Quick Reference Guide

Chemical Engineering Curriculum - Prerequisite Flowchart

Freshman
- Engineering Analysis
- Math
- Chem
- DTC
- Speech
- Theme

Sophomore
- ChE 210*, 211
- ChE 212
- Organic Chem
- Physics
- Mat Sci
- Theme

Junior
- ChE 321, 322
- ChE 323
- ChE 307
- Stats
- ChE 275
- Tech Electives

Senior
- ChE 341, 342, 351, 352
- Tech Electives

*ChE 210 may be taken in the first year or sophomore year.

Total Requirements - 48 classes

Basic Courses:
A. Mathematics - 4 classes
   - MATH 220-1
   - MATH 228-1
   - MATH 220-2
   - MATH 228-2
B. Engineering Analysis - 4 classes
   - GEN ENG 205-1,2,3,4

C. Basic Sciences - 4 classes
   - PHYSICS 135-2,3 (has labs)
   - CHEM 131,132, or 151,152, or 171,172 (has labs)

D. Design and Communication - 3 classes
   - ENGLISH & DSGN 106-1,2
   - COMM ST (Speech) 102, or PERF ST (Performance) 103 or 203

Distribution Requirements:
E. Social Sci/Humanities (Theme) - 7 classes
F. Unrestricted Electives - 5 classes

Core Curriculum:
G. Major Program – 16 required classes + 5 technical electives
   - CHEM 215-1,2: Organic Chemistry (+ labs)
   - CHEM ENG 210: Analysis of Chemical Process Systems
   - CHEM ENG 211: Thermodynamics
   - CHEM ENG 212: Phase Equilibrium and Staged Separations
   - CHEM ENG 275: Cell & Molecular Biology for Engineers or BIOL SCI 201 or 202
   - CHEM ENG 307: Kinetics & Reactor Engineering
   - CHEM ENG 312: Probability and Statistics for Chemical Engineers OR IEMS 303
   - CHEM ENG 321: Fluid Mechanics
   - CHEM ENG 322: Heat Transfer
   - CHEM ENG 323: Mass Transfer
   - CHEM ENG 341: Dynamics and Control of Chemical and Biological Processes
   - CHEM ENG 342: Chemical Engineering Lab
   - CHEM ENG 351: Process Economics, Design & Evaluation
   - CHEM ENG 352: Chemical Engineering Design Projects
   - MAT SCI 301: Chemical Aspects of Engineering Materials (has lab)

Technical Electives - 5 classes
You may choose an area of specialization: (OR follow technical elective guidelines - Section IIIIB)
- Bioengineering, Chemical Process Engineering, Design, Environmental Engineering and Sustainability,
- Nanotechnology and Molecular Engineering, or Polymer Science and Engineering
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I. INTRODUCTION TO CHEMICAL ENGINEERING

Welcome to Chemical Engineering!

Chemical Engineering is a unique major that exists at the intersection of science and engineering. Building on a foundation of chemistry, biology, physics, and mathematics, the chemical engineering program expands student expertise to thermodynamics, transport processes, and chemical kinetics. Our curriculum provides students with the core chemical engineering fundamentals, while offering options to specialize in bioengineering, environmental engineering and sustainability, polymer science and engineering, design, process engineering, or nanotechnology and molecular engineering. In addition, students in the program have the opportunity to participate in a wide range of activities while on campus, including undergraduate research, co-op or internship, minors or certificates, study abroad, and student organizations.

Graduates of the undergraduate program in Chemical Engineering will

1. Behave ethically and consider the social implications of their work, especially as it affects the health, safety, and environment of citizens worldwide.

2. Think critically and creatively, especially about the use of technology to address local and global problems.

3. Be leaders in their chosen fields.

4. Excel in engineering practice, research, and management in industries based on chemistry and biology, such as the chemical, energy, advanced materials, microelectronics, pharmaceutical, biotechnology, and consumer products industries.

5. Apply their broad chemical engineering training to excel in areas such as entrepreneurship, medicine, law, government, and education.

6. Excel in top-ranked graduate programs and professional schools.

This document lists the degree requirements for chemical engineering undergraduates in the McCormick BS Program. Students may plan their coursework using the sample course sequence provided. Additional details are available about major requirements, the Biotechnology minor, the Honors Program, and student research opportunities.
II. BASIC SCIENCE, MATH, ENGINEERING ANALYSIS, AND NON-TECHNICAL COURSES

A. Mathematics (4 classes)
These mathematics courses build up foundational skills that are necessary for engineering.

<table>
<thead>
<tr>
<th>Class Number</th>
<th>Class Title</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 220-1</td>
<td>Single-Variable Differential Calculus</td>
<td>First-year</td>
</tr>
<tr>
<td>MATH 220-2</td>
<td>Single-Variable Integral Calculus</td>
<td>First-year</td>
</tr>
<tr>
<td>MATH 228-1</td>
<td>Multivariable Differential Calculus for Engineering</td>
<td>First-year</td>
</tr>
<tr>
<td>MATH 228-2</td>
<td>Multivariable Integral Calculus for Engineering</td>
<td>Sophomore</td>
</tr>
<tr>
<td><strong>Honors (by invitation):</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ESAM 252-1</td>
<td>Honors Calculus for Engineers (Substitutes MATH 228-1)</td>
<td>First-year</td>
</tr>
<tr>
<td>ESAM 252-2</td>
<td>Honors Calculus for Engineers (Substitutes MATH 228-2)</td>
<td>First-year</td>
</tr>
</tbody>
</table>

B. Engineering Analysis (4 classes)
These courses are taken by all students entering McCormick. They build a strong background in Linear Algebra, Statics, Systems Analysis, and Differential Equations. These courses also build up a background in MATLAB programming that is useful throughout the undergraduate curriculum and in engineering practice.

<table>
<thead>
<tr>
<th>Class Number</th>
<th>Class Title</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>GEN ENG 205-1</td>
<td>Engineering Analysis 1</td>
<td>First-year</td>
</tr>
<tr>
<td>GEN ENG 205-2</td>
<td>Engineering Analysis 2</td>
<td>First-year</td>
</tr>
<tr>
<td>GEN ENG 205-3</td>
<td>Engineering Analysis 3</td>
<td>First-year</td>
</tr>
<tr>
<td>GEN ENG 205-4</td>
<td>Engineering Analysis 4</td>
<td>Sophomore</td>
</tr>
<tr>
<td><strong>Honors (by invitation):</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GEN ENG 206-1</td>
<td>Honors Engineering Analysis 1</td>
<td>First-year</td>
</tr>
<tr>
<td>GEN ENG 206-4</td>
<td>Honors Engineering Analysis 4</td>
<td>First-year</td>
</tr>
</tbody>
</table>

**Grades:** Students who are unable to complete all of their required math and engineering analysis courses with grades of at least "C-" may not meet the prerequisites for some Chemical Engineering courses.

Students transferring into the major may have component courses in place of the Engineering Analysis sequence. Students should consult with their advisor or Undergrad Program Director for assistance with planning courses.
C. Basic Sciences (4 classes)
These basic chemistry and physics courses provide scientific background on which the chemical engineering curriculum builds.

