CHEMICAL ENGINEERING

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Chemical engineering is concerned primarily with the principles and processes involved in the conversion of raw materials into products vital to modern civilization. The products of the chemical and process industries range from antibiotics to zirconium, from petroleum to pharmaceuticals, from agricultural chemicals to plastics and synthetic rubber. The rapid introduction of new products gives chemical engineering its characteristic concern with the management and development of innovation. Chemical engineers have always played a pivotal role in the field of energy and more recently have become key players in sustainability and biotechnology.

While clearly rooted in chemistry, chemical engineering is a distinct discipline that makes significant contributions to society. Concerns about efficient utilization of raw materials, cost-effective and safe processing strategies, and environmental impact have shaped the evolution of the field. Chemical engineers are uniquely skilled in understanding molecular transformations; working over a wide range of scales, from molecular to global; analyzing quantitatively; and viewing, synthesizing, and analyzing large, complex systems.

Preparation for careers in the field requires a comprehension of physical, chemical, biological, and engineering principles. The chemical engineering curriculum provides broad fundamental training and prepares graduates for the chemical and process industries or for advanced study. The program aims at developing graduates who can plan, design, and operate new processes, who can contribute to the development of new chemical products, and who have potential for managerial responsibility in highly technical industrial enterprises.

Areas of Specialization

The curriculum permits students to select one of these six areas of specialization or plan an alternate program with an adviser.

- Bioengineering
- Chemical process engineering
- Design
- Environmental engineering and sustainability
- Nanotechnology and molecular engineering
- Polymer science and engineering

Laboratories

The Undergraduate Chemical Engineering Laboratory provides facilities for exploring firsthand the quantitative experimental implications of fundamental laws in their application to practical problems of heat transfer, distillation, reaction engineering, and other basic operations. A computing laboratory is used in a variety of courses.

Programs of Study

- Chemical Engineering Degree (https://catalogs.northwestern.edu/undergraduate/engineering-applied-science/chemical-engineering/chemical-engineering-degree)
- Biotechnology and Biochemical Engineering Minor (https://catalogs.northwestern.edu/undergraduate/engineering-applied-science/chemical-engineering/biotechnology-biochemical-engineering-minor)

CHEM_ENG 190-0 Engineering of Chemical and Biological Processes (1 Unit) Survey of engineering principles as they are applied to processes involving chemical and biological transformations. Examples from the chemical, pharmaceutical, biotechnology, food processing, electronics, and other industries. Impact of economics, ethics, and other nontechnical constraints.

CHEM_ENG 210-0 Analysis of Chemical Process Systems (1 Unit) Introduction to process systems. Material balances and stoichiometry. Analysis of process system flow sheets. Introduction to departmental computing facilities. Basic numerical analysis. Prerequisites: CHEM 132-0, CHEM 152-0, or CHEM 172-0; GEN_ENG 205-3 (may be taken concurrently).

CHEM_ENG 211-0 Thermodynamics (1 Unit) The first and second laws of thermodynamics. Entropy and equilibrium. Material and energy balances. Equations of state and properties of fluids. Solutions, phase equilibria, and chemical reactions. Prerequisite: CHEM_ENG 210-0.

CHEM_ENG 212-0 Phase Equilibrium and Staged Separations (1 Unit) Thermodynamic models of mixtures and phase equilibrium. Analysis and design of staged separation processes such as distillation, absorption, stripping, and extraction. Prerequisites: CHEM_ENG 210-0, CHEM_ENG 211-0.

CHEM_ENG 275-0 Molecular & Cell Biology for Engineers (1 Unit) Introduction to cell and molecular biology concepts that provide the foundation for modern biotechnology and bioengineering. Prerequisite: CHEM 132-0, CHEM 152-0, or CHEM 172-0.

CHEM_ENG 307-0 Kinetics and Reactor Engineering (1 Unit) Chemical reaction kinetics with application to the design of chemical reactors. Prerequisites: CHEM_ENG 210-0, CHEM_ENG 211-0, CHEM_ENG 321-0, CHEM_ENG 322-0.

