

SMITH SCHOOL OF CHEMICAL & BIOMOLECULAR ENGINEERING

Curriculum Information for the Class of 2025 and thereafter

The program in chemical & biomolecular engineering begins with a foundation in mathematics, chemistry, biology, and physics. These fundamentals are used to develop the analytical tools of chemical & biomolecular engineering - fluid mechanics, chemical thermodynamics, and chemical kinetics - in the sophomore and junior years. Chemical process units - such as chemical reactors, bioreactors, distillation columns, and heat exchangers - are analyzed with these tools, beginning in the junior year. In the senior year you design chemical processes by integrating process units with regard to economics, safety, and environmental impact. This program will prepare you for professional practice in traditional areas of chemical & biomolecular engineering - chemicals, polymers, petroleum, utilities, pharmaceuticals, and foods - as well as emerging areas of biotechnology, microchemical systems, and electronic materials.

The Chemical & Biomolecular Engineering curriculum requires more chemistry than other engineering programs. Prospective majors must plan their program carefully so that they will complete two years of chemistry before their junior year. If you are unsure whether you will major in chemical & biomolecular engineering, you are advised to take the required chemistry. Otherwise you may have to take chemistry during the summer to complete the curriculum in four years.

Biology Requirement

Every student must complete one of the seven following options in biology: (1) Biomolecular Engineering - CHEME 2880, (2) Bioprocess Engineering - CHEME 5430, (3) Advanced Placement - a score of 5 on the CEEB AP exam or a score of 7 on the IB Higher Level exam, (4) eight credits of a pre-med biology sequence; BioG 1500+1440+BioMG 1350, BioG 1107+1108+1500, (5) microbiology - BioMI 2900 (3 credits), (6) biochemistry - BioMG 3300 (4 credits) - academic year, or BioBM 3330 (4 credits) - summer, or (7) biochemistry - BioMG 3350 (4 credits), or BioMG 3310 (3 credits) and BioMG 3320 (2 credits). If your schedule permits, you may wish to fulfill the biology requirement in your freshman year.

Freshman Year

Chemistry Requirement

If you do not have advanced placement (AP) credit for chemistry, you must take the Chem 2090-2080 freshman chemistry sequence. If you have AP credit for Chem 2090 you have two options: AP credit and ChemE 2080 (spring) or Chem 2150 (fall) and AP credit. If your AP credit has given you a good chemistry background, you should consider the more aggressive sequence, Chem 2150 (fall) and AP credit.

If you have a strong chemistry background and your AP credit has created vacancies in your schedule, you can take organic chemistry as a freshman. Chemical & Biomolecular Engineering students typically take Chem 3570 or Chem 3530 with the Chem 2510 laboratory in the fall semester of their junior year. But some upper class students report that they were adequately prepared to complete Chem 3570 or Chem 3530 and Chem 2510 their first semester.

Sophomore Year

Applying for Affiliation

You may apply for affiliation with the School of Chemical & Biomolecular Engineering during the fall semester of your sophomore year by submitting an *Application for Major Affiliation* to the School's undergraduate office, 226 Olin Hall. The School will approve your application if you satisfy the criteria set by the College and the School. The College requires that you have completed pertinent portions of the common curriculum (for example, Math 2930, CS 1112, Phys 1112, and an EngrI course) by the end of your third semester and have a cumulative GPA of at least 2.0. The School requires no more than one grade below C- in chemistry, mathematics, physics, or engineering courses, a GPA of at least 2.2 in chemistry, mathematics, physics, and engineering courses, and a semester GPA of at least 2.0, and that you complete EngrD 2190.

Chemistry Requirement

You need to take physical chemistry during your sophomore year because two required courses in the junior year - ChemE 3130 and ChemE 3900 - require material from physical chemistry. The required physical chemistry courses are Chem 3890 and ChemE 2200 and the laboratory course Chem 2900.

Physics Requirement

Because Chemical & Biomolecular Engineers take Chem 2080 they are not required to take Phys 2214.

Chemical & Biomolecular Engineering Requirement

Enrollment in EngrD/ChemE 2190, Chemical Process Design & Analysis, is required to apply for affiliation with chemical & biomolecular engineering. It is offered only in the fall semester and can be counted as an engineering distribution. ChemE 3230, Fluid Mechanics, must be completed in the spring semester of the sophomore year.

Engineering Distribution Requirement

The Major requires Chem 3890; we recommend that you count Chem 3890 as an engineering distribution. EngrD/ChemE 2190 and an Introduction to Engineering course will satisfy your other two engineering distributions.