<table>
<thead>
<tr>
<th>Class Number</th>
<th>Class Title</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 110*</td>
<td>Quantitative Problem Solving in Chemistry</td>
<td>First-year</td>
</tr>
<tr>
<td>CHEM 131 &amp; 132</td>
<td>General Chemistry 1 &amp; 2</td>
<td>First-year</td>
</tr>
<tr>
<td>OR CHEM 151 &amp; 152</td>
<td>Accelerated General Chemistry 1 &amp; 2</td>
<td>First-year</td>
</tr>
<tr>
<td>OR CHEM 171 &amp; CHEM 172</td>
<td>Advanced General Inorganic Chemistry</td>
<td>First-year</td>
</tr>
<tr>
<td>AND</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PHYSICS 135-2</td>
<td>General Physics – Electricity; Magnetism</td>
<td>Sophomore</td>
</tr>
<tr>
<td>PHYSICS 135-3</td>
<td>General Physics – Modern Physics; Waves</td>
<td>Sophomore</td>
</tr>
<tr>
<td>OR PHYSICS 140-2</td>
<td>Fundamentals of Physics – Electricity; Magnetism</td>
<td>Sophomore</td>
</tr>
<tr>
<td>PHYSICS 140-3</td>
<td>Fundamentals of Physics – Modern Physics; Waves</td>
<td>Sophomore</td>
</tr>
</tbody>
</table>

* Note 1: CHEM 110 is taken as an unrestricted elective for students completing the Chem 131, 132 sequence.
** Note 2: Chemistry and Physics require concurrent enrollment in the laboratory courses.
*** Note 3: IMPORTANT: If you enroll in one of the general chemistry courses you must complete of the full sequence (131 and 132; or 151 and 152; or 171 and 172) with grades of C- or above, or you will be unable to register for Chem 215-1. This applies regardless of whether you have AP credits for General Chemistry.

Grades: The prerequisites for Organic Chemistry are the completion of the general chemistry sequence with laboratory with all grades of "C-" or above.

D. Design and Communication (3 classes)
The Design Thinking and Communication (DTC) courses (English and DSGN 106-1,2) introduce incoming engineers to the design process by involving them in a real project for a client. Students learn and follow the design process, culminating in the building of a prototype to satisfy the client's needs. Informal and formal reports and presentations provide an opportunity to improve technical communication skills, which are of great importance in subsequent engineering courses and in engineering practice. The speech requirement provides additional training in public speaking.

<table>
<thead>
<tr>
<th>Class Number</th>
<th>Class Title</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGLISH 106-1,2</td>
<td>Writing in Special Contexts</td>
<td>First-year</td>
</tr>
<tr>
<td>DSGN 106-1,2</td>
<td>Engineering Design and Communication</td>
<td>First-year</td>
</tr>
<tr>
<td>Select one of the following: COMM ST 102</td>
<td>Public Speaking</td>
<td>Any</td>
</tr>
<tr>
<td>PERF ST 103</td>
<td>Analysis and Performance of Literature</td>
<td>Any</td>
</tr>
<tr>
<td>PERF ST 203</td>
<td>Performance Culture and Communication</td>
<td>Any</td>
</tr>
</tbody>
</table>
E. Social Sciences & Humanities - Theme (7 classes)
The humanities/social sciences theme requirement (or “Theme”) calls for McCormick students to
develop an area of competency related to the study of social science and humanities. To fulfill the
requirement, each student selects a set of related courses built around one central “theme” or topic of
interest to the student. There are more than 1,600 courses that qualify.

Choose seven courses total from two categories - Social & Behavioral Sciences (SBS) and
Humanities (HUM). See the theme guidelines on the McCormick webpage for the updated lists of
approved theme courses.
http://www.mccormick.northwestern.edu/students/undergraduate/social-science-humanities-theme/index.html

Nearly all courses from the departments and programs listed in each category will count, but there
is a list of disallowed courses from those departments and a list of allowed courses from other
departments (see webpage). For your theme you must:

- Indicate courses that are thematically related (minimum of three, up to all seven)
- Create a title for their theme and describe it in a brief narrative
- Comply with the following course limits:
  - A maximum of five courses may be chosen from a single category (SBS or HUM)
  - No more than three 100-level courses
    - Exception: up to four 100-level courses if three are foreign language

Theme forms are part of the McCormick Advising System (MAS). Please log in to complete your
theme form within MAS, ideally before your junior year, even if you don’t know whether a class
will be offered in the quarter you want to take it. There is no limit to the number of times you can
edit your theme form. And it is better to get approval for a theme before you commit to taking a
class that won’t be approved for the theme.

F. Unrestricted Electives (5 classes)
These five classes may be taken at any time during an undergraduate's education and may be any class
taken from any school. They can be used to pursue minors or certificates in ChE or in other
departments, schools, and disciplines.
III. CHEMICAL ENGINEERING MAJOR

A. Required Courses (21 classes)
These classes prepare students for a variety of careers in chemical engineering and form the core of the curriculum. The fundamentals presented in these courses are useful in many fields from biological engineering to materials and energy engineering to consumer and chemical products, to name just a few.

In the sophomore year we begin with Analysis of Chemical Process Systems (210) and Thermodynamics (211) which serve as the starting point for understanding chemical and molecular behavior and interactions. While Fluid Mechanics (321) begins the junior-level transport sequence that discusses the movement of chemical entities mass, momentum, and energy. Upper-level courses explore further topics, such as the transformation and separation of chemicals. Capstone experiences in the senior year put all these concepts together into a system-wide analysis of chemical processes and equipment.

200-level courses

<table>
<thead>
<tr>
<th>Class Number</th>
<th>Class Title</th>
<th>Year</th>
<th>Prerequisites</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 215-1*</td>
<td>Organic Chemistry I</td>
<td>Sophomore</td>
<td>CHEM 132/152/172</td>
</tr>
<tr>
<td>CHEM 215-2*</td>
<td>Organic Chemistry II</td>
<td>Sophomore</td>
<td>CHEM 215-1</td>
</tr>
<tr>
<td>CHEM ENG 210</td>
<td>Analysis of Chemical Process</td>
<td>First-year or</td>
<td>CHEM 132/152/172</td>
</tr>
<tr>
<td></td>
<td>Systems</td>
<td>Sophomore</td>
<td></td>
</tr>
<tr>
<td>CHEM ENG 211</td>
<td>Thermodynamics</td>
<td>Sophomore</td>
<td>CHEM ENG 210</td>
</tr>
<tr>
<td>CHEM ENG 212</td>
<td>Phase Equilibrium and Staged</td>
<td>Sophomore</td>
<td>CHEM ENG 210, 211</td>
</tr>
<tr>
<td></td>
<td>Separations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CHEM ENG 275**</td>
<td>Molecular and Cell Biology for</td>
<td>Soph or Jr.</td>
<td>CHEM 132/152/172</td>
</tr>
<tr>
<td></td>
<td>Engineers</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* All Organic Chemistry courses require concurrent registration in the lab (CHEM 235-1,2). Sequence may be replaced with CHEM 212-1,2 (lab 232-1,2) for ISP students. Students entering before 2021 may have older course numbering CHEM 210-1,2.

** May be replaced with BIOL SCI 201 or 202. If you have tested out of 201, and have completed BIOL SCI 202, you may use 202 to replace CHEM ENG 275.
### 300-level courses

<table>
<thead>
<tr>
<th>Class Number</th>
<th>Class Title</th>
<th>Year</th>
<th>Prerequisites</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM ENG 307</td>
<td>Kinetics and Reactor Engineering</td>
<td>Junior</td>
<td>CHEM ENG 210, 211, 321, 322</td>
</tr>
<tr>
<td>CHEM ENG 312</td>
<td>Probability and Statistics for Chemical Engineering</td>
<td>Jr. or Sr.</td>
<td>Completion of math requirements</td>
</tr>
<tr>
<td>OR IEMS 303*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CHEM ENG 321</td>
<td>Fluid Mechanics</td>
<td>Junior</td>
<td>Completion of math and GEN ENG 205-4 (C- or better)</td>
</tr>
<tr>
<td>CHEM ENG 322</td>
<td>Heat Transfer</td>
<td>Junior</td>
<td>Math Req., GEN ENG 205-4; CHEM ENG 321 is strongly recommended</td>
</tr>
<tr>
<td>CHEM ENG 323</td>
<td>Mass Transfer</td>
<td>Junior</td>
<td>CHEM ENG 321, 322</td>
</tr>
<tr>
<td>CHEM ENG 341</td>
<td>Dynamics and Control of Chemical and Biological Processes</td>
<td>Senior</td>
<td>Senior Standing, CHEM ENG 307</td>
</tr>
<tr>
<td>CHEM ENG 342</td>
<td>Chemical Engineering Laboratory</td>
<td>Senior</td>
<td>CHEM ENG 212, 307, 321, 322, 323</td>
</tr>
<tr>
<td>CHEM ENG 352</td>
<td>Chemical Engineering Design Projects</td>
<td>Senior</td>
<td>CHEM ENG 351</td>
</tr>
<tr>
<td>MAT SCI 301</td>
<td>Chemical Aspects of Engineering Materials</td>
<td>So., Jr., or Sr.</td>
<td>CHEM 131/151/171</td>
</tr>
</tbody>
</table>

* Requires IEMS 202 Probability as a prerequisite (or another probability equivalent) and EECS 111 is recommended.

