DEPARTMENT OF CHEMICAL AND BIOLOGICAL ENGINEERING

NORTHWESTERN UNIVERSITY

INFORMATION FOR MAJORS IN CHEMICAL ENGINEERING

Revised Winter 2009

I. INTRODUCTION

This booklet has been prepared to assist you in planning your education as a major in Chemical Engineering at Northwestern University. The primary function is to expand on the information about the department program presented in the Undergraduate Study Bulletin. Secondary functions are to provide information relevant to long-term career planning and to bring to your attention available extracurricular services that may enhance your education.

II. ADVISING

The McCormick School assigns a faculty advisor to each incoming freshman; this advisor may or may not be a member of the Chemical & Biological Engineering faculty. If a freshman who has been assigned a non-ChBE advisor desires to switch to a chemical engineering faculty member, this can be easily handled by contacting Professor Torkelson (j-torkelson@northwestern.edu or 491-7449), who will then assist the student in completing the necessary paper work.

Further, any questions that cannot be handled to the student's satisfaction by his/her assigned advisor should be addressed to Professor Torkelson who is the Director of the Undergraduate Program in the department.

Students in the sophomore through senior years are assigned faculty advisors who have their major appointments in the department. Typically, 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 Torkelson.

III. UNDERGRADUATE PROGRAM

The Chemical Engineering curriculum consists of sixteen courses which constitute the major and which build on a number of required technical courses in Engineering Analysis, Design and Communication, Basic Engineering, and Mathematics, Physics, and Chemistry, and are supplemented by non-technical courses in the Humanities and Social Sciences. Representative schedules for four-year and five-year (cooperative education) programs are presented in the Appendix. Recommendations and requirements of various parts of the 48-course sequence are outlined below.

Required courses in Engineering Analysis, Mathematics, Physics, and Chemistry are taken mainly during the first two years of study. The required and recommended courses have been selected to provide students a broad exposure to various aspects of engineering and the natural sciences, while also providing a firm background necessary for the Chemical Engineering courses taken from the sophomore through senior years. These courses and the Sample Course Sequences have been assembled with careful attention to prerequisites, required laboratories, class meeting conflicts, distribution of electives, etc. If changes from these are desired (because of special interests of the student or a non-standard cooperative education schedule) or required (because of advanced placement or transfer into Chemical Engineering from another major), the student should be aware that serious complications may arise. Any significant deviation from prerequisite requirements

should be cleared with your advisor and/or Professor Torkelson prior to undertaking an unconventional course sequence.

All entering freshmen are required to enroll in the Engineering First curriculum consisting of Engineering Analysis 1-4 and Engineering Design and Communication 1 & 2 (formally known as Design 106-1,2 and English 106-1,2). Substitutions due to exceptional circumstances must be approved by petition, for example for transfer students.

Basic Components of the Curriculum (48 courses)

A. Mathematics. The following four courses are required:

MATH 220 (formerly 214-1)	Differential Calculus of One Variable
MATH 224 (formerly 214-2)	Integral Calculus of One Variable
MATH 230 (formerly 214-3)	Multivariable Differential Calculus
MATH 234 (formerly 215)	Multiple Integration and Vector Calculus

ESAM 252-1,2 (Honors calculus for engineers) may be substituted for Math 230 and 234 for students with appropriate AP credit, and who are invited to take this sequence.

B. Engineering Analysis. The following four courses are required:

GEN ENG 205-1	Engineering Analysis 1
GEN ENG 205-2	Engineering Analysis 2
GEN ENG 205-3	Engineering Analysis 3
GEN ENG 205-4	Engineering Analysis 4

ESAM 252-3 (Honors calculus for engineers) takes the place of GEN ENG 205-4 for students pursuing the honors sections of Engineering Analysis.

Note: 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. Students in such a situation at the end of sophomore year should give serious consideration to changing to other majors at that time.

C. Basic Sciences. The following four courses are required:

CHEM 102	General Inorganic Chemistry
CHEM 103	General Physical Chemistry
or	
CHEM 171	Accelerated General Inorganic Chemistry
CHEM 172	Accelerated General Physical Chemistry
and	
PHYSICS 135-2	General Physics - Electricity and Magnetism
PHYSICS 135-3	General Physics – Intro to Modern Physics; Waves

Notes:
Chemistry - Students who place into the CHEM 101-103 sequence must take CHEM 101 as an unrestricted elective. If students place into CHEM 171-172, they are encouraged to take that sequence. Students who are unable to complete the freshman chemistry sequence 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, see Appendix A) requires as prerequisites grades of "C-" or better in all freshman chemistry courses. Students who are unable to complete the freshman chemistry sequence in their first year with all grades of "C" or above should seriously consider another major.
Physics - Students should complete Physics 135-2&3 by the end of the sophomore year (see Appendix A).

