

**McCormick**

**Northwestern Engineering**

*DEPARTMENT OF CHEMICAL AND BIOLOGICAL ENGINEERING*

# **INFORMATION FOR MAJORS IN CHEMICAL ENGINEERING**

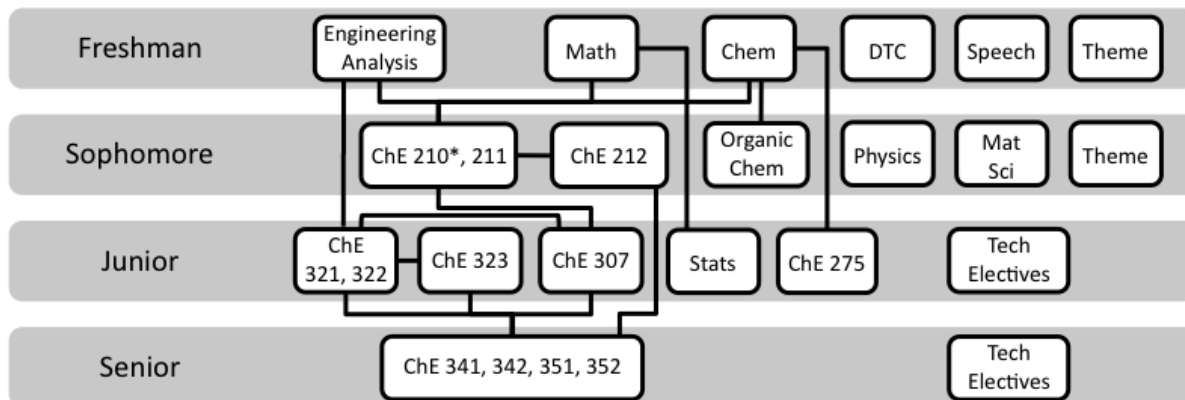
---

*Fall 2018*

*Updated Apr. 2018*

## Quick Reference Guide

## Chemical Engineering Curriculum - Prerequisite Flowchart



\*Sophomore year has two variants; ChE 210 may be taken in sophomore or freshman year.

## Total Requirements - 48 classes

## Basic Courses:

- |   |  |
|---|--|
| <p>A. Mathematics - 4 classes</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> MATH 220    <input type="checkbox"/> MATH 230</li> <li><input type="checkbox"/> MATH 224    <input type="checkbox"/> MATH 234</li> </ul> <p>B. Engineering Analysis - 4 classes</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> GEN ENG 205-1,2,3,4</li> </ul> <p>C. Basic Sciences - 4 classes</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> <input type="checkbox"/> PHYSICS 135-2,3</li> <li><input type="checkbox"/> <input type="checkbox"/> CHEM 131,132, or 151,152, or 171,172</li> </ul> | <p>D. Design and Communication - 3 classes</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> <input type="checkbox"/> ENGLISH &amp; DSGN 106-1,2</li> <li><input type="checkbox"/> COMM ST (Speech) 102, or PERF ST (Performance) 103 or 203</li> </ul> <p>E. Basic Engineering - 5 classes</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> CHEM ENG 210</li> <li><input type="checkbox"/> CHEM ENG 211</li> <li><input type="checkbox"/> MAT SCI 301</li> <li><input type="checkbox"/> CHEM ENG 312 or IEMS 303</li> <li><input type="checkbox"/> CHEM ENG 321</li> </ul> |
|---|--|

## Distribution Requirements:

- |  |   |
|--|---|
| <p>F. <input type="checkbox"/> Social Sci/Humanities (Theme) - 7 classes</p> | <p>G. <input type="checkbox"/> Unrestricted Electives - 5 classes</p> |
|--|---|

## Core Curriculum:

- H. Major Program – 11 required classes + 5 technical electives
- |  |   |
|--|---|
| <ul style="list-style-type: none"> <li><input type="checkbox"/> CHEM 210-1: Organic Chemistry</li> <li><input type="checkbox"/> CHEM 210-2: Organic Chemistry</li> <li><input type="checkbox"/> CHEM ENG 212: Phase Equilibrium and Staged Separations</li> <li><input type="checkbox"/> CHEM ENG 275: Cell &amp; Molecular Biology for Engineers or BIOL SCI 215 or 219</li> <li><input type="checkbox"/> CHEM ENG 307: Kinetics &amp; Reactor Engineering</li> </ul> | <ul style="list-style-type: none"> <li><input type="checkbox"/> CHEM ENG 322: Heat Transfer</li> <li><input type="checkbox"/> CHEM ENG 323: Mass Transfer</li> <li><input type="checkbox"/> CHEM ENG 341: Dynamics and Control of Chemical and Biological Processes</li> <li><input type="checkbox"/> CHEM ENG 342: Chemical Engineering Lab</li> <li><input type="checkbox"/> CHEM ENG 351: Process Economics, Design &amp; Evaluation</li> <li><input type="checkbox"/> CHEM ENG 352: Chemical Engineering Design Projects</li> </ul> |
|--|---|
- Technical Electives - 5 classes
- Choose **area of specialization**: (OR follow **technical elective guidelines** - Section IIIB)  
*Bioengineering, Chemical Process Engineering, Design, Environmental Engineering and Sustainability, Nanotechnology and Molecular Engineering, or Polymer Science and Engineering*