CHEM_ENG 312-0 Probability and Statistics for Chemical Engineering (1 Unit) Introduction to probability theory and statistical methods necessary for analyzing the behavior of processes and experiments. Statistical tests for detecting significant changes in process parameters. Prerequisite: MATH 220-0, MATH 224-0, MATH 230-0, & MATH 234-0, or ES_APPM 252-1 & ES_APPM 252-2.

CHEM_ENG 321-0 Fluid Mechanics (1 Unit) Derivation and applications of continuity and Navier-Stokes equations. Macroscopic mass, momentum, and energy balance. Dimensional analysis: friction factors in pipes and packed beds; drag coefficients. Prerequisites: completion of mathematics requirements with no grades of D; GEN_ENG 205-4 (C- or better).

CHEM_ENG 322-0 Heat Transfer (1 Unit) The differential equations of energy transport. Solutions for various applications. Prerequisites: completion of mathematics requirements with no grades of D; GEN_ENG 205-4 (C- or better); CHEM_ENG 321-0 recommended.

CHEM_ENG 323-0 Mass Transfer (1 Unit) Diffusion and rate concepts; application to distillation, extraction, absorption, humidification, drying. Prerequisites: CHEM_ENG 321-0, CHEM_ENG 322-0.

CHEM_ENG 330-0 Molecular Engineering and Statistical Mechanics (1 Unit) Basic statistical mechanics. Applications to thermodynamics, kinetics, and transport of various engineering systems, including frontier areas of chemical and biological engineering. Not open to students who have taken CHEM_ENG 406-0, CHEM 342-3, or PHYSICS 332-0. Prerequisite: CHEM_ENG 211-0 or another thermodynamics course;

courses in probability and statistics, heat transfer, or other transport recommended.

CHEM_ENG 341-0 Dynamics and Control of Chemical and Biological Processes (1 Unit) Dynamic behavior of chemical process components. Feedback control principles. Prerequisites: CHEM_ENG 307-0; senior standing.

CHEM_ENG 342-0 Chemical Engineering Laboratory (1 Unit) Operation and control of process equipment for the determination of operating data. Analysis and written presentation of results. Prerequisites: CHEM_ENG 212-0, CHEM_ENG 307-0, CHEM_ENG 321-0, CHEM_ENG 322-0, CHEM_ENG 323-0.

CHEM_ENG 345-0 Process Optimization for Energy and Sustainability (1 Unit) Modern techniques and application to the design and operation of chemical process systems. Steady-state and dynamic methods. Experimental search for the optimum. Prerequisite: junior standing.

CHEM_ENG 351-0 Process Economics, Design, & Evaluation (1 Unit) Preliminary design of industrial processes for the production of chemical and allied products by the application of the engineering sciences and economics. Prerequisites: CHEM_ENG 212-0, CHEM_ENG 307-0, CHEM_ENG 321-0, CHEM_ENG 322-0, CHEM_ENG 323-0.

CHEM_ENG 352-0 Chemical Engineering Design Projects (1 Unit) Design of chemical and process plants applying the principles of unit operations, thermodynamics, reaction kinetics, and economics. Mechanical design and selection of chemical process equipment. Prerequisite: CHEM_ENG 351-0.

CHEM_ENG 355-0 Chemical Engineering Product Design (1 Unit) Properties and selection of chemicals for products from single-molecule pharmaceuticals to devices to manufactured products such as food and consumer goods. Prerequisite: junior standing.

CHEM_ENG 361-0 Introduction to Polymers (1 Unit) Polymerization mechanisms and their relation to molecular structure, polymerization processes, and the mechanical properties of polymers, especially flow behavior. Prerequisites: CHEM_ENG 211-0 or other thermodynamics course; CHEM 210-1.

CHEM_ENG 364-0 Chemical Processing and the Environment (1 Unit) Application of chemical engineering fundamentals to environmental problems. Chemistry and mechanisms, chemical reaction and rate, and transport emphasized. Risk assessment and analysis revealed through case studies. Prerequisites: CHEM_ENG 212-0, CHEM_ENG 307-0.

