McCormick

Northwestern Engineering

DEPARTMENT OF CHEMICAL AND BIOLOGICAL ENGINEERING

INFORMATION FOR MAJORS IN CHEMICAL ENGINEERING

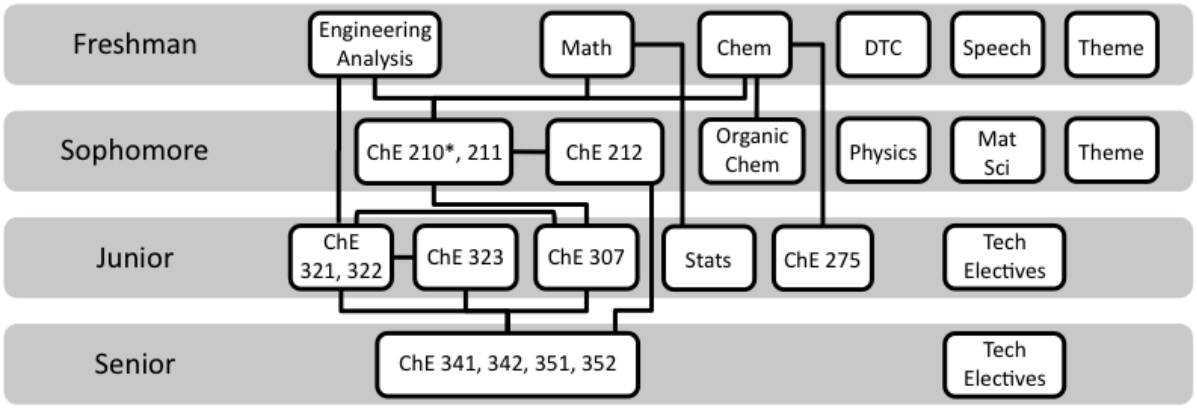
Fall 2014

McCormick

Northwestern Engineering

Quick Reference Guide

Chemical Engineering Curriculum - Prerequisite Flowchart



**Starting Spring 2015, sophomore year has two variants; ChE 210 may be taken in sophomore or freshman year.*

Total Requirements - 48 classes

Basic Courses:

A. Mathematics - 4 classes
- ❑ MATH 220 ❑ MATH 224
- ❑ MATH 230 ❑ MATH 234

B. Engineering Analysis - 4 classes
- ❑ ❑ ❑ ❑ GEN ENG 205-1,2,3,4

C. Basic Sciences - 4 classes
- ❑ ❑ PHYSICS 135-2,3
- ❑ ❑ CHEM 102,103 or 171,172

D. Design and Communication - 3 classes
- ❑ ❑ ENGLISH & DSGN 106-1,2
- ❑ GEN CMN (SPEECH) 102 or 103

E. Basic Engineering - 5 classes
- ❑ CHEM ENG 210
- ❑ CHEM ENG 211
- ❑ MAT SCI 301
- ❑ CHEM ENG 312 or IEMS 303
- ❑ CHEM ENG 321

Distribution Requirements:

F. ❑ Social Sci/Humanities (Theme) - 7 classes

G. ❑ Unrestricted Electives - 5 classes

Core Curriculum:

H. Major Program – 11 required classes + 5 technical electives
- ❑ CHEM 210-1: Organic Chemistry
- ❑ CHEM 210-2: Organic Chemistry
- ❑ CHEM ENG 212: Phase Equilibrium and Staged Separations
- ❑ CHEM ENG 275: Cell & Molecular Biology for Engineers or BIOL SCI 215 or 216
- ❑ CHEM ENG 307: Kinetics & Reactor Engineering
- ❑ 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

❑ Technical Electives - 5 classes

Choose **area of specialization**: (OR follow **technical elective guidelines** - Section IIB)

Chemical Process Engineering
Bioengineering
Environmental Engineering and Sustainability
Polymer Science and Engineering
Design
Nanotechnology and Molecular 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. 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.