# Table of Contents

<b>I. INTRODUCTION TO CHEMICAL ENGINEERING .....</b>	<b>4</b>
<b>II. BASIC SCIENCE COURSES AND NON-TECHNICAL COURSES .....</b>	<b>5</b>
A. MATHEMATICS (4 CLASSES) .....	5
B. BASIC SCIENCES (4 CLASSES) .....	5
C. ENGINEERING ANALYSIS (4 CLASSES) .....	6
D. DESIGN AND COMMUNICATION (3 CLASSES).....	6
E. BASIC ENGINEERING (5 CLASSES) .....	7
F. SOCIAL SCIENCES & HUMANITIES - THEME (7 CLASSES) .....	7
G. UNRESTRICTED ELECTIVES (5 CLASSES) .....	8
<b>III. CHEMICAL ENGINEERING MAJOR .....</b>	<b>9</b>
A. REQUIRED COURSES (11 CLASSES) .....	9
B. TECHNICAL ELECTIVES (5 CLASSES).....	10
C. COURSE CONSIDERATIONS AND COURSE SCHEDULE .....	12
<b>IV. ADDITIONAL ACADEMIC OPPORTUNITIES.....</b>	<b>14</b>
A. HONORS PROGRAM .....	14
B. RESEARCH OPPORTUNITIES.....	14
C. MINOR IN BIOTECHNOLOGY AND BIOCHEMICAL ENGINEERING.....	15
D. COOPERATIVE EDUCATION (CO-OP) AND INTERNSHIPS.....	16
E. KELLOGG CERTIFICATE .....	16
F. MINORS AND DOUBLE MAJORS .....	16
G. PRE-MED.....	17
<b>V. GENERAL INFORMATION .....</b>	<b>18</b>
A. ADVISING .....	18
B. ACADEMIC HONESTY .....	18
C. SAFETY .....	18
D. ACCREDITATION .....	18
E. AMERICAN INSTITUTE OF CHEMICAL ENGINEERS (AIChE) .....	19
F. EMPLOYMENT .....	19
G. GRADUATE SCHOOL OPPORTUNITIES.....	19
<b>VI. APPENDICES .....</b>	<b>21</b>
A. APPENDIX A: SAMPLE COURSE SEQUENCES .....	21
B. APPENDIX B: APPROVED TECHNICAL ELECTIVE COURSE LISTING .....	23

# 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 COURSES AND NON-TECHNICAL COURSES

### A. Mathematics (4 classes)

These mathematics courses build up foundational skills that are necessary for engineering.

Class Number	Class Title	Year
MATH 220	Differential Calculus of One Variable	Freshman
MATH 224	Integral Calculus of One Variable	Freshman
MATH 230	Multivariable Differential Calculus	Freshman
MATH 234	Multiple Integration and Vector Calculus	Sophomore
<b>Honors (by invitation):</b>		
ESAM 252-1	Substitutes MATH 230	Freshman
ESAM 252-2	Substitutes MATH 234	Freshman

### B. Basic Sciences (4 classes)

These basic chemistry and physics courses provide scientific background on which the chemical engineering curriculum builds.

Class Number	Class Title	Year
CHEM 110* **	Quantitative Problem Solving in Chemistry	Freshman
CHEM 131**	General Chemistry 1	Freshman
CHEM 132**	General Chemistry 2	Freshman
<b>OR</b>		
CHEM 151**	Accelerated General Chemistry 1	Freshman
CHEM 152**	Accelerated General Chemistry 2	Freshman
<b>OR</b>		
CHEM 171**	Advanced General Inorganic Chemistry	Freshman
CHEM 172**	Advanced General Physical Chemistry	Freshman
<b>AND</b>		
PHYSICS 135-2**	General Physics - Electricity and Magnetism	Sophomore
PHYSICS 135-3**	General Physics - Intro to Modern Physics; Waves	Sophomore

\* - Taken as an unrestricted elective for students completing the Chem 131, 132 sequence.

\*\* Chemistry and Physics require concurrent enrollment in the laboratory courses.