D. Design and Communication. All three of the following design and communication courses should be taken during the freshmen year.

ENGLISH 106-1,2 (1 unit total)	Writing in Special Contexts
DSGN 106-1,2 (1 unit total)	Engineering Design and Communications
GEN SPEECH 102 or 103	

Note: Students unable to take the 106-1,2 courses (e.g. transfer students) must petition to be exempted. These students must substitute courses for both the writing and the design requirements of the 106 courses. The writing requirement may be fulfilled by taking either English 105 or 205. The design requirement must be fulfilled by taking a course with substantial design content (defined as a course that requires students to solve an open-ended problem with clearly defined specifications). This course substitution must be approved via a curriculum petition.

E. Basic Engineering. The following five courses are required:

CHEM ENG 210	Analysis of Chemical Process Systems
CHEM ENG 211	Thermodynamics
CHEM ENG 321	Fluid Mechanics
MAT SCI 301*	Principles of the Properties of Materials
One course from:	CHEM ENG 312 Probability and Statistics for Chemical Engineering
	BME 220 Introduction to Biomedical Statistics
	IEMS 201 Introduction to Statistics
	IEMS 303 Statistics I†

* May be replaced by petition with MAT SCI 201 for students transferring from another major which requires MAT SCI 201 for graduation.
† Note that this course requires IEMS 202, Probability, as a prerequisite.

F. Social Sciences and Humanities. The seven courses fulfilling this requirement must satisfy the Theme requirement. Your academic advisor and an Assistant Dean must approve your choice of a Theme. See your advisor to discuss this requirement.

G. Unrestricted Electives. These five courses may be taken at anytime.

H. Chemical Engineering Major (16 courses)

1. Required Courses (twelve).

In the approximate order in which they are typically taken, these are as follows:

CHEM 210-1*	Organic Chemistry I
CHEM 210-2*	Organic Chemistry II
CHEM ENG 212	Phase Equilibrium and Staged Separations
CHEM ENG 322	Heat Transfer
CHEM ENG 275†	Biological Science for Engineers
CHEM 342-2	Quantum Mechanics and Spectroscopy
CHEM ENG 307	Kinetics and Reactor Engineering
CHEM ENG 323	Mass Transfer
CHEM ENG 341	Process Dynamics and Control
CHEM ENG 342	Chemical Engineering Laboratory
CHEM ENG 351	Process Economics, Design, and Evaluation
CHEM ENG 352	Chemical Engineering Design Projects

* CHEM 212-1 and 212-2 may substitute for CHEM 210-1 and 210-2
† may be substituted with BIOL SCI 210-2

2. Technical Electives (four courses).

(a) One 300- or 400-level CHEM ENG course excluding CHEM ENG 399.
(b) One 200- or 300-level science elective chosen from any of the following: 200- or 300-level Biol_Sci, Chemistry, Physics or Materials Science course (excluding any 299 or 399 courses); CHEM ENG 361; BME 302; or BME 303.
(c) One 300- or 400-level Engineering or 300-level Biol_Sci, Chemistry, or Physics course (excluding 399 except in CHEM ENG); or CHEM ENG 399; or Biol_Sci 210-3.
(d) One 200-, 300, or 400-level engineering or 200- or 300-level Biol_Sci, Chemistry, or Physics course (excluding any 299 and 399 courses).

Only 1 ChE 399 is allowed as part of the 4 science and technical electives.

Electives may be chosen to define an 'area of specialization' as described in Appendix B. During the junior year, students should discuss the choice of electives with their advisors. Suggested courses for standard areas of specialization (Chemical Process Engineering, Biomedical Engineering, Biotechnology, Environmental Engineering, Polymer Science and Engineering) are listed in Appendix B. These lists satisfy the Technical Elective requirements listed above.

