Chemical Engineering

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Faculty of the Department of Chemical and Environmental Engineering

Professors Eric Altman, †Michelle Bell, †Gaboury Benoit, †Stephen Edberg, Menachem Elimelech, Abbas Firoozabadi (Adjunct), †Thomas Graedel, Gary Haller, †Edward Kaplan, Yehia Khalil (Adjunct), Michael Loewenberg, Robert McGraw (Adjunct), Lisa Pfefferle, Joseph Pignatello (Adjunct), Daniel Rosner, †James Saiers, †Mark Saltzman, †Udo Schwarz, T. Kyle Vanderlick, Paul Van Tassel, †Kurt Zilm

Associate Professors †Eric Dufresne, †Tarek Fahmy, Jaehong Kim, Chinedum Osuji, Jordan Peccia, Andre Taylor, Corey Wilson, Julie Zimmerman

Assistant Professors Drew Gentner, Desiree Plata

† A joint appointment with primary affiliation in another department or school.

Energy, the environment, and health care are key challenges facing humanity in the twenty-first century. Chemical engineering is a discipline well placed to confront these challenges. Chemical engineering is rooted in the basic sciences of mathematics, chemistry, physics, and biology; a traditional engineering science core of thermodynamics, transport phenomena, and chemical kinetics; a rigorous design component; and an expanding focus on emerging topics in materials, nanotechnology, and life sciences. The discipline has grown from its petrochemical origins to become central to state-of-the-art technologies in microelectronics, alternative energy, biomedicine, and pharmaceutics.

The Chemical Engineering program is principally focused on basic and engineering sciences and on problem solving. Additional emphasis is on communication, analysis of experiments, and chemical process design. A special feature of the program is the accessibility of laboratory research—most Chemical Engineering majors participate in faculty-led research projects, often resulting in publication and/or presentation at national meetings.

Chemical Engineering graduates find a wide range of professional opportunities in academia, industry, government, business, and the nonprofit sector. Many majors go on to graduate programs in chemical, biomedical, or environmental engineering or to medical, law, or business schools.

The educational objectives of the Chemical Engineering program are the following. Graduating students will achieve positions of leadership within academia, industry, and government; excel in top graduate programs in chemical, biomedical, environmental, and related engineering fields; excel in top professional schools in fields such as law, medicine, or management; join and rise in the ranks of large and small corporations; become successful entrepreneurs; practice engineering toward the benefit of humankind.

Students considering a Chemical Engineering major are encouraged to take two terms of chemistry and mathematics during the freshman year, and to contact the director of undergraduate studies.

Requirements of the major Two degree programs are offered: a B.S. in Chemical Engineering accredited by the Engineering Accreditation Commission of ABET, Inc., and a B.S. in Engineering Sciences (Chemical).

Prerequisites Students in both degree programs take the following prerequisite courses: MATH 112, 115, and ENAS 151 or equivalent; PHYS 180, 181; CHEM 161 and 165, or CHEM 163 and 167 (or CHEM 114, 115), and CHEM 134L (or CHEM 118); ENAS 130. Students with advanced high school preparation may reduce the number of prerequisites.

B.S. degree program in Chemical Engineering The curriculum for the ABET-accredited B.S. degree in Chemical Engineering requires eighteen term courses, including the following courses beyond the prerequisites:

1. Mathematics: ENAS 194 or equivalent
2. Chemistry: CHEM 174 and 175 (or CHEM 124 and 125), or CHEM 220 and either 221 or 230; CHEM 332, 333, and 330L
3. Engineering science: MENG 361 and three term courses chosen from engineering electives
4. Chemical engineering: CENG 210, 300, 301, 315, 411, 412, 480

Senior requirement In their senior year students must pass CENG 416, Chemical Engineering Process Design.