\*\*\* If you enroll in one of the chemistry courses, the full chemistry sequence (131, 132; or 151, 152; or 171,172) must be completed, or you will be unable to register for Chem 210-1. This applies regardless of whether you have AP credits for General Chemistry.

**Grades:** Students who are unable to complete the freshman chemistry sequence with laboratory in their first year with all grades of "C-" or above are automatically behind in their schedule as CHEM 210-1 Organic Chemistry (usually taken in the sophomore year) requires as prerequisites grades of "C-" or better in all freshman chemistry courses.

### **C. 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.

<b>Class Number</b>	<b>Class Title</b>	<b>Year</b>
GEN ENG 205-1	Engineering Analysis 1	Freshman
GEN ENG 205-2	Engineering Analysis 2	Freshman
GEN ENG 205-3	Engineering Analysis 3	Freshman
GEN ENG 205-4	Engineering Analysis 4	Sophomore
<b>Honors (by invitation):</b>		
GEN ENG 206-1	Honors Engineering Analysis 1	Freshman
GEN ENG 206-4	Honors Engineering Analysis 4	Freshman

**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.

### **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.

<b>Class Number</b>	<b>Class Title</b>	<b>Year</b>
ENGLISH 106-1,2	Writing in Special Contexts	Freshman
DSGN 106-1,2	Engineering Design and Communication	Freshman
COMM ST 102	Public Speaking	Any
PERF ST 103	Analysis and Performance of Literature	Any
<b>OR</b>		
PERF ST 203	Performance Culture and Communication	Any

### E. Basic Engineering (5 classes)

These courses present fundamental engineering topics that are the starting prerequisites for many other courses within the curriculum. Analysis of Chemical Process Systems (210) and Thermodynamics (211) serve as the starting point for the sophomore-level classes in chemical engineering, while Fluid Mechanics (321) begins the junior-level transport sequence.

Class Number	Class Title	Year
CHEM ENG 210	Analysis of Chemical Process Systems	Fr. or So.
CHEM ENG 211	Thermodynamics	Sophomore
CHEM ENG 321	Fluid Mechanics	Junior
MAT SCI 301*	Principles of the Properties of Materials	So., Jr, or Sr.
CHEM ENG 312	Probability and Statistics for Chemical Engineering	Jr. or Sr.
<b>OR</b>		
IEMS 303**	Statistics	Jr. or Sr.

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

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

### F. 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.

All students with catalog year 2016 or later (current sophomores and freshmen) will use the revised rules. Students with catalog years earlier than 2016 have the option to continue with the old rules or use the revised rules. Students with catalog year 2016 and later will be able to access the revised requirements through the online theme form that is available in the McCormick Advising System (MAS).

#### Revised Rules (Catalog year 2016 and later):

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 are a list of disallowed courses from those departments and a list of allowed course 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*

**Old Rules (prior to Catalog year 2016):**

The seven theme courses must be chosen from approved lists of Fine Arts, Language and Literature (FAL), Historical Studies and Values (HSV) or Social and Behavioral Sciences (SBS) courses. A paper form is still required for the old rules. (Students may also choose to adopt the new rules.)

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 theme options:

<b>Option A</b>	<b>Option B</b>
Three courses in focus area	Five courses in focus area
At least two courses from each category (FAL/HSV/SBS)	No more than five courses from one category (FAL/HSV/SBS)
No more than three 100-level courses	

Visit the McCormick website for an extensive list of courses according to category:

<http://www.mccormick.northwestern.edu/students/undergraduate/social-science-humanities-theme/index.html>

<http://www.mccormick.northwestern.edu/documents/students/undergraduate/forms/approved-theme-course-listing.pdf>

**G. 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 (11 classes)

These classes prepare students for a variety of careers in chemical engineering and form the core of the curriculum.

Year	Class Number	Class Title	Prerequisites
Sophomore	CHEM 210-1*	Organic Chemistry I	CHEM 132/152/172
Sophomore	CHEM 210-2*	Organic Chemistry II	CHEM 210-1
	CHEM 230-2	Organic Chemistry lab	
Sophomore	CHEM ENG 212	Phase Equilibrium and Staged Separations	CHEM ENG 210, 211
Soph or Jr.	CHEM ENG 275**	Molecular and Cell Biology for Engineers	CHEM 132/152/172
Junior	CHEM ENG 307	Kinetics and Reactor Engineering	CHEM ENG 210, 211, 321, 322
Junior	CHEM ENG 322	Heat Transfer	Math Req., GEN ENG 205-4; CHEM ENG 321 is strongly recommended
Junior	CHEM ENG 323	Mass Transfer	CHEM ENG 321, 322
Senior	CHEM ENG 341	Dynamics and Control of Chemical and Biological Processes	Senior Standing, CHEM ENG 307
Senior	CHEM ENG 342	Chemical Engineering Laboratory	CHEM ENG 212, 307, 321, 322, 323
Senior	CHEM ENG 351	Process Economics, Design, & Evaluation	CHEM ENG 212, 307, 321, 322, 323
Senior	CHEM ENG 352	Chemical Engineering Design Projects	CHEM ENG 351

\* - May be replaced with CHEM 212-1 & CHEM 212-2, CHEM 232-2 (lab)

\*\* - May be replaced with BIOL SCI 215 or 219

#### Important Notes:

- The grade point average of the 16 courses (11 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 two courses may carry a grade of "D".
- None of the 11 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 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 16 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 two may carry a grade of "D".

