# CHEMICAL ENGINEERING (BS)

Duffield College of Engineering

Program Website (https://www.duffield.cornell.edu/cbe/major/)

**CIP:** 14.0701 | **HEGIS:** 0906.00 | **NYSED:** 05591

## Program Description

The Chemical Engineering major is accredited by the Engineering Accreditation Commission of ABET (https://www.abet.org/). A major in Chemical Engineering is a rigorous mix of chemistry, engineering, research, and electives readies you for careers in a variety of industries - pharmaceuticals, petroleum, electronics, consumer-products, food-processing and more. Our graduates excel in top schools and industries and quickly move up to key technical and managerial roles.

## Academic Standards

### Academic Standing

Chemical Engineering Majors must meet the following criteria for good standing at the end of each semester:

- Semester GPA greater than or equal to 2.0
- Cumulative GPA greater than or equal to 2.2
- GPA greater than or equal to 2.2 each semester in required chemical engineering courses
- At most, one grade below C- in required chemical engineering courses during the undergraduate program
- No failing grades
- Students must make adequate progress toward the degree requirements

When Chemical Engineering Majors are not in good standing their academic performance will be reviewed by the Chemical Engineering faculty, which may result in an academic warning, a required leave of absence or withdrawal from the college.

## Program Information

- Program Mode of Delivery: In Person
- Program Location: Ithaca, NY
- Minimum Credits for Degree: 136

## Program Requirements

The undergraduate major in chemical engineering comprises a coordinated sequence of in person full-time courses beginning in the sophomore year and extending through the fourth year. Students who plan to enter the major take CHEM 2090 and CHEM 2091 - CHEM 2080 and CHEM 2081 or CHEM 2150 with AP credit during the first year.

| Code | Title | Hours |
|---|---|---|
| **Common Curriculum** | | |
| *Mathematics* | | |
| MATH 1910 | Calculus for Engineers | 4 |
| MATH 1920 | Multivariable Calculus for Engineers | 4 |
| MATH 2930 | Differential Equations for Engineers | 4 |
| Select one of the following: | | 4 |
| MATH 2940 | Linear Algebra for Engineers | |
| CEE 3040 | Uncertainty Analysis in Engineering | |
| ENGRD 2700 | Eng Probability and Statistics: Modeling and Data Science | |
| *Physics* | | |
| PHYS 1112<br>& PHYS 1110 | Physics I: Mechanics and Heat<br>and Introduction to Experimental Physics | 4 |
| or PHYS 1116 | Physics I: Mechanics and Special Relativity | |
| PHYS 2213 | Physics II: Electromagnetism | 4 |
| or PHYS 2217 | Physics II: Electricity and Magnetism | |
| *Chemistry* | | |
| Select one of the following: | | 8 |
| CHEM 2090<br>& CHEM 2091<br>& CHEM 2080<br>& CHEM 2081 | Engineering General Chemistry<br>and Engineering General Chemistry Laboratory<br>and General Chemistry II<br>and General Chemistry II Laboratory [1] | |
| AP Chem credit & CHEM 2080 & CHEM 2081 [1] | | |
| AP Chem credit & CHEM 2150 [1] | | |
| *Computing* | | |
| CS 1110 | Introduction to Computing: A Design and Development Perspective | 4 |
| or CS 1112 | Introduction to Computing: An Engineering and Science Perspective | |
| *First-Year Writing Seminars* | | |
| Choose any two first-year writing seminar courses | | 6 |
| *Engineering Communications Requirement* | | |
| CHEME 4320 | Chemical Engineering Capstone Design I [2] | 4 |
| *Engineering Distribution* | | |
| Any ENGRI course (ENGRI 1120 recommended) | | 3 |
| CHEM 3890 | Honors Physical Chemistry I [3] | 4 |
| ENGRD 2190 | Chemical Process Design and Analysis | 4 |
| *Liberal Studies Distribution* | | |
| Select six courses from Duffield College of Engineering Graduation Requirements Liberal Studies Distribution below. | | 18 |
| *Advisor-approved Electives* | | |
| Select courses based on the criteria from Duffield College of Engineering Graduation Requirements Electives below. [1] | | 6 |

1. CHEM 2080 & CHEM 2081 (CHEM 2150) fulfills one of the two Advisor-approved Elective credits.
2. CHEME 4320 fulfills the Engineering Communications Requirement and must be completed by Chemical Engineering majors. Refer to Duffield Engineering Core Requirements Engineering Communications Category B: Via Other Paths below.
3. CHEM 3890 is required by the Major, and it is recommended that this course be counted as an engineering distribution course. In this case, the fourth credit may apply as an Advisor-approved Elective credit.

| Code | Title | Hours |
|---|---|---|
| **Major Requirements** [4] | | |
| *Required Courses* | | |
| CHEME 2200 | Physical Chemistry II for Engineers | 4 |
| CHEME 3230 | Fluid Mechanics | 4 |
| CHEM 2900 | Introductory Physical Chemistry Laboratory [5] | 2 |
| CHEME 3130 | Chemical Engineering Thermodynamics | 4 |
| CHEME 3240 | Heat and Mass Transfer | 4 |

