Chemical Engineering

Kevin Gillis, Chair
Department of Chemical and Biomedical Engineering
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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 is intended to challenge 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.

The 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 X. Liu**, P. J. Pinhero**, Y. Xing**, X. Zeng**
Associate Professor K. D. Hammond**, R. E. Rogers**, B. D. Ulery**, Z. Yan**
Assistant Professor M. J. Young**
Associate Teaching Professor J. Park**
Assistant Teaching Professor S. P. Christensen*, R. Lim
Professor Emeritus R. K. Bajpai*, P. C. H. Chan*, T. K. Ghosh*, D. G. Retzloff*, D. S. Viswanath*

* 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

- BS in Chemical Engineering (https://catalog.missouri.edu/collegeofengineering/chemicalengineering/bs-chemical-engineering/)
  - with emphasis in Biochemical (https://catalog.missouri.edu/collegeofengineering/chemicalengineering/bs-chemical-engineering-emphasis-biochemical/)
  - with emphasis in Environmental (https://catalog.missouri.edu/collegeofengineering/chemicalengineering/bs-chemical-engineering-emphasis-environmental/)
  - with emphasis in Materials (https://catalog.missouri.edu/collegeofengineering/chemicalengineering/bs-chemical-engineering-emphasis-materials/)

Advising and Scholarship Information Contact
Scott Christensen (Director of Undergraduate Studies)
W2028 Lafferre Hall
(573) 882-3536

Engineering Advising
(573) 884-6961
muengradvising@missouri.edu
https://engineering.missouri.edu/student-services/advising (https://engineering.missouri.edu/student-services/advising/)

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 (https://catalog.missouri.edu/collegeofengineering/chemicalengineering/ms-chemical-engineering/)
- PhD in Chemical Engineering (https://catalog.missouri.edu/collegeofengineering/chemicalengineering/phd-chemical-engineering/)

Admissions and Advising Contacts:
Department of Chemical Engineering
Reginald E. Rogers, Jr. (Director of Graduate Studies)
W2024 Lafferre Hall
(573) 882-4103

Heather Roberts
W2030 Lafferre Hall
(573) 884-8610

About Chemical Engineering

Established in 1903, 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 as listed below.

Faculty Research

Currently active research areas include batteries, biochemical engineering, biomass, biomaterials, catalysis, computational modeling and simulation, corrosion, electrochemistry, environmental sciences, ionic liquids, materials science, mass transfer, nanomaterials, nuclear materials, polymers, separations, solar energy, surface science, and water treatment.

Facilities and Resources

There are many facilities in the Program and elsewhere on campus for research, including atomic force microscopy (AFM), computer clusters,

electron microscopy, femtosecond lasers, and the country's largest university-based nuclear reactor. The University also maintains an extensive network of libraries across the entire campus; the Engineering Library provides convenient access to the most frequently-accessed books and journals in engineering disciplines.

Internal Funding

Research and teaching assistantships are available to qualified students for the entire year. The yearly stipends for graduate students are a minimum of $22,180 for MS students and $24,394 for PhD students. 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 Holtsmith 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 freshman-level students. Introduction to careers and opportunities in chemical engineering, basic engineering principles and balances, and simple calculations. Graded on A-F basis only.

Credit Hours: 2
Prerequisites: MATH 1100

CH_ENG 1000H: Introduction to Chemical Engineering - Honors
Orientation course for freshman-level students. Introduction to careers and opportunities in chemical engineering, basic engineering principles and balances, and simple calculations. Graded on A-F basis only.

Credit Hours: 2
Prerequisites: MATH 1100. Honors eligibility required

CH_ENG 2225: Mass and Energy Balance
Fundamental analysis of mass and energy balances as applied to chemical processes. Students will use mass balances to analyze single-unit and multiple-unit non-reactive and reactive processes. Gas behavior and basic phase equilibrium will be introduced to demonstrate the complexity of mass balances. Energy balances will be introduced to show students the energy costs for running any process. Students will learn how the different forms of energy (internal, kinetic, and potential) are related to heat and work. Graded on A-F basis only.