Six suggested areas of specialization are described below. 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 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 219 (Cell Biology) in place of CHEM ENG 275 in the major program.

1. CHEM ENG 375 Biochemical Engineering
2. CHEM ENG 371 (Transport Phenomena in Living Systems), 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: Principles and Applications)
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 215 (Genetics and Molecular Biology), BIOL SCI 217 (Physiology), BIOL SCI 308 (Biochemistry, or BIOL SCI 301, Principles of Biochemistry) **OR** CHEM 210-3 (Organic Chemistry III)
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 Water) **OR** MAT SCI 381 (Materials for Energy-Efficient Technology)
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
3. MAT SCI 331 Physical Properties of Polymers
4. CHEM 210-3 (Organic Chemistry III), MAT SCI 360 (Introduction to 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.

<b>Course</b>	<b>Quarter</b>
CHEM ENG 210 - Analysis of Chemical Process Systems	Fall, Spring
CHEM ENG 211 - Thermodynamics	Fall, Winter
CHEM ENG 212 - Phase Equilibrium and Staged Separations	Winter, Spring
CHEM ENG 275 - Molecular and Cell Biology for Engineers	Winter
CHEM ENG 307 - Kinetics and Reactor Engineering	Spring
CHEM ENG 312 - Probability and Statistics for Chemical Engineering	Winter
CHEM ENG 321 - Fluid Mechanics	Fall
CHEM ENG 322 - Heat Transfer	Winter
CHEM ENG 323 - Mass Transfer	Spring
CHEM ENG 341 - Dynamics and Control of Chemical and Biological Processes	Winter
CHEM ENG 342 - Chemical Engineering Laboratory	Fall, Wint, Spr
CHEM ENG 351 - Process Economics, Design, and Evaluation	Fall, Winter
CHEM ENG 352 - Chemical Engineering Design Projects	Winter, Spring
CHEM ENG 330 - Molecular Engineering and Statistical Mechanics	Spring
CHEM ENG 345 - Process Optimization for Energy and Sustainability	Winter
CHEM ENG 355 - Chemical Product Design	Winter
CHEM ENG 361 - Introduction to Polymers	Fall
CHEM ENG 365 - Sustainability, Technology, and Society	Fall
CHEM ENG 367 – Quantitative Methods in Life Cycle Analysis	Variable <sup>+</sup>
CHEM ENG 371 - Transport Phenomena in Living Systems	Winter <sup>+</sup>
CHEM ENG 372 - Bionanotechnology	Winter
CHEM ENG 373 – Biotechnology and Global Health	Fall
CHEM ENG 375 - Biochemical Engineering	Winter
CHEM ENG 376 – Synthetic Biology	Fall <sup>+</sup>
CHEM ENG 377 - Bioseparations	Spring <sup>+</sup>
CHEM ENG 379 - Computational Biology: Principles and Applications	Spring <sup>+</sup>
CHEM ENG 382 – Regulatory Sciences in Biotechnology	Spring <sup>+</sup>
CHEM ENG 395 - Selected Topics in Chemical Engineering (by petition)	Variable <sup>+</sup>
CHEM ENG 399 - Projects	All year

Not all classes are offered every year. Courses marked with a + in this list may not be offered every year. Students should speak with advisors about predicted future offerings for the purposes of long-term planning. See also the online schedule for the current academic year schedule: <http://www.mccormick.northwestern.edu/chemical-biological/courses/index.html>

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

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

ES APPM 311-1,2: Methods of Applied Mathematics  
ES APPM 311-3: Methods of Applied Mathematics: Complex Variables  
MATH 351: Fourier Series and Boundary Value Problems  
(MATH 351 and ESAPPM 311-2 are considered duplicate courses; credit cannot be received for both courses).