** May be replaced by petition with MAT SCI 201 for students transferring from another major that requires MAT SCI 201 for graduation.

** Important Notes:**

- The grade point average of the 21 courses (16 above + 5 technical electives, see pages 9-10) used to satisfy the Chemical Engineering major requirements must be at least 2.00. Further, no more than three courses may carry a grade of "D".
- None of the 16 required courses above may be taken on a Pass/No Credit (P/N) basis.
B. Technical Electives (5 classes)

The technical electives may be used to create an individualized area of specialization within the major. In this section students will learn of the general requirements for the five technical elective courses as well as some suggested courses for themes within chemical engineering.

**General requirements to be satisfied by all students:**

1. Two 300- or 400-level CHEM ENG classes from *Category A*
2. One 300- or 400-level CHEM ENG class from *Category A OR CHEM ENG 399 OR approved 200- or 300-level Engineering class from Category B*
3. CHEM ENG 361 OR BMD ENG 302, 303 OR one approved 200- or 300-level advanced Science/Math class from *Category C*
4. One course from *Category A, B, C, D OR CHEM ENG 390*

**Important notes:**

- **Refer to Appendix B for Approved Classes by Category.** In brief, Category A includes CHEM ENG classes, Category B includes other classes with high engineering content, Category C includes classes with more science content, and Category D includes some classes that don’t neatly fall into one of the other categories.
- Only one unit of CHEM ENG 399 (or 399 in general) may be counted toward the five technical electives.
- **All 395 classes must be approved by petition (including those suggested below) to count as a technical elective.**
- Only two courses that are counted towards the 5 technical electives may be taken on a Pass/No Credit (P/N) basis. Chemical Engineering courses may not be taken on a P/N basis if they are to be counted toward the 5 technical electives.
- The grade point average of the 21 courses for the major in Chemical Engineering must be at least 2.00. Further, no more than two courses may carry a grade of "P" and no more than three may carry a grade of "D".

Six suggested areas of specialization are described in this section. Each comprises a list of complementary or related courses that together satisfy the general technical elective requirements (above). Students are not required to follow these suggested lists exactly, but each student’s selected set of electives must still satisfy the general requirements detailed above.
Areas of Specialization:

**CHEMICAL PROCESS ENGINEERING**
1. CHEM ENG 345 Process Optimization for Energy and Sustainability
2. CHEM ENG 355 Chemical Product Design
3. CHEM ENG 365 (Sustainability, Technology, and Society), CHEM ENG 367 (Quantitative Methods in Life Cycle Analysis), CHEM ENG 375 (Biochemical Engineering), CHEM ENG 377 (Bioseparations), OR MAT SCI 318 (Materials Selection)
4. CHEM ENG 361 Introduction to Polymers
5. Any elective from Category A, B, C, or D

**BIOENGINEERING**
Use BIOL SCI 201 or 202 (Molecular Biology or Cell Biology) in place of CHEM ENG 275 in the major program.
1. CHEM ENG 375 Biochemical Engineering
2. CHEM ENG 372 (Bionanotechnology), CHEM ENG 373 (Biotechnology and Global Health), CHEM ENG 376 (Synthetic Biology), CHEM ENG 377 (Bioseparations), OR CHEM ENG 379 (Computational Biology: Analysis and Design of Living Systems)
3. CHEM ENG OR BMD ENG course from Category A or B
4. BMD ENG 302 (Systems Physiology), BMD ENG 303 (Systems Physiology), BIOL SCI 201 (Molecular Biology) or BIOL SCI 202 (Cell Biology), BIOL SCI 301 (Biochemistry), OR CHEM 215-3 (Advanced Organic Chemistry)
5. Any elective from Category A, B, C, or D

**ENVIRONMENTAL ENGINEERING AND SUSTAINABILITY**
1. CHEM ENG 365 Sustainability, Technology, and Society
2. CHEM ENG 367 (Quantitative Methods in Life Cycle Analysis) OR CHEM ENG 345 (Process Optimization for Energy and Sustainability)
3. CIV ENG 367 (Chemical Processes in Aquatic Systems) OR MAT SCI 381 (Energy Materials)
4. CHEM ENG 361 (Introduction to Polymers) OR CHEM 393 (Green Chemistry)
5. Any elective from Category A, B, C, or D

**POLYMER SCIENCE AND ENGINEERING**
1. CHEM ENG 361 Introduction to Polymers
2. CHEM ENG 330 Molecular Engineering and Statistical Mechanics OR CHEM ENG 395 Special Topic “Structure and Dynamics of Soft Materials”
3. MAT SCI 331 Soft Materials
4. CHEM 210-3 (Organic Chemistry III), CHEM 215-3 (Advanced Organic Chemistry), MAT SCI 360 (Electron Microscopy), OR MAT SCI 361 (Crystallography and Diffraction)
5. Any elective from Category A, B, C, or D
DESIGN

1. CHEM ENG 355 Chemical Product Design
2. CHEM ENG 345 Process Optimization for Energy and Sustainability
3. DSGN 384-1 (Interdisciplinary Design Projects I), DSGN 308 (Human-Centered Product Design), OR DSGN 384-2 (Interdisciplinary Design Project II)
4. CHEM ENG 361 (Introduction to Polymers) OR CHEM 393 (Green Chemistry)
5. Any elective from Category A, B, C, or D

NANOTECHNOLOGY AND MOLECULAR ENGINEERING

1. CHEM ENG 330 Molecular Engineering and Statistical Mechanics
2. CHEM ENG 361 Introduction to Polymers
3. MAT SCI 376 Nanomaterials
4. CHEM 307 (Materials and Nanochemistry), CHEM 342-2 (Quantum Mechanics and Spectroscopy), OR PHYSICS 358 (Nanolithography)
5. Any elective from Category A, B, C, or D

C. Course Considerations and Course Schedule

The following table contains all of the chemical engineering courses currently offered by the Northwestern Chemical and Biological Engineering Department and the typical times they are offered. This list may be helpful when selecting technical and unrestricted electives.

