Department of Chemical Engineering

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Chemical engineering is a broad discipline based on chemistry, mathematics, physics and biology that applies the principles of engineering science and process systems engineering to the development and commercialization of new products and processes. Engineering science provides experimental and theoretical models for predicting the behavior of fluid flow and heat transfer in materials and biological systems, as well as chemical reactions and mass transfers that take place in multi-component mixtures. Process systems engineering provides methodologies for the systematic design and analysis of processes, including their control, safety, and environmental impact. The department emphasizes the basic principles of engineering science and process systems engineering through problem solving, and it strives to broaden the experience of students by offering a significant number of electives, undergraduate research projects, an integrated masters degree, industrial internships and study abroad programs, all of which benefit from our strong industrial ties.

A career in chemical engineering offers challenging and well-compensated positions in a wide variety of growth industries. Graduates may supervise the operation of chemical plants, redesign chemical processes for pollution prevention, or be involved in the research and development of new products or processes in high technology areas. These activities require knowledge of chemical reactions and catalysis, separation technologies and energy recovery systems, all of which are thoroughly presented in our curriculum. In the petroleum industry, for example, our national need for fuels demands well-trained chemical engineers in catalysis. A significant number of chemical engineers are also hired by industries associated with colloids (fine particles), polymers (plastics and resins), and coatings (e.g., paint, integrated circuits). Opportunities exist in biotechnology, the computer industry, environmental firms, and consulting companies. Other examples include the processing of advanced polymeric systems, thin films for the semiconductor and data storage industry, and chip fabrication. A growing number of consulting companies hire chemical engineers to develop computer software for the simulation and real-time optimization of chemical processes, for predicting how toxic chemicals are dispersed and degraded in soils and in the atmosphere, and for evaluating the economic feasibility of industrial projects. The diversity of career opportunities arises from the depth and breadth of the curriculum. For instance, the pharmaceutical industry recruits chemical engineers who possess a combined expertise in process engineering and biochemistry/molecular biology.

The curriculum emphasizes the fundamentals of physical, chemical, and biological phenomena, mathematical modeling, exposure to biotechnology and problem solving techniques. These provide rigorous preparation for immediate employment after graduation, or a strong basis for graduate school. The depth and breadth of coursework makes chemical engineering an excellent major for students interested in either medical or business school. Computing is integrated throughout the curriculum, and extensive use is made of mathematical modeling and simulation software in the department’s Computational Laboratory. The Robert Rothfus Laboratory and Lubrizol Analytical Laboratory feature state-of-the-art experiments that illustrate applications in safety, environmental, product development, and computerized data acquisition and control.

Educational Objectives and Outcomes

The objectives for the program are that graduates of the department will obtain employment or attend graduate school, will advance in their chosen careers, and will be productive and fulfilled professionals throughout their careers. The curriculum and programs are developed to prepare students to attain these educational objectives.

Students majoring in chemical engineering learn the science and engineering that govern chemical processing systems. Fundamental principles, problem solving, systems analysis and design, development of self-confidence, and communication skills are emphasized. Students are made aware of modern tools, industrial needs and societal issues. This combination of fundamental knowledge and skills provides a firm foundation for future learning and career growth. The goal of the department is to produce students who will become leaders in their careers. Students who complete the curriculum will have attained the following educational outcomes:

• an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
• an ability to function on multidisciplinary teams
• an ability to identify, formulate, and solve engineering problems
• an understanding of professional and ethical responsibility
• an ability to communicate effectively
• the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
• a recognition of the need for, and an ability to engage in, life-long learning
• a knowledge of contemporary issues
• an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

The department offers a number of special programs for students majoring in Chemical Engineering. In addition to the double majors offered by the College of Engineering such as Biomedical Engineering and Engineering & Public Policy, students may choose from a variety of minors in technical areas offered by the College of Engineering. Undergraduate research projects are also available in the areas of bioengineering, complex fluids engineering, environmental engineering, process systems engineering, and catalysis & surface science. Students may participate in study abroad programs during their junior year. In addition to the University program with EPFL in Switzerland and ITESM Monterey in Mexico, the department provides its own exchange programs with Yonsei University in Seoul, Korea, the University of Aachen in Germany, and Imperial College in London, Great Britain. The latter two programs are jointly organized with industrial partners, i.e., Bayer Corporation, Air Products & Chemicals, and Procter & Gamble respectively. Students may also participate in Practical Internships for Senior Chemical Engineering Students, a one-year industrial internship program offered between the Junior and Senior years. Finally, qualified students may enroll in our Master of Chemical Engineering program. This degree is typically completed in the fifth year. However, depending on the number of advanced placement courses and course load at Carnegie Mellon, this degree could be awarded during the B.S. graduation, or after one additional semester.

