

# CHEMICAL ENGINEERING (CHEM\_ENG)

**CHEM\_ENG 101-0 Getting to Know Chemical Engineering (0 Unit)** This survey course is an overview of the discipline of chemical engineering, and its undergraduate program at Northwestern. It is primarily targeted to first-years who are considering the major. We will discuss the most recent areas of research, career paths after graduation, and engineering ethics. Most course sessions will involve external speakers.

**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 relevant to engineering problems. Students are encouraged but not required to be familiar with coding prior to taking this course. Prerequisites: MATH 220-1, 220-2, 228-1, 228-2 or equivalent, and COMP\_SCI 150-0.

**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 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 selected topics related to sustainability, sustainable development, global climate changes, natural and renewal resources and utilization, industrial ecology, eco-efficiency, technology related to sustainability such as biofuel, electrification of transportation, and water purification, and role of policy and business risk assessment. Prerequisites: junior standing in science or engineering; familiarity with process system analysis, energy and material balances (such as found in CHEM\_ENG 210-0 or CIV\_ENV 260-0).

#### **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 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 228-1 (formerly listed as 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.

Prerequisite: CHEM\_ENG 275-0 or BIOL\_SCI 201-0 or BIOL\_SCI 202-0 (formerly 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 201-0 or BIOL\_SCI 202-0 (formerly BIOL\_SCI 215-0 or BIOL\_SCI 219-0).

#### **CHEM\_ENG 378-0 Deconstructing Synthetic Biology – Biotechnology Case Studies Across Scales (1 Unit)**

Synthetic biology uses concepts across STEM fields to reuse, repurpose and redesign biological systems to solve important global challenges. Here, we break down how synthetic biology solutions integrate concepts across five spatiotemporal scales—molecular, network, cell/cell-free systems, biological communities and societal—using case studies in

sustainability, biomanufacturing and human health. The deconstruction approach enables students to better tackle scientific challenges.

#### **CHEM\_ENG 379-0 Computational Biology: Analysis and Design of Living Systems (1 Unit)**

This course provides an introduction to fundamental principles and methods for computational and mathematical analysis of natural and engineered biological systems. Emphasis is placed upon understanding and designing biological systems based upon conceptual framings including multi-scale networks, dynamic control, genetic circuits, and biological programs.

#### **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 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.