| | | |
|---|---|---|
| CHEM 3570 | Organic Chemistry for the Life Sciences [5,6] | 3 |
| or CHEM 3590 | Honors Organic Chemistry I | |
| CHEM 2510 | Introduction to Experimental Organic Chemistry [5] | 2 |
| CHEME 3010 | Career Perspectives | 1 |
| CHEME 3320 | Analysis of Separation Processes | 4 |
| CHEME 3720 | Introduction to Process Dynamics and Control | 2 |
| CHEME 3900 | Chemical Kinetics and Reactor Design | 4 |
| CHEME 4320 | Chemical Engineering Capstone Design I [2] | 4 |
| CHEME 4620 | Chemical Engineering Capstone Design II | 4 |
| **Elective Courses** [7] | | |
| *Major approved Electives* | | |
| Select courses based on the criteria from Major-approved Elective Course Requirements | | 9 |
| *Major approved Elective: Biology Elective* | | |
| Select one of the following: | | 3-8 |
| Advanced placement: a score of 5 on the CEEB AP exam or a score of 7 on the IB Higher Level exam | | |
| CHEME 2880 | Biomolecular Engineering: Fundamentals and Applications | |
| CHEME 5430 | Bioprocess Engineering | |
| 8 credits of a pre-med biology sequence: BIOG 1500, BIOMG 1350, and BIOG 1440 or BIOG 1445 | | |
| BIOMI 2900 | General Microbiology Lectures | |
| BIOMG 3300 | Principles of Biochemistry, Individualized Instruction | |
| or BIOMG 33 | Principles of Biochemistry: Proteins, Metabolism, and Molecular Biology | |
| BIOMG 3310 & BIOMG 3320 | Principles of Biochemistry: Proteins and Metabolism and Principles of Biochemistry: Molecular Biology | |
| *Advanced CHEME Electives* [8] | | |
| Select six credits of the following: | | 6 |
| CHEME 4020 | Molecular Principles of Biomedical Engineering | |
| CHEME 4130 | Introduction to Nuclear Science and Engineering | |
| CHEME 4310 | Principles of Electrochemical Engineering | |
| CHEME 4410 | Air Pollution Control | |
| CHEME 4430 | Kinetics and Dynamics in Molecular and Cellular Systems | |
| CHEME 4440 | Colloids and Aerosols | |
| CHEME 4660 | Financial Data Markets and Mayhem for Scientists and Engineers | |
| CHEME 4770 | Principles in Process and Lean Engineering | |
| CHEME 4800 | Principles of Computational Thinking for Engineers | |
| CHEME 4840 | Microchemical and Microfluidic Systems | |
| CHEME 5430 | Bioprocess Engineering | |
| CHEME 5610 | Concepts of Chemical Engineering Product Design | |
| CHEME 6310 | Engineering Principles for Drug Delivery | |
| CHEME 6400 | Polymeric Materials | |
| CHEME 6660 | Sustainable Energy Choices – Technologies and Economics [9] | |
| CHEME 6661 | Bioenergy and Biofuels Module [9] | |
| CHEME 6662 | Solar Energy Module [9] | |
| CHEME 6663 | Geothermal Energy Module [9] | |
| CHEME 6664 | Hydrokinetic and Aerodynamic Energy Module [9] | |
| CHEME 6667 | Transportation Energy Systems Module [9] | |
| CHEME 6670 | Fossil Fuels Module [9] | |
| CHEME 6671 | Nuclear Energy Module [9] | |
| CHEME 6676 | Energy Markets and Regulations Module [9] | |
| CHEME 6679 | Energy Storage Module [9] | |
| CHEME 6681 | Energy Analysis Project [9] | |
| CHEME 6682 | [9] | |
| CHEME 6800 | Computational Optimization | |
| CHEME 6880 | Industrial Big Data Analytics and Machine Learning | |
| CHEME 6888 | Deep Learning | |

[4] Major requirements must be completed for a letter grade.

[5] The Major program includes 7 credits of courses outside the Major. These are satisfied by courses in chemistry.

[6] Pre-health students are highly recommended to complete 8 credits of organic chemistry. Students with a strong chemistry background, and room in their spring schedule due to AP credits, might consider taking CHEM 3590 Honors Organic Chemistry I with CHEM 2510 Introduction to Experimental Organic Chemistry in semester 4. Some complete organic chemistry in the first year when AP credit has created openings.

[7] The electives in semesters 6, 7, and 8 comprise 12 credits of major-approved electives including the biology requirement and 6 credits of advanced CHEME electives.

[8] Advanced CHEME electives must be satisfied by specifically approved CHEME courses.

[9] Three one-credit modules associated with CHEME 6660 Sustainable Energy Choices – Technologies and Economics may be combined to satisfy one Advanced Chemical Engineering Elective.

## Major-approved Elective Course Requirements

- ABET requires at least 48 credits of engineering courses. The chemical engineering degree requirements provide 45 credits of engineering courses. Therefore at least three credits of electives - Approved Electives, Major Approved Electives, or the Biology Elective - must be courses offered by the Engineering College. If you take CEE 3040 or ENGRD 2700 in place of MATH 2940 , this counts as an elective engineering course.
- Major-approved electives and Advisor-approved electives require the approval of your faculty advisor.
- Three of the Major-approved Electives, minimum of 9 credits, are intended to build on the foundation of fundamentals taken in one's first two years.
- Major-approved electives are usually advanced technical courses, at level 3000 and above although ENGRD 2700 , CS 2800 and similar courses are appropriate.
- Major-approved electives can be approved only after you have affiliated with chemical & biomolecular engineering and have an advisor in chemical & biomolecular engineering.
- The Major-approved electives are technical or professionally oriented courses approved by your chemical & biomolecular engineering advisor.
- Refer to the Electives Courses section Major approved Elective: Biology Elective to make a course selection.

# University Graduation Requirements Requirements for All Students

In order to receive a Cornell degree, a student must satisfy academic and non-academic requirements.

## Academic Requirements

A student's college determines degree requirements such as residency, number of credits, distribution of credits, and grade averages. It is the student's responsibility to be aware of the specific major, degree, distribution, college, and graduation requirements for completing their chosen program of study. See the individual requirements listed by each college or school or contact the college registrar's office (https://registrar.cornell.edu/service-resources/college-registrar-directory) for more information.