Credit Hours: 3
Prerequisites or Corequisites: MATH 1700; CHEM 1410 and CHEM 1411
Prerequisites: A grade of C- or better in MATH 1500; a grade of C- or better in CHEM 1400 and CHEM 1401; CH_ENG 1000 or instructor and director of undergraduate studies consent required

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CH_ENG 2225H: Mass and Energy Balance - Honors
Fundamental analysis of mass and energy balances as applied to chemical processes. Students will use mass balances to analyze single-unit and multiple-unit non-reactive and reactive processes. Gas behavior and basic phase equilibrium will be introduced to demonstrate the complexity of mass balances. Energy balances will be introduced to show students the energy costs for running any process. Students will learn how the different forms of energy (internal, kinetic, and potential) are related to heat and work. Honors students will also be expected to complete two mini-projects applying what they learn throughout the course. Each project will be open-ended and will require students to complete background research on the given process prior to completing the assigned tasks. Students will be expected to meet with the instructor outside of class for guidance in completion of the projects. A short presentation of the project solution to the class will be required. Graded on A-F basis only.

Credit Hours: 3
Prerequisites or Corequisites: MATH 1700; CHEM 1410 and CHEM 1411
Prerequisites: Honors eligibility required; a grade of C- or better in MATH 1500; a grade of C- in CHEM 1400 and CHEM 1401; CH_ENG 1000 or consent of both instructor and director of undergraduate studies

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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 2303: Harnessing the Atom in Everyday Life: Fulfill M Curie's Dream
(same as NU_ENG 2303). Introduction to applications of nuclear science and technology, utilizing web-based learning scenarios.

Credit Hours: 3

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: 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: PHYSCS 2750, MATH 2300, and a grade of C- or better in CH_ENG 2225; MATH 4100 or consent of instructor

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CH_ENG 3234: Heat and Mass Transfer
Fundamentals of steady and transient heat conduction, convection, and radiation; nondimensionalization; Fick's laws of diffusion; gas, liquid, and solid diffusion; Knudsen diffusion; heat and mass transfer coefficients and correlations; heat exchanger analysis and design; heat fins; boundary layers; external and internal convection; natural convection; two-phase heat and mass transfer; multicomponent diffusion; diffusion in the presence of chemical reaction; heat and mass transfer equipment.

Credit Hours: 3
Prerequisites: CH_ENG 3233

CH_ENG 3235: Separation Processes
Separation processes in chemical engineering, including evaporation, absorption, distillation, extraction, leaching, membrane separation, and drying. Graded on A-F basis only.

Credit Hours: 3
Prerequisites or Corequisites: CH_ENG 3262
Prerequisites: CH_ENG 2225 and CH_ENG 2226 and CH_ENG 3233
Recommended: CH_ENG 3234 or concurrent enrollment

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; C- or better in ENGLSH 1000
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, PHYSCS 2760; C- or better in ENGLSH 1000
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. Graded on A-F basis only.

Credit Hours: 3
Prerequisites or Corequisites: MATH 2300, PHYSCS 2750
Prerequisites: Grade of C- or better in CH_ENG 2225; grade of C- or better in MATH 1700

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: CH_ENG 2226; 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 or Corequisites: CH_ENG 3233
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 Hour: 2-4
Prerequisites: instructor's consent

CH_ENG 4160: Food Process Engineering
(same as BIOL_EN 4160, F_S 4160; cross-leveled with BIOL_EN 7160, CH_ENG 7160, F_S 7160). Food engineering is an interdisciplinary field that connects agricultural and biological engineering, chemical engineering, food science, biochemistry, human nutrition, and other fields involving food systems to improve the health of people and planet. The course introduces underlying engineering principles in food processing, and unit operations in food industries. Topics include fluid flow, heat transfer in food processing, preservation process, dehydration, refrigeration, food freezing, psychrometrics, food packaging, emerging technologies, and sustainability.