Mathematics Requirements

Sophomores must be enrolled in (or have already completed) Math 2930 to apply for affiliation with chemical & biomolecular engineering in the fall semester and must be enrolled in (or have already completed) Math 2940 to apply for affiliation with chemical & biomolecular engineering in the spring semester.

Students affiliated with Chemical & Biomolecular Engineering may substitute either CEE 3040 - Uncertainty Analysis in Engineering - or EngrD 2700 - Basic Engineering Probability and Statistics - for Math 2940.

Approved and Major-Approved Electives

An approved elective is any course that meets an educationally sound objective. An approved elective must be approved by your academic advisor. You may take an approved elective in any semester, but you will find it difficult to do so in your first three semesters unless you have AP credit or you attend summer school. Chem 2080 usually serves as one of the two approved electives.

Major-approved electives are intended to build on the foundation of fundamentals taken in one's first two years. Major-approved electives are usually advanced technical courses, at level 3000 and above although EngrD 2700, AEP 2640, CS 2800 and similar courses are appropriate. Major-approved electives can be approved only *after* you have affiliated with chemical & biomolecular engineering and have an advisor in chemical & biomolecular engineering. The Major-approved electives are technical or professionally oriented courses approved by your chemical & biomolecular engineering advisor.

If you want a biomolecular focus you should use the following courses as electives: BIOBM 3300 as a Major Approved Elective, and ChemE 4010, 4020, 4810, and 5430 as Advanced Chemical Engineering Electives and Major-Approved Electives.

Junior and Senior Years

You should consult the Typical Curriculum on the next page to plan your junior and senior years. The various electives may be taken any semester. Plan your schedule to optimize your choices for your Biology Elective, Advanced Chemical Engineering Electives, and Major-Approved Electives.

The Graduation Checklist on page 7 is a useful tally of your progress. You must write a unique course on every row; no course may be used to satisfy more than one requirement. You must complete at least 134 credits to earn a degree in chemical engineering.

TYPICAL CURRICULUM in CHEMICAL & BIOMOLECULAR ENGINEERING
for a student with no advanced placement credits (class of 2025 and thereafter)

<u>Semester 1</u>		<u>Semester 2</u>	
Math 1910	4	Math 1920	4
Chem 2090	4	Phys 1112	4
EngrI/ChemE 1120	3	Chem 2080 (Approved Elective)	4
Freshman Writing Seminar	<u>3</u>	CS 1112	4
	14	Freshman Writing Seminar	<u>3</u>
			19
<u>Semester 3</u>		<u>Semester 4</u>	
Math 2930	4	Math 2940/CEE 3040/EngrD 2700	4
Phys 2213	4	Chem 2900 (Major)	2
EngrD/ChemE 2190	4	ChemE 2200 (Major)	4
Chem 3890 (EngrD Distribution)	4	ChemE 3230 (Major)	4
Liberal Studies Distribution	<u>3</u>	Liberal Studies Distribution	<u>3</u>
	19		17
<u>Semester 5</u>		<u>Semester 6</u>	
ChemE 3130 (Major)	4	ChemE 3010 (Major)	1
ChemE 3240 (Major)	4	ChemE 3320 (Major)	4
Chem 3570/3530 (Major)	3	ChemE 3720 (Major)	2
Chem 2510 (Major)	2	ChemE 3900 (Major)	4
Biology Elective**	3	Major-Approved Elective***	3
Liberal Studies Distribution	<u>3</u>	Liberal Studies Distribution	<u>3</u>
	19		17
<u>Semester 7</u>		<u>Semester 8</u>	
ChemE 4320 (Major)	4	ChemE 4620/4630 (Major)	4
Advanced ChemE Elective*	3	Advanced ChemE Elective*	3
Major-Approved Elective***	3	Liberal Studies Distribution	3
Major-Approved Elective***	3	Approved Elective	<u>3</u>
Liberal Studies Distribution	<u>3</u>		13
	16		

* The Advanced Chemical Engineering Electives, which are usually taken in semesters 7 and 8, must be satisfied by ChemE 4020, 4130, 4610, 4700, 4840, 5230, 5430, 5440, 5610, 5640, 5700, 5720, 6240, 6310, 6400, 6440, 6610, 6640, 6650, 6660 or 6800. In addition, three of the one-credit modules associated with ChemE 6660 - ChemE 6661-6681 - may be combined to satisfy one Advanced Chemical Engineering Elective.