It is recommended that students include advanced mathematics among their technical electives, especially those who may be considering graduate studies in chemical engineering. Some courses appropriate for the Chemical Engineering major are as follows:

ES APPM 3l1 - 1,2	Methods of Applied Mathematics
ES APPM 3l1 - 3	Methods of Applied Mathematics: Complex Variables
MATH 351	Fourier Series and Boundary Value Problems

Chemical Engineering offers many 300-level elective courses which should be considered when planning technical electives:

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 372	Interfacial Phenomena in Bionanotechnology
CHEM ENG 375	Biochemical Engineering
CHEM ENG 377	Bioseparations
CHEM ENG 379	Computational Biology: Principles and Applications
CHEM ENG 390	Personal and Organizational Effectiveness
CHEM ENG 395	Special Topics in Chemical Engineering (varies by topic)
CHEM ENG 399	Projects

Seniors may also take graduate (400-level Chemical Engineering) courses as a part of their major program. Advance consultation with the advisor and the course instructor is required. (Typically, approval will not be given to students with less than a "B" average in their major courses or in the prerequisites necessary for the graduate course.) Courses which have been taken by undergraduates in recent years include the following:

CHEM ENG 406	Selected Topics in Thermodynamics
CHEM ENG 408	Chemical Engineering Kinetics and Reactor Design
CHEM ENG 424	Transport Phenomena
CHEM ENG 451	Applied Molecular Modeling
CHEM ENG 462	Viscoelasticity and Flow in Polymer Systems
CHEM ENG 463	Polymerization Reaction Engineering
CHEM ENG 475	Cell-Material Interactions
CHEM ENG 479	Animal Cell and Tissue Culture
CHEM ENG 489	Special Topics

3. Opportunities for Research.

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.

4. 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. Torkelson) and the Associate Dean.

The McCormick Honors Program requires a two-quarter course sequence of independent study and three units of approved advanced study with a grade of "B" or better. The two-quarter course sequence in independent study is satisfied by CHEM ENG 399 Projects, which involves investigation of a chemical engineering research problem and submission of a final report. This work is supervised by a Chemical Engineering faculty member. Regarding the three units of approved advanced study, at least one of the courses should be something not typically taken by a large fraction of chemical engineering undergraduates. This may include ES APPM 311, a 400-level course in Chemical engineering, or a 300-level course in another department requiring substantial prerequisites which usually precludes it from being used in the sixteen-course major program. The other two courses include any classes which chemical engineering graduate students may count for credit in their degree program (300- or 400-level technical courses in other departments, and the 300-level Chemical Engineering courses listed in Technical Electives/Specialization (section III.H.3 of this booklet)). 200-level classes cannot be used to satisfy the course requirement. The courses selected must be approved by the Honors Program advisor (Professor Torkelson).

5. Certificate in Biotechnology and Biochemical Engineering.

This certificate program provides specific training for students wishing to enter the biotechnology and bioprocessing fields (pharmaceuticals, biomaterials, etc.). Unlike the “areas of specialization” within the major, this certificate will appear on NU transcripts, providing more tangible credentials for prospective employers or graduate schools. The certificate includes core courses in biological science and biochemical engineering, as well as electives to provide greater depth in fundamental biology and engineering applications. The certificate also requires at least one quarter of independent study to provide hands-on practical experience.

Ten units of science and technical electives define the certificate:

- Core courses (5 units)

Biol 210-1 Genetics and Evolutionary Biology
Biol 210-2 Biochemistry and Molecular Biology
Biol 210-3 Physiology and Cell Biology
ChE 375 Biochemical Engineering
ChE 377 Bioseparations

- Independent study (1 unit)

One unit of ChE 399 in a bio lab. Up to two additional units may be used; see below. Students should verify with Prof. Snurr that the project and laboratory are appropriately bio-related.

- Advanced electives (4 units), from each of the lists below:

A. One advanced ChE Biotechnology course (ChE 372, 379, 478, 479)
B. One advanced Biological Science course (Biol 301, 315, 319, 323, 333, 355, 390)
C. Other electives from lists A and B or BME 315, BME 317, Chem 210-3, ChE 475, Civ Eng 441, or up to two additional units of ChE 399 (as described above)

Note that students must earn a BS degree from McCormick to earn the certificate. A minimum 2.0 grade point average must be maintained in the 10 courses that define the certificate.

Students wishing to obtain the certificate are required to submit the declaration form available in the ChBE office or from Prof. Torkelson. *This must be done before the beginning of the final quarter of study at Northwestern.* Students are advised to consult with their advisor much earlier than this to plan out their course of study.