## Non-academic Requirements

**Conduct Matters**. Students must satisfy any outstanding sanctions, penalties or remedies imposed or agreed to under the Student Code of Conduct (Code) or Policy 6.4. Where a formal complaint under the Code or Policy 6.4 is pending, the University will withhold awarding a degree otherwise earned until the adjudication process set forth in those procedures is complete, including the satisfaction of any sanctions, penalties or remedies imposed.

**Financial Obligations**. Outstanding financial obligations will not impact the awarding of a degree otherwise earned or a student's ability to access their official transcript. However, the University may withhold issuing a diploma until any outstanding financial obligations owing to the University are satisfied.

# Additional Requirements for Undergraduate Students

The University has two requirements for graduation that must be fulfilled by all undergraduate students: the swim requirement, and completion of two physical education courses. For additional information about fulfilling University Graduation Requirements, see the Physical Education website (https://scl.cornell.edu/pe/).

## Physical Education

All undergraduate students are required to take two credits (two courses) of Physical Education prior to graduation. It is recommended they complete the two courses during their first year at Cornell. Credit in Physical Education may be earned by participating in courses offered (https://catalog.cornell.edu/courses/pe/) by the Department of Athletics and Physical Education and Cornell Outdoor Education, by being a registered participant on a varsity athletic team, or performing in the marching band.

Students with medical concerns should contact the Office of Student Disability Services (http://sds.cornell.edu/).

## Swim Requirement

The Faculty Advisory Committee on Athletics and Physical Education has established a basic swimming and water safety competency requirement for all undergraduate students. Normally, the requirement is taken during the Fall Orientation process at Helen Newman Hall or Teagle Hall pools. The requirement consists of the following: jump or step feet-first into the deep end of the pool, float or tread for one minute, turn around in a full circle, swim 25 yards using any stroke(s) of choice without touching the bottom or holding on to the sides (there is no time limit) and exit from the water. Students who do not complete the swim requirement during their first year, during a PE swim class or during orientation in subsequent years, will have to pay a $100 fee. Any student who cannot meet this requirement must register for PE 1100 Beginning Swimming as their physical education course before electives can be chosen.

If a student does not pass the swim requirement in their first Beginning Swimming PE class, then the student must take a second Beginning Swimming PE class (PE 1100 or PE 1101). Successful completion of two Beginning Swimming classes (based on attendance requirements) with the instructor's recommendation will fulfill the University's swim requirement.

Students unable to meet the swim requirement because of medical reasons should contact the Office of Student Disability Services (http://sds.cornell.edu/). When a waiver is granted by the Faculty Committee on Physical Education, an alternate requirement is imposed. The alternate requirement substitute is set by the Director of Physical Education.

# Duffield College of Engineering Graduation Requirements

## Undergraduate Study

Students in the Cornell Duffield College of Engineering spend most of their first two years of undergraduate studies in the Common Curriculum, which is administered by the College Curriculum Governing Board (CCGB) through the associate dean for undergraduate programs and Engineering Advising. By the end of their third semester, they typically apply to affiliate with an Engineering major and must be affiliated by the start of their fifth semester.

Criteria for affiliation with the majors are described in this section under "Affiliation with a Major". The Undergraduate Duffield Engineering Majors are listed on the Duffield College of Engineering Programs page (https://catalog.cornell.edu/engineering/#programstext).

Many of the majors have a corresponding minor, in which the student can pursue a secondary interest if eligible. In addition, there are minors that cut across majors including applied mathematics, engineering management, engineering statistics, game design, artificial intelligence, information science, and business. See Engineering Minors section of the Duffield College of Engineering Programs page (https://catalog.cornell.edu/engineering/#programstext) for a listing of Undergraduate Minors.

## Duffield Engineering Core Requirements - Engineering Major

### Duffield Engineering Majors

To receive the bachelor of science degree, students must meet the requirements of the Common Curriculum (outlined below) as set forth by the Cornell Duffield College of Engineering, including the requirements of their chosen major, as established by the school or department that administers the major. (Further explanation of the revised Common Curriculum and major flow charts are provided in the Engineering Undergraduate Handbook. (https://cornellengineeringhandbook.freeflowdp.com/cornellengineeringhandbook/library/))

| Course Category | Credits |
|---|---|
| Mathematics (major-specific)[1] | 14-16 |
| Physics (major-specific)[1] | 8-13 |

| | |
|---|---|
| Chemistry (major-specific)[1] | 4-8 |
| Fourth Science (major-specific)[1] | 3-4 |
| First-year Writing seminars | ≥6 |
| Engineering Communications[2] | 1-3 |
| Computing | 4 |
| Engineering Distribution | |
| a. One introduction to engineering (ENGRI) | 3-4 |
| b. Two different category engineering distributions (ENGRD) | 6-8 |
| Liberal studies distribution | ≥18 |
| Advisor Approved electives | ≥6 |
| Major program | |
| a. Major-required courses | ≥30 |
| b. Major-approved electives | ≥9 |
| c. Courses outside the major | ≥9 |
| Two semesters of physical education and demonstration of proficiency in swimming (university requirement) | |

1 The total number of math and science credits must be =>29 credits.
2 Engineering-communication courses may simultaneously fulfill another requirement.

Total credits required for graduation vary by major (see Engineering Majors).

### Mathematics

The normal program in mathematics includes MATH 1910, MATH 1920, MATH 2930 or MATH 2940 (depending on the major), and a major-specific math course for some majors. At least C– must be attained in these courses; if not, the course must be repeated immediately before the next course in the sequence is taken. Failure to achieve at least C– the second time will result in, at minimum, an automatic required leave of absence for one semester from Duffield Engineering. Courses that are taken a second time do not yield additional credit toward a degree.

