Department of Chemical Engineering

Carl Laird, Interim Department Head
Office: Doherty Hall 2100B
www.cheme.engineering.cmu.edu/ (http://www.cheme.engineering.cmu.edu/)

Chemical Engineering is a broad discipline that combines chemistry, mathematics and physics with its own unique principles of *chemical engineering science* and *process systems engineering* to develop new products and manufacturing processes. Chemical engineering science refers to the material properties and models that help the chemical engineer understand and predict the transformation of chemical compounds at all stages of their conversion from raw materials to value added products. Process systems engineering provides methodologies for the systematic design, optimization, control, operation and analysis of a system of operations by which a product is manufactured, as well as the economic, safety, sustainability and environmental assessment of these processes.

Modern chemical engineering practice brings together a deep understanding of molecular properties and process design to not only develop more energy-efficient and sustainable manufacturing processes for currently existing products but also to develop new consumer and industrial products that provide enhanced functionality while making more efficient use of resources. As a result, the Chemical Engineering profession offers challenging and well-compensated careers in industries across the economy. Nearly all aspects of modern life use the products of chemical engineering. The pharmaceutical industry recruits chemical engineers to use their knowledge of chemical reaction engineering and separation processes to produce pure and effective pharmaceutical agents and drug delivery systems, and the biopharmaceutical industry attracts chemical engineers who can apply this expertise to biomanufacturing systems based on microbiology and biochemistry. In the chemical and energy sectors, chemical engineers develop catalysts and processes to improve yields in the production of commodity and specialty chemicals and fuels, and they develop new battery systems, fuel cells and biofuels to help build the renewable energy economy. Material manufacturers hire chemical engineers to develop large scale processes to synthesize polymers as resins for formulated products or as fabricated device components. The semiconductor industry seeks the chemical processing expertise of chemical engineers to manufacture chips, integrated circuits, and photovoltaic cells. Chemical engineers in the consumer products industries use their knowledge of chemical transformations to formulate and manufacture nearly all the products that people use in their everyday lives. Consulting companies seek chemical engineers for evaluation of the economic feasibility, environmental impact, and sustainability of industrial projects and to develop software for the design, analysis and operation of manufacturing processes. Finally, the curricular emphasis on the analysis and optimization of complex systems makes Chemical Engineering an excellent preparatory major for students interested in medical or business schools.

The Chemical Engineering curriculum develops deep problem solving skills through challenging, open-ended problems in chemical engineering science, process systems engineering, process system design and product design. Computing is integrated throughout the curriculum. The department supports extensive use of mathematical modeling and simulation software. Students in the Robert Rothfus Laboratory and Lubrizol Analytical Laboratory learn to use computerized data acquisition and control systems as they develop experimental tests of chemical engineering theory or process design alternatives. With its focus on complex chemical and biochemical processes, Chemical Engineering is a natural pairing with the Additional Major in Biomedical Engineering or the Biomedical Engineering minor. Chemical Engineering students pursue many different minors. It is particularly well aligned with the CIT Designated Minor in Colloids, Polymers and Surfaces and the University's Minor in Environmental and Sustainability Studies.

Program Educational Objectives and Student Outcomes

Program Educational Objectives

The Carnegie Mellon University Chemical Engineering Bachelor of Science degree program strives to produce graduates who:

- possess deep knowledge of chemical engineering fundamentals and the ability to combine them with advanced modeling and computational strategies to solve complex problems;
- strive for excellence in their professional activities, with a commitment to safety and ethical practices;
- understand the impact of their work in a global, economic, environmental, and societal context, which includes valuing the perspective of people with diverse backgrounds and experiences;
- are excellent communicators;
- excel both as leaders and as members of working teams; and
- are well prepared for immediate success in either professional employment or advanced education.

Learning Outcomes

Students who complete the Bachelor of Science in Chemical Engineering at Carnegie Mellon University will acquire:

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 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.