B.S. degree program in Engineering Sciences (Chemical) The B.S. degree in Engineering Sciences (Chemical) requires ten term courses beyond the prerequisites, chosen in consultation with the director of undergraduate studies. The standard program includes the following courses:

1. Mathematics: ENAS 194 or equivalent
2. Chemistry: CHEM 174 and 175 (or CHEM 124 and 125), or CHEM 220 and either 221 or 230, or CHEM 332 and 333
3. Engineering science: MENG 361
4. Chemical engineering: CENG 210, 300, 301, 315, 411

**Senior requirement**  In their senior year students must complete a senior research project in CENG 490.

**REQUIREMENTS OF THE MAJOR**

**CHEMICAL ENGINEERING, B.S.**

**Prerequisites**  MATH 112, 115, ENAS 151 or equivalent; CHEM 161 and 165, or CHEM 163 and 167 (or CHEM 114, 115), and CHEM 134L (or CHEM 116L), or CHEM 167 (or CHEM 118); PHYS 180, 181; ENAS 130

**Number of courses**  18 term courses beyond prereqs (incl senior req)

**Specific courses required**  ENAS 194 or equivalent; CHEM 174 and 175 (or CHEM 124 and 125), or CHEM 220 and either 221 or 230; CHEM 332, 333, and 330L; MENG 361; CENG 210, 300, 301, 315, 411, 412, 480

**Distribution of courses**  3 addtl electives in engineering

**Senior requirement**  CENG 416

**ENGINEERING SCIENCES (CHEMICAL), B.S.**

**Prerequisites**  MATH 112, 115, ENAS 151 or equivalent; CHEM 161 and 165, or CHEM 163 and 167 (or CHEM 114, 115), and CHEM 134L (or CHEM 116L), or CHEM 167 (or CHEM 118); PHYS 180, 181; ENAS 130

**Number of courses**  10 term courses beyond prereqs (incl senior req)

**Specific courses required**  ENAS 194 or equivalent; CHEM 174 and 175 (or CHEM 124 and 125), or CHEM 220 and either 221 or 230, or CHEM 332 and 333; MENG 361; CENG 210, 300, 301, 315, 411

**Senior requirement**  CENG 490

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* CENG 120b / ENAS 120b / ENVE 120b, Introduction to Environmental Engineering  Jordan Peccia
  Introduction to engineering principles related to the environment, with emphasis on causes of problems and technologies for abatement. Topics include air and water pollution, global climate change, hazardous chemical and emerging environmental technologies. Prerequisites: high school calculus and chemistry or CHEM 161, 165 or CHEM 163, 167 (may be taken concurrently) or permission of instructor.  QR, SC

CENG 210a / ENVE 210a, Principles of Chemical Engineering and Process Modeling  André Taylor
  Analysis of the transport and reactions of chemical species as applied to problems in chemical, biochemical, and environmental systems. Emphasis on the interpretation of laboratory experiments, mathematical modeling, and dimensional analysis. Lectures include classroom demonstrations. Prerequisite: MATH 120 or permission of instructor.  QR, SC RP

CENG 300a, Chemical Engineering Thermodynamics  Chinedum Osuji
  Analysis of equilibrium systems. Topics include energy conservation, entropy, heat engines, Legendre transforms, derived thermodynamic potentials and equilibrium criteria, multicomponent systems, chemical reaction and phase equilibria, systematic derivation of thermodynamic identities, criteria for thermodynamic stability, and introduction to statistical thermodynamics. Prerequisite: MATH 120 or ENAS 151 or permission of instructor.  QR, SC RP

CENG 315b / ENVE 315b, Transport Phenomena  Michael Loewenberg
  Unified treatment of momentum, energy, and chemical species transport including conservation laws, flux relations, and boundary conditions. Topics include convective and diffusive transport, transport with homogeneous and heterogeneous chemical reactions and/or phase change, and interfacial transport phenomena. Emphasis on problem analysis and mathematical modeling, including problem formulation, scaling arguments, analytical methods, approximation techniques, and numerical solutions. Prerequisite: ENAS 194 or permission of instructor.  QR, SC RP

CENG 320a / BENG 463a, Immunoengineering  Staff
  Introduction to immunoengineering, a field combining immunology with the physical sciences and engineering. Focus on biophysical principles and biomaterial applications for understanding and engineering immunity.  SC