### Physics

The normal program in physics includes PHYS 1112, PHYS 1110, PHYS 2213, and PHYS 2214 or the corresponding honors courses (PHYS 1116, PHYS 1110, PHYS 2210, PHYS 2217, and PHYS 2218). Engineering students should attain at least C– in each math prerequisite of a physics course before taking the physics course (e.g., C– in MATH 1910 before taking PHYS 1112 and C– in MATH 1920 before taking PHYS 2213). Substitutions for PHYS 2214 are possible in certain majors. Please consult the Engineering Undergraduate Handbook (https://cornellengineeringhandbook.freeflowdp.com/cornellengineeringhandbook/library/) for details.

### Chemistry

CHEM 2090 and CHEM 2091 is required. While the content of CHEM 2090 and CHEM 2091 is the same as that of CHEM 2070 and CHEM 2071, Engineering students are expected to take CHEM 2090 and CHEM 2091.

Typically, CHEM 2090 and CHEM 2091 is taken during the first year, but students who are eligible to start the physics sequence (PHYS 1112, PHYS 1110, PHYS 2213, and PHYS 2214, depending on the major), based on completion of math prerequisites, may postpone CHEM 2090 and CHEM 2091 until the sophomore year.

Students considering Chemical Engineering or a health-related career such as medicine must take CHEM 2090 and CHEM 2091 in the fall of their first year and CHEM 2080 and CHEM 2081 in the spring semester.

### Computing

Students must complete one Introduction to Computing course during either semester of the first year. Students can take either CS 1110 or CS 1112. Some majors may have a preference of either CS 1110 or CS 1112, however, either one will count toward the degree requirement. CS 1132 and CS 1133 cannot substitute for the Computing requirement but can count toward Advisor Approved electives.

## First-Year Writing Seminars

Each semester of their first year, students choose a first-year writing seminar from courses offered by over 30 different departments across the university. These courses offer the student practice in writing English prose and college level discourse within a small class (<20) setting.

## Engineering Communications

Students can fulfill the Engineering Communications Requirement using one of the options below. See the Engineering Communications Program website (https://www.engineering.cornell.edu/courses-requirements/bachelor-science-requirements/engineering-communications-requirement/) for more information.

### Category A: Via the Engineering Communications Program Courses and Opportunities

1. **Engineering Communication Program Courses**
   Courses in this category, offered by the Engineering Communications Program (ECP), develop communication skills in a variety of genres, including writing, presenting, multimodal forms, graphics, charts, posters, and other. These courses fulfill the Engineering Communications Requirement for Cornell Duffield Engineering.

| Code | Title | Hours |
|---|---|---|
| ENGRC 3025 | Creating and Communicating Your Digital Professionalism | 1 |
| ENGRC 3026 | Engineering Presentations and Expert Presence | 1 |
| ENGRC 3027 | Cross-cultural Communications and Ethics in the Workplace | 1 |
| ENGRC 3340 | Independent Study in Engineering Communications | 1-3 |
| ENGRC 3350 | Organizational Communications for Engineers | 3 |
| ENGRC 3500 | Engineering Communications | 3 |
| ENGRC 3600 | Communicating Data for Engineers | 3 |
| ENGRC 3700 | Communications Consulting for Engineers | 3 |

2. **Complete a Communication-Intensive Co-op, listed as ENGRC 3024**
   This is an opportunity to combine work and academics. Some co-op students do a significant amount of writing and other communicative work on the job; under certain circumstances, a set of authentic work artifacts combined with on-site manager reviews and guide, reflective summary assignments with an ECP instructor will satisfy the Engineering Communications Requirement. This option does not count toward the Liberal Studies requirements. Students should begin organizing this request the semester prior to being on-site for the co-op or internship. Not offered AY 2026-2027.
3. **Enroll in and pass** ENGRC 3023
   Students must apply for and pass this 1-credit attachment to a 3-credit or 4-credit engineering course in a major that is not one of the officially designated W-I or C-I courses. Engineering instructors may occasionally wish to extend communication opportunities added work inside their course for a given semester so that it will fulfill

the Engineering Communications Requirement. With approval from the College Curriculum Governing Board (CCGB) Subcommittee on Engineering Communications, instructors may have students co-register in ENGRC 3023, which may be taken more than once with different courses by permission of the engineering instructors. The highest grade possible for ENGRC 3341 is an "A." This option does not count toward the Liberal Studies requirement for engineers, even via petition. More information can be found at the Cornell Engineering website (https://www.engineering.cornell.edu/courses-requirements/bachelor-science-requirements/engineering-communications-requirement/engrc-3023/).
To begin, send an email to engrcomm_info@cornell.edu, requesting the full ENGRC 3023 information and application packet. Please insert "3023 request" in the subject line.
Paperwork is due by the last Wednesday in January for the Spring semester.

4. **Enroll in and pass** ENGRC 3341.

   Students must apply for and pass this 1-credit opportunity, where the student is guided by a Cornell Duffield Engineering professor on a directed, semester-long project. Sometimes, a student may be involved in a significant amount of engineering or technical communication elsewhere in Duffield Engineering. In these cases, it may be possible to petition the CCGB's Subcommittee on Engineering Communications for permission to use this work for future projects (not past ones) to meet the Engineering Communications Requirement.

   Students and their mentoring Engineering faculty should plan ahead for this option. To request the information packet and application form, email engrcomm_info@cornell.edu with "3341 request" in the subject line. For questions or to schedule an appointment, email the same address.

Please note that this option does not fulfill the Liberal Studies requirement, even with a petition. The highest grade possible for ENGRC 3341 is an "A." Because it is a 1-credit course, it cannot be used to meet a Liberal Studies requirement, even by petition.