The department offers a number of special programs for students majoring in Chemical Engineering. In addition to the additional majors offered by the College of Engineering such as: Biomedical Engineering (BME), Engineering Design, Innovation & Entrepreneurship (EDIE), and Engineering & Public Policy (EPP), 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. The department offers the Chemical Engineering Summer Scholars (ChESS) program to support undergraduate research within the department. Students may participate in study abroad programs during their Junior year. In addition to the University Study Abroad programs, the department provides its own exchange programs with: RWTH Aachen in Germany, Imperial College in London, Great Britain, Universidad Nacional del Litoral in Argentina, and Yonsei University in Seoul, Korea. A summer exchange program in Dortmund, Germany is also available. Students may also participate in Practical Internships for Senior Chemical Engineering Students (PISCES), 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 for Class of 2025 and Beyond

Minimum units required for B.S. in Chemical Engineering 391

The program in chemical engineering within the Department of Chemical Engineering is accredited by the Engineering Accreditation Commission of ABET, https://www.abet.org, under the commission's General Criteria and Program Criteria for Chemical, Biochemical, Biomolecular, and Similarly Named Engineering Programs.

First Year

Fall		Units
21-120	Differential and Integral Calculus	10
76-xxx	Designated Writing/Expression Course	9
99-101	Core@CMU	3
06-100	Introduction to Chemical Engineering	12

09-105	Introduction to Modern Chemistry I	10
		44

Spring		Units
21-122	Integration and Approximation	10
xx-xxx	Introductory Engineering Elective (other than ChE)	12
33-141	Physics I for Engineering Students	12
xx-xxx	General Education Course	9
		43

Second Year

Fall		Units
21-254	Linear Algebra and Vector Calculus for Engineers	11
06-223	Chemical Engineering Thermodynamics	12
06-222	Sophomore Chemical Engineering Seminar	1
09-106	Modern Chemistry II	10
xx-xxx	Computer Sci./Physics II *	10-12
xx-xxx	General Education Course	9
39-210	Experiential Learning I	0
		53-55

Spring		Units
06-261	Fluid Mechanics	9
06-262	Mathematical Methods of Chemical Engineering	12
09-221	Laboratory I: Introduction to Chemical Analysis	12
xx-xxx	Physics II/Computer Sci. *	12-10
xx-xxx	General Education Course	9
39-220	Experiential Learning II	0
		54-52

* Computer Science/Physics II: Students should complete 15-110 Principles of Computing or 15-112 Fundamentals of Programming and Computer Science as well as 33-142 Physics II for Engineering and Physics Students by the end of the Sophomore year. The recommended sequence is 33-141 /33-142 for engineering students, however, 33-151/ 33-152 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 advisor 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
09-106	Modern Chemistry II	10
09-221	Laboratory I: Introduction to Chemical Analysis	12
15-110	Principles of Computing	10-12
or 15-112	Fundamentals of Programming and Computer Science	
33-141	Physics I for Engineering Students	12
33-142	Physics II for Engineering and Physics Students	12
99-101	Core@CMU	3

Third Year

Fall		Units
06-325	Numerical Methods and Machine Learning for Chemical Engineering	6
06-326	Optimization Modeling and Algorithms	6
06-322	Junior Chemical Engineering Seminar **	2
06-323	Heat and Mass Transfer	9
09-217	Organic Chemistry I	9-10
or 09-219	Modern Organic Chemistry	
06-310	Molecular Foundations of Chemical Engineering	9
xx-xxx	General Education Course	9
39-310	Experiential Learning III	0
		50-51

Spring		Units
06-361	Unit Operations of Chemical Engineering	9
06-363	Transport Process Laboratory	9
06-364	Chemical Reaction Engineering	9
xx-xxx	Advanced Chemistry Elective**/***	9
xx-xxx	Unrestricted Elective	9
xx-xxx	General Education Course	9
		54

Fourth Year

Fall		Units
06-421	Chemical Process Systems Design	12
06-423	Unit Operations Laboratory	9
xx-xxx	Unrestricted Elective	9
xx-xxx	Unrestricted Elective	9
xx-xxx	General Education Course	9
		48

Spring		Units
06-463	Chemical Product Design ****	9
06-464	Chemical Engineering Process Control	9
xx-xxx	Unrestricted Elective	9
xx-xxx	Unrestricted Elective	9
xx-xxx	General Education Course	9
		45

** For students pursuing Chemical Engineering with an Additional Major in Biomedical Engineering, the 06-322 Junior Chemical Engineering Seminar is replaced by 42-201 Professional Issues in Biomedical Engineering.
Students pursuing Chemical Engineering with an Additional Major in Engineering and Public Policy are waived from taking the Advanced Chemistry Elective. They will take 36-220.