<table>
<thead>
<tr>
<th>Course</th>
<th>Quarter</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM ENG 210 - Analysis of Chemical Process Systems</td>
<td>Fall, Spring</td>
</tr>
<tr>
<td>CHEM ENG 211 - Thermodynamics</td>
<td>Winter</td>
</tr>
<tr>
<td>CHEM ENG 212 - Phase Equilibrium and Staged Separations</td>
<td>Spring</td>
</tr>
<tr>
<td>CHEM ENG 275 - Molecular and Cell Biology for Engineers</td>
<td>Winter</td>
</tr>
<tr>
<td>CHEM ENG 307 - Kinetics and Reactor Engineering</td>
<td>Spring</td>
</tr>
<tr>
<td>CHEM ENG 312 - Probability and Statistics for Chemical Engineering</td>
<td>Winter</td>
</tr>
<tr>
<td>CHEM ENG 321 - Fluid Mechanics</td>
<td>Fall</td>
</tr>
<tr>
<td>CHEM ENG 322 - Heat Transfer</td>
<td>Winter</td>
</tr>
<tr>
<td>CHEM ENG 323 - Mass Transfer</td>
<td>Spring</td>
</tr>
<tr>
<td>CHEM ENG 341 - Dynamics and Control of Chemical and Biological Processes</td>
<td>Winter</td>
</tr>
<tr>
<td>CHEM ENG 342 - Chemical Engineering Laboratory</td>
<td>Fall, Wint, Spr</td>
</tr>
<tr>
<td>CHEM ENG 351 - Process Economics, Design, and Evaluation</td>
<td>Fall, Winter</td>
</tr>
<tr>
<td>CHEM ENG 352 - Chemical Engineering Design Projects</td>
<td>Winter, Spring</td>
</tr>
<tr>
<td>CHEM ENG 330 - Molecular Engineering and Statistical Mechanics</td>
<td>Variable*</td>
</tr>
<tr>
<td>CHEM ENG 345 - Process Optimization for Energy and Sustainability</td>
<td>Winter</td>
</tr>
<tr>
<td>CHEM ENG 355 - Chemical Product Design</td>
<td>Variable*</td>
</tr>
<tr>
<td>CHEM ENG 361 - Introduction to Polymers</td>
<td>Fall</td>
</tr>
<tr>
<td>CHEM ENG 365 - Sustainability, Technology, and Society</td>
<td>Fall</td>
</tr>
<tr>
<td>CHEM ENG 367 - Quantitative Methods in Life Cycle Analysis</td>
<td>Variable*</td>
</tr>
<tr>
<td>CHEM ENG 372 - Bionanotechnology</td>
<td>Winter</td>
</tr>
</tbody>
</table>
Additional courses to consider when choosing technical electives:

Special topics classes are typically offered year-round but have a different area of focus each quarter:

- CHEM ENG 395: Special Topics in Chemical Engineering
- CHEM ENG 489: Selected Topics in Chemical Engineering

*CHEM ENG 395 courses must be approved by petition for use as technical electives, as by their nature they may span engineering topics, advanced math and science, as well as general education, and therefore how they can be counted within the five technical electives will vary from offering to offering.

Advanced mathematics courses help build a strong mathematical foundation and are especially useful for students considering graduate school:

- ES APPM 311: Methods of Applied Mathematics
- ES APPM 312: Complex Variables
- MATH 351: Fourier Series and Boundary Value Problems

Students going to graduate school are encouraged to take CHEM ENG 330 Molecular Engineering and Statistical Mechanics and CHEM 342-2 Quantum Mechanics and Spectroscopy.

Computer programming is a useful skill. The following courses may be appropriate depending on your background:

- COMP SCI 111: Fundamentals of Computer Programming I
- COMP SCI 150: Fundamentals of Computer Programming 1.5
- COMP SCI 211: Fundamentals of Computer Programming II

Seniors may also take graduate (400-level) Chemical Engineering courses as part of their technical electives. Advance consultation with the advisor and course instructor is required.
IV. ADDITIONAL ACADEMIC OPPORTUNITIES

A. Honors Program
Students with a GPA of 3.50 or higher may apply for admission to the Honors Program during the Junior or Pre-senior year. Admission requires contacting the Associate Dean for Undergraduate Education (Professor Burghardt) in the McCormick School and completing appropriate forms which must be approved by the Honors Program advisor in Chemical Engineering (Professor Cole) and the Associate Dean.

Requirements:

- GPA of 3.50 or higher
- Two-quarter sequence of independent study (CHEM ENG 399: Projects) with a final report
- Three units of advanced study (must be approved by the Honors Program advisor):
  - One course typically not taken by a large fraction of undergraduate chemical engineers. Examples include ES APPM 311, graduate chemical engineering courses, or a 300-level course in another department with substantial prerequisites.
  - Two 300- or 400-level technical courses

B. Research Opportunities
Students may receive course credit for research through CHEM ENG 399 Projects. This option is usually limited to juniors and seniors, and it is the student's responsibility to find a faculty member to serve as supervisor of the project. Many of the faculty in Chemical Engineering also involve undergraduates in their research programs as volunteer researchers, work-study students, or regular-payment research aides. Students should consult their advisors or other faculty concerning such opportunities as well as check with the Work-Study Office. Faculty research interests may be found on the department web page.

www.mccormick.northwestern.edu/chemical-biological/academics/undergraduate/research-opportunities.html

www.mccormick.northwestern.edu/chemical-biological/research/areas

The McCormick Research Opportunities page also includes useful information:
www.mccormick.northwestern.edu/students/undergraduate/research-opportunities/

Also check out the Office of Undergraduate Research (OUR) for more information on connecting to opportunities and getting funding for research projects. undergradresearch.northwestern.edu/
C. Minor in Biotechnology and Biochemical Engineering

This minor provides training for students interested in industries that create and manufacture bio-based fuels and industrial chemicals, biopharmaceuticals, biomaterials, and agents for gene and cell therapies.

Ten units of science and engineering are required for the minor:

1. BIOL SCI 201: Molecular Biology\(^1,2\)
2. BIOL SCI 202: Cell Biology\(^1\)
3. BIOL SCI 203: Genetics and Evolution
4. BIOL SCI 301: Biochemistry
5. CHEM ENG 375: Biochemical Engineering
6. CHEM ENG 377: Bioseparations\(^3\)
7. Biology Laboratories\(^4\): All of the following (0.34 units each)
   - BIOL SCI 232 Molecular and Cellular Processes Laboratory
   - BIOL SCI 233 Genetics and Molecular Processes Laboratory
   - BIOL SCI 234 Investigative Laboratory
   Or a unit of 399 in an approved laboratory.
8. One of the following: CHEM ENG 371, 372, 373, 376, 379, 382, 475, 478, 479, or approved 395 by petition
10. A unit of 399\(^5\) or an elective from #8 above OR one of the following: BIOL SCI 315, 323, 325, 328, 330, 332, 341, 353, 355, 361, 363, 378, 380, 390, 395, BMD ENG 302, 315, 316, 317, 344, 346, 347, 348, 446, CHEM 210-3, CHEM 215-3, CIV ENG 361-1, 441, 442, MAT SCI 353, 370

Footnotes:
\(^1\) CHEM ENG 275 can be used instead of BIOL SCI 201 or 202 only in cases when a student has taken CHEM ENG 275 before deciding to pursue the minor.
\(^2\) The Biotech Minor requires 3 units of Biology coursework. Exemptions or course reductions are NOT granted for students taking the Biological Sciences Department placement test, and who test out of and skip BIOL SCI 201. These students may complete BIOL SCI 202 and 203 and petition to use an upper-level Biology course to complete the required 3 units.
\(^3\) CHEM ENG 377 can be taken before 375 and with junior standing; 377 may only be offered in alternate years.
\(^4\) The full set of these courses may be used to complete the laboratory component of the minor.
\(^5\) Up to two units of 399 research in an approved lab may be used as electives. Students should verify with the minor coordinator that the project and laboratory are appropriate.
Regulations:

- Students must earn a BA/BS degree from Northwestern University to earn the minor.
- A minimum 2.0 grade point average must be maintained in the 10 courses that define the minor.
- At least 5 units of the minor may not be used (double counted) to fulfill requirements in the student’s major program.
- A maximum of two (2) classes not offered by the department may be taken P/N for the minor. Students must also comply with departmental and McCormick P/N regulations for courses that double count between the minor and the major program.
- Students not majoring in Chemical Engineering should take the Bio Sci core courses (201, 202, 203, AND 301) listed in the minor before taking Chem Eng 375 and 377. In addition, students should take thermodynamics (Chem 342-1) and recommended Advanced Cell Biology (Bio Sci 315) to prepare for Chem Eng 375 and 377.
- In order to receive recognition for completing the minor, a student must complete the minor declaration form, obtain the required approvals, and submit the form to the McCormick Academic Services Office before the beginning of the student’s final quarter as an undergraduate.