** Options for the biology requirement are discussed on page 1.

SUMMARY OF CREDITS

16	Mathematics
8	Physics
4	Freshman Chemistry
4	Computing
11	Engineering Distribution (EngrD 2190, Chem 3890*, and Introduction to Engineering)
6	Approved Electives (includes Chem 2080)
12	Major-Approved Electives (includes the Biology Requirement)
49	Major Program
<u>24</u>	Liberal Studies and Freshman Writing Seminars
134	MINIMUM TOTAL CREDITS

*If another course is used as an engineering distribution, Chem 3890 must be taken as an approved elective. Note that Chem 3890 is 4 credits. If Chem 3890 is used as an engineering distribution, the 4th credit can be used toward the Approved Electives requirements.

REQUIRED CHEMISTRY & CHEMICAL ENGINEERING COURSES

Chem 2090 and 2080	Engineering General Chemistry
Chem 2510	Introduction to Experimental Organic Chemistry
Chem 3570 or 3530	Organic Chemistry for the Life Sciences
Chem 2900	Introductory Physical Chemistry Laboratory
Chem 3890	Honors Physical Chemistry I
EngrD/ChemE 2190	Chemical Process Design & Analysis
ChemE 2200	Physical Chemistry II for Engineers
ChemE 3010	Nonresident Lectures
ChemE 3130	Chemical Engineering Thermodynamics
ChemE 3230	Fluid Mechanics
ChemE 3240	Heat and Mass Transfer
ChemE 3320	Analysis of Separation Processes
ChemE 3720	Introduction to Process Dynamics and Control
ChemE 3900	Reaction Kinetics and Reactor Design
ChemE 4320	Chemical Engineering Laboratory
ChemE 4620/4630	Chemical Process Design/Practice of Chemical Engineering Product Design

CHEMICAL & BIOMOLECULAR ENGINEERING ELECTIVES FOR UNDERGRADUATES

EngrI/ChemE 1120	Introduction to Chemical Engineering
ChemE 2880	Biomolecular Engineering
BME 3010/ChemE 4010	Cellular Principles of Biomedical Engineering
BME 3020/ChemE 4020	Molecular Principles of Biomedical Engineering
BME 6210/ChemE 6310	Engineering Principles for Drug Delivery
ChemE 4610	Concepts of Chemical Engineering Product Design
ChemE 4710	Lean Operations Design & Process Optimization
ChemE 4810/BME 4810	Biomedical Engineering
ChemE 4840	Microchemical and Microfluidic Systems
ChemE 4900	Undergraduate Projects in Chemical Engineering
ChemE 5204	Turbomachinery Applications,
ChemE 5205	Industrial Applications of Fluid Dynamics
ChemE 5207	Hydrocarbon Resources
ChemE 5208	Renewable Resources from Agriculture
ChemE 5240	Chemical Process Safety Management
ChemE 5430	Bioprocess Engineering
ChemE 5660	Financial Data, Markets, and Mayhem for Scientists and Engineers
ChemE 5700	Process Control Strategies
ChemE 6240/M&AE 5240	Physics of Micro-and Nano-scale Fluid Mechanics
ChemE 6310	Engineering Principles for Drug Delivery
ChemE 6400	Polymeric Materials
ChemE 6440	Aerosols and Colloids
ChemE 6640	Energy Economics
ChemE 6650	Energy Engineering
ChemE 6641 and 6642	one-credit modules associated with ChemE 6640 and 6650
ChemE 6660	Analysis of Sustainable Energy Systems
ChemE 6661-6680	one-credit modules associated with ChemE 6660.
ChemE 6800	Computational Optimization
ChemE 6880	Industrial Big Data Analytics and Machine Learning

Although a specialization within Chemical & Biomolecular Engineering is not required, some students specialize for career goals or personal interest. The following list of courses is intended to guide you in planning an area of specialization. Inclusion on this list does not guarantee that a course qualifies as an approved elective or as a Major-approved elective; consult your advisor. This list is not exhaustive.