*** **Advanced Chemistry Elective** may be any technical course offered by the Department of Chemistry for at least 9 units at the 200-level or above, or one of the following: 03-232 Biochemistry, 06-607 Physical Chemistry of Colloids and Surfaces, or 06-609/09-509 Physical Chemistry of Macromolecules. Students may petition the Undergraduate Committee to approve other chemistry-focused courses offered by other departments on a case-by-case basis.

**** The 06-463 Chemical Product Design requirement is waived for BME Additional Major students completing 42-401 Foundations of Biomedical Engineering Design (6 units, fall) AND 42-402 Biomedical Engineering Design Project (9 units, spring).

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: 391.
3. All mathematics (21-xxx) courses required for the engineering degree taken at Carnegie Mellon must have a minimum grade of C in order to be counted toward the graduation requirement for the BS engineering degree.
4. A minimum grade of C must be achieved in any required mathematics (21-xxx) course that is a pre-requisite for the next higher level required mathematics (21-xxx) course.
5. Overloads are permitted only for students maintaining a QPA of 3.5 or better during the preceding semester.
6. 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.
7. 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 CIT Honors Research Project for eligible Seniors.
8. Advanced undergraduates may also take Chemical Engineering graduate courses (600 or 700 level).

Additional Major in Engineering and Public Policy (EPP)

Students may pursue an Additional Major in Chemical Engineering and EPP. This Additional Major is built around electives in Social Analysis, Probability and Statistics courses, and projects. Specific course choices should be discussed with the student's advisor and an EPP advisor.

Additional Major in Engineering Design, Innovation & Entrepreneurship (EDIE)

Students may pursue an Additional Major in Chemical Engineering and EDIE. Specific course choices should be discussed with the student's advisor and an EDIE advisor.

Additional Major in Biomedical Engineering (BME)

Students may pursue an Additional Major in Chemical Engineering and BME. Specific course choices should be discussed with the student's 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: Additive Manufacturing, Audio Engineering, Biomedical Engineering, Colloids, Polymers & Surfaces, Electronic Materials, Global Engineering, Materials Science and Engineering and Mechanical Behavior of Materials. 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 or the Minor in Environmental and Sustainability Studies, are also available outside of CIT. These should be discussed with the student's advisor.

Colloids, Polymers and Surfaces Minor

Professor Robert Tilton, *Director of CPS Minor*
Location: Doherty Hall A207C

The sequence of courses in the Colloids, Polymers and Surfaces (CPS) designated minor provides an opportunity to explore the science and engineering of fine particles and macromolecules as they relate to complex fluids and interfacially engineered materials. These topics are very relevant to technology and product development in industries that manufacture pharmaceuticals, coatings and paints, pulp and paper, biomaterials, surfactants and cleaning products, cosmetics and personal care products, food, textiles and fibers, nanoparticles, polymer/plastics, composite materials.

Course Requirements

Minimum units required for minor: 45

This minor requires a total of five classes with a minimum of 45 units. The following four courses are mandatory:

06-609/09-509	Physical Chemistry of Macromolecules	9
06-607	Physical Chemistry of Colloids and Surfaces	9
06-426	Experimental Colloid Surface Science	9
06-466	Experimental Polymer Science	9

In addition, the student must take one CPS related elective course from the following list:

06-612	Formulation Engineering	12
06-610	Rheology and Structure of Complex Fluids	9
09-502	Organic Chemistry of Polymers	9
27-565	Nanostructured Materials	9
27-477	Introduction to Polymer Science and Engineering	9

Other CPS electives are possible but must be approved by the Director of the CPS minor, Professor Tilton

The Chemical Engineering curriculum develops deep problem solving skills through challenging, open-ended problems in chemical engineering science, process systems engineering, process system design and product design. Computing is integrated throughout the curriculum. The department supports extensive use of mathematical modeling and simulation software. Students in the Robert Rothfus Laboratory and Lubrizol Analytical Laboratory learn to use computerized data acquisition and control systems as they develop experimental tests of chemical engineering theory or process design alternatives. With its focus on complex chemical and biochemical processes, Chemical Engineering is a natural pairing with the Additional Major in Biomedical Engineering or the Biomedical Engineering minor. Chemical Engineering students pursue many different minors. It is particularly well aligned with the CIT Designated Minor in Colloids, Polymers and Surfaces and the University's Minor in Environmental and Sustainability Studies.