D. Cooperative Education (Co-op) and Internships

The Cooperative Engineering Education Program (co-op) allows undergraduate engineering students to integrate periods of classroom study with periods of paid, practical work experience related to their academic major and career goals. Permanent employment is not an obligation for either employers or co-op students, but most students receive impressive permanent job offers as a result of the co-op experience. To receive the co-op certificate, students must be in good academic standing and complete a minimum of 4 work quarters of work prior to graduation. To get started, students must attend a co-op orientation session. To get started, register for CRDV 301, and visit the McCormick Office of Career Development for more information. [www.mccormick.northwestern.edu/career-development/programs/#coop](http://www.mccormick.northwestern.edu/career-development/programs/#coop)

E. Kellogg Certificate

The Kellogg School of Management Certificate Program for Undergraduates offers early exposure to — and preparation for — careers in consulting, financial services and other data-driven professions. Students enrolled in the program may choose between two four-course certificates: the Financial Economics Certificate or the Managerial Analytics Certificate. Both tracks help students improve their critical thinking skills, business acumen and understanding of strategic models that are used in a wide range of industries and occupations. Additional information and how to apply is available online. [www.kellogg.northwestern.edu/certificate.aspx](http://www.kellogg.northwestern.edu/certificate.aspx)
F. Minors and Double Majors

Electives within the Chemical Engineering curriculum may be used to fulfill the departmental program requirements of another major (in McCormick or another school of the University). Satisfactory completion of the requirements for the second program will be noted on the student’s transcript. McCormick also offers several minors:

www.mccormick.northwestern.edu/academics/undergraduate/programs/certificates-and-minors/

Students interested in pursuing a minor or a double major should consult with their advisor at an early stage.

G. Pre-med

The Chemical Engineering major can serve as a strong foundation for medical school. Many of the pre-med requirements fit within the major program (Inorganic Chemistry, 2 quarters of Organic Chemistry, Physics, one quarter of Biology, Math) or can be accommodated in the electives (3rd quarter Organic Chemistry, additional Biology, English). The University Academic Advising Center can provide guidance about applying to medical school.

www.northwestern.edu/health-professions-advising/services/get-advising/index.html
www.northwestern.edu/health-professions-advising/pre-health-tracks/index.html
V. GENERAL INFORMATION

A. Advising
The McCormick School assigns a First Year Advisor to each incoming freshman. At the end of freshmen year, advisors are reassigned so that the student has an advisor in his or her major. Normally, the advisor continues to advise the same students from sophomore through senior years. Beyond assisting with course selections, the advisor can be helpful in career choices (temporary or permanent employment, graduate studies, etc.) because of the close relationship developed over the years. Students wishing to switch advisors should contact Professor Cole.

Any questions that cannot be handled to the student’s satisfaction by his/her assigned advisor should be addressed to Professor Cole (jennifer-cole@northwestern.edu) who is the Director of the Undergraduate Program in the department.

B. Academic Honesty
Students are expected to maintain high standards of integrity in their academic work. Instructions given by faculty regarding the degree of interaction among students allowed on homework, lab reports, projects, etc., must be followed. If you do not understand what is allowed in terms of interaction in a particular course, ask the instructor. In the case of reports that use information from other articles, texts, etc., proper attribution of the references must be made. Plagiarism will not be tolerated. McCormick policies on academic integrity can be found at the following website: www.mccormick.northwestern.edu/students/academic-integrity.html

C. Safety
Some of the courses in Chemical Engineering have laboratories to provide meaningful practical experience, and a number of students take CHEM ENG 399 in order to undertake projects in a research laboratory setting. The course instructor, teaching assistants, or research supervisor will instruct you as to safe procedures, and enter you into the safety plan of the lab in which you are working. However, you are cautioned that despite the best instruction, safe practice originates with the student. There is no substitute for common sense. When in doubt about a procedure, ask before you execute it. Make use of safety manuals and material safety data sheets made available to you, and use resources available to you on-line or in the library, such as the Merck Index. Laboratory guidelines can be found at the Office of Research Safety: researchsafety.northwestern.edu
D. Accreditation
The Department of Chemical and Biological Engineering offers the Bachelor of Science Degree in Chemical Engineering. The bachelor of science in chemical engineering program is accredited by the Engineering Accreditation Commission of ABET, www.abet.org. ABET accreditation, which is administered on a national basis, means among other things that the time spent in undergraduate study at Northwestern helps to meet the requirements for registration as a Professional Engineer.

E. American Institute of Chemical Engineers (AIChE)
Northwestern has an active undergraduate student chapter of the American Institute of Chemical Engineers. This student branch of the main professional society in Chemical Engineering provides a great opportunity to learn more about the department, your fellow students, and career and graduate school opportunities. Events commonly held include informal mixers with faculty and graduate students, short talks by faculty or professionals from companies about work opportunities and interests or the transition from school to work, and informational meetings about finding summer, coop, or permanent employment in the profession or how to choose graduate schools in Chemical Engineering for those planning to pursue M.S. or Ph.D. degrees. Other recent activities include attendance at meetings of the local Chicago AIChE chapter and plant trips. All undergraduates are encouraged to participate. Announcements of meetings will be made in undergraduate classes and will be posted in the Undergraduate Bulletin Board (next to Room E127 TECH) and the AIChE Bulletin Board (next to Room E110 TECH).

F. Employment
Faculty in the department are active in research. Many faculty provide opportunities for undergraduates to participate in exciting new developments in Chemical Engineering and earn modest income. Students interested in such part-time work (academic year) or full-time summer jobs should consult individual faculty and the Work-Study Office for opportunities. The department also hires undergraduates on a limited basis to serve as office help.

For cooperative education opportunities, as well as summer internships with companies, students should consult the McCormick’s Engineering Career Development (ECD) office. www.mccormick.northwestern.edu/career-development/

Both McCormick’s ECD office and Northwestern Career Advancement (NCA, www.northwestern.edu/careers/) are open to you when searching for permanent employment opportunities. Most on-campus interviews are held very early in the fall quarter, with a small number held winter quarter. Undergraduates planning to use ECD or NCA should see that their resumes and associated material are submitted by early July in order to take full advantage of the fall quarter recruiting season.
G. Graduate School Opportunities

Students who may pursue M.S. or Ph.D. degrees in Chemical Engineering should talk with their advisors and other faculty. Students should be aware that applications usually must be filed by December or early January of the senior year for full consideration for financial aid for graduate studies. Unlike undergraduate school, Ph.D. programs in Chemical Engineering will typically provide full financial aid (monthly stipend plus full tuition payment) to admitted students, regardless of financial background.

Students interested in pursuing graduate degrees in medicine, law, dentistry, business, etc. should consult their advisors and offices at Northwestern specifically set up for this purpose.

H. Assistance and Accommodations

College is not always easy and sometimes we all need help to find the resources we need to be successful. This list provides links to other parts of campus that may be of use to you.

