-space modeling, simulation, and experimental validation; stability analysis; feedback design and experimental studies; methods for disturbance rejection.

**Credit Hours:** 3  
**Prerequisites:** CH_ENG 2225, CH_ENG 2226, MATH 4100  
**Recommended:** CH_ENG 3261, MATH 4140

**CH_ENG 4385: Chemical Engineering Design I**
The course presents optimum design methods, cost estimation, material selection and other relevant areas for the design of chemical plants. In addition, chemical safety and risk assessment will be covered. Graded on A-F basis only.

**Credit Hours:** 3  
**Prerequisites or Corequisites:** CH_ENG 3262, CHEM 2110

**CH_ENG 4391: Process Synthesis**
The course develops skills in process synthesis, including optimization, cost estimation, and economic analysis. Chemical safety and process control will be reviewed. Graded on A-F basis only.

**Credit Hours:** 3  
**Prerequisites or Corequisites:** CH_ENG 3262, CHEM 2110

**CH_ENG 4401: Finite Element Methods in Chemical Engineering**
(cross-leveled with CH_ENG 7401). The numerical solution of engineering problems in heat and mass transport, computational fluid dynamics, and chemical reactions including electromagnetic effects are treated in full detail using finite element methods and computational software to solve problems in one, two, and three dimensional spaces. Both time dependent and steady state solutions are considered. Graded on A-F basis only.

**Credit Hours:** 3  
**Prerequisites or Corequisites:** CH_ENG 4363  
**Prerequisites:** CH_ENG 2226, CH_ENG 3234, CH_ENG 3235, CH_ENG 3262, CHEM 2110  
**Recommended:** CH_ENG 4370 or concurrent enrollment

**CH_ENG 4464: Electrochemical Reaction Engineering Science**
(cross-leveled with CH_ENG 7464). Phenomenological behavior of electrochemical processes (battery emphasis). Theoretical interpretations
Chemical Engineering

of diffusion and reaction processes including system modeling. Graded on A-F basis only.

**Credit Hours:** 3  
**Prerequisites:** CH_ENG 3261 or MAE 2300 or CHEM 4310 or instructor's consent  
**Recommended:** A course in thermodynamics or physical chemistry

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**CH_ENG 4980: Process Synthesis and Design**  
(cross-leveled with CH_ENG 7980). Continuation of CH_ENG 4385: application of chemical analysis and modeling to a capstone design project.

**Credit Hours:** 3  
**Prerequisites:** CH_ENG 3262, CH_ENG 4363, CH_ENG 4385  
**Recommended:** CH_ENG 4370 or concurrent enrollment

**CH_ENG 4980W: Process Synthesis and Design - Writing Intensive**  
(cross-leveled with CH_ENG 7980). Continuation of CH_ENG 4385: application of chemical analysis and modeling to a capstone design project.

**Credit Hours:** 3  
**Prerequisites:** CH_ENG 3262, CH_ENG 4363, CH_ENG 4385  
**Recommended:** CH_ENG 4370 or concurrent enrollment

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**CH_ENG 4990: Undergraduate Research in Chemical Engineering**  
Directed study of chemical engineering problems.

**Credit Hour:** 2-4  
**Prerequisites:** instructor's consent

**CH_ENG 4995: Undergraduate Research in Chemical Engineering - Honors**  
Individual research for a senior thesis; research is supervised by the chemical engineering faculty. The thesis is to be defended before the departmental Honors committee.

**Credit Hour:** 3-6  
**Prerequisites:** senior standing

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**CH_ENG 7001: Topics in Chemical Engineering**  
Current and new technical developments in chemical engineering.

**Credit Hours:** 3  
**Prerequisites:** instructor's consent

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**CH_ENG 7220: Hazardous Waste Management**  
(same as CV_ENG 7220; cross-leveled with CH_ENG 4220, CV_ENG 4220). Engineering principles involved in handling, collection transportation, processing and disposal of hazardous waste minimization, legislation on hazardous wastes and groundwater contamination.

**Credit Hours:** 3

**CH_ENG 7232: Ceramic Materials and Processing**  
(same as MAE 7232; cross-leveled with CH_ENG 4232, MAE 4232). Treatment of ceramics materials, structure, and ceramic processing with hands-on demonstration/labs. Graded on A-F basis only.

**Credit Hours:** 3  
**Prerequisites:** MAE 2200 or equivalent course

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**CH_ENG 7270: Design of Experiments and Statistical Quality Control for Process Engineers**  
(same as BIOL_EN 7270; cross-leveled with CH_ENG 4270, BIOL_EN 4270). A practical statistical tool box for experimenters: process means, effects of variables, factorial experiments, and statistical quality control.