6. Regulations Governing the Major Program.

a. Only two courses selected from the four major program electives may be taken on a Pass/No Credit (P/N) basis. These courses may not be Chemical Engineering courses. (Note: Named courses in Chemistry such as CHEM 210-1, 210-2, and 342-2, which serve as a part of the sixteen courses in the major program, also may not be taken P/N.) The only circumstance in which a student may take a Chemical Engineering course on a P/N basis is if it is used as an unrestricted elective.

b. The grade point average of the 16 courses presented to satisfy the major in Chemical Engineering must be at least 2.00. Further, no more than two courses may carry a grade of "P" (see paragraph [a] above) and no more than two may carry a grade of "D".

IV. ADDITIONAL INFORMATION

A. Address and Telephone Numbers. Be sure that both your advisor and the Department Office have current local mailing address, e-mail address and telephone numbers. These are needed occasionally for important communications. Cooperative education students should also supply off-campus addresses.

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 feel that you 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.

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. 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 in the library, such as Merck's Index.

D. Accreditation. The curriculum of the Chemical Engineering Department is approved by the Accreditation Board of Engineering and Technology (ABET). 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 (AlChE). 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 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 AlChE 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 some 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. Students should consult the Work-Study Office for these opportunities. For Cooperative Education opportunities, as well as a limited number of summer internships with companies, students should consult the Cooperative Education office. Permanent employment opportunities as well as a limited number of summer positions with companies are regularly handled by the Placement Center in Scott Hall. Most on-campus interviews are held fall quarter, with a small number held winter quarter. Undergraduates planning to use the Placement Center should see that their resumes and associated material are submitted by early October 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 January of the senior year for full consideration for financial aid for graduate studies. Unlike undergraduate school, graduate programs in Chemical Engineering will often provide full financial aid (monthly stipend plus full tuition payment) to admitted students, regardless of financial background.

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

H. When leaving Northwestern. After graduation, please supply the Department Office with information as to future job or study plans, and a mailing address. The Department sends an annual newsletter to alumni and always welcomes visits from alumni and friends.

APPENDIX A

CHEMICAL ENGINEERING SAMPLE PROGRAM SEQUENCES

STANDARD 4-YEAR CHEMICAL ENGINEERING PROGRAM			
Year:	Fall	Winter	Spring
Freshman	Math 220[1] Chem 101 or 171 Gen Eng 205-1 Elective or Speech	Math 224[1] Chem 102 or 172 Gen Eng 205-2 Idea 106-1/Eng 106-1	Math 230[1] Chem 103 or elective Gen Eng 205-3 Idea 106-2/Eng 106-2
Sophomore	Math 234[1] 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 322 Chem 342-2 ChE 275[3] 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[4] Elective	ChE 341 ChE 352 Elective Elective	ChE 342 Elective Elective Elective
Notes	1. See p. 4 for old numbering of Math courses. 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 210 during the junior year. Biol 210-2 takes the place of ChE 275. 4. ChE 361 may be used as either an advanced science or technical elective (not both).		

Most required ChE courses are offered only once per year, as indicated in the above table. Senior design (351&352) and lab (342) courses are generally offered twice per year. Elective courses are typically scheduled as follows:

Fall: 361, 372
Winter: 312, 364, 375, 390
Spring: 345 (alternate years), 365, 371 (alternate years), 377 (alternate years)

Please be aware that the offering of classes will vary from year to year. Current and planned course offerings in the department may be obtained from the Registrar web site or from the ChBE web site.

STANDARD COOP (5-YEAR) CHEMICAL ENGINEERING PROGRAM			
Year:	Fall	Winter	Spring
Freshman	Math 220[1] Chem 101 or 171 Gen Eng 205-1 Elective/Speech	Math 224[1] Chem 102 or 172 Gen Eng 205-2 Idea 106-1/Eng 106-1	Math 230[1] Chem 103 or elective Gen Eng 205-3 Idea 106-2/Eng 106-2
Sophomore	Math 234[1] 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 322 Chem 342-2 ChE 275[3] Elective	COOP
Pre-Senior	MSE 301 Elective[4] Elective Elective	COOP	ChE 307 ChE 323 Elective[3] Elective
Senior (variant 2)	COOP	ChE 341 ChE 351 Elective Elective	ChE 342 ChE 352 Elective Elective
Notes	1. See p. 4 for old numbering of Math courses. 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 210 during the junior year. Biol 210-2 takes the place of ChE 275. 4. ChE 361 may be used as either an advanced science or technical elective (not both).		