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:

EECS 111 Fundamentals of Computer Programming  
EECS 211 Object-Oriented Programming in C++

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 (Prof. 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 pre-requisites.
  - 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/undergraduate/research-opportunities.html](http://www.mccormick.northwestern.edu/chemical-biological/undergraduate/research-opportunities.html)

[www.mccormick.northwestern.edu/chemical-biological/research/areas](http://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/](http://www.mccormick.northwestern.edu/students/undergraduate/research-opportunities/)

### 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 215: Genetics and Molecular Biology<sup>1</sup>
2. BIOL SCI 217: Physiology **OR** BME 303 Systems Physiology
3. BIOL SCI 219: Cell Biology<sup>1</sup>
4. BIOL SCI 308: Biochemistry (recommended, esp. for non-engineers, or BIOL SCI 301, Principles of Biochemistry)
5. CHEM ENG 375: Biochemical Engineering
6. CHEM ENG 377: Bioseparations<sup>2</sup>
7. Biology Laboratories or Independent study (1 unit): Either
  - One unit of 399 research in an approved lab. Up to two additional units may be used; see below. Students should verify with the minor coordinator that the project and laboratory are appropriate. **OR**
  - All of the following (0.34 units each)
    - o BIOL SCI 220 Genetic and Molecular Processes Laboratory
    - o BIOL SCI 221 Cellular Processes Laboratory
    - o BIOL SCI 222 Physiological Processes Laboratory
8. One of the following: CHEM ENG 371, 372, 373, 376, 379, 382, 475, 478, 479, or approved 395 by petition
9. Another unit of 399 or an elective from #8 above **OR** one of the following: BIOL SCI 315, 319, 323, 328, 330, 332, 341, 353, 355, 361, 363, 378, 380, 390, 395, BMD ENG 317, 343, 344, 346, 349-1, CHEM 210-3, CIV ENG 361-1, 441, 442
10. Another unit of 399 or an elective from #8 above **OR** one of the following: BIOL SCI 315, 319, 323, 328, 330, 332, 341, 353, 355, 361, 363, 378, 380, 390, 395, BMD ENG 317, 343, 344, 346, 349-1, CHEM 210-3, CIV ENG 361-1, 441, 442

<sup>1</sup> - CHEM ENG 275 can be used instead of BIOL SCI 215 or 219 only in cases when a student has taken CHEM ENG 275 before deciding to pursue the minor.

<sup>2</sup> - CHEM ENG 377 can be taken before 375 and with junior standing; 377 may only be offered in alternate years.

#### 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 courses 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 (215, 217, 219, and 301/308) 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. <http://www.mccormick.northwestern.edu/career-development/programs/index.html#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. <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/](http://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 (3<sup>rd</sup> 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/pre-med/](http://www.northwestern.edu/health-professions-advising/pre-med/)

## 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](mailto: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/undergraduate/academic-integrity.html](http://www.mccormick.northwestern.edu/students/undergraduate/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: <https://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, <http://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 office.

<http://www.mccormick.northwestern.edu/career-development/>

Permanent employment opportunities as well as a limited number of summer positions with companies are regularly handled by University Career Services. Most on-campus interviews are held very early in the fall quarter, with a small number held winter quarter. **Undergraduates planning to use the University Career Services Center 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.

## VI. APPENDICES

### A. Appendix A: Sample Course Sequences

STANDARD 4-YEAR CHEMICAL ENGINEERING PROGRAM			
Year:	Fall	Winter	Spring
Freshman	Math 220 Chem 110, 151, or 171 Gen Eng 205-1 Elective or Speech	Math 224 Chem 131, 152, or 172 Gen Eng 205-2 Dsgn 106-1/Eng 106-1	Math 230 Chem 132 or ChE 210 <sup>1</sup> Gen Eng 205-3 Dsgn 106-2/Eng 106-2
Sophomore (variant 1: ChE 210 taken in Freshman year)	Math 234 Gen Eng 205-4 Chem 210-1 ChE 211	ChE 212 Chem 210-2 Phys 135-2 Elective	Elective or MSE 301 Phys 135-3 Elective <sup>2</sup> Elective
Sophomore (variant 2: ChE 210 taken in Sophomore year)	Math 234 Chem 210-1 Gen Eng 205-4 ChE 210	ChE 211 Chem 210-2 Phys 135-2 Elective	ChE 212 Phys 135-3 Elective <sup>2</sup> Elective
Junior	ChE 321 Elective <sup>3</sup> or MSE 301 Elective Elective	ChE 322 ChE 275 <sup>3</sup> ChE 312 <sup>4</sup> Elective	ChE 307 ChE 323 Elective <sup>3</sup> or MSE 301 Elective
Senior (variant 1)	ChE 342 Elective or MSE 301 Elective Elective	ChE 341 ChE 351 Elective Elective	ChE 352 Elective Elective Elective
Senior (variant 2)	ChE 351 Elective or MSE 301 Elective Elective	ChE 341 ChE 352 Elective Elective	ChE 342 Elective Elective Elective
Notes	<ol style="list-style-type: none"> <li>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 sophomore sequence (210, 211, 212). Otherwise students may take an elective.</li> <li>Chemistry 210-3 may be taken here as an advanced science elective; a full year of organic chemistry is required to satisfy standard pre-med requirements.</li> <li>Students pursuing a bio-related specialization, or who wish to satisfy pre-med requirements, typically take Biol Sci 215, 217, 219 during the sophomore or junior year. Biol Sci 215 or 219 can take the place of ChE 275.</li> <li>IEMS 303 may be used in place of ChE 312, however IEMS 303 has a prerequisite of IEMS 202 and recommended EECS 111. This option may be appealing to students pursuing the Kellogg Certificates.</li> </ol>		