Curriculum

The program in chemical engineering within the Department of Chemical Engineering is accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org.

First Year

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<tr>
<th>Course</th>
<th>Units</th>
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<tbody>
<tr>
<td>Fall</td>
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<tr>
<td>21-120 Differential and Integral Calculus</td>
<td>10</td>
</tr>
<tr>
<td>76-xxx Designated Writing/Expression Course</td>
<td>9</td>
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<tr>
<td>99-101 Computing @ Carnegie Mellon</td>
<td>3</td>
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<tr>
<td>06-100 Introduction to Chemical Engineering</td>
<td>12</td>
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<tr>
<td>09-105 Introduction to Modern Chemistry I</td>
<td>10</td>
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<td>44</td>
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<tr>
<td>Spring</td>
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<tr>
<td>21-122 Integration, Differential Equations and Approximation</td>
<td>10</td>
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<tr>
<td>xx-xxx Introductory Engineering Elective (other than ChE)</td>
<td>12</td>
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<tr>
<td>33-106 Physics I for Engineering Students</td>
<td>12</td>
</tr>
<tr>
<td>xx-xxx General Education Course</td>
<td>9</td>
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Second Year

<table>
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<th>Course</th>
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<tbody>
<tr>
<td>Fall</td>
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<tr>
<td>21-259 Calculus in Three Dimensions</td>
<td>9</td>
</tr>
<tr>
<td>06-221 Thermodynamics</td>
<td>9</td>
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<tr>
<td>06-222 Sophomore Chemical Engineering Seminar</td>
<td>1</td>
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<tr>
<td>09-106 Modern Chemistry II</td>
<td>10</td>
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<tr>
<td>xx-xxx Computer Sci./Physics II</td>
<td>10-12</td>
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<tr>
<td>xx-xxx General Education Course</td>
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Department of Chemical Engineering

Third Year

At the end of the Sophomore year, a student should have completed the recommended courses for the major. Students should consult with their faculty advisors as soon as possible.

For those students who have not taken 06-100 as one of the two first-year courses, 06-100 should be taken in the Fall Semester of the Sophomore year. The General Education Course normally taken during that semester may be postponed until the Junior year. These students should consult with their faculty advisors as soon as possible.

At the end of the Sophomore year, a student should have completed the following required basic science and computer science courses:

- 09-105 Introduction to Modern Chemistry I (10 units)
- 09-106 Modern Chemistry II (10 units)
- 09-221 Laboratory I: Introduction to Chemical Analysis (12 units)
- 15-110 Principles of Computing (10 units)
- or 15-112 Fundamentals of Programming and Computer Science (10 units)
- 33-106/33-107 Physics II for Engineering Students (12 units)
- 33-111/33-112 or 33-131/33-132 will also meet the CIT Physics requirement.
- 33-110 Introduction to Computer Science/Physics II: Students should complete 15-110 Principles of Computing and 06-100 and one other Introductory Engineering Elective. There are also five Unrestricted Electives. At most, 9 units of ROTC or Physical Education can be counted toward these electives. Students must discuss choice of electives with their faculty advisors.
- 33-102 Introduction to Modern Chemistry I (10 units)
- 33-107 Modern Chemistry II (10 units)
- 99-101 Theoretical Foundations of Computer Science (3 units)

Third Year

Fall

- 06-321 Chemical Engineering Thermodynamics (9 units)
- 06-322 Junior Chemical Engineering Seminar (2 units)
- 06-323 Heat and Mass Transfer (9 units)
- 09-217 Organic Chemistry I (9 units)
- or 09-219 Modern Organic Chemistry (9 units)
- 09-347 Advanced Physical Chemistry (12 units)
- xx-xx General Education Course (9 units)

Spring

- 06-361 Unit Operations of Chemical Engineering (9 units)
- 06-363 Transport Process Laboratory (6 units)
- 06-364 Chemical Reaction Engineering (9 units)
- 03-232 Biochemistry I ** (9 units)
- xx-xx Unrestricted Elective (9 units)
- xx-xx General Education Course (9 units)

Units: 54-52

Spring/Summer

- 09-221 Honors Research Project for eligible Seniors.

Fourth Year

Fall

- 06-421 Chemical Process Systems Design (12 units)
- 06-423 Unit Operations Laboratory (9 units)
- xx-xx Unrestricted Elective (9 units)
- xx-xx Unrestricted Elective (9 units)
- xx-xx General Education Course (9 units)

Units: 48

Spring

- 06-462 Optimization Modeling and Algorithms (6 units)
- 06-463 Chemical Product Design (6 units)
- 06-464 Chemical Engineering Process Control (9 units)
- xx-xx Unrestricted Elective (9 units)
- xx-xx General Education Course (9 units)

Units: 48

**Students pursuing a Chemical Engineering/Engineering and Public Policy double major are waived from taking the Biochemistry Elective. They will take 06-221.