**Credit Hours:** 3  
**Prerequisites:** experience with Excel or instructor's consent

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**CH_ENG 7311: Chemodynamics**  
(cross-leveled with CH_ENG 4311). Environmental movement of chemicals in air, water, and soil; designed to introduce students to the basic principles and techniques useful for the prediction of the movement and fate chemicals in ecosystems.

**Credit Hours:** 3  
**Prerequisites:** CH_ENG 3234 or instructor's consent

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**CH_ENG 7312: Air Pollution Control**  
(cross-leveled with CH_ENG 4312). Modeling of urban air pollution and control techniques. Topics treated are plume dispersion theories, photochemistry, methods of monitoring, methods of industrial abatement and legal aspects.

**Credit Hours:** 3  
**Prerequisites:** CH_ENG 3234 or instructor's consent

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**CH_ENG 7315: Principles of Biochemical Engineering**  
(same as BIOL_EN 7315; cross-leveled with CH_ENG 4315, BIOL_EN 4315). This course serves as an introduction to the application of biological, biochemical, and engineering fundamentals for biochemical processing. Topics include biological basics, enzyme kinetics, metabolic pathways, cell growth kinetics, analysis of intracellular flux, thermodynamics of biological reactions, and bioreactor design and modeling. Analyses proceed through the use of mass balances, energy balances, and empirical or theoretical models.

**Credit Hours:** 3  
**Prerequisites:** BIOL_EN 2180 (for biological engineering students) or CH_ENG 2225 (for chemical engineering students) or Instructor's consent  
**Recommended:** BIOL_EN 3180 (for Biological Engineering students) or CH_ENG 3234 (for Chemical Engineering students) as a prerequisite or a co-requisite

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**CH_ENG 7316: Biomass Refinery Operation**  
(same as BIOL_EN 7316; cross-leveled with CH_ENG 4316, BIOL_EN 4316). Design and operation of processes for conversion and/or fractionation of biomass and associated upstream and downstream unit operations. Emphasis on separations and product recovery.

**Credit Hours:** 3  
**Prerequisites:** BIOL_EN 2180 or CH_ENG 2225 or instructor's consent

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**CH_ENG 7317: Chemical Processing in Semiconductor Device**  
(cross-leveled with CH_ENG 4317). This course covers the current plasma processing methods used to produce semiconductor devices with emphasis on memory devices. The physics and chemistry of how plasmas are formed, sustained and interact with the semiconductor devices are introduced. It includes physical and material properties of materials used in semiconductor devices.

**Credit Hours:** 3  
**Prerequisites:** BIOL_EN 2180 or MAE 2180 or CH_ENG 2225 or instructor's consent
wafer being processed. Plasma chemistry and the chemical reactions used in plasma etching are discussed.

**Credit Hours:** 3  
**Prerequisites:** PHYSCS 2760, CHEM 1320, and MATH 4100 or MATH 7100

**CH_ENG 7319: Introduction to Polymers**  
(cross-leveled with CH_ENG 7319). This course provides a general introduction to polymer materials and their engineering applications. The course centers on two aspects: (i) fundamental knowledge about polymer properties and synthesis; and (ii) an introduction of some emerging polymer materials, including polymer nanocomposites, conductive polymers, biodegradable polymers, self-healing polymers, and hydrogels. Examples from current literature are also introduced to expose students to the frontier research in the field.

**Credit Hours:** 3  
**Prerequisites or Corequisites:** CH_ENG 4363  
**Prerequisites:** CHEM 3210, CH_ENG 3234, CH_ENG 3262

**CH_ENG 7335: Intermediate Transport Phenomena**  
(cross-leveled with CH_ENG 4335). Integrated study of momentum, heat and mass transport.

**Credit Hours:** 3  
**Prerequisites:** CH_ENG 3234, and MATH 4100 or MATH 7100

**CH_ENG 7401: Finite Element Methods in Chemical Engineering**  
(cross-leveled with CH_ENG 4401). The numerical solution of engineering problems in heat and mass transport, computational fluid dynamics, and chemical reactions including electromagnetic effects are treated in full detail using finite element methods and computational software to solve problems in one, two, and three dimensional spaces. Both time dependent and steady state solutions are considered. Graded on A-F basis only.

