Chemical Engineering

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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, with two degree programs (see below), 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.

Upon graduation, Yale's Chemical Engineering students are expected to have achieved "Student Outcomes" as defined by ABET (www.abet.org) and the program. The Chemical Engineering major produces graduates who demonstrate: (1) an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics; (2) an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors; (3) an ability to communicate effectively with a range of audiences; (4) an ability to recognize ethical and professional responsibilities in engineering situations and to make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts; (5) an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives; (6) an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions; and (7) an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

Yale and ABET also look ahead, several years beyond graduation. Program educational objectives provide the expectations for graduates early in their career. The Chemical Engineering objectives are to produce graduates who: (1) have mastery of the basic principles of science and modern chemical engineering practice and are able to adapt and creatively apply them to solve new problems in a broad range of fields; (2) become ethical professionals who advance chemical engineering practice and knowledge in

multiple fields and recognize the local and global impacts of their work on humans and the environment; (3) are able to work well with people from diverse backgrounds and are committed to the advancement of women and under-represented groups in engineering; (4) have a strong educational foundation enabling them to study in graduate and professional schools as well as become leaders in STEM or non-STEM career paths; and (5) are committed to, and engage in, lifelong learning throughout their careers.

PREREQUISITES

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

Students in both degree programs (see below) take the following prerequisite courses: MATH 1120, 1150, and ENAS 1510 or MATH 1200; CHEM 1610 and 1650 or CHEM 1630 and 1670; CHEM 1340L and 1360L; PHYS 1800, 1810 or PHYS 2000, 2010 or PHYS 2600. Students with advanced high school preparation may reduce the number of prerequisites by placing out of certain courses.

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). All students majoring in Chemical Engineering and Engineering Sciences (Chemical) must follow the requirements listed below as approved by the program's faculty.

B.S. degree program in Chemical Engineering The curriculum for the ABET-accredited B.S. degree in Chemical Engineering requires 19 courses, totaling 18.5 credits, including the senior requirement (CENG 4160), and the following courses beyond the prerequisites:

1. Computing: ENAS 1300 or CPSC 1001 or CPSC 2000
2. Mathematics: ENAS 1940
3. Chemistry: CHEM 1740 or CHEM 2200; CHEM 2220L; CHEM 3320 and 3330
4. Engineering: Four term courses chosen from engineering electives
5. Chemical engineering: CENG 1500 or CENG 2100; CENG 3000, 3010, 3140 (or MENG 3422), CENG 3150, 4110, 4120L, 4800

B.S. degree program in Engineering Sciences (Chemical) The B.S. degree in Engineering Sciences (Chemical) requires 12 term courses for 12 credits, including the senior requirement, CENG 4160 or CENG 4900, and the following courses beyond the prerequisites, chosen in consultation with the DUS:

1. Computing: ENAS 1300 or CPSC 1001 or CPSC 2000
2. Mathematics: ENAS 1940
3. Chemistry: CHEM 1740 or CHEM 2200; and CHEM 3320
4. Engineering: One term course chosen from engineering electives
5. Chemical engineering: CENG 1500 or CENG 2100; CENG 3000, 3010, 3140 (or MENG 3422), CENG 3150, 4110

Credit/D/Fail No course taken Credit/D/Fail may be applied toward the requirements of the major. The DUS may consider requests under special circumstances.

Outside credit Courses taken at another institution or during an approved summer or term-time study abroad program may count toward the major requirements with DUS approval.

SENIOR REQUIREMENT

B.S. degree program in Chemical Engineering In their senior year, students must complete a senior research project in CENG 4160.

B.S. degree program in Engineering Sciences (Chemical) In their senior year, students must complete a senior research project in CENG 4160 or CENG 4900.

SUMMARY OF MAJOR REQUIREMENTS

CHEMICAL ENGINEERING, B.S.

Prerequisites MATH 1120, 1150; ENAS 1510 or MATH 1200; CHEM 1610 and 1650 or CHEM 1630 and 1670; CHEM 1340L and 1360L; PHYS 1800, 1810 or PHYS 2000, 2010 or PHYS 2600.

Number of courses 19 courses, totaling 18.5 credits, beyond prereqs (incl senior req)

Specific courses required ENAS 1940; CHEM 1740 or CHEM 2200; CHEM 2220L; CHEM 3320, 3330; CENG 1500 or CENG 2100; CENG 3000, 3010, 3140 (or MENG 3422), CENG 3150, 4110, 4120L, 4800

Distribution of courses 1 from ENAS 1300, CPSC 1001, or 2000; 4 addtl electives in engineering

Senior requirement CENG 4160

ENGINEERING SCIENCES (CHEMICAL), B.S.

Prerequisites MATH 1120, 1150; ENAS 1510 or MATH 1200; CHEM 1610 and 1650 or CHEM 1630 and 1670; CHEM 1340L and 1360L; PHYS 1800, 1810 or PHYS 2000, 2010 or PHYS 2600.

Number of courses 12 term courses for 12 credits beyond prereqs (incl senior req), chosen in consultation with DUS

Specific courses required ENAS 1940; CENG 1500 or CENG 2100; CENG 3000, 3010, 3140 (or MENG 3422), CENG 3150, 4110

Distribution of courses 1 from ENAS 1300, CPSC 1001, or 2000; CHEM 1740 or CHEM 2200; CHEM 3320; 1 engineering elective

Senior requirement CENG 4160 or CENG 4900

FACULTY OF THE DEPARTMENT OF CHEMICAL AND ENVIRONMENTAL ENGINEERING

Professors Eric Altman, †Paul Anastas, †Michelle Bell, †Ruth Blake, Menachem Elimelech, John Fortner, Gary Haller (*Emeritus*), †Edward Kaplan, Jaehong Kim, Michael Loewenberg, †Andrew Miranker, Jordan Peccia, Lisa Pfefferle, Daniel Rosner

(*Emeritus*), †Mark Saltzman, †Udo Schwarz, T. Kyle Vanderlick, Paul Van Tassel, Julie Zimmerman

Associate Professors Drew Gentner, Mingjiang Zhong

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Lecturers †Anikó Bezur, †Paul Whitmore

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