Notes:

1. In addition to the graduation requirement of an overall QPA of 2.0 (not counting the First Year), the Department of Chemical Engineering requires a cumulative QPA of 2.0 in all chemical engineering courses (all those numbered 06-xxx).

2. Minimum number of units required for graduation: 936.

3. Overloads are permitted only for students maintaining a QPA of 3.0 or better during the preceding semester.

4. Electives: To obtain a Bachelor of Science degree in Chemical Engineering, students must complete 06-100 and one other Introductory Engineering Elective. There are also five Unrestricted Electives. At most, 9 units of ROTC or Physical Education can be counted toward these electives. Students must discuss choice of electives with their faculty advisors.

5. Undergraduate Research: Independent research projects are available by arrangement with a faculty advisor. Many students conduct these research projects for elective credit by enrolling in 06-200, 06-300, or 06-400 (Sophomore, Junior, or Senior Research Projects) or 39-500 Honors Research Project for eligible Seniors.

6. Advanced undergraduates may also take Chemical Engineering graduate courses (600+ level).

Double Major in Engineering and Public Policy (EPP)

Students may pursue a double major in Chemical Engineering and EPP. This double major is very flexible, built around Electives, Social Analysis, Probability and Statistics courses, and projects. Specific course choices should be discussed with a faculty advisor and an EPP advisor.

Double Major in Biomedical Engineering (BME)

Students may pursue a double major in Chemical Engineering and BME. Specific course choices should be discussed with a faculty advisor and a BME advisor.

Minors with a B.S. in Chemical Engineering

Chemical Engineering students are eligible for any CIT Designated Minor. Those minors that are especially well suited to Chemical Engineers include Biomedical Engineering, Electronic Materials, Colloids, Polymers, & Surfaces, Engineering Design, Environmental Engineering and Sustainability, Data Storage Systems Technology, and Automation and Control Engineering. The minor requirements may be fulfilled with electives. Other minors, such as the Supply Chain Management minor in association with the Tepper School of Business, are also available outside of CIT. These should be discussed with a faculty advisor.

Minor in Colloids, Polymers, and Surfaces (CPS)

Historically, the CPS coursework sequence has had a long-standing popularity among chemical engineering students. A detailed description of the minor can be found in the CIT Minors section of this catalog, or ask your Chemical Engineering faculty advisor, or the Director of CPS. Chemical Engineering students may use four of their electives to obtain the CPS minor. This is a sequence of closely related courses that explore the science and engineering of polymeric materials, particulates, micro-structured fluids, and interfacially engineered materials. Completion of the following five courses constitutes the CPS minor:

- 06-221 Thermodynamics (9 units)
- 06-426 Experimental Colloid Surface Science (9 units)
- 06-466 Experimental Polymer Science (9 units)
- 06-607 Physical Chemistry of Colloids and Surfaces (9 units)
- 06-609/06-509 Physical Chemistry of Macromolecules (9 units)

Typically, 06-607 is taken in the spring of the Junior year, while 06-609 also known as 09-509, 06-426 and 06-466 are taken during the Senior year.
Practical Internships for Senior Chemical Engineering Students (PISCES)

Chemical Engineering students may apply in the fall of their Junior year for a salaried, one-year PISCES with a partner company. Admitted students begin their internships after completion of the Junior year. Following the internship, students return to complete their Senior year. There are several advantages of a one full-year internship, including the opportunity to gain a breadth of professional experience that is not generally possible in a shorter program, more opportunity to make important contributions to the partner company, and the opportunity to complete Senior year courses in their normal sequence with no need for curriculum rearrangements. Interested students should consult with their faculty advisors.

International Chemical Engineering Exchange Programs

Chemical Engineering students may apply during their Sophomore year to spend their Junior year at the University of Aachen in Germany, Yonsei University in Seoul, Korea, or at Imperial College in London, Great Britain. A summer exchange program in Dortmund, Germany is also available. These exchange programs provide a great opportunity for students to obtain international experience while taking courses very similar to those offered at Carnegie Mellon. Students considering any of these programs should consult with their faculty advisors, and students considering the Aachen program in particular are advised to take at least one introductory German course before or during their Sophomore year.

