CHEMICAL & BIOLOGICAL ENGINEERING

Concentration Descriptions
Technical Electives List

Students must select one of the following concentrations for the Bachelor of Science in Chemical Engineering (B.S.Ch.E.) degree program: Chemical Process Engineering (CHPE), Bioengineering (BIOE), Environmental Engineering (ENEN), Materials Processing (MAPR), or Semiconductor Manufacturing (SCMF). Each concentration for the B.S.Ch.E. requires 6 credit hours total of technical electives.

CHEMICAL PROCESS ENGINEERING (CHPE)

The Chemical Process Engineering concentration is designed to provide maximum flexibility for students to pursue career opportunities in a wide range of industries as a process engineer. Historically, many chemical process engineers have found employment in the petroleum or chemical industries, and many still do. However, chemical engineers with a strong process engineering foundation are in increasing demand in many other technology areas, including pharmaceuticals, semiconductors and electronic materials, and environmental or "green" engineering. This concentration builds on the traditional process engineering emphasis, allowing the technical electives to be chosen by the student in consultation with his adviser to fit the interests or professional goals of the student.

Complete 6 credit hours from the following list or from any Technical Elective listed under any of the other concentrations.

Course	Title	Hours	Notes
MATH 311	Vector Analysis	3	
MATH 312	Partial Differential Equations for Engineering	3	
MATH 313	Complex Variables	3	
MATH 314	Linear Algebra with Applications	3	Offered most semesters, including summers
STAT 345	