**Academic Support and Learning Advancement (ASLA)** helps students find the academic support they need to succeed. The office offers study groups, peer tutoring, coaching and strategies for studying. [www.northwestern.edu/academic-support-learning/](http://www.northwestern.edu/academic-support-learning/)

**Accessible NU (ANU)** office oversees accommodations for students with disabilities. [www.northwestern.edu/accessiblenu/about-us/index.html](http://www.northwestern.edu/accessiblenu/about-us/index.html)

**Counseling and Psychological Services (CAPS)** offers mental health services for students on the Evanston campus. [www.northwestern.edu/counseling/](http://www.northwestern.edu/counseling/)

**Office of Fellowships** helps students connect to fellowship opportunities for a wide variety of ambitions ranging from studying a new language to pursuing research to prestigious post-graduate opportunities to funding for graduate school. [www.northwestern.edu/fellowships/index.html](http://www.northwestern.edu/fellowships/index.html)

**Student Enrichment Services (SES)** offers their services to first-generation students, low income students, and/or DACA/Undocumented students. They help students navigate campus resources, host community building groups, as well as emergency financial, food, or legal aid. [www.northwestern.edu/enrichment/about/index.html](http://www.northwestern.edu/enrichment/about/index.html)

**The Writing Place** at Northwestern offers a variety of services to students who have writing assignments, from class papers to undergraduate theses. [www.writing.northwestern.edu/](http://www.writing.northwestern.edu/)
### VI. APPENDICES

#### Appendix A: Sample Course Sequences

<table>
<thead>
<tr>
<th>Year</th>
<th>Fall</th>
<th>Winter</th>
<th>Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>First-year</strong></td>
<td>Math 220-1</td>
<td>Math 220-2</td>
<td>Math 228-1</td>
</tr>
<tr>
<td></td>
<td>Chem 110, 151, or 171</td>
<td>Chem 131, 152, or 172</td>
<td>Chem 132 or</td>
</tr>
<tr>
<td></td>
<td>Gen Eng 205-1</td>
<td>Gen Eng 205-2</td>
<td>ChE 210 or Chem 215-1</td>
</tr>
<tr>
<td></td>
<td>Elective or Speech</td>
<td>Dsgn 106-1/Eng 106-1</td>
<td>Gen Eng 205-3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Dsgn 106-2/Eng 106-2</td>
</tr>
<tr>
<td><strong>Sophomore</strong></td>
<td>Math 228-2</td>
<td>ChE 211</td>
<td>ChE 212</td>
</tr>
<tr>
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<td>Gen Eng 205-4</td>
<td>Chem 215-2</td>
<td>Elective or MSE 301</td>
</tr>
<tr>
<td></td>
<td>ChE 210 or Elective</td>
<td>Elective</td>
<td>Elective</td>
</tr>
<tr>
<td><strong>Junior</strong></td>
<td>ChE 321</td>
<td>ChE 322</td>
<td>ChE 307</td>
</tr>
<tr>
<td></td>
<td>Elective or MSE 301</td>
<td>ChE 275</td>
<td>ChE 323</td>
</tr>
<tr>
<td></td>
<td>Elective</td>
<td>ChE 312</td>
<td>Elective</td>
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<tr>
<td></td>
<td>Elective</td>
<td>Elective</td>
<td>Elective</td>
</tr>
<tr>
<td><strong>Senior (variant 1)</strong></td>
<td>ChE 342</td>
<td>ChE 351</td>
<td>ChE 352</td>
</tr>
<tr>
<td></td>
<td>Elective or MSE 301</td>
<td>ChE 351</td>
<td>Elective</td>
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<tr>
<td></td>
<td>Elective</td>
<td>Elective</td>
<td>Elective</td>
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<tr>
<td></td>
<td>Elective</td>
<td>Elective</td>
<td>Elective</td>
</tr>
<tr>
<td><strong>Senior (variant 2)</strong></td>
<td>ChE 351</td>
<td>ChE 341</td>
<td>ChE 342</td>
</tr>
<tr>
<td></td>
<td>Elective or MSE 301</td>
<td>ChE 351</td>
<td>Elective</td>
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<tr>
<td></td>
<td>Elective</td>
<td>Elective</td>
<td>Elective</td>
</tr>
<tr>
<td></td>
<td>Elective</td>
<td>Elective</td>
<td>Elective</td>
</tr>
</tbody>
</table>

#### Notes:

1. Students who are ahead in the Math sequence or have completed the Chemistry sequence may be interested in taking the early offering of the ChE 210 that begins the sophomore sequence or starting the organic chemistry sequence Chem 215-1. Otherwise, students may take an elective.
2. Chemistry 215-3 may be taken here as an advanced science elective; a full year of organic chemistry is required to satisfy standard pre-med requirements.
3. Students pursuing a bio-related specialization, or who wish to satisfy pre-med requirements, typically take Biol Sci 201, 202, 203, which begins its sequence in the Spring quarter. Biol Sci 201 or 202 can take the place of ChE 275.
4. IEMS 303 may be used in place of ChE 312, however IEMS 303 has prerequisites of IEMS 202 and EECS 111. This option may be appealing to students pursuing the Kellogg Certificates.
## STANDARD COOP (5-YEAR) CHEMICAL ENGINEERING PROGRAM

<table>
<thead>
<tr>
<th>Year:</th>
<th>Fall</th>
<th>Winter</th>
<th>Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td>First-year</td>
<td>Math 220-1&lt;br&gt;Chem 110, 151, or 171&lt;br&gt;Gen Eng 205-1&lt;br&gt;Elective or Speech</td>
<td>Math 220-2&lt;br&gt;Chem 131, 152, or 172&lt;br&gt;Gen Eng 205-2&lt;br&gt;Dsgn 106-1/Eng 106-1</td>
<td>Math 228-1&lt;br&gt;Chem 132 or ChE 210 or Chem 215-1&lt;br&gt;Gen Eng 205-3&lt;br&gt;Dsgn 106-2/Eng 106-2</td>
</tr>
<tr>
<td>Sophomore</td>
<td>Math 228-2&lt;br&gt;Gen Eng 205-4&lt;br&gt;Chem 215-1 or 215-2&lt;br&gt;ChE 210 or Elective</td>
<td>ChE 211&lt;br&gt;Chem 215-2&lt;br&gt;Phys 135-2&lt;br&gt;Elective</td>
<td>ChE 212&lt;br&gt;Elective or MSE 301&lt;br&gt;Phys 135-3&lt;br&gt;Elective²</td>
</tr>
<tr>
<td>Junior</td>
<td>ChE 321&lt;br&gt;Elective³ or MSE 301&lt;br&gt;Elective&lt;br&gt;Elective</td>
<td>ChE 275³&lt;br&gt;ChE 322&lt;br&gt;ChE 312⁴&lt;br&gt;Elective</td>
<td>COOP⁵</td>
</tr>
<tr>
<td>Pre-Senior</td>
<td>Elective or MSE 301&lt;br&gt;Elective&lt;br&gt;Elective&lt;br&gt;Elective</td>
<td>COOP</td>
<td>ChE 307&lt;br&gt;ChE 323&lt;br&gt;Elective⁵&lt;br&gt;Elective</td>
</tr>
<tr>
<td>Senior</td>
<td>COOP</td>
<td>ChE 341&lt;br&gt;ChE 351&lt;br&gt;Elective&lt;br&gt;Elective</td>
<td>ChE 342&lt;br&gt;ChE 352&lt;br&gt;Elective&lt;br&gt;Elective</td>
</tr>
</tbody>
</table>

### Notes:

1. Students who are ahead in the Math sequence or have completed the Chemistry sequence may be interested in taking the early offering of the ChE 210 that begins the sophomore sequence or starting the organic chemistry sequence Chem 215-1. Otherwise, students may take an elective.

2. Chemistry 215-3 may be taken here as an advanced science elective; a full year of organic chemistry is required to satisfy standard pre-med requirements.

3. Students pursuing a bio-related specialization, or who wish to satisfy pre-med requirements, typically take Biol Sci 201, 202, 203 during the sophomore or junior year. Biol Sci 201 or 202 can take the place of ChE 275.

4. IEMS 303 may be used in place of ChE 312, however IEMS 303 has prerequisites of IEMS 202 and EECS 111. This option may be appealing to students pursuing the Kellogg Certificates.