Fifth Year Master of Chemical Engineering (MChE)

This degree offers qualified undergraduate students the opportunity to obtain a Masters degree in Chemical Engineering in less than one academic year. The goal of the program is to produce skilled engineers who will have a deeper understanding of the fundamentals of chemical engineering as well as a broader set of professional skills and exposure to other technical disciplines. The MChE degree requires the completion of at least 96 units, with a cumulative QPA of 3.0. Junior and Senior undergraduates from the disciplines. The MChE degree requires the completion of at least 96 units, with a cumulative QPA of 3.0. Three letters of recommendation are also required. The deadline for application is February 1 for the Fall semester and October 15 for the Spring semester. All applications should be submitted to the Graduate Admissions Committee of Chemical Engineering.

Faculty

JOHN L. ANDERSON, Adjunct Professor of Chemical Engineering – Ph.D., University of Illinois; Carnegie Mellon, 1976–.

SHERLEY ANNA, Professor of Chemical Engineering – Ph.D., Harvard University; Carnegie Mellon, 2003–.

LORENZ T. BIEGLER, University Professor and Bayer Professor of Chemical Engineering – Ph.D., University of Wisconsin; Carnegie Mellon, 1981–.

RAJ CHAKRABARTI, Associate Professor – Ph.D., Princeton University; Carnegie Mellon, 2012–.

KRIS N. DAHL, Associate Professor of Chemical Engineering – Ph.D., University of Pennsylvania; Carnegie Mellon, 2006–.

MICHAEL M. DOMACH, Professor of Chemical Engineering – Ph.D., Cornell University; Carnegie Mellon, 1983–.

NEIL M. DONAHUE, Professor of Chemical Engineering and Chemistry – Ph.D., Massachusetts Institute of Technology; Carnegie Mellon, 2000–.

ANDREW J. GELLMAN, Lord Professor of Chemical Engineering, Head of Department – Ph.D., University of California, Berkeley; Carnegie Mellon, 1992–.

CHRYSANTHOS GOUNARIS, Assistant Professor of Chemical Engineering – Ph.D., Princeton University; Carnegie Mellon, 2013–.

IGNACIO E. GROSSMANN, Assistant Professor of Chemical Engineering – Ph.D., Imperial College, University of London; Carnegie Mellon, 1979–.

ANNETTE M. JACOBSON, Teaching Professor of Chemical Engineering and Director of Colloids, Polymers, and Surfaces Program – Ph.D., Carnegie Mellon; Carnegie Mellon, 1988–.

MYUNG S. JHON, Professor of Chemical Engineering – Ph.D., University of Chicago; Carnegie Mellon, 1980–.

ADITYA KAHR, Assistant Professor of Chemical Engineering – Ph.D, California Institute of Technology; Carnegie Mellon, 2010–.

JOHN KITCHIN, Associate Professor of Chemical Engineering – Ph.D., University of Delaware; Carnegie Mellon, 2006–.


MEAGAN MAUTER, Assistant Professor of Chemical Engineering – Ph.D., Yale University; Carnegie Mellon, 2013–.

JAMES B. MILLER, Research Scientist – Ph.D., Carnegie Mellon University; Carnegie Mellon, 2006–.

Spyros N. Pandis, Research Professor of Chemical Engineering and Engineering and Public Policy – Ph.D., California Institute of Technology; Carnegie Mellon, 1993–.

DENNIS C. PRIEVE, Gulf Professor Of Chemical Engineering – Ph.D., University of Delaware; Carnegie Mellon, 1974–.

TODD M. PRZYBYCIE, Professor Of Chemical Engineering And Biomedical Engineering – Ph.D., California Institute of Technology; Carnegie Mellon, 1998–.

NIKOLAOS V. SAHINIDIS, John E. Swearingen Professor of Chemical Engineering – Ph.D., Carnegie Mellon University; Carnegie Mellon, 2007–.

JAMES W. SCHNEIDER, Professor of Chemical Engineering – Ph.D., University of Minnesota; Carnegie Mellon, 1999–.

PAUL J. SIDES, Professor of Chemical Engineering – Ph.D., University of California, Berkeley; Carnegie Mellon, 1981–.

ROBERT D. TILTON, Professor of Chemical Engineering – Ph.D., Stanford University; Carnegie Mellon, 1992–.

LYNN M. WALKER, Professor of Chemical Engineering – Ph.D., University of Delaware; Carnegie Mellon, 1997–.

ARThur w. wEstERBERG, Emeritus, University Professor of Chemical Engineering – Ph.D., Dic, Imperial College, University of London; Carnegie Mellon, 1976–.

KATHRYN Whitehead, Assistant Professor of Chemical Engineering – Ph.D., University of California; Carnegie Mellon, 2012–.

B. ERIK YDSTIE, Professor of Chemical Engineering – Ph.D., Imperial College, University of London; Carnegie Mellon, 1992–.