**Credit Hours:** 3  
**Prerequisites or Corequisites:** MATH 4100  
**Prerequisites:** CHEM 1330, CH_ENG 2226  
**Recommended:** CH_ENG 3234 and CH_ENG 4363, or concurrent enrollment

**CH_ENG 7464: Electrochemical Reaction Engineering Science**  
(cross-leveled with CH_ENG 4464). Phenomenological behavior of electrochemical processes (battery emphasis). Theoretical interpretations of diffusion and reaction processes including system modeling. Graded on A-F basis only.

**Credit Hours:** 3  
**Prerequisites:** CH_ENG 3261 or MAE 2300 or CHEM 4310 or instructor's consent  
**Recommended:** A course in thermodynamics or physical chemistry

**CH_ENG 7980: Synthesis and Design of Chemical Process**  
(cross-leveled with CH_ENG 4980). This is a heuristics-based design course intended to assist students in bringing together capabilities from previous course. An emphasis is placed on the creation process of design. Graded on A-F basis only.

**Credit Hours:** 3  
**Prerequisites:** CH_ENG 3262, CH_ENG 4363, CH_ENG 4385  
**Recommended:** CH_ENG 4370 or concurrent enrollment

**CH_ENG 8001: Advanced Topics in Chemical Engineering**

**Credit Hours:** 3  
**Prerequisites:** instructor's consent

**CH_ENG 8029: Advanced Plasma Processing**  
Concepts and techniques in novel plasma processing: plasma characteristics, plasma sputtering, plasma enhanced chemical vapor deposition (PECVD), plasma etching, plasma treatment, plasma fabrication of nano-structured materials and diamondlike films, biomedical applications.

**Credit Hours:** 3

**CH_ENG 8085: Problems in Chemical Engineering**  
Supervised investigation in chemical engineering to be presented in the form of a report.

**Credit Hour:** 1-5  
**Prerequisites:** instructor's consent

**CH_ENG 8087: Seminar in Chemical Engineering**  
Reviews investigations and projects of importance in chemical engineering.

**Credit Hour:** 1

**CH_ENG 8230: Advanced Ceramic Materials**  
(same as BIOL_EN 8230 and MAE 8230). To provide an advanced level understanding between processing, properties, and microstructure of ceramic materials. Topics include crystallography, defect chemistry, transport properties, microstructure, and forming methods. Graded on A-F basis only.

**Credit Hours:** 3

**CH_ENG 8336: Advanced Heat and Momentum Transfer**  
Advanced study of these transport phenomena.

**Credit Hours:** 3  
**Prerequisites:** CH_ENG 3235 or instructor's consent

**CH_ENG 8337: Advanced Mass Transfer**  
Advanced study of mass transfer.

**Credit Hours:** 3  
**Prerequisites:** CH_ENG 4336 or instructor's consent

**CH_ENG 8338: Analysis of Equilibrium Stage Processes**  
Advanced study of stage processes.

**Credit Hours:** 3  
**Prerequisites:** CH_ENG 2226, CH_ENG 3235 and CH_ENG 3262

**CH_ENG 8451: Advanced Chemical Engineering Thermodynamics I**  
Advanced thermodynamics; particular reference to its application to chemical engineering.

**Credit Hours:** 3  
**Prerequisites:** CH_ENG 3262 or instructor's consent
CH_ENG 8452: Advanced Chemical Engineering Thermodynamics II
Introduction to the methods of statistical thermodynamics and statistical mechanics. The method of ensembles, Maxwell-Boltzmann statistics, the kinetic theory of gases, and theories of liquids. Applications of statistical mechanics to the prediction of physical and chemical properties such as rate coefficients, diffusion coefficients, and conductivities. Graded A-F only.

Credit Hours: 3  
Prerequisites: CH_ENG 8451 or instructor's consent

CH_ENG 8463: Chemical Reaction Engineering Science
Phenomenological behavior of catalysts. Theoretical interpretations for heterogeneous and homogeneous catalysts.

Credit Hours: 3  
Prerequisites: CH_ENG 4363

CH_ENG 8470: Mathematical Studies of Chemical Engineering Operation
Analytical methods applied to solution of chemical engineering problems.

Credit Hours: 3  
Prerequisites: MATH 4100

CH_ENG 8990: Research-Masters Thesis in Chemical Engineering
Independent investigation in chemical engineering, to be presented as a thesis. Graded on a S/U basis only.

Credit Hour: 1-99  
Prerequisites: Masters candidate

CH_ENG 9990: Research-Doctoral Dissertation in Chemical Engineering
Independent investigation in chemical engineering, to be presented as a thesis. Graded on a S/U basis only. candidate

Credit Hour: 1-99  
Prerequisites: Ph.D