5. Students following the traditional coop schedule typically are on coop during the summers after the sophomore, junior, and senior years.
## Appendix B: Approved Technical Elective Course Listing

### Category A
- **CHEM ENG 330** Molecular Engineering and Statistical Mechanics
- **CHEM ENG 345** Process Optimization for Energy and Sustainability
- **CHEM ENG 355** Chemical Product Design
- **CHEM ENG 361** Introduction to Polymers
- **CHEM ENG 364** Chemical Processing and the Environment
- **CHEM ENG 365** Sustainability, Technology, and Society
- **CHEM ENG 367** Quantitative Methods in Life Cycle Analysis
- **CHEM ENG 372** Bionanotechnology
- **CHEM ENG 373** Biotechnology and Global Health
- **CHEM ENG 375** Biochemical Engineering
- **CHEM ENG 376** Synthetic Biology
- **CHEM ENG 377** Bioseparations
- **CHEM ENG 379** Computational Biology: Analysis and Design of Living Systems
- All 400-level CHEM ENG classes

### Category B (listings by department or educational program)

#### Biomedical Engineering
- **271-0**: Intro to Biomechanics
- **301-0**: Systems Physiology
- **302-0**: Systems Physiology
- **303-0**: Systems Physiology
- **314-0**: Models in Biochemistry
- **315-0**: Appl of Genetic Engineering
- **316-0**: Engg Design of Therap. Antibodies
- **317-0**: Biochemical Sensors
- **325-0**: Intro to Medical Imaging
- **327-0**: Magnetic Resonance Imaging
- **333-0**: Modern Optical Microscopy & Imaging
- **343-0**: Biomaterials & Medical Devices
- **344-0**: Biological Performance of Materials
- **346-0**: Tissue Engineering
- **347-0**: Foundations of Regenerative Engg
- **348-0**: Applications of Regenerative Engg
- **365-0**: Control of Limbs and Artificial Replcmnt
- **366-0**: Biomechanics of Movement
- **371-0**: Mechanics of Biological Tissue
- **377-0**: Intermediate Fluid Mechanics
- **378-0**: Transport Fundamentals
- **390-1**: Biomedical Engineering Design
- **395-0**: Topics in Biomed Engg (by petition)

#### Civil and Environmental Engineering
- **205-0**: Economics and Finance for Engineers
- **216-0**: Mechanics Of Materials I
- **221-0**: Theory of Structures I
- **250-0**: Earth Surface Engineering
- **302-0**: Engineering Law
- **327-0**: Finite Element Methods in Mechanics
- **340-0**: Hydraulics and Hydrology
- **346-0**: Ecohydrology
- **355-0**: Engineering Groundwater Flow
- **360-0**: Sustainable Water Systems
- **367-0**: Chemical Processes in Aquatic Systems
- **368-0**: Sustainability: The City
- **371-0**: Transportation Planning/Analysis
- **376-0**: Transportation System Operations
- **395-0**: Special Topics (by petition)

#### General Engineering
- **220-1,2**: Analy/Comp Graph (0.5 unit each course, need to take both for 1 credit equivalent)
Computer Engineering (COMP_ENG)
205-0: Fundamentals of Computer System Software
346-0: Microprocessor System Design
357-0: Design Automation in VLSI
358-0: Intro to Parallel Computing
361-0: Comp Architecture I
362-0: Comp Architecture Project
366-0: Embedded Systems
391-0: CMOS VLSI Circuit Design
392-0: VLSI Systems Design Projects
393-0: Adv Low Power VLSI & Mix-Signal IC
394-0: Software Project Management
395-0: Special Topics (by petition)

Computer Science (COMP_SCI)
211-0: Fundamentals of Computer Programming II
213-0: Introduction to Computer Systems
214-0: Data Structures & Algorithms
230-0: Programming for Engineers
321-0: Programming Languages
322-0: Compiler Construction
325-1: Artificial Intelligence Programming
337-0: Natural Language Processing
338-0: Practicum Intelligent Info Systems
339-0: Intro to Database Systems
340-0: Introduction to Networking
343-0: Operating Systems
344-0: Design of Computer Problem Solvers
345-0: Distributed Systems
348-0: Intro Artificial Intelligence
349-0: Machine Learning
351-1: Intro to Computer Graphics
393-0: Software Construction
394-0: Agile Software Development
396-0: Special Topics (by petition)

Electrical Engineering (ELEC_ENG)
202-0: Intro to Electrical Engineering
225-0: Fundamentals of Electronics
250-0: Physical Electronics and Devices
307-0: Communications Systems
308-0: Adv Electromagnetics & Photonics
332-0: Intro to Computer Vision
333-0: Intro Communication Networks
353-0: Digital Microelectronics
359-0: Digital Signal Processing
360-0: Intro to Feedback Systems
363-0: Digital Filtering
374-0: Intro to Digital Control
378-0: Digital Communications
379-0: Lasers and Coherent Optics
380-0: Wireless Communications
382-0: Photonic Information Processing
383-0: Fiber Optic Communications
390-0: Intro to Robotics
395-0: Special Topics (by petition)

Design Engineering
305-0: Human-Centered Service Design
308-0: Human-Centered Product Design
346-0: Design for Fabrication
384-1: Interdisciplinary Design Projects I
384-2: Interdisciplinary Design Projects II
386-0: Manufacturing Engineering Design

Industrial Engineering and Management Sciences
304-0: Stat Learning for Data Analysis
307-0: Quality Improvement by Experimental Design
308-0: Data Science & Analytics
310-0: Operations Research
313-0: Foundations of Optimization
315-0: Stochastic Models
317-0: Discrete Event Systems Simulation
351-0: Optimization Methods in Data Science
373-0: Intro to Financial Engineering
381-0: Supply Chain Modeling & Analysis
382-0: Production Planning & Scheduling
<table>
<thead>
<tr>
<th>Category C (listings by department or educational program)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biological Sciences (in Weinberg)</td>
</tr>
<tr>
<td>201-0: Molecular Biology</td>
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<td>202-0: Cell Biology</td>
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<tr>
<td>203-0: Genetics and Evolution</td>
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<tr>
<td>215-0: Genetics and Molecular Biology*</td>
</tr>
<tr>
<td>217-0: Physiology*</td>
</tr>
<tr>
<td>219-0: Cell Biology*</td>
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<tr>
<td>*not offered after Winter 2021</td>
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<tr>
<td>301-0: Biochemistry</td>
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<tr>
<td>315-0: Advanced Cell Biology</td>
</tr>
<tr>
<td>319-0: Biology of Animal Viruses</td>
</tr>
<tr>
<td>323-0: Bioinformatics</td>
</tr>
<tr>
<td>328-0: Microbiology</td>
</tr>
<tr>
<td>Chemistry (in Weinberg)</td>
</tr>
<tr>
<td>210-3: Organic Chemistry</td>
</tr>
<tr>
<td>or 215-3: Advanced Organic Chemistry</td>
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</table>

Materials Science and Engineering

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
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<tbody>
<tr>
<td>383-0</td>
<td>Service Operations Management</td>
</tr>
<tr>
<td>395-0</td>
<td>Special Topics (by petition)</td>
</tr>
<tr>
<td>333-0</td>
<td>Plant-Animal Interactions</td>
</tr>
<tr>
<td>337-0</td>
<td>Quant Methods for Ecology &amp; Conserv</td>
</tr>
<tr>
<td>355-0</td>
<td>Immunobiology</td>
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<tr>
<td>361-0</td>
<td>Protein Structure and Function</td>
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<tr>
<td>363-0</td>
<td>Biophysics</td>
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<tr>
<td>378-0</td>
<td>Functional Genomics</td>
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<tr>
<td>380-0</td>
<td>Biology of Cancer</td>
</tr>
<tr>
<td>390-0</td>
<td>Intro Dynamic Systems</td>
</tr>
<tr>
<td>395-0</td>
<td>Special Topics (by petition)</td>
</tr>
</tbody>
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Mechanical Engineering