Most required ChE courses are offered only once per year, as indicated in the above table. Senior design (351&352) and lab (342) courses are generally offered twice per year. Elective courses are typically scheduled as follows:

Fall: 361, 372
Winter: 312, 364, 375, 390
Spring: 345 (alternate years), 365, 371 (alternate years), 377 (alternate years)

Please be aware that the offering of classes will vary from year to year. Current and planned course offerings in the department may be obtained from the Registrar web site, or from the ChBE web site.

APPENDIX B

AREAS OF SPECIALIZATION AND COURSES

In the Major Program requirement of 16 courses, 12 are specified as required courses, while 4 science and technical elective courses may be used to form an area of specialization. The six standard areas of specialization are described below. A maximum of one unit of CHEM ENG 399 may be used within each of the areas of specialization. Each of these specializations is consistent with the 'universal' requirements listed on p. 5 in Section H.2.

CHEMICAL PROCESS ENGINEERING
(i) 200 or 300 level science elective
(ii) Suggested electives (3):

CHEM ENG 345	Process Optimization
CHEM ENG 361	Introduction to Polymers
CHEM ENG 364	Chemical Processing and the Environment
CHEM ENG 365	Sustainability, Technology, and Society
CHEM ENG 372	Interfacial Phenomena and Bionanotechnology
CHEM ENG 375	Biochemical Engineering
CHEM ENG 377	Bioseparations (Prerequisites CHEM ENG 275 or Biol_Sci 210-2; CHEM 323 (may be taken concurrently))
CHEM ENG 379	Computational Biology: Principles and Applications
CHEM ENG 408	Chemical Reaction Engineering and Kinetics
CHEM ENG 410	Applied Catalysis and Reaction Engineering
ECE 328	Numerical Methods for Engineers
ES APPM 311-1,2	Methods of Applied Mathematics
ES APPM 311-3	Meth. of Applied Mathematics: Complex Variables

At least one of the three electives must be a 300- or 400-level course (other than or in addition to CHEM ENG 399) offered by the Chemical Engineering Department.

BIOMEDICAL ENGINEERING
(i) CHEM ENG 371 (Transport Phenomena in Living Systems)
(ii) Use BIOL SCI 210-2 (Biochemistry and Molecular Biology) in place of CHEM ENG 275 in the major program.
(iii) Use BME 302 (Systems Physiology) or BME 303 (Systems Physiology) or BIOL SCI 210-3 (Physiology and Cell Biology) as the advanced science course.
(iv) Suggested electives (2):

BIOL SCI 210-1,3	Genetics and Evolutionary Biology; Physiology and Cell Biology
BME 302	Systems Physiology
BME 303	Systems Physiology
BME 317	Biochemical Sensors
BME 320	Biomedical Signals and Imaging
BME 325	Introduction to Medical Imaging
BME 343	Biomaterials and Medical Devices
BME 346	Tissue Engineering

BME 372	Hemodynamics
BME 379	Artificial Organs
CHEM 210-3	Organic Chemistry III
CHEM ENG 361	Introduction to Polymers
CHEM ENG 375	Biochemical Engineering
CHEM ENG 475	Cell-Material Interactions
CHEM ENG 479	Cell Culture and Ex Vivo Tissue Engineering
ECE 328	Numerical Methods for Engineers

BIOTECHNOLOGY

(i) CHEM ENG 375 (Biochemical Engineering)

(ii) Use BIOL SCI 210-2 (Biochemistry and Molecular Biology) in place of CHEM ENG 275 in the major program.

(iii) 200 or 300 level science elective (BIOL SCI courses recommended)

(iv) Suggested electives (2):

BIOL SCI 210-1,3	Genetics and Evolutionary Biology; Physiology and Cell Biology
BIOL SCI 301	Biochemistry
BIOL SCI 315	Cell Biology
BME 346	Tissue Engineering
CHEM ENG 371	Transport Phenomena in Living Systems
CHEM ENG 372	Interfacial Phenomena and Bionanotechnology
CHEM ENG 377	Bioseparations
CHEM ENG 379	Computational Biology: Principles and Applications

ENVIRONMENTAL ENGINEERING

(i) CHEM ENG 364 (Chemical Processing and the Environment) or CHEM ENG 365 (Sustainability, Technology, and Society)