CHEM_ENG 365-0 Sustainability, Technology, and Society (1 Unit) Technical discussion of sustainability, sustainable development, global warming, natural and renewable resources and utilization, industrial ecology, eco-efficiency, technology related to sustainability, and risk assessment. Prerequisite: junior standing in science or engineering.

CHEM_ENG 367-0 Quantitative Methods in Life Cycle Analysis (1 Unit) Lifecycle analysis (LCA) framework for environmental assessment of technology systems, focusing on modeling methods for systems mass and energy flows, process and input-output-based systems inventories, environmental impact analysis, and methods for robust engineering decisions. MECH_ENG 367-0 is taught with CHEM_ENG 367-0; may not receive credit for both courses.

CHEM_ENG 371-0 Transport Phenomena in Living Systems (1 Unit) Application of transport theory, principally diffusion, to movement of molecules in biological systems, including blood, cornea, microcirculation, and lung. Prerequisites: CHEM_ENG 275-0 or BIOL_SCI 215-0 or BIOL_SCI 219-0; CHEM_ENG 321-0, CHEM_ENG 323-0, BMD_ENG 270-0, or equivalent; or consent of instructor.

CHEM_ENG 372-0 Bionanotechnology (1 Unit) Physical biology of the cell and its implications for nanotechnology, with a focus on the quantitative description of sizes, shapes, times, and energies at the nanoscale. Prerequisite: MATH 230-0.

CHEM_ENG 373-0 Biotechnology and Global Health (1 Unit) Recent advances in synthetic biology and genetic, metabolic, and tissue engineering. Design, development, and commercialization of healthcare technologies for countries in the developing world and the challenges of deploying preventative, diagnostic, and therapeutic products in these settings.

CHEM_ENG 375-0 Biochemical Engineering (1 Unit) Modern biochemical engineering. Life sciences: microbiology, biochemistry, and molecular genetics. Metabolic stoichiometry, energetics, growth kinetics, transport phenomena in bioreactors, and product recovery. Prerequisite: CHEM_ENG 307-0, CHEM_ENG 323-0, or consent of instructor.

CHEM_ENG 376-0 Principles of Synthetic Biology (1 Unit) Overview of synthetic biology's foundations in the natural sciences and engineering and its applications in medicine, biotechnology, and green chemistry. How engineering driven approaches may be used to accelerate design-build-test loops required for reprogramming existing biological systems and constructing new ones. Prerequisites: CHEM_ENG 275-0 or BIOL_SCI 215-0 or BIOL_SCI 219-0

CHEM_ENG 377-0 Bioseparations (1 Unit) Downstream process in biotechnology. Separation and lysis of cells. Recovery of organelles and proteins. Protein separation and purification. Prerequisites: CHEM_ENG 323-0 (may be taken concurrently); CHEM_ENG 275-0 or BIOL_SCI 215-0 or BIOL_SCI 219-0.

CHEM_ENG 379-0 Computational Biology: Principles & Applications (1 Unit) Introduction to the development and application of data-analytical and theoretical methods, mathematical modeling, and computational simulation techniques to the study of biological systems.

CHEM_ENG 381-0 Practical Biological Imaging (1 Unit) Theory and practice of biological microscopy in a lab setting; image acquisition, analysis, and the ethics of image manipulation.

CHEM_ENG 382-0 Regulatory Sciences in Biotechnology (1 Unit) Course on topics at the intersection of science, engineering, and biotech regulatory compliance. Federal regulations for drug product development; regulatory compliance processes and organizational structure; interface between biotechnology processes and regulatory sciences; global harmonization of regulations; regulatory documentation.

CHEM_ENG 390-0 Personal & Organizational Effectiveness (1 Unit) Introduction to nontechnical skills required in a business environment, with the goal of increasing personal effectiveness and marketability of seniors and graduate students. Prerequisite: senior standing.

CHEM_ENG 395-0 Special Topics in Chemical Engineering (1 Unit) Topics suggested by students or faculty and approved by the department.

CHEM_ENG 399-0 Projects (1 Unit) Supervised investigation of a chemical engineering problem with submission of a final report.