Polymer Processing

ChemE 6400	Polymeric Materials
MSE 5210	Properties of Solid Polymers
MSE 5230 [#]	Physics of Soft Materials
MSE 5240 [#]	Synthesis of Polymeric Materials
FSAD 3350 [#]	Fiber Science

Energy

ChemE 5207	Hydrocarbon Resources
ChemE 5208	Renewable Resources from Agriculture
ChemE 6640	Energy Economics
ChemE 6650	Energy Engineering
ChemE 6660	Analysis of Sustainable Energy Systems

Quality Control

EngrD 2700	Basic Engineering Probability and Statistics
OR&IE 3120	Industrial Data and Systems Analysis

Economic Analysis

EngrD 2700	Basic Engineering Probability and Statistics
ORIE 3150	Financial and Managerial Accounting
ORIE 4150	Economic Analysis of Engineering Systems
ORIE 4152/MAE 4610	Entrepreneurship for Engineers
NCC 5060	Managerial Finance
NBA 5530	Accounting and Financial Decision Making

Computer-Aided Design

CS 2110/EngrD 2110	Object-Oriented Programming and Data Structures
CS 3420/ECE 3140	Embedded Systems
CS 4320	Introduction to Database Systems

Optimization

EngrD 2700	Basic Engineering Probability and Statistics
ORIE 3300	Optimization I
ORIE 3310	Optimization II
ORIE 3510	Introductory Engineering Stochastic Processes I

Biomedical Engineering

BME 3010/ChemE 4010	Cellular Principles of Biomedical Engineering
BME 3020/ChemE 4020	Molecular Principles of Biomedical Engineering
BME 6210/ChemE 6310	Engineering Principles for Drug Delivery
BioG 1500	Investigative Biology Laboratory
BioMG 1350	Introductory Biology: Cell and Developmental Biology
BioAP 3160	Cellular Physiology
BioAP 4580	Mammalian Physiology
BioBM 3300 or 3310	Principles of Biochemistry, Individual Instruction or Proteins and Metabolism
BioBM 4320	Survey of Cell Biology

[#]Course offered alternate years. Consult Course Roster for current listings.

Biotechnology

ChemE 5430	Bioprocess Engineering
BME 5010	Bioengineering Seminar
BEE 4640 [#]	Bioseparation Processes
BioBM 3300 or 3310	Principles of Biochemistry
BioBM 4320	Survey of Cell Biology
BioMI 2900	General Microbiology
BioMI 2910	General Microbiology Laboratory Lectures
BioMI 4160 [#]	Bacterial Physiology

Chemical Processes

ChemE 3700	Applied Process Control
ChemE 5430	Bioprocess Engineering

Food Science

FD SC 2000	Introduction to Physiochemical and Biological Aspects of Foods
FD SC 3940/BioMI 3940	Applied and Food Microbiology
FD SC 3960 [#]	Food Safety Assurance
FD SC 4170, 4180	Food Chemistry I and II (BIOBM 3300 recommended)
FD SC 4230	Food Processing A: Unit Operations and Food Packaging
FD SC 4250	Unit Operations and Dairy Foods Processing

Environmental Quality

BEE 4750	Environmental Systems Analysis
ChemE 5430	Bioprocess Engineering
ChemE 6610	Air Pollution Control
CEE 3510	Environmental Quality Engineering
CEE 6580	Biodegradation and Biocatalysis

Materials Science

ChemE 6400	Polymeric Materials
MSE 3010 [#]	Materials Chemistry
MSE 2610/MAE 3120	Mechanical Properties of Materials, Junior Laboratory II
MSE 5210	Properties of Solid Polymers
MSE 5310 [#]	Introduction to Ceramics

Electronic Materials

ECE 3150	Introduction to Microelectronics
MSE 3050	Electronic, Magnetic and Dielectric Properties of Materials
MSE 5410/ECE 4360	Nanofabrication

Applied Mathematics

MAE 3100 [#]	Introduction to Applied Mathematics
MATH 3110	Introduction to Analysis

[#]Course offered alternate years. Consult Course Roster for current listings.

Chemical & Biomolecular Engineering Graduation Checklist (Class of 2025 and thereafter)

Name: _____ e-mail address: _____

	course	credits	AP, DE, or TS	semester										
				1	2	3	4	5	6	7	8	9	10	
Common Curriculum	Math 1910	4												
	Math 1920	4												
	Math 2930	4												
	Math 2940/CEE 3040/EngrD 2700	4												
	Chem 2090	4												
	Physics 1112/1116	4												
	Physics 2213/2217	4												
	ComS 1110/1112/1114/1115	4												
	Freshman Writing Seminar 1	3												
	Freshman Writing Seminar 2	3												

Engr Distribution	Intro to	EngrI	3											
	Engr Distr 2	EngrD 2190	4											
	Engr Distr 3	Chem 3890	4											