Credit Hours: 3
Prerequisites: CH_ENG 3234 or 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 4231: Transport Phenomena in Materials Processing
(same as MAE 4231, BIOL_EN 4231; cross-leveled with MAE 7231, CH_ENG 7231, BIOL_EN 7231). Applications of fluid flow, heat transfer, and mass transfer in steady-state and unsteady-state materials processing with applications to metals, polymers, and ceramics. Graded on A-F basis only.

Credit Hours: 3
Prerequisites or Corequisites: CH_ENG 3234
Prerequisites: C- or better in MATH 4100

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 4235: Advanced Separation Processes
(cross-leveled with CH_ENG 7235). This advanced-level course builds on concepts taught in CH_ENG 3235 (Separation Processes). Topics to be covered include more in-depth discussion of adsorption, membrane separation, extraction, and crystallization as they pertain to practical operations. Unsteady systems will be introduced to translate ideal conditions to common real conditions. Differential analyses of mass transfer will be presented to understand molecular-level transport phenomena. Case studies will be introduced to connect fundamental concepts to real-world applications. Students who enroll in this course will be expected to have a firm grasp on differential equations and the fundamental principles behind heat and mass transfer. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: MATH 4100, CH_ENG 3234, CH_ENG 3235

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 or CHEM 1400

CH_ENG 4306: Advanced Engineering Math
(same as NU_ENG 4306; cross-leveled with NU_ENG 7306). 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
Prerequisites: CH_ENG 3234 or instructor's consent

CH_ENG 4315: Principles of Biochemical Engineering
(same as BIOL_EN 4315; cross-leveled with CH_ENG 7315, BIOL_EN 7315). 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 4316: Biomass Refinery Operations
(same as BIOL_EN 4316; cross-leveled with CH_ENG 7316, 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 (for Biological Engineering students) or CH_ENG 2225 (for Chemical Engineering students) or instructor's consent

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CH_ENG 4317: Chemical Processing in Semiconductor Devices
(cross-leveled with CH_ENG 7317). 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 wafers being processed. Plasma chemistry and the chemical reactions used in plasma etching are discussed. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: PHYSCS 2760, CHEM 1320 or CHEM 1400, and MATH 4100 or MATH 7100

CH_ENG 4318: Energy Technology and Sustainability
(cross-leveled with CH_ENG 7318). An introductory course on energy technology, resources, practices, and common calculations used for energy analysis. Recommended: at least one thermodynamics or physical chemistry course (examples: CHEM 4310, CH_ENG 3261, ENGINR 2300, MAE 2300, PHYSCS 4120) or instructor's consent.

Credit Hours: 3

CH_ENG 4318H: Energy Technology and Sustainability - Honors
(cross-leveled with CH_ENG 7318). An introductory course on energy technology, resources, practices, and common calculations used for energy analysis. May be repeated for credit. Recommended: at least one thermodynamics or physical chemistry course (examples: CHEM 4310, CH_ENG 3261, ENGINR 2300, MAE 2300, PHYSCS 4120) or instructor's consent.

Credit Hours: 3

CH_ENG 4319: 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 2110, CH_ENG 3234, CH_ENG 3262

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 4360: Biomanufacturing Technologies
(same as BIOL_EN 4360, BME 4360; cross-leveled with BIOL_EN 7360, CH_ENG 7360). This course is an introduction to biomanufacturing technologies and processes for manufacturing biological products (e.g., vaccine, antibodies, and therapeutic proteins). It mainly covers process development, unit operations, product evaluation, facilities, and regulatory compliance. It is an interdisciplinary course of biochemistry, microbiology, and engineering. The purpose of this course is to help the students acquire the knowledge of modern biomanufacturing and prepare them for rapidly growing fields in biomanufacturing. Graded on A-F basis only.

Credit Hours: 3

Prerequisites: BIOL_EN 2180 and BIOL_EN 3180 (for biological engineering students) -or- CH_ENG 2225 and CH_ENG 3234 (for chemical engineering students) -or- consent of instructor

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CH_ENG 4363: Chemical Reaction Engineering and Technology
Introduction to the design and operation of chemical reactors using the fundamentals of thermodynamics, chemistry, material and energy balances, and transport phenomena. Students will understand reaction rates, size ideal isothermal chemical reactors, understand thermal effects, design chemical reactors in non-ideal situations, understand mass transfer effects on reactions, and design chemical reactors with mass transfer effects taken into account. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: CHEM 1330 or CHEM 1410 and CH_ENG 2226 and CH_ENG 3234
Recommended: CH_ENG 3262

CH_ENG 4370: Process Dynamics and Control
Theoretical modeling and simulation of nonlinear processes; state-space modeling; empirical modeling and model validation; stability analysis; feedback design and simulation; methods for disturbance rejection.