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

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

4. Be leaders in their chosen fields.

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

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

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
Honors (by invitation):		
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 101*	General Chemistry	Freshman
CHEM 102	General Inorganic Chemistry	Freshman
CHEM 103	General Physical Chemistry	Freshman
OR		
CHEM 171	Accelerated General Inorganic Chemistry	Freshman
CHEM 172	Accelerated General Physical Chemistry	Freshman
AND		
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

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.

Class Number	Class Title	Year
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
Honors (by invitation):		
GEN ENG 206-1	Honors Engineering Analysis 1	Freshman
GEN ENG 206-2	Honors Engineering Analysis 2	Freshman
GEN ENG 206-3	Honors Engineering Analysis 3	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-" typically have significant difficulty in core 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.

Class Number	Class Title	Year
ENGLISH 106-1,2	Writing in Special Contexts	Freshman
DSGN 106-1,2	Engineering Design and Communication	Freshman
GEN CMN 102	Public Speaking	Any
OR		
GEN CMN 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.
OR		
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)

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 Fine Arts, Language and Literature (FAL), Historical Studies and Values (HSV) or Social and Behavioral Sciences (SBS). 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.

Option A	Option 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/undergraduates/curriculum/theme/index.html

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 103/172
Sophomore	CHEM 210-2*	Organic Chemistry II	CHEM 210-1
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 103/172
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

** - May be replaced with BIOL SCI 215 or 216

Important Notes:

- The grade point average of the 16 courses (11 above + 5 technical electives, see pages 8-9) 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
2. CHEM ENG 355 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 216 (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 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 218 (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 345 Process Optimization
3. CIV ENG 367 (Aquatic Chemistry) **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 Soft Materials
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 Product Design
2. CHEM ENG 345 Process Optimization
3. DSGN 298 (Interdisciplinary Design Projects I), DSGN 308 (Human-Centered Product Design), **OR** DSGN 398 (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.

Course	Quarter
CHEM ENG 210 - Analysis of Chemical Process Systems	Fall, Spring '15
CHEM ENG 211 - Thermodynamics	Winter
CHEM ENG 212 - Phase Equilibrium and Staged Separations	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	Spring
CHEM ENG 355 - Chemical Product Design	Winter
CHEM ENG 361 - Introduction to Polymers	Fall
CHEM ENG 365 - Sustainability, Technology, and Society	Fall
CHEM ENG 371 - Transport Phenomena in Living Systems	Winter^{+}
CHEM ENG 375 - Biochemical Engineering	Winter
CHEM ENG 377 - Bioseparations	Spring^{+}
CHEM ENG 379 - Computational Biology: Principles and Applications	Spring^{+}
CHEM ENG 395 - Selected Topics in Chemical Engineering	Variable
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.chbe.northwestern.edu/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	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 Carr) 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.

http://www.chbe.northwestern.edu/undergraduate/current/research/index.html
http://www.chbe.northwestern.edu/research/index.html

The McCormick Research Opportunities page also includes useful information:
http://www.mccormick.northwestern.edu/undergraduates/research/index.html

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
2. BIOL SCI 216: Cell Biology **OR** CHEM ENG 275 Molecular & Cell Biology for Engineers[1]
3. BIOL SCI 217: Physiology **OR** BME 303 Systems Physiology
4. BIOL SCI 218: Biochemistry
5. CHEM ENG 375: Biochemical Engineering
6. CHEM ENG 377: Bioseparations[2]
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, 379, 475, 478, or 479
9. Another unit of 399 or an elective from #8 above **OR** one of the following: BIOL SCI 309, 315, 319, 323, 333, 355, 390, BME 317, CHEM 210-3, CIV ENG 441
10. Another unit of 399 or an elective from #8 above **OR** one of the following: BIOL SCI 309, 315, 319, 323, 333, 355, 390, BME 317, CHEM 210-3, CIV ENG 441

[1] - CHEM ENG 275 can be used instead of BIOL SCI 215 or 216 only in cases when a student has taken CHEM ENG 275 before deciding to pursue the minor.

[2] - 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 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.

Students from outside ChE should meet with the minor coordinator, Prof. William Miller, or the Assistant Chair, Prof. Jennifer Cole, to discuss how to satisfy the pre-requisites for the required courses, especially CHEM ENG 375.