(ii) 200 or 300 level science elective

(iii) Suggested electives (2):

Chem 393	Green Chemistry
CIV ENG 355	Engineering Aspects of Groundwater Flow
CIV ENG 356	Transport Processes in Porous Media
CIV ENG 359	Hazardous Waste Management
CIV ENG 360	Environmental Impact Evaluation
CIV ENG 361	Public Health Engineering
CIV ENG 363	Community Air Pollution
CIV ENG 364	Sanitary Engineering
CIV ENG 365	Radiation Health
CIV ENG 366	Ecosystems and Ecotoxicology
CIV ENG 367	Aquatic Chemistry
CIV ENG 368	Industrial Hygiene and Environmental Control

POLYMER SCIENCE AND ENGINEERING
(i) CHEM ENG 361 (Introduction to Polymers)
(ii) 200 or 300 level science elective: MAT SCI 331 strongly recommended
(iii) Suggested electives (2):

BME 343	Biomaterials and Medical Devices
BME 344	Biological Performance of Materials
CHEM 210-3	Organic Chemistry III
CHEM ENG 372	Interfacial Technology and Bionanotechnology
CHEM ENG 408	Kinetics and Reactor Design
CHEM ENG 462	Viscoelasticity and Flow in Polymer Systems
CHEM ENG 463	Polymerization Reaction Engineering
MAT SCI 331	Physical Properties of Polymers (strongly recommended)
MAT SCI 360	Introduction to Electron Microscopy
MAT SCI 361	Crystallography and Diffraction
MAT SCI 385	Image Analysis
MAT SCI 444	High Polymers in Solid State

GENERAL CHEMICAL ENGINEERING
(i) One 300- or 400-level CHEM ENG course excluding CHEM ENG 399.
(ii) One 200- or 300-level science elective chosen from any of the following: 200- or 300-level Biol_Sci, Chemistry, Physics or Materials Science course (excluding any 299 or 399 courses); CHEM ENG 361; BME 302; or BME 303.
(iii) One 300- or 400-level Engineering or 300-level Biol_Sci, Chemistry, or Physics course (excluding 399 except in CHEM ENG); or CHEM ENG 399; or Biol_Sci 210-3.
(iv) One 200-, 300, or 400-level engineering or 200- or 300-level Biol_Sci, Chemistry, or Physics course (excluding any 299 and 399 courses).

Only 1 ChE 399 is allowed as part of the 4 science and technical electives.

APPENDIX C

QUICK OVERVIEW OF CHEMICAL ENGINEERING COURSE REQUIREMENTS FOR CHEMICAL ENGINEERING MAJORS

Total Requirements - 48 classes

A. Mathematics - 4

MATH 220 (214-1)	Should be completed by the end of sophomore
MATH 224 (214-2)	year with grades of "C-" or better
MATH 230 (214-3)	
MATH 234 (215)	

B. Engineering Analysis - 4

GEN ENG 205-1,2,3,4	Should be completed by the end of sophomore year with grades of "C-" or better

C. Basic Sciences - 4

PHYSICS 135-2,3	Should be completed by the end of sophomore year
CHEM 171 and 172	Should be completed by end of freshman year with no "D's" or "C-'s" in
or 102 and 103	Chemistry

D. Design and Communication - 3

ENGLISH & GEN ENG 106-1,2
GEN SPEECH 102 or 103

E. Basic Engineering - 5

CHEM ENG 210
CHEM ENG 211
CHEM ENG 321
MAT SCI 301
Select one of CHEM ENG 312, BME 220, IEMS 201 or IEMS 303

F. Social Sciences & Humanities Theme - 7

G. Unrestricted Electives - 5

H. Major Program - 16

CHEM 210-l	Organic Chemistry
CHEM 210-2	Organic Chemistry
CHEM 342-2	Quantum Mechanics & Spectroscopy
CHEM ENG 212	Phase Equilibrium and Staged Separations
CHEM ENG 275	Cell & Molecular Biology for Engineers
CHEM ENG 307	Reactor Engineering
CHEM ENG 322	Heat Transfer
CHEM ENG 323	Mass Transfer
CHEM ENG 341	Process Dynamics & Control
CHEM ENG 342	Chemical Engineering Lab
CHEM ENG 351	Process Economics, Design & Evaluation
CHEM ENG 352	Chemical Engineering Design Projects

4 technical electives as described on p. 5