STANDARD COOP (5-YEAR) CHEMICAL ENGINEERING PROGRAM			
Year:	Fall	Winter	Spring
Freshman	Math 220 Chem 110, 151, or 171 Gen Eng 205-1 Elective/Speech	Math 224 Chem 131, 152, or 172 Gen Eng 205-2 Dsgn 106-1/Eng 106-1	Math 230 Chem 132 or ChE 210 <sup>1</sup> Gen Eng 205-3 Dsgn 106-2/Eng 106-2
Sophomore (variant 1: ChE 210 taken in Freshman year)	Math 234 Gen Eng 205-4 Chem 210-1 ChE 211	ChE 212 Chem 210-2 Phys 135-2 Elective	Elective or MSE 301 Phys 135-3 Elective <sup>2</sup> Elective
Sophomore (variant 2: ChE 210 taken in Sophomore year)	Math 234 Gen Eng 205-4 Chem 210-1 ChE 210	ChE 211 Chem 210-2 Phys 135-2 Elective	ChE 212 Phys 135-3 Elective <sup>2</sup> Elective
Junior	ChE 321 Elective <sup>3</sup> or MSE 301 Elective Elective	ChE 275 <sup>3</sup> ChE 322 ChE 312 <sup>4</sup> Elective	COOP <sup>5</sup>
Pre-Senior	Elective or MSE 301 Elective Elective Elective	COOP	ChE 307 ChE 323 Elective <sup>3</sup> Elective
Senior	COOP	ChE 341 ChE 351 Elective Elective	ChE 342 ChE 352 Elective Elective
Notes	<ol style="list-style-type: none"> <li>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 sophomore sequence (210, 211, 212). Otherwise students may take an elective.</li> <li>Chemistry 210-3 may be taken here as an advanced science elective; a full year of organic chemistry is required to satisfy standard pre-med requirements.</li> <li>Students pursuing a bio-related specialization, or who wish to satisfy pre-med requirements, typically take Biol 215, 217, 219 during the sophomore or junior year. Biol 215 or 219 takes the place of ChE 275.</li> <li>IEMS 303 may be used in place of ChE 312, however IEMS 303 has a prerequisite of IEMS 202 and recommended EECS 111. This option may be appealing to students pursuing the Kellogg Certificates.</li> <li>Students following the traditional coop schedule typically are on coop during the summers after the sophomore, junior, and senior years.</li> </ol>		

**B. Appendix B: Approved Technical Elective Course Listing**Category A

CHEM ENG 330 Molecular Engineering and Statistical Mechanics	CHEM ENG 372 Bionanotechnology
CHEM ENG 345 Process Optimization for Energy and Sustainability	CHEM ENG 373 Biotechnology and Global Health
CHEM ENG 355 Chemical Product Design	CHEM ENG 375 Biochemical Engineering
CHEM ENG 361 Introduction to Polymers	CHEM ENG 376 Synthetic Biology
CHEM ENG 364 Chemical Processing and the Environment	CHEM ENG 377 Bioseparations
CHEM ENG 365 Sustainability, Technology, and Society	CHEM ENG 379 Computational Biology: Principles and Applications
CHEM ENG 367 Quantitative Methods in Life Cycle Analysis	CHEM ENG 382 Regulatory Sciences in Biotechnology
CHEM ENG 371 Transport Phenomena in Living Systems	CHEM ENG 395 Special Topics in Chemical Engineering (by petition)
	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 of 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: Mod Optical Microscopy & Imaging  
 343-0: Biomaterials/Medical Devices  
 344-0: Biological Performance of Materials  
 346-0: Tissue Engineering  
 365-0: Control of Limbs and Artificial Replcmnt  
 366-0: Biomechanics of Movement  
 371-0: Soft Tissue Mechanics  
 377-0: Intermediate Fluid Mechanics  
 378-0: Transport Fundamentals  
 390-0: Biomedical Engineering Design  
 395-0: Top 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: MetrIgy-HydrIgy  
 355-0: Hyrdogeology and Subsurf Contamination  
 361-1: Environmental Microbiology  
 361-2: Public & Environmental Health  
 363-0: Environ Engrg Apps I: Air & Land  
 364-0: Sustainable Water Systems  
 367-0: Chemical Processes in Water  
 368-0: Sustainability: The City  
 371-0: Transportation Planning/Analysis  
 376-0: Transportation System Operations  
 395-0: Special Topics (by petition)