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/mcd/Programs/Co-op/index.html

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:
http://www.mccormick.northwestern.edu/undergraduates/bachelors-degree-curriculum/engineering-minors.html

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 (freshmen 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. http://www.northwestern.edu/advising-center/health-professions/pre-med/

V. GENERAL INFORMATION

A. Advising

The McCormick School assigns a faculty advisor to each incoming freshman. At the end of freshmen year, advisors may be 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: http://www.mccormick.northwestern.edu/undergraduates/current_students/academic_integrity/

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: http://www.research.northwestern.edu/ors/

D. Accreditation

The Department of Chemical and Biological Engineering offers the Bachelor of Science Degree in Chemical Engineering. The 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 Office of Career Development.
http://www.mccormick.northwestern.edu/mcd/

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 101 or 171 Gen Eng 205-1 Elective or Speech	Math 224 Chem 102 or 172 Gen Eng 205-2 Dsgn 106-1/Eng 106-1	Math 230 Chem 103 or ChE 210[1] Gen Eng 205-3 Dsgn 106-2/Eng 106-2
Sophomore (variant 1: ChE 210 taken in Fr. year, beginning Sp15)	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[2] Elective
Sophomore (variant 2: ChE 210 taken in So. 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[2] Elective
Junior	ChE 321 Elective[3] or MSE 301 Elective Elective	ChE 322 ChE 275[3] ChE 312[4] Elective	ChE 307 ChE 323 Elective[3] 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	1. Advanced students who are ahead in the Math sequence or have completed the accelerated Chem sequence may be interested in taking the early offering of the ChE sophomore sequence (210, 211, 212) beginning Spring 2015. Otherwise students may take an elective. 2. Chem 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. 3. Students pursuing a bio-related specialization, or who wish to satisfy pre-med requirements, typically take Biol 215-217 during the sophomore or junior year. Biol 215 or 216 takes the place of ChE 275. 4. IEMS 303 may be used in place of ChE 312, however IEMS 303 has a prerequisite of IEMS 202. This option may be appealing to students pursuing the Kellogg Certificates.		

STANDARD COOP (5-YEAR) CHEMICAL ENGINEERING PROGRAM			
Year:	Fall	Winter	Spring
Freshman	Math 220 Chem 101 or 171 Gen Eng 205-1 Elective/Speech	Math 224 Chem 102 or 172 Gen Eng 205-2 Dsgn 106-1/Eng 106-1	Math 230 Chem 103 or ChE 210[1] Gen Eng 205-3 Dsgn 106-2/Eng 106-2
Sophomore (variant 1: ChE 210 taken in Fr. Year, beginning Sp15)	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[2] 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[2] Elective
Junior	ChE 321 Elective[3] or MSE 301 Elective Elective	ChE 275[3] ChE 322 Che 312[4] Elective	COOP[5]
Pre-Senior	MSE 301 Elective Elective Elective	COOP	ChE 307 ChE 323 Elective[3] Elective
Senior	COOP	ChE 341 ChE 351 Elective Elective	ChE 342 ChE 352 Elective Elective
Notes	1. Advanced students who are ahead in the Math sequence or have completed the accelerated Chem sequence may be interested in taking the early offering of the ChE sophomore sequence (210, 211, 212) beginning Spring 2015. Otherwise students may take an elective. 2. Chem 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. 3. Students pursuing a bio-related specialization, or who wish to satisfy pre-med requirements, typically take Biol 215-217 during the sophomore or junior year. Biol 215 or 216 takes the place of ChE 275. 4. IEMS 303 may be used in place of ChE 312, however IEMS 303 has a prerequisite of IEMS 202. 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.		