- All 3341 paperwork must be submitted by the last Wednesday of January for consideration for Spring semester consideration.
- All 3341 paperwork must be submitted by the last Wednesday of August for consideration for Fall semester consideration.
- Students who are approved will enroll in a 1cr graded course using a PIN provided by the Engineering Communications Program Director.

5. **Complete and Pass a One Credit Partner Course**

The current options are below, and they require enrollment in the departmental course (usually three credits) and its corresponding ENRGRC course (one credit). The below courses do not count toward the Liberal Studies requirement for engineers, even via petition:

| Code | Title | Hours |
|---|---|---|
| ENGRC 3152 | Communication for Game Development [1] | 1 |
| ENGRC 3610 | Communication for Transportation Engineering [2] | 1 |
| ENGRC 4152 | Communication for Advanced Game Development [3] | 1 |

[1] 1cr partnered with CS 3152 Introduction to Computer Game Architecture/INFO 3152 Introduction to Computer Game Design

[2] 1cr partnered with CEE 3610 Introduction to Transportation Engineering

[3] 1cr partnered with CS 4152 Advanced Topics in Computer Game Architecture/INFO 4152 Advanced Topics in Computer Game Design

**Category B: Via Other Paths**

1. **Take an officially designated Writing-Intensive (W-I) or Communication-Intensive (C-I) engineering course.**

   - Note: The following course list is not comprehensive, as different engineering departments may offer W-I or C-I courses on an ad-hoc basis. Indeed, these offerings can change each semester. Students need to check with their major advisors each semester to confirm if a course will fulfill the Engineering Communications Requirement; curriculum approvals are made by each major via CCGB approval. W-I or C-I courses are based in a major, as part of that major's regular core offerings to its declared/affiliated undergraduate majors. This option does not count toward the Liberal Studies requirement for engineers, even via petition. See also the CE Undergraduate Handbook (https://www.engineering.cornell.edu/engineering-undergraduate-handbook/).
   - It's important to note that these options usually only fulfill the Engineering Communications Requirement for their own majors. Students, advisors, and departments need to cross check against each student's major requirements for graduation. The Engineering Communications Program does not control, monitor, or assess for these courses. This option does not count toward the Liberal Studies requirement for engineers, even via petition.

| Code | Title | Hours |
|---|---|---|
| BEE 4530 | Computer-Aided Engineering: Applications to Biological Processes (crosslisted) | 3 |
| BEE 4730 | Watershed Engineering | 4 |
| BEE 4590 | Physical Design in Biological Engineering | 3 |
| BME 4190 | Laboratory Techniques for Molecular, Cellular, and Systems Engineering | 3 |
| BME 4390 | Circuits, Signals and Sensors: Instrumentation Laboratory | 3 |
| BME 4490 | Biomechanics Laboratory (crosslisted) | 3 |
| CHEME 4320 | Chemical Engineering Capstone Design I | 4 |
| ECE 4920 | ECE Technical Writing | 1 |
| MAE 4272 | Fluids and Heat Transfer Laboratory | 3 |
| MSE 4030 | Senior Materials Laboratory I | 4 |
| ORIE 4100 | Manufacturing Systems Design: A Consulting Boot Camp | 4 |

2. **Enroll in and Pass** COMM 3020 or COMM 3030

   - Enroll in and pass COMM 3020 or COMM 3030 taught by the Department of Communication (in the College of Agriculture and Life Sciences). The Engineering Communications Program does not control, monitor, or assess for these courses. This option does not count toward the Liberal Studies requirement for engineers, even via petition. See also the CE Undergraduate Handbook (https://www.engineering.cornell.edu/students/undergraduate-students/curriculum/engineering-undergraduate-handbook).

3. **Enroll in and pass HADM 3670, taught through the Nolan School**

   - The Engineering Communications Program does not control, monitor, or assess for these courses. This option does not

also fulfill the Liberal Studies requirement, even via petition.
See also the Engineering Undergraduate Handbook (https://www.engineering.cornell.edu/engineering-undergraduate-handbook/).

## Engineering Distribution

The Common Curriculum requires three distribution courses (=>9 credits). One Introduction to Engineering course and two distribution courses.

**Introduction to Engineering:**
An introduction to engineering course (designated ENGRI) is expected to be completed by the end of a student's first year. This course introduces students to the engineering process and provides a substantive experience in an open-ended problem-solving context. See the Introduction to Engineering course listing for current course offerings.

Two engineering distribution (ENGRD) courses (6–8 credits) must be selected from two different categories listed below.

1. **Scientific computing:**

| Code | Title | Hours |
|---|---|---|
| ENGRD 2110 | Object-Oriented Programming and Data Structures (crosslisted) | 4 |
| ENGRD 2112 | Object-Oriented Design and Data Structures - Honors (crosslisted) | 5 |
| ENGRD 2140 | Computer Systems Programming (crosslisted) | 4 |
| ENGRD 3200 | Engineering Computation (crosslisted) | 4 |

2. **Materials Science:**
   ENGRD 2610 Mechanical Properties of Materials: From Nanodevices to Superstructures
   ENGRD 2620 Electronic Materials for the Information Age
3. **Mechanics:**
   ENGRD 2020 Statics and Mechanics of Solids
   Note: Majors in Engineering Physics may use AEP 3330 as an ENGRD in this category.
4. **Probability and statistics:**
   ENGRD 2700 Eng Probability and Statistics: Modeling and Data Science
   Note: Majors in Engineering Physics may substitute MATH 4710 for ENGRD 2700. Majors in Civil Engineering, Biological Engineering, and Environmental Engineering may substitute CEE 3040 for ENGRD 2700.
   ENGRD 2720
5. **Electrical sciences:**

| Code | Title | Hours |
|---|---|---|
| ENGRD 2100 | Introduction to Circuits for Electrical and Computer Engineers (crosslisted) | 4 |
| ENGRD 2300 | Digital Logic and Computer Organization (crosslisted) | 4 |
| ENGRD 2550 | Engineering Quantum Information Hardware (crosslisted) | 3 |