Liberal Studies Distribution		3												
indicate the Group of each		3												
elective: CA, HA, LA, KCM,		3												
SBA, or Foreign Language		3												
		3												
		3												

Approved Electives	Chem 2080	4												
		2 or 3												

Major	ChemE 2200	4													
	ChemE 3010	1													
	ChemE 3130	4													
	ChemE 3230	4													
	ChemE 3240	4													
	ChemE 3320	4													
	ChemE 3720	2													
	ChemE 3900	4													
	ChemE 4320	4													
	ChemE 4620/4630	4													
	Advanced ChemE Elective	ChemE	3												
	Advanced ChemE Elective	ChemE	3												
	Courses outside the Major	Chem 2900	2												
		Chem 2510	2												
		Chem 3570/3530/3590	3												
	Biology Elective														
	Major-Approved Elective														
Major-Approved Elective															
Major-Approved Elective															

Extra														
Extra														

See Instructions and Notes on other side

revised 2/3/23

Instructions

- To fulfill the requirements for graduation (134 credits minimum), complete ***all*** blank spaces in the 'course' column. Circle, underline or write it in the course column the department and course number that matches the course completed on your transcript. Listing 'extra' courses is optional.
- You must list a unique course for every line on the checklist. No course may be used to satisfy more than one requirement.
- Mark an 'x' to indicate the semester each course was taken, or indicate AP (Advanced Placement), DE (Department Exam), or TS (Transfer Credit).

Notes

- The following combinations satisfy the requirement for a full year of freshman chemistry: Chem 2090+Chem 2080, Chem 2150+Chem 2160, AP Chem+Chem 2080, AP Chem + Chem 2150.
- Only three of Chem 3890's four credits are needed to satisfy the Engineering Distribution. You may apply the fourth credit toward satisfying the six-credit requirement for Approved Electives.
- See the *Courses of Study* catalog for descriptions of the six Liberal Studies Groups. You must take courses from at least three different Groups and at least two Liberal Studies courses must have a course number ≥ 2000 .

Having difficulty identifying courses that satisfy the liberal studies distribution requirement? Go to this link: <https://apps.engineering.cornell.edu/liberalstudies> and click on the tabs in the gray area at the top of the page for lists of liberal studies courses broken down by 1) the two colleges at which liberal studies courses are primarily taught [A&S and CALS], or 2) liberal studies category [HA, CA, LA, KCM, SBA, FL].

As the liberal studies distribution is reviewed and updated, newly approved courses are added, and can be found by clicking on the "other yes" tab. Courses that have been reviewed and denied liberal studies status can be found by clicking on the "other no" tab. If you have questions about liberal study policy, there's a tab for that too. Still confused? Call 255-7414, email (adv_engineering), or visit Engineering Advising (180 Rhodes Hall).

- ChemE 4320 satisfies the College's requirement for a writing-intensive technical course.
- The Advanced Chemical Engineering Electives can be satisfied by ChemE 4010, 4020, 4130, 4610, 4700, 4810, 4840, 5430, 5440, 5640, 5720, 6240, 6310, 6400, 6440, 6610, 6640, 6650, 6660, or 6800. In addition, three of the six one-credit modules associated with ChemE 6660 - ChemE 6661-6675 - may be combined to satisfy one Advanced Chemical Engineering Elective.
- An Approved Elective is any course that meets an educationally sound objective. An Approved Elective must be approved by your academic advisor.
- Major-Approved Electives are intended to build on the foundation of fundamentals taken in one's first two years. Major-Approved Electives are usually advanced technical courses, at level 300 and above although EngrD 2700, AEP 2640, ComS 2800, and similar courses are appropriate. The Major-Approved Electives are technical or professionally oriented courses approved by your chemical and biomolecular engineering advisor.
- The Biology Elective may be satisfied by any of the following seven options.
 - ChemE 2880, or
 - ChemE 5430, or
 - Advanced Placement - a score of 5 on the CEEB AP exam or a score of 7 on the IB Higher Level exam, or
 - eight credits of a pre-med biology sequence; such as BioG 1500+1440+BioMG 1350, BioG 1107+1108+1500, or, microbiology – BioMI 2900 (3 credits) or,
 - biochemistry – BioMG 3300 (4 credits) - academic year, or BioMG 3330 (4 credits) - summer session, or
 - biochemistry – BioMG 3350 (4 credits) or BioMG 3310 (3 credits) and BioMG 3320 (2 credits).