Credit Hours: 3
Prerequisites: CH_ENG 2226, CH_ENG 3261, MATH 4100
Recommended: 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 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 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: MATH 4100
Prerequisites: CHEM 1330 or CHEM 1410, CH_ENG 2226
Recommended: CH_ENG 3234 and CH_ENG 4363, or concurrent enrollment

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CH_ENG 4464: Electrochemical Science and Technology
(cross-leveled with CH_ENG 7464). The course covers the scientific and technological knowledge of electrochemical processes. It deals with fundamental principles relevant to electrochemical engineering (e.g., reaction kinetics, thermodynamics, and transport phenomena). Case studies would include, for example, electrochemical synthesis, electrocatalysis, and energy conversion and storage (e.g., batteries and fuel cells). Graded on A-F basis only.

Credit Hours: 3
Prerequisites: CHEM 1330 or CHEM 1410 and CH_ENG 3261 (or instructor's consent required)

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; C- or better in ENGLSH 1000
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; C- or better in ENGLSH 1000
Recommended: CH_ENG 4370 or concurrent enrollment

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: instructor consent; senior standing

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

Credit Hours: 3
Prerequisites: instructor's consent

CH_ENG 7160: Food Process Engineering
(same as BIOL_EN 7160, F_S 7160; cross-leveled with CH_ENG 4160, BIOL_EN 4160, F_S 4160). Food engineering is an interdisciplinary field that connects agricultural and biological engineering, chemical engineering, food science, biochemistry, human nutrition, and other fields involving food systems to improve the health of people and planet. The course introduces underlying engineering principles in food processing, and unit operations in food industries. Topics include fluid flow, heat transfer in food processing, preservation process, dehydration, refrigeration, food freezing, psychrometrics, food packaging, emerging technologies, and sustainability.

Credit Hours: 3
Prerequisites: CH_ENG 3234 or equivalent

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 7231: Transport Phenomena in Materials Processing
(same as MAE 7231, BIOL_EN 7231; cross-leveled with MAE 4231, BIOL_EN 4231, CH_ENG 4231). Applications of fluid flow, heat transfer, and mass transfer in steady-state and unsteady-state materials processing with applications to metals, polymers, and ceramics. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: CH_ENG 3234 or equivalent; MATH 4100 or equivalent

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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

CH_ENG 7235: Advanced Separation Processes
(cross-leveled with CH_ENG 4235). This advanced-level course builds on concepts taught in CH_ENG 3235 (Separation Processes). Topics to be covered include more in-depth discussion of adsorption, membrane separation, extraction, and crystallization as they pertain to practical operations. Unsteady systems will be introduced to translate ideal conditions to common real conditions. Differential analyses of mass transfer will be presented to understand molecular-level transport phenomena. Case studies will be introduced to connect fundamental concepts to real-world applications. Students who enroll in this course will be expected to have a firm grasp on differential equations and the fundamental principles behind heat and mass transfer. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: MATH 4100 or MATH 7100 or equivalent; CH_ENG 3234, CH_ENG 3235 or equivalents

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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

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

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

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 Devices
(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 wafers being processed. Plasma chemistry and the chemical reactions used in plasma etching are discussed.

Credit Hours: 3
Prerequisites: PHYSCS 2760 and CHEM 1320 or CHEM 1400, and MATH 4100 or MATH 7100

CH_ENG 7318: Energy Technology and Sustainability
(cross-leveled with CH_ENG 4318). This is graduate elective/survey course that accompanies CH_ENG 4318. The course focuses on energy technology, resources, practices, and common calculations used for energy analysis. Recommended: at least one thermodynamics or physical chemistry course (examples: CHEM 4310, CH_ENG 3261, ENGINR 2300, MAE 2300, PHYSCS 4120) or instructor's consent.