B. Appendix B: Approved Technical Elective Course Listing

Category A

CHEM ENG 330 Molecular Engineering and Statistical Mechanics
CHEM ENG 345 Process Optimization
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 371 Transport Phenomena in Living Systems
CHEM ENG 375 Biochemical Engineering
CHEM ENG 377 Bioseparations
CHEM ENG 379 Computational Biology: Principles and Applications
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 Physio
302-0: Sys Physiology
303-0: Systems Phys
308-0: Biomed Engg Lab
310-0: Mol & Cell Aspct
314-0: Models
315-0: App Genetic Engg
317-0: Biochem Sensors
325-0: Medical Imaging
327-0: Magn Reson Imag
333-0: Mod Optical Microscopy & Imag
343-0: Biomats/Med Devices
344-0: Biolog Perf Mats
346-0: Tissue Engg
350-0: Transp Fundamtls
365-0: Artif Repl Limbs
366-0: Movemt Biomechcs
371-0: Mech Biol Tissue
377-0: Intermed Fl Mech
379-0: Artific Organs
383-0: Cardiov Instrmtn
390-0: Biom Engg Design
395-0: Top Biomed Engg (by petition)

Civil and Environmental Engineering

216-0: Mech Of Mtls I
221-0: Theory Struc I
250-0: Intro Soil Mech
267-0: Chem Nat Environ
302-0: Engineering Law
327-0: Fin El Meth Mech
340-0: Fluid Mechanics II
346-0: Metrlgy-Hydrlgy
355-0: Eng Aspects Groundwater Flow
359-0: Haz Waste Mgmt
360-0: Env Impact Eval
361-1: Environ Microbiol
361-2: Public & Env Health
363-0: Environ Engrg Apps I: Air & Land
364-0: Environ Engrg Apps I: Water
366-0: Ecosys/Ecotox
367-0: Aquatic Chemistry
371-0: Transp Plan/Anal
376-0: Trans Sys Oper
395-0: Special Topics (by petition)

Electrical Engineering and Computer Science

202-0: Intro to EE
205-0: Comp Sys Softwr
211-0: Obj-Oriented Programming in C++
213-0: Intro to Computer Systems
225-0: Fund of Elect
230-0: Prog for Comp Engg
231-0: Advanced Programming for CE
250-0: Phys Electronics
270-0: Appl Elect Dev
307-0: Communications
308-0: Electromag/Photon
313-0: Telecomm Netwks
317-0: Data Mgt/Inf Pro
322-0: Compiler Construction
325-1: Artif Intel Prog
332-0: Dig Image Anal
333-0: Intr Comm Netwks
337-0: Nat Lang Proc
338-0: Practicum Intelligent Info Sys
339-0: Intro Databs Sys
340-0: Intro to Ntwkng
343-0: Operat Systems
344-0: Comp Prob Solvrs
346-0: Micropro Sys Des
347-1 and 347-2: Micro Sys Proj I and II
348-0: Int Artfcial Int
351-0: Int Comp Graphcs
353-0: Dig Elec Cir Sys
357-0: Automation in VLSI
358-0: Intro Paral Comp
359-0: Dig Sig Process
360-0: Feedback Systems
361-0: Comp Archi
362-0: Comp Arch Proj
363-0: Digital Filtering
374-0: Int Dig Control
378-0: Digital Communic
379-0: Lasers and Coherent Optics
380-0: Wireless Communications
382-0: Photonic Info Processing
383-0: Fiber Optic Comm
386-0: Comp Elect & Photo
390-0: Intro to Robotics
391-0: VLSI Sys Design
392-0: VLSI Design Proj
393-0: Dsgn & Anly of Intg Circuits
394-0: Soft Pro Mgt Dev
395-0: Spec Topics in Comp Sc (by petition)
397-0: Spec Topics Electrical Engg (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 Methods Data Mining
305-0: Stats Qual Imprv
306-0: Decision Analysis
307-0: Qual Improv Exp Dsgn
310-0: Oper Research
313-0: Det Models & Opt
315-0: Stoch Mod & Sim
317-0: Disc-Event Systems Sim
326-0: Engg Econ/Fin
340-0: Field Proj Meth
373-0: Intro to Financial Engineering
381-0: Sup Chain Mod & Analysis
382-0: Prod Plan/Sched
383-0: Service Operations Management
390-1: Sys Proj Mgmt I
390-2: Sys Proj Mgmt II
395-0: Spec Top in IE (by petition)

Design Engineering

305-0: Human-Centered Service Dsgn
308-0: Human-Centered Prod Design
384-1,2: Interdisc Dsgn Proj I & II
386-0: Manufacturing Eng Design
395-0: Spec Top in Design (by petition)