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 internship 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 advisor.

International Chemical Engineering Exchange Programs

Chemical Engineering students may apply during their Sophomore year to spend their Junior year at RWTH Aachen in Germany, Yonsei University in Seoul, Korea, Universidad Nacional del Litoral in Argentina, 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 advisor, 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)

The CIT Integrated Masters/Bachelors (IMB) Degree program provides the opportunity for qualified undergraduate students to obtain a master's degree in Chemical Engineering with one or two extra semesters of study. The goal is to deepen our graduates' understanding of the fundamentals of chemical engineering, and to provide them with a broader set of professional skills or to expose them to other technical disciplines.

The MChE program is a 96 unit course work degree aimed at undergraduate students from Carnegie Mellon and candidates from other universities. No financial support is available. For Carnegie Mellon students, the degree typically would be completed in their fifth year. Depending on advanced placement and semester overloads, however, CMU students can complete the degree at the time of the B.S. graduation or with one additional semester. All students must have graduate status once they have completed their B.S. degree; beyond eight semesters, degree program students must have full-time graduate student status in at least one (e.g., their final) semester whether or not they have already completed their BS degree. Upon graduating from this program, students seek industrial positions or placement in graduate programs at other universities.

A minimum of five completed semesters in residence as an undergraduate student and an overall QPA of 3.0 is required for eligibility. Taking the GRE and recommendation letters are not required. The application fee is waived for currently-enrolled undergraduate Chemical Engineering students.

The MChE program differs from the MS program because the MChE program does not require a project report or thesis.

Faculty

SHELLEY ANNA, Vice Provost for Faculty and Professor of Chemical Engineering – Ph.D., Harvard University; Carnegie Mellon, 2003–

JOANNE BECKWITH MADDOCK, Assistant Teaching Professor of Chemical Engineering – Ph.D., University of Michigan; Carnegie Mellon, 2022–

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

DAPHNE WUI YARN CHAN, Assistant Professor of Chemical Engineering – Ph.D., Massachusetts Institute of Technology; Carnegie Mellon, 2022-–

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

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

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

GABRIEL GOMES, Assistant Professor of Chemistry and Chemical Engineering – Ph.D., Florida State University; Carnegie Mellon, 2022–

HAMISH GORDON, Assistant Professor of Chemical Engineering – Ph.D., University of Oxford; Carnegie Mellon, 2022–

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

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

ANNETTE JACOBSON, Emeritus, Teaching Professor of Chemical Engineering – Ph.D., Carnegie Mellon University; Carnegie Mellon, 1988–

COTY JEN, Assistant Professor of Chemical Engineering – Ph.D., University of Minnesota; Carnegie Mellon, 2018–

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

ADITYA KHAIR, Professor of Chemical Engineering – PhD, California Institute of Technology; Carnegie Mellon, 2010–

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

CARL LAIRD, Professor and Interim Department Head of Chemical Engineering – Ph.D., Carnegie Mellon; Carnegie Mellon, 2021–

ALEXANDRA NEWBY, Assistant Teaching Professor of Chemical Engienering – Ph.D., Carnegie Mellon University; Carnegie Mellon, 2024–

TAGBO NIEPA, Arthur Hamerschlag Associate Professor of Chemical Engineering – Ph.D., Syracuse University; Carnegie Mellon, 2023–

GRIGORIOS PANAGAKOS, Assistant Research Professor of Chemical Engineering – Ph.D., Technical University of Denmark; Carnegie Mellon, 2018–

ANNE SKAJA ROBINSON, Trustee Professor of Chemical Engineering – Ph.D., University of Illinois at Urbana-Champaign; Carnegie Mellon, 2019–

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

DERIN SEVENLER, Assistant Professor of Chemical Engineering – Ph.D., Boston University; Carnegie Mellon, 2024–

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

SUSANA C. STEPPAN, Emeritus, Associate Teaching Professor of Chemical Engineering – PhD, University of Massachusetts; Carnegie Mellon, 2004–

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

ANA INES TORRES, Assistant Professor of Chemical Engineering – Ph.D., University of Minnesota; Carnegie Mellon, 2022–

ARTHUR W. WESTERBERG, Emeritus, University Professor of Chemical Engineering – Ph.D., DIC, Imperial College, University of London; Carnegie Mellon, 1976–

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

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