## Northwestern Engineering

*Electrical Engineering and Computer Science*

202-0: Intro to EE  
 205-0: Fundamentals Computer Sys Software  
 211-0: Fundamentals of Computer Prog II  
 213-0: Intro to Computer Systems  
 214-0: Data Structures Data Mgmt  
 225-0: Fundamentals of Electronics  
 230-0: Programming for Engineers  
 231-0: Advanced Programming for CE  
 250-0: Physical Electronics and Devices  
 270-0: Appl Elect Dev  
 307-0: Communications Systems  
 308-0: Electromagnetics/Photonics  
 317-0: Data Mgt/Information Processing  
 321-0: Programming Languages  
 322-0: Compiler Construction  
 325-1: Artificial Intelligence Programming  
 332-0: Intro to Computer Vision  
 333-0: Intro Communication Networks  
 337-0: Intro to Semantic Info Processing  
 338-0: Practicum Intelligent Info Systems  
 339-0: Intro to Databases  
 340-0: Intro to Computer Networking  
 343-0: Operating Systems  
 344-0: Design of Problem Solvers  
 345-0: Distributed Systems  
 346-0: Microprocessor System Design  
 347-1 and 347-2: Micro Sys Project I and II  
 348-0: Intro Artificial Intelligence  
 349-0: Machine Learning  
 351-1: Intro to Computer Graphics  
 351-2: Intermediate Computer Graphics  
 353-0: Dig Elec Cir Sys  
 357-0: Automation in VLSI CAD  
 358-0: Intro to Parallel Comp  
 359-0: Digital Signal Processing  
 360-0: Intro to Feedback Systems  
 361-0: Comp Architecture I  
 362-0: Comp Architecture Project  
 363-0: Digital Filtering

366-0: Embedded Systems  
 374-0: Intro to Digital Control  
 378-0: Digital Communications  
 379-0: Lasers and Fiber Optics  
 380-0: Wireless Communications  
 382-0: Photonic Info Processing  
 383-0: Fiber Optic Communications  
 386-0: Comp Elect & Photonics  
 390-0: Intro to Robotics  
 391-0: CMOS VLSI Circuits Design  
 392-0: VLSI Design Projects  
 393-0: Dsgn & Anly of Intg Circuits  
 394-0: Software Project Mgt Develop  
 395-0: Spec Topics in Comp Sc (by petition)  
 396-0: 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)

*Industrial Engineering and Management Sciences*

304-0: Stat Learning for Data Analysis  
 305-0: Stats Qual Imprv  
 306-0: Decision Analysis  
 307-0: Quality Improv Expt Design  
 308-0: Data Science & Analytics  
 310-0: Operations Research  
 313-0: Foundations of Optimization  
 315-0: Stochastic Models  
 317-0: Discrete-Event System Sim  
 340-0: Field Proj Meth  
 351-0: Optimization Methods in Data Science  
 373-0: Intro to Financial Engineering  
 381-0: Sup Chain Modeling & Analysis  
 382-0: Production Planning/Scheduling  
 383-0: Service Operations Management  
 395-0: Spec Top in IE (by petition)

*Design Engineering*

305-0: Human-Centered Service Design



## Northwestern Engineering

308-0: Human-Centered Prod Design	395-0: Special Topics (by petition)
346-0: Design for Fabrication	
384-1: Interdisciplinary Design Projects I	<i>Mechanical Engineering</i>
384-2: Interdisciplinary Design Projects II	224-0: Experimental Engineering
386-0: Manufacturing Engineering Design	233-0: Electronics Design
	240-0: Mechical Design & Manufacturing
<i>Materials Science and Engineering</i>	314-0: Theory of Machines - Dynamics
314-0: Thermodynamics of Materials	315-0: Theory of Machines - Design Elements
315-0: Phase Equilibria & Diffusion of Mats	317-0: Molec Modeling Micromech
316-1: Microstructural Dynamics	318-0: Multiscale Simul
316-2: Microstructural Dynamics	333-0: Intro to Mechatronics
318-0: Materials Selection	340-1: Computer-Integ Manuf (each course [1,2,3] is 1 unit)
331-0: Soft Materials	340-2: Computer-Integ Manuf
332-0: Mechanical Behavior of Solids	340-3: Computer-Integ Manuf
333-0: Composites	346-0: Intro to Tribology
341-0: Intro Mod Ceram	359-0: Reliability Engineer
351-2: Intro Physics of Materials	362-0: Stress Analysis
355-0: Elect Mats	363-0: Mechanical Vibrations
360-0: Electron Microscopy	373-0: Engg Fluid Mechanics
362-0: Imperfections	377-0: Heat Transfer
370-0: Biomaterials	381-0: Intro to MEMS
376-0: Nanomaterials	382-0: Expts in Micro/Nano Sci and Engg
380-0: Intro Surface Sci & Spectroscopy	385-0: Nanotechnology
381-0: Energy Materials	389-0: Molecular Machines in Biology
382-0: Electrochem Energy Mats & Devices	390-0: Intro Dynamic Systems
385-0: Electronic/Thermal Properties Matls	395-0: Spec Topics (by petition)
390-0: Materials Design	
391-0: Process Design	

