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 schools. 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.

The objectives for the department 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 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:

- mathematics, science, and engineering skills, and the ability to apply them to solve engineering problems,
- the ability to design and conduct experiments and interpret data,
- the ability to design a component or system, within realistic constraints,
- the ability to identify, formulate and solve engineering problems,
- the ability to use modern engineering tools,
- the ability to function on teams,
- an understanding of personal and professional ethics,
- an ability to communicate effectively,
- an ability to understand impact of engineering in a global/societal context,
- an appreciation and capability for life-long learning,
- a knowledge of contemporary issues facing engineers.

The department offers a number of special programs for students majoring in Chemical Engineering. In addition to the double majors or minors offered by the College of Engineering such as Biomedical Engineering and Manufacturing Management & Consulting, students may choose a minor in Colloids, Polymers, and Surfaces. Undergraduate research projects are also available in the areas of bioengineering, complex fluids engineering, environmental engineering, process systems engineering, and solid state materials. 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 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

First Year

	Fall	Units
21-120	Differential and Integral Calculus	10
76-xxx	Designated Writing/Expression Course	9
99-101	Computing @ Carnegie Mellon	3
06-100	Intro to Chemical Engineering	12
09-105	Intro to Modern Chemistry	10
		44
	Spring	
21-122	Integration, Differential Equation & Approximation	10
xx-100/101	Introductory Engineering Elective (other than ChE)	12
33-106	Physics for Engineering Students I	12
xx-xxx	General Education Course	9
		43

Second Year

	Fall	Units
21-259	Calculus in Three-Dimensions	9
06-221	Thermodynamics	9
06-222	Sophomore Chemical Engineering Seminar	1
09-106	Modern Chemistry II	10
xx-xxx	Computer Sci./Physics II*	10 or 12
xx-xxx	General Education Course	9
		48 or 50

	Spring	
06-261	Fluid Mechanics	9
06-262	Mathematical Methods of Chemical Engineering	12
09-221	Lab I: Introduction to Chemical Analysis	12
xx-xxx	Physics II/Computer Sci.*	12 or 10
xx-xxx	General Education Course	9
		52 or 54

* Computer Science/Physics II: Students should complete 15-100 (Introductory/ Intermediate Programming) as well as 33-107 (Physics for Engineering Students II) by the end of the Sophomore year. The recommended sequence is 33-106 / 107 for engineering students, however, 33-111 / 112 or 33-131 / 132 will also meet the CIT Physics requirement.

For those students who have not taken 06-100 as one of the two Introductory Engineering Electives, 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	10
09-106	Modern Chemistry II	10
09-221	Lab I: Introduction to Chemical Analysis	12
15-100	Introductory/Intermediate Programming	10
33-106	Physics for Engineering Students I	12
33-107	Physics for Engineering Students II	12
99-10x	Computing @ Carnegie Mellon	3

Third Year

	Fall	Units
06-321	Chemical Engineering Thermodynamics	9
06-322	Junior Chemical Engineering Seminar	2
06-323	Heat and Mass Transfer	9
09-217	Organic Chemistry I	9
09-347	Advanced Physical Chemistry	12
xx-xxx	General Education Course	9
		50
	Spring	
06-361	Unit Operations of Chemical Engineering	9
06-362	Chemical Engineering Process Control	9
06-363	Transport Processes Laboratory	6
03-232	Biochemistry**	9
xx-xxx	Elective	9
xx-xxx	General Education Course	9
		51

Fourth Year

	Fall	Units
06-421	Chemical Process Systems Design	12
06-422	Chemical Reaction Engineering	9
06-423	Unit Operations Laboratory	9
xx-xxx	Elective	9
xx-xxx	General Education Course	9
		48
	Spring	
06-462	Optimization Modeling and Algorithms	6
06-463	Chemical Product Design	6
xx-xxx	Elective	9
xx-xxx	Elective	9
xx-xxx	Elective	9
xx-xxx	General Education Course	9
		48

** Students pursuing a Chemical Engineering/Engineering and Public Policy double major are waived from taking the Biochemistry Elective. They will take 36-220.

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: 386.
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, 300, or 400 (Sophomore, Junior, or Senior Research Projects) or 39-500 (CIT Honors Research) for eligible Seniors.

The following two tracks have been designed as thematic guidelines. Students are not required to follow either of these tracks. They may take courses from both tracks and they may take courses that are not listed in either track. The Process Systems Track is designed for students interested in focusing on the design and optimization of chemical processes. The Chemical Engineering Sciences Track is designed for students interested in the scientific principles underlying the fabrication and processing of synthetic and/or biological materials.

Some electives contain elements of both tracks and are therefore listed under each. Undergraduate research projects that fit either track are available by arrangement with a faculty advisor.