Credit Hours: 3

CH_ENG 7319: Introduction to Polymers
(cross-leveled with CH_ENG 4319). 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 2110, 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 7360: Biomanufacturing Technologies
(same as BIOL_EN 7360; cross-leveled with BME 4360, CH_ENG 4360). This course is an introduction to biomanufacturing technologies and processes for manufacturing biological products (e.g., vaccines, antibodies, and therapeutic proteins). It mainly covers process development, unit operations, product evaluation, facilities, and regulatory compliance. It is an interdisciplinary course of biochemistry, microbiology, and engineering. The purpose of this course is to help the students acquire the knowledge of modern biomanufacturing and prepare them for rapidly growing fields in biomanufacturing. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: CH_ENG 2225 and CH_ENG 3234 or equivalents

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 or MATH 7100
Prerequisites: CHEM 1330 or CHEM 1410, CH_ENG 2226
Recommended: CH_ENG 3234 and CH_ENG 4363, or concurrent enrollment

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CH_ENG 7464: Electrochemical Science and Technology
(cross-leveled with CH_ENG 4464). The course covers the scientific and technological knowledge of electrochemical processes. It deals with fundamental principles relevant to electrochemical engineering (e.g., reaction kinetics, thermodynamics, and transport phenomena). Case studies would include, for example, electrochemical synthesis, electrocatalysis, and energy conversion and storage (e.g., batteries and fuel cells). Graded on A-F basis only.

Credit Hours: 3
Prerequisites: CHEM 1330 or CHEM 1410 and CH_ENG 3261 or their equivalents, or instructor's consent required

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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; C- or better in ENGLSH 1000
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
(same as BIOL_EN 8087). Recent investigations and project of importance in chemical engineering and related fields. Discussion of current literature; preparation and presentation of papers. Graded on A-F basis only.

Credit Hour: 1

CH_ENG 8088: Chemical Engineering Graduate Seminar Continuation
(same as BIOL_EN 8088). Seminar for graduate students enrolled in Chemical Engineering program. Features invited speakers from external to university as well as graduate student presentations. Graded on S/U basis only.

Credit Hours: 0

CH_ENG 8230: Advanced Ceramic Materials
(same as BIOL_EN 8230, 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

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
An advanced course on chemical thermodynamics emphasizing the mathematical and physical foundations of thermodynamics. Topics include the postulates of thermodynamics, thermodynamic potentials and the Legendre transformation, thermodynamic stability and metastability, critical phenomena, models of non-ideal phase and chemical reaction equilibria, adsorption, surface and interfacial equilibria, irreversible thermodynamics, and a brief introduction to statistical thermodynamics.

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: Advanced Chemical Reaction Engineering
Advanced study of kinetics and reactor engineering with emphasis on the chemistry, transport, thermodynamics, and interfacial phenomena associated with catalysis and catalyst deactivation; the relationship between thermodynamics and kinetics and the molecular basis of kinetics; and polymer kinetics and reaction engineering. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: CH_ENG 4363 or equivalent

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 8615: Atomistic Materials Analytics
(same as DATA_SCI 8615, BIOL_EN 8615, CMP_SC 8615, MAE 8615, ECE 8615, CHEM 8615). Introduction to the principles of materials characterization and analysis leading to information extraction from experimental and computational data sets. Examines theoretical and practical issues associated with understanding the relationships between atomic/molecular structure and material properties. Describes encoding and visualizing atomic structure information. Measurement techniques covered include Ultraviolet-Visible (UV-Vis) spectroscopy, (Fourier Transform) Infrared Spectroscopy (FTIR), X-ray diffraction (XRD), and electronic conductivity. Covers standard data processing techniques, including sparse vs. abundant data, preprocessing and normalization, fixed length vs. variable length data, heterogeneous data streams, feature extraction, and the role of simulated data. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: DATA_SCI 7010, DATA_SCI 8010, Instructor consent required

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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