CENG 351a / BENG 351a, Biotransport and Kinetics  Kathryn Miller-Jensen
  Creation and critical analysis of models of biological transport and reaction processes. Topics include mass and heat transport, biochemical interactions and reactions, and thermodynamics. Examples from diverse applications, including drug delivery, biomedical imaging, and tissue engineering. Prerequisites: MATH 115, ENAS 194; BIOL 101 and 102; CHEM 161, 163, or 167; BENG 249.  QR
CENG 373a / ENVE 373a, Air Pollution Control  Drew Gentner
An overview of air quality problems worldwide with a focus on emissions, chemistry, transport, and other processes that govern
dynamic behavior in the atmosphere. Quantitative assessment of the determining factors of air pollution (e.g., transportation and other
combustion–related sources, chemical transformations), climate change, photochemical “smog,” pollutant measurement techniques, and
air quality management strategies. Prerequisite: ENVE 210.  QR, SC  RP

* CENG 377a / ENVE 377a, Water Quality Control  Jaehong Kim
Study of the preparation of water for domestic and other uses and treatment of wastewater for recycling or discharge to the environment.
Topics include processes for removal of organics and inorganics, regulation of dissolved oxygen, and techniques such as ion exchange,
electrodialysis, reverse osmosis, activated carbon adsorption, and biological methods. Prerequisite: ENVE 120 or permission of instructor.  SC  RP

CENG 410a, Biomolecular Engineering  Corey Wilson
A survey of the principles and scope of biomolecular engineering. Discussion of concepts at the interface of applied mathematics, biology,
biophysical chemistry, and chemical engineering that are used to develop novel molecular tools, materials, and approaches based on
biological building blocks and machinery. Modeling the physicochemical properties that confer function in biological systems; low- and
high-resolution protein engineering; the design of synthetic interactomes.  RP

CENG 411a, Separation and Purification Processes  Lisa Pfefferle
Theory and design of separation processes for multicomponent and/or multiphase mixtures via equilibrium and rate phenomena. Topics
include single-stage and cascaded absorption, adsorption, extraction, distillation, partial condensation, filtration, and crystallization
processes. Applications to environmental engineering (air and water pollution control), biomedical-chemical engineering (artificial
organs, drug purification), food processing, and semiconductor processing. Prerequisite: CENG 300 or 315 or permission of instructor.  QR, SC  RP

CENG 412Lb / CENG 412, Chemical Engineering Laboratory and Design  Paul Van Tassel and Corey Wilson
An introduction to design as practiced by chemical and environmental engineers. Engineering fundamentals, laboratory experiments,
and design principles are applied toward a contemporary chemical process challenge. Sustainability and economic considerations are
emphasized.  SC

CENG 416b / ENVE 416b, Chemical Engineering Process Design  Paul Van Tassel and Corey Wilson
Study of the techniques for and the design of chemical processes and plants, applying the principles of chemical engineering and
economics. Emphasis on flowsheet development and equipment selection, cost estimation and economic analysis, design strategy and
optimization, safety and hazards analysis, and environmental and ethical considerations. Enrollment limited to seniors majoring in
Chemical Engineering or Environmental Engineering.  QR, SC  RP

CENG 471a or b, Independent Research  Michael Loewenberg
Faculty-supervised individual student research and design projects. Emphasis on the integration of mathematics with basic and
engineering sciences in the solution of a theoretical, experimental, and/or design problem. May be taken more than once for credit.

CENG 480a, Chemical Engineering Process Control  Eric Altman
Transient regime modeling and simulations of chemical processes. Conventional and state-space methods of analysis and control design.
Applications of modern control methods in chemical engineering. Course work includes a design project. Prerequisite: ENAS 194 or
permission of instructor.  QR, SC  RP

* CENG 490a or b, Senior Research Project  Michael Loewenberg
Individual research and/or design project supervised by a faculty member in Chemical Engineering, or in a related field with permission
of the director of undergraduate studies.

RELATED COURSE THAT COUNTS TOWARD THE MAJOR
MENG 361a, Mechanical Engineering II: Fluid Mechanics  Mitchell Smooke
Mechanical properties of fluids, kinematics, Navier-Stokes equations, boundary conditions, hydrostatics, Euler’s equations, Bernoulli’s
equation and applications, momentum theorems and control volume analysis, dimensional analysis and similitude, pipe flow, turbulence,
concepts from boundary layer theory, elements of potential flow. Prerequisites: ENAS 194 or equivalent, and physics at least at the level of
PHYS 180.  QR, SC  RP