Materials Science and Engineering

314-0: Thermo Mat
315-0: Phase Eq & Dif
316-1: Micro Dynamics
316-2: Micro Dynamics
318-0: Materials Selection
331-0: Phys Prop Of Pol
332-0: Mech Behav Solid
333-0: Composite Matls
335-0: Polymer Proc
341-0: Intro Mod Ceram
351-2: Intro Phys Mat
355-0: Elect Mats
360-0: Int Elec Micrscp
362-0: Imperfections
370-0: Biomaterials
376-0: Nanomaterials
380-0: Surf Sci Spectro
381-0: Mats Energy Efficient Tech
390-0: Materials Design
391-0: Process Design
395-0: Special Topics (by petition)

Mechanical Engineering

224-0: Experimentl Engg
240-0: Mech Des & Manuf
314-0: Machine Dynamics
315-0: Machine Elements
317-0: Molec Modeling Micromech
318-0: Multiscale Simul
333-0: Intro to Mechatronics
340-1: Computer-Integ Manuf (each course [1,2,3] is 1 unit)
340-2: Computer-Integ Manuf
340-3: Computer-Integ Manuf
346-0: Intro to Tribol
359-0: Reliab Engineer
362-0: Stress Analysis
363-0: Mech Vibrations
365-0: Fin Elem Stress
370-0: Thermo II
373-0: Engg Fluid Mech
377-0: Heat Transfer
381-0: Intro to MEMS
382-0: Exp in Micro/Nano Sc and Eng
385-0: Nanotechnology
389-0: Molecular Machines in Biology
390-0: Intro Dyn Syst
391-0: Fund Control Sys
395-0: Spec Topics (by petition)

<u>Category C (listings by department or educational program)</u>

Engineering Sciences and Applied Mathematics

311-1: Meth Applied Math
311-2: Meth Applied Math
311-3: Meth Applied Math
346-0: Modeling/Computation

Biological Sciences (in Weinberg)

215-0: Genet and Molec Bio
216-0: Cell Bio
217-0: Physiology
218-0: Biochemistry
301-0: Biochemistry
309-0: Biochemistry
315-0: Cell Bio
319-0: Bio Animal Viruses
321-0: Physical Biochem
323-0: Bioinformatics
333-0: Plant-Animal Interact
355-0: Immunology
390-0: Molec Bio

Chemistry (in Weinberg)

210-3: Organic Chem
220-0: Intro Instrum Anal
301-0: Principles Org Chem
302-0: Principles Inorg Chem

305-0: Chem 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 Chem

Civil and Environmental Engineering
201-0: Earth A: A Habitable Planet
202-0: Health of Biosphere
203-0: Energy and Environment: Automobile

Environmental Sciences (in Weinberg)
201-0: Earth A: A Habitable Planet
202-0: Health of Biosphere
203-0: Energy and Environment: Automobile

Mathematics (in Weinberg)
310-1: Probability and Stochastic Processes
310-2: Probability and Stochastic Processes
310-3: Probability and Stochastic Processes
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)
252-0: Intro Computational Phys
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

<u>Category D (listings by engineering department or educational program)</u>

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: Fund of Circuits
222-0: Signals & Systems
223-0: Fund of Solid State Engineerng
224-0: Fund of Electromag & Photonics
302-0: Prob Sys Ran Sig
303-0: Adv Digital Des
310-0: Math Found Comp
311-0: Data Struc & Mgt
328-0: Num Meth for Eng
330-0: Human Computer Interaction
336-0: Des Anal Alg
370-0: Computer Game Design
381-0: Elec Materials
384-0: Solid Elec Cond
385-0: Optoelectronics
388-0: Microelec Technl
389-0: Supercond Appl

Industrial Engineering and Management Sciences

202-0: Probability
224-0: Prin of Acctg/Fin
325-0: Engineering Entrepreneurship
342-0: Organizational Behavior
343-0: Proj Mgmt for Engineers
345-0: Negotiations and Conflict Resolution for Engineers

Materials Science and Engineering

351-1: Intro Phys Mat