Category C (listings by department or educational program)

<i>Engineering Sciences and Applied Mathematics</i>	301-0: Principles of Biochemistry
311-1: Meth Applied Math	308-0: Biochemistry (cannot use both 308 and 301)
311-2: Meth Applied Math	315-0: Advanced Cell Biology
312-0: Complex Variables	319-0: Bio Animal Viruses
346-0: Modeling/Computation	321-0: Physical Biochem
	323-0: Bioinformatics
<i>Biological Sciences (in Weinberg)</i>	328-0: Microbiology
215-0: Genetics and Molecular Biology	330-0: Plant Biology
217-0: Physiology	333-0: Plant-Animal Interact
219-0: Cell Biology	337-0: Quant Methods for Ecology & Conserv

355-0: Immunobiology

361-0: Protein Structure and Function

363-0: Biophysics

378-0: Functional Genomics

380-0: Biology of Cancer

390-0: Adv Molecular Biology

*Chemistry (in Weinberg)*

210-3: Organic Chemistry

220-0: Intro Instrumental Analysis

301-0: Principles Organic Chem

302-0: Principles Inorganic Chem

303-0: Principles Physical Chem

305-0: Chemistry Life Processes

306-0: Environmental Chem

307-0: Materials and Nanochem

314-0: Bioorganic Chem

316-0: Medicinal Chem

329-0: Analytical Chem

333-0: Inorganic Chem

342-1: Thermodynamics

342-2: Quantum Mech and Spectroscopy

342-3: Kinetics and Stat Thermo

350-1: Adv Laboratory 1

350-2: Adv Laboratory 2

350-3: Adv Laboratory 3

393-0: Green Chemistry

*Civil and Environmental Engineering*

202-0: Biol. & Ecological Principles

203-0: Earth in the Anthropocene

317-0: Biogeochemistry

*Environmental Sciences (in Weinberg)*

201-0: Earth A: A Habitable Planet

202-0: Health of Biosphere

*Mathematics (in Weinberg)*

310-1: Probability and Stochastic Processes

310-2: Probability and Stochastic Processes

310-3: Probability and Stochastic Processes

314-0: Prob and Statistics for Econometrics

325-0: Complex Analysis

351-0: Fourier Analysis

353-0: Qualitative Diff Eqs

354-1: Chaotic Dynamical Systems

354-2: Chaotic Dynamical Systems

360-1: MENU: Applied Analysis

360-2: MENU: Applied Analysis

366-1: Math Models in Finance

366-2: Math Models in Finance

368-0: Intro Optimization

*Materials Science and Engineering*

361-0: Crystallography & Diffraction

*Physics (in Weinberg)*

330-1: Classical Mechanics

330-2: Classical Mechanics

332-0: Statistical Mechanics

333-1: Adv Electricity and Magnetism

333-2: Adv Electricity and Magnetism

337-0: Intro Solid-State Phys

357-0: Biophotonics Lab

358-0: Nanolithography

Category D (listings by engineering department or educational program)

*Civil and Environmental Engineering*

304-0: Civil/Envr Eng Syst Analysis

306-0: Uncert Analysis Civ Eng

*Electrical Engineering and Computer Science*

203-0: Intro to Computer Eng

221-0: Fundamentals of Circuits

222-0: Fundamntls Signals & Systems

223-0: Fund of Solid State Engineerng

224-0: Fund of Electromag & Photonics  
302-0: Prob Systms Random Signals  
303-0: Adv Digital Logic Design  
328-0: Numerical Methods for Eng  
330-0: Human Computer Interaction  
336-0: Design Analysis Algorithms  
370-0: Computer Game Design  
381-0: Electronic Properties Materials  
384-0: Solid State Electronic Devices  
385-0: Optoelectronics  
388-0: Nanotechnology  
389-0: Superconductivity Applications

#### *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: Proj Mgmt for Engineers  
345-0: Negotiation  
365-0: Analytics for Social Good

#### *Materials Science and Engineering*

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