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
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<tbody>
<tr>
<td>224-0</td>
<td>Experimental Engineering</td>
</tr>
<tr>
<td>233-0</td>
<td>Electronics Design</td>
</tr>
<tr>
<td>240-0</td>
<td>Mechanical Design &amp; Manufacturing</td>
</tr>
<tr>
<td>314-0</td>
<td>Machines Dynamics</td>
</tr>
<tr>
<td>315-0</td>
<td>Theory of Machines: Design Elements</td>
</tr>
<tr>
<td>333-0</td>
<td>Intro to Mechatronics</td>
</tr>
<tr>
<td>340-0</td>
<td>Computer Integ Manuf (each course [1,2,3] is 1 unit)</td>
</tr>
<tr>
<td>340-1</td>
<td>Computer Integrated Manufacturing</td>
</tr>
<tr>
<td>340-2</td>
<td>Computer Integrated Manufacturing</td>
</tr>
<tr>
<td>340-3</td>
<td>Computer Integrated Manufacturing</td>
</tr>
<tr>
<td>359-0</td>
<td>Reliability Engineering</td>
</tr>
<tr>
<td>362-0</td>
<td>Stress Analysis</td>
</tr>
<tr>
<td>363-0</td>
<td>Mechanical Vibrations</td>
</tr>
<tr>
<td>373-0</td>
<td>Engg Fluid Mechanics</td>
</tr>
<tr>
<td>381-0</td>
<td>Intro to MEMS</td>
</tr>
<tr>
<td>382-0</td>
<td>Expts in Micro/Nano Sci and Engg</td>
</tr>
<tr>
<td>385-0</td>
<td>Nanotechnology</td>
</tr>
<tr>
<td>390-0</td>
<td>Intro Dynamic Systems</td>
</tr>
<tr>
<td>395-0</td>
<td>Special Topics (by petition)</td>
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</table>

Category C (listings by department or educational program)
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Department/Program</th>
</tr>
</thead>
<tbody>
<tr>
<td>301-0</td>
<td>Principles Organic Chemistry</td>
<td>Environmental Sciences (in Weinberg)</td>
</tr>
<tr>
<td>302-0</td>
<td>Principles Inorganic Chemistry</td>
<td>201-0: Earth: A Habitable Planet</td>
</tr>
<tr>
<td>303-0</td>
<td>Principles of Physical Chemistry</td>
<td>202-0: The Health of the Biosphere</td>
</tr>
<tr>
<td>305-0</td>
<td>Chemistry of Life Processes</td>
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</tr>
<tr>
<td>306-0</td>
<td>Environmental Chemistry</td>
<td>Mathematics (in Weinberg)</td>
</tr>
<tr>
<td>307-0</td>
<td>Materials and Nanochemistry</td>
<td>310-1: Probability and Stochastic Processes</td>
</tr>
<tr>
<td>314-0</td>
<td>Bioorganic Chemistry</td>
<td>310-2: Probability and Stochastic Processes</td>
</tr>
<tr>
<td>316-0</td>
<td>Medicinal Chemistry</td>
<td>310-3: Probability and Stochastic Processes</td>
</tr>
<tr>
<td>329-0</td>
<td>Analytical Chemistry</td>
<td>314-0: Prob and Statistics for Econometrics</td>
</tr>
<tr>
<td>333-0</td>
<td>Inorganic Chemistry</td>
<td>325-0: Complex Analysis</td>
</tr>
<tr>
<td>342-1</td>
<td>Thermodynamics</td>
<td>351-0: Fourier Analysis and Boundary Value</td>
</tr>
<tr>
<td>342-2</td>
<td>Quantum Mech and Spectroscopy</td>
<td>353-0: Qualitative Theory Differential Equations</td>
</tr>
<tr>
<td>342-3</td>
<td>Kinetics and Stat Thermodynamics</td>
<td>354-0: Chaotic Dynamical Systems</td>
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<tr>
<td>350-1</td>
<td>Adv Laboratory 1</td>
<td>360-1: MENU: Applied Analysis</td>
</tr>
<tr>
<td>350-2</td>
<td>Adv Laboratory 2</td>
<td>360-2: MENU: Applied Analysis</td>
</tr>
<tr>
<td>350-3</td>
<td>Adv Laboratory 3</td>
<td>366-0: Mathematical Models in Finance</td>
</tr>
<tr>
<td>393-0</td>
<td>Green Chemistry</td>
<td>368-0: Intro Optimization</td>
</tr>
<tr>
<td></td>
<td>Civil and Environmental Engineering</td>
<td></td>
</tr>
<tr>
<td>202-0</td>
<td>Biol. &amp; Ecological Principles</td>
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<tr>
<td>203-0</td>
<td>Earth in the Anthropocene</td>
<td></td>
</tr>
<tr>
<td>317-0</td>
<td>Biogeochemistry</td>
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<tr>
<td></td>
<td>Engineering Sciences and Applied Math.</td>
<td></td>
</tr>
<tr>
<td>311-1</td>
<td>Meth Applied Math*</td>
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</tr>
<tr>
<td>311-2</td>
<td>Meth Applied Math*</td>
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</tr>
<tr>
<td>*Courses to be replaced in Fall 2021, but will be offered in Fall 2020 as ESAPPM 395</td>
<td></td>
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</tr>
<tr>
<td>312-0</td>
<td>Complex Variables</td>
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</tr>
<tr>
<td>346-0</td>
<td>Modeling/Computation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Civil and Environmental Engineering</td>
<td></td>
</tr>
<tr>
<td>330-0</td>
<td>Human Computer Interaction</td>
<td>Computer Engineering (COMP_ENG)</td>
</tr>
<tr>
<td>330-0</td>
<td>Crystallography &amp; Diffraction</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Materials Science and Engineering</td>
<td></td>
</tr>
<tr>
<td>330-1</td>
<td>Classical Mechanics</td>
<td></td>
</tr>
<tr>
<td>330-2</td>
<td>Classical Mechanics</td>
<td></td>
</tr>
<tr>
<td>332-0</td>
<td>Statistical Mechanics</td>
<td></td>
</tr>
<tr>
<td>333-1</td>
<td>Adv Electricity and Magnetism</td>
<td></td>
</tr>
<tr>
<td>333-2</td>
<td>Adv Electricity and Magnetism</td>
<td></td>
</tr>
<tr>
<td>337-0</td>
<td>Intro Solid-State Phys</td>
<td></td>
</tr>
<tr>
<td>357-0</td>
<td>Biophotonics Lab</td>
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</tr>
<tr>
<td>358-0</td>
<td>Nanolithography</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Computer Science (COMP_SCI)</td>
<td></td>
</tr>
<tr>
<td>203-0</td>
<td>Intro to Computer Eng</td>
<td></td>
</tr>
<tr>
<td>303-0</td>
<td>Adv Digital Logic Design</td>
<td></td>
</tr>
</tbody>
</table>
**Electrical Engineering (ELECT ENG)**

- 221-0: Fundamentals of Circuits
- 222-0: Fundamentals Signals & Systems
- 223-0: Fundamentals of Solid State Engineering
- 224-0: Fundamentals of Electromag & Photonics
- 302-0: Prob Sys: Random Signals
- 328-0: Numerical Methods for Eng
- 381-0: Electronic Properties Materials
- 384-0: Solid State Electronic Devices
- 385-0: Optoelectronics
- 388-0: Nanotechnology
- 389-0: Superconductivity Applications

**Materials Science and Engineering**

- 337-0: Conducting Polymers
- 351-1: Intro Physics Materials
- 371-0: Biominerals: Heir Archt/Funct

**Design Engineering**

(may combine 2 half unit courses)

- 240-0: Solid Modeling (0.5 unit)
- 245-0: Intro 3D CAD: NX I Lect (0.5 unit)
- 246-0: Intro 3D CAD: NX II Lect (0.5 unit)
- 306-0: UX Design
- 320-0: Intro Industrial Design Methods
- 345-0: Computer-Aid Manufact (0.5 unit)
- 348-0: Adv Topics: Rapid Prototyp (0.5 unit)
- 350-0: Intellectual Property and Innovation
- 380-1: Industrial Design Projects I
- 380-2: Industrial Design Projects II

**Industrial Engineering and Management Sciences**

- 202-0: Probability
- 325-0: Engineering Entrepreneurship
- 341-0: Social Network Analysis
- 342-0: Organizational Behavior
- 343-0: Project Management for Engineers
- 345-0: Negotiation and Conflict Resolution
- 365-0: Analytics for Social Good