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

Process Systems Track

06-200, 300, or 400	Sophomore, Junior, or Senior Research Projects
or	
39-500	CIT Honors Research
06-606	Computational Methods for Large Scale Process Design and Analysis
06-608	Safety Issues in Science and Engineering Practice
06-619	Semiconductor Processing Technology
06-630	Atmospheric Chemistry Air Pollution and Global Change
06-708	Advanced Process Dynamics and Control
06-713	Mathematical Techniques in Chemical Engineering
06-715	Advanced Process Synthesis
06-717	Biotechnology and Environmental Processes
06-720	Advanced Process Systems Engineering
06-722	Bio Process Design
12-271	Introduction to Computer Applications in Civil & Environmental Engineering
12-411	Engineering Economics
12-651	Air Quality Engineering
15-111	Intermediate/Advanced Programming
15-200	Advanced Programming/Practicum
15-211	Fundamental Data Structures and Algorithms
18-470	Fundamentals of Control
19-424	Energy and the Environment
21-127	Concepts of Mathematics
21-292	Operations Research I
24-451	Feedback Control Systems
27-322	Processing of Metals
36-220	Engineering Statistics and Quality Control
70-371	Production/Operations Management
70-391	Finance

Chemical Engineering Sciences Track

03-240	Cell Biology
03-231	Biochemistry I
03-330	Genetics
03-380	Virology
03-438	Physical Biochemistry
03-441	Molecular Biology of Prokaryotes
03-442	Molecular Biology
06-200, 300, or 400	Sophomore, Junior, or Senior Research Projects (or 39-500 CIT Honors Research)
06-426	Experimental Colloid Surface Science
06-466	Experimental Polymer Science
06-607	Physical Chemistry of Colloids and Surfaces
06-608	Safety Issues in Science and Engineering Practice
06-609/ 09-509	Physical Chemistry of Macromolecules
06-610/ 09-545	Rheology and Structure of Complex Fluids
06-619	Semiconductor Processing Technology
06-620	Global Atmospheric Chemistry-
06-640	Principles and Applications of Molecular Simulation

06-702	Advanced Reaction Kinetics
06-703	Advanced Fluid Dynamics
06-704	Advanced Heat and Mass Transfer
06-705	Advanced Chemical Engineering Thermodynamics
06-712	Colloids and Dispersions
06-713	Mathematical Techniques in Chemical Engineering
06-714	Surfaces and Absorption
06-716	Electrochemical Engineering
06-717	Biotechnology and Environmental Processes
06-722	Bio Process Design
09-348	Inorganic Chemistry
09-510	Introduction to Green Chemistry
12-651	Air Quality Engineering
21-372	Partial Differential Equations
24-321	Thermal-Fluids Engineering
27-357	Intro to Materials Selection
33-107	Physics for Engineering Students II
33-211	Physics III: Modern Essentials
33-225	Quantum Physics and Structure of Matter
33-228	Electronics I
42-202	Physiology
42-424	Biological Transport

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 or an EPP faculty representative.

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 or a BME faculty representative.

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, Engineering Design, Environmental Engineering, Data Storage Systems Technology, and Automation and Control Engineering. The minor requirements may be fulfilled with electives. Other minors, such as the Manufacturing Management and Consulting 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, microstructured fluids, and interfacially engineered materials. Completion of the following five courses constitutes the CPS minor:

06-221	Thermodynamics	9
06-607	Physical Chemistry of Colloids and Surfaces	9
06-426	Experimental Colloid and Surface Science	9
06-466	Experimental Polymer Science	9
06-609	Physical Chemistry of Macromolecules (cross-listed as 09-509)	9

Typically 06-607 is taken in the Spring of the Junior year, while 06-609/09-509, 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 or at Imperial College in London, Great Britain. Students should register for 06-050 - Study Abroad, Fall and/or 06-051 - Study Abroad, Spring. 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 department may apply to the MChE program if they have an overall 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—.

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

KRIS N. DAHL, Assistant 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—.

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

STEINAR HAUAN, Associate Professor of Chemical Engineering — Ph.D., Norwegian Institute of Science and Technology; Carnegie Mellon, 1999—.

MOHAMMAD F. ISLAM, Assistant Professor of Chemical Engineering – Ph.D., Lehigh University; Carnegie Mellon, 2005—.

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—.

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

EDMOND I. KO, Adjunct Professor of Chemical Engineering — Ph.D., Stanford University; Carnegie Mellon, 1980—.

KUN LI, Professor Emeritus of Chemical Engineering — Sc.D., Carnegie Mellon University; Carnegie Mellon, 1962—.

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. PRZYBYCIEN. 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—.

HERBERT L. TOOR, Emeritus Professor of Chemical Engineering — Ph.D., Northwestern University; Carnegie Mellon, 1953—.

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—.

LEE R. WHITE, Professor of Chemical Engineering — Ph.D., Australian National University; Carnegie Mellon, 1998—.

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