6. **Thermodynamics and energy balances:**

   ENGRD 2111 Biomolecular Thermodynamics
   ENGRD 2190 Chemical Process Design and Analysis
   ENGRD 2210 Thermodynamics

1. **Earth and life sciences:**

| Code | Title | Hours |
|---|---|---|
| ENGRD 2250 | The Earth System (crosslisted) | 4 |
| ENGRD 2400 | Observing the Earth: Remote Sensing and GIS | 3 |
| ENGRD 2510 | Engineering Processes for Environmental Sustainability (crosslisted) | 3 |
| ENGRD 2600 | Principles of Biological Engineering (crosslisted) | 3 |

2. **Biology and chemistry:**

| Code | Title | Hours |
|---|---|---|
| ENGRD 2202 | Biomedical Transport Phenomena (crosslisted) | 3 |
| CHEM 3890 | Honors Physical Chemistry I | 4 |
| BIOMG 3300 | Principles of Biochemistry, Individualized Instruction | 4 |
| or BIOMG 3310 | Principles of Biochemistry: Proteins and Metabolism | |
| or BIOMG 3350 | Principles of Biochemistry: Proteins, Metabolism, and Molecular Biology | |

**Additional Information**
Some majors may require completion of 9 specific engineering distribution courses for affiliation (acceptance into the major), or as a prerequisite for upper-class courses. For complete information, please see Affiliation with a Major and the flow charts for each major in the Engineering Undergraduate Handbook (https://www.engineering.cornell.edu/engineering-undergraduate-handbook/).

Note: Some majors require additional distribution courses after affiliation.

## Liberal Studies Distribution

Global and diverse societies require that engineers have an awareness of historical patterns, an appreciation for different cultures, professional ethics, the ability to work in multifaceted groups, and superior communication skills. Cornell has a rich curriculum in the humanities, arts, and social sciences, enabling every engineering student to obtain a truly liberal education. The rationale for these distribution courses is discussed in the Requirements for Graduation section of the Engineering Undergraduate Handbook (https://www.engineering.cornell.edu/engineering-undergraduate-handbook/) and these courses should be chosen with as much care and foresight as courses from technical areas.

Requirements:

- At least six courses (totaling at least 18 credits)
- The six courses must be chosen from the categories listed and come from at least three different groups outlined in the following section
- At least 3 or more credits must be chosen from Group 7
- No more than two courses may be chosen from Group 6 (CE)
- At least two courses must be at the 2000 level or higher

The categories outlined above have been organized into seven Groups based on common themes in content. Those Groups are as follows:

**Group 1. Cultural Analysis, Literature and the Arts, Social Differences**
- Cultural Analysis (CA)
- Literature and the Arts (LA)
- Literature, the Arts and Design (LAD)

- Arts, Literature, and Culture (ALC)
- Social Difference (SCD-HA only. SCD-AS not allowed in this group.)

**Group 2. Historical Analysis**
- Historical Analysis (HA/ HST)

**Group 3. Ethics, Cognition, and Moral Reasoning**
- Knowledge, Cognition, and Moral Reasoning (KCM)
- Ethics and the Mind (ETM)

**Group 4. Social Science and Global Citizenship**
- Social and Behavioral Analysis (SBA)
- Social Sciences (SSC)
- Global Citizenship (GLC)

**Group 5. Foreign Languages (not literature courses) (FL)**
- Courses teaching language skills, inclusive of reading, writing, listening, and spoken non-English languages, at beginning to advanced levels.

**Group 6. Communications in Engineering (CE)**
- Engineering specific courses exploring communication as a way of acting in the world
- Courses must be specifically designated by CCGB as satisfying the CE category (no petitions)
- No more than two courses from this category may be used to satisfy the liberal studies requirement
- To review (CE-EN) distribution requirement definition and course list, please visit the Duffield College of Engineering Distribution Requirement List (https://catalog.cornell.edu/enrollment-credit-requirements/distribution-codes/engineering/) section of this catalog

**Group 7. Race and Equity**
- Social Difference (SCD-AS only. SCD-HA not allowed in this group)
- Diversity (D-AG only. D-HE not allowed in this group)

Students should utilize the current Catalog as the master list of approved liberal studies courses. Refer to Cornell Engineering Advising's Liberal Studies Policies (https://liberal-studies.engineering.cornell.edu/) webpage for complete lists of additional approved courses and unacceptable courses. Please direct any questions to Engineering Advising, 180 Rhodes Hall.

### Electives

- **Advisor Approved electives:** 6 credits required (approved by the faculty advisor[1]). Courses must be =>1100 level to count toward the degree. Some courses =>1100 cannot count toward the degree such as MATH 1110 or MATH 1900 or CS 1109 since these are courses that are lower than where the degree requirements in the curriculum begin. Because these courses should help develop and broaden the skills of the engineer, faculty advisors generally accept the following as approved electives (as long as they are not being used elsewhere toward degree requirements):
  - One additional introduction-to-engineering course (ENGRI)
  - Engineering distribution courses
  - Courses stressing written or oral communication
  - Upper-level engineering courses
  - Advanced courses in mathematics
  - Rigorous courses in the biological and physical sciences
  - Courses in business, economics, or language (when they serve the student's educational and academic objectives)
  - Courses that expand the major or another part of the curriculum, including liberal studies electives not already being used toward the Liberal Studies Distribution requirement.
  - Up to 6 credits of approved electives may come from ROTC courses at the 3000-level or higher.
- **Major-approved electives:** 9 credits (approved by the major and faculty advisors in the major). Refer to the major curricula for descriptions of courses in this category.
- **Electives outside the major:** 9 credits of courses outside the major to ensure breadth of engineering studies; these courses may be subject to major specific requirements for appropriateness.

[1] In the event a student and their faculty advisor disagree regarding the suitability of an approved elective, the student may appeal the decision to the Director of Undergraduate Studies (Associate Director) for their major department or to the Associate Dean for Undergraduate Programs.

## First-Year Requirements

During the first year, engineering students are expected to complete (or receive credit for) the following core requirements:

| Code | Title | Hours |
|---|---|---|
| MATH 1910<br>& MATH 1920 | Calculus for Engineers<br>and Multivariable Calculus for Engineers | 8 |
| Select two of the following: | | |
| CHEM 2080<br>& CHEM 2081 | General Chemistry II<br>and General Chemistry II Laboratory [1,2] | 4 |
| CHEM 2090<br>& CHEM 2091 | Engineering General Chemistry<br>and Engineering General Chemistry Laboratory [1,2] | 4 |
| PHYS 1112 | Physics I: Mechanics and Heat | 3 |
| PHYS 1110 | Introduction to Experimental Physics | 1 |
| PHYS 2213 | Physics II: Electromagnetism | 4 |
| PHYS 2214 | Physics III: Oscillations, Waves, and Quantum Physics (or the Honors equivalent) [1,2] | 4 |
| One of: CS 111X | | 4 |
| Two first-year writing seminars | | 6 |
| One introduction to engineering (ENGRI) course | | 3-4 |
| Two physical education courses and the university swim competency | | 2 |

[1] Depends on the major.

[2] Depending on the major, students interested in chemical engineering, pre-med, or other health-related careers should enroll in the CHEM 2090 and CHEM 2091- CHEM 2080 and CHEM 2081 sequence during their first year.
Students interested in biomedical engineering should additionally complete BIOMG 1350 during the first year.

## Affiliation with a Major

Students are encouraged to apply for affiliation with a major during the first semester of their sophomore year, although earlier affiliation may be possible. This is done by completing the Application for Major Affiliation via the Engineering Registrar's website. To affiliate, students must:

1. make good progress toward completing required courses in the common curriculum,
2. have a GPA ≥ 2.0, and

3. have satisfied the major's course and grade requirements as specified below:

Students must be affiliated or conditionally affiliated with a major by the beginning of their fifth semester or they will be withdrawn from the Duffield Engineering, and therefore Cornell.

### Biological Engineering [1]

Minimum cumulative GPA of 2.5 and at most one grade below C– in any math, chemistry, physics, and engineering courses: CS 1110 , CS 1112, ENGRI, ENGRD, and any engineering course cross-listed with ENGRI or ENGRD. Completion of BEE 2600/ENGRD 2600 or ENGRD 2510 with at least C–,and one year of Introductory Biology (two lectures and a lab) with grades of at least C–. Allowable courses include BIOMG 1350, BIOG 1440, BIOG 1445 BIOG 1500, and BIOEE 1610. No more than two credits of research/project team and two credits of arts performance courses will count toward the cumulative GPA required for affiliation.

### Biomedical Engineering

Minimum GPA of 2.4 in designated math, science, and engineering courses completed with grades of C- or higher.

To apply for affiliation in the third semester, a student must be on track to complete the following requirements by the end of the third semester: BIOMG 1350 (or a score of 5 on the CEEB AP Exam (or equivalent)), MATH 1910, MATH 1920, MATH 2930, PHYS 1112, PHYS 1110, PHYS 2213, CHEM 2090 CHEM 2091, ENGRD 2111, CS 111X, and any ENGRI. BIOG 1440 cannot be used to satisfy this requirement.

To apply for affiliation in the fourth semester, a student must be on track to complete the above courses plus the following additional courses by the end of the fourth semester: MATH 2940, ENGRD 2020, BME 2000, and BME 2010.

### Chemical Engineering

At most one grade below C- in chemistry, math, physics, and chemical engineering courses, and a GPA ≥2.2 in math, science, and engineering courses (except independent study, seminar, research, or project teams).

To apply for affiliation in the third semester, a student must be on track to complete the following requirements by the end of the semester:

- Mathematics: MATH 1910 , MATH 1920 , and MATH 2930
- Chemistry: CHEM 2090 & CHEM 2091 , and CHEM 2080 & CHEM 2081 (or a score of 5 on the CEEB Advanced Placement exam for Chemistry) and CHEM 2150 or CHEM 2080 & CHEM 2081 )
- Physics: PHYS 1112 , PHYS 1110 , and PHYS 2213
- Computing: CS 111X
- Engineering Distribution: One Introduction to Engineering course (ENGRI 1XXX), ENGRD 2190 , and CHEM 3890
- Two First-Year Writing Seminars
- One Liberal Studies Distribution course

Students applying in the fourth semester must be on track to complete the following prerequisites for junior year as well as the core requirements listed above: MATH 2940 or CEE 3040 or ENGRD 2700 , CHEM 2900 , CHEME 2200 , CHEME 3230 , and additional Liberal Studies Distribution course.

### Civil Engineering

GPA ≥ 2.0 in all engineering, math, and science courses that have been completed at the time of affiliation. C grade or higher in ENGRD 2020.

### Computer Science

At least C (not C-) in all completed CS courses and all critical math courses. GPA ≥ 2.5 in CS 2110/ CS 2112 and CS 2800/ CS 2802, or ECE 2400/ENGRD 2140 and CS 2800/CS 2802 and CS 3110. CS GPA calculation may be supplemented by the following courses: CS 3110 and CS 3410/ CS 3420. GPA ≥ 2.3 between MATH 1920 and any other completed critical math course(s): MATH 2940, MATH 4710, STSCI 3080, CS 4850, ECON 3130, ECE 3100, ENGRD 2700. If only AP/CASE credit appears, then another Cornell critical math course must be taken to affiliate. Qualifying courses must be taken at Cornell for a letter grade. A required supplemental application must be submitted along with the College of Engineering Application for Major Affiliation.

### Earth and Atmospheric Sciences

The following courses must be completed or currently enrolled in at the time of affiliation: MATH 1910, MATH 1920, MATH 2930, MATH 2940, PHYS 1110, PHYS 1112, PHYS 2213, CHEM 2090 & CHEM 2091, CHEM 2080 & CHEM 2081 (or CHEM 1570 or PHYS 2214). Must have at least a C- in all courses taken and a cumulative GPA of 2.3 or higher.

### Electrical and Computer Engineering

At least C+ in: MATH 2930 or MATH 2940, PHYS 2213, and one of ECE 2100/ENGRD 2100, ECE 2720 or ECE 2300/ENGRD 2300. Must have a GPA ≥ 2.5 in (if completed): MATH 1920, MATH 2930, MATH 2940, PHYS 2213, ENGRD 2110, ECE 2400/ENGRD 2140, ECE 2300/ENGRD 2300, ECE 2100/ENGRD 2100, ECE 2720/ENGRD 2720.

### Engineering Physics

At least B– in all required math and physics courses: MATH 1910, MATH 1920, MATH 2930, MATH 2940, PHYS 1110, PHYS 1112/PHYS 1116, PHYS 2213/PHYS 2217, PHYS 2214/PHYS 2218, PHYS 2210.

### Environmental Engineering [1]

GPA ≥ 2.0 in all math, science, and engineering courses. At least C– in BEE 2510/ENGRD 2510.

### Independent Major

An Independent Major (IM) Application Form is required with full support from two faculty advisors, one from the proposed Primary Area and one from the proposed Secondary Area. Open to undergraduate students who wish to apply and affiliate with the IM, or students already affiliated with an engineering major who wish to change their major to the IM, or students from another college at Cornell who wish to internally transfer to the IM.

Students must complete three semesters in the engineering curriculum and are encouraged to apply by the end of their sophomore year. Applications are accepted from sophomore year through senior year. Completion of MATH 1910, MATH 1920, and one ENGRD with at least a C-. A cumulative GPA of at least a 2.2 required. See the IM website (https://www.engineering.cornell.edu/independent-major/) for specific requirements and deadlines.

### Information Science Systems, and Technology

At least a C in two of MATH 2940, CS 2110/ENGRD 2110, and ENGRD 2700 (must have taken at least two of these courses at time of affiliation). GPA ≥ 2.5 between CS 2110/ENGRD 2110,ENGRD 2700, and all completed MATH and ISST Major core courses. Qualifying courses must be taken at Cornell, and for a letter grade. A required supplemental application (https://affiliations.coecis.cornell.edu/is/) must be submitted

to ISST in addition to the College of Engineering's Application for Major Affiliation.

Students in their senior year of study intending to change majors to ISST or add ISST as a second major must submit a course plan to demonstrate they can complete all degree requirements by their current expected graduation date.

### Materials Science and Engineering

On track to complete by the end of the fourth semester the following required courses, and completion of at least 24 credits from these courses (including AP or transfer), when applying for affiliation: MATH 1910, MATH 1920, MATH 2930, MATH 2940 (all with a minimum grade of C-), PHYS 1112/PHYS 1116, PHYS 2213/PHYS 2217, CHEM 2090 & CHEM 2091, and CS 1110/CS 1112.

Additionally, students must have at least a grade of C in the category 2 (Materials Sciences) ENGRD course used for affiliation, and have a cumulative GPA ≥2.0 in the completed required math, physics, chemistry, computing, and (if taken) MSE 2010, MSE 2030, and MSE 2060 courses.

For any course that is repeated, the most recent grade will be used for affiliation requirements. However, repeated grades will be included for GPA calculations.

Students who will not satisfy these requirements by the end of the fourth semester should contact the MSE department about alternative paths to affiliation.

### Mechanical Engineering

At least C– in ENGRD 2020 and all completed required math, physics, chemistry, and computer science courses. ENGRD 2210 is recommended prior to affiliation. GPA > 2.5 in these courses: ENGRD 2210 (if taken), MATH 2930, PHYS 2213, and ENGRD 2020.

### Operations Research and Engineering

At least C in each of ENGRD 2700 and MATH 2940. GPA ≥ 2.2 in math, science, and engineering courses (both overall and in the term immediately before affiliation). At least C– in all ORIE courses completed thus far. Good academic standing in the College of Engineering.

[1] Students may major in biological engineering and environmental engineering through the College of Engineering or the College of Agriculture and Life Sciences (CALS). Students who do so through the College of Agriculture and Life Sciences are jointly administered by the College of Engineering and the College of Agriculture and Life Sciences.

## Learning Outcomes

The chemical engineering curriculum is designed to facilitate the following student outcomes, which collectively prepare graduates to attain the educational objectives of the chemical engineering program:

Upon completion of the B.S. degree, chemical engineering students will be able to demonstrate:

- The ability to identify, formulate, and solve complex bio/biomedical engineering problems by applying principles of engineering, biology, human physiology, chemistry, calculus-based physics, computer science, mathematics and statistics.
- The 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.
- The ability to communicate effectively with a range of audiences.
- The 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.
- The 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.
- The ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.
- The ability to acquire and apply new knowledge as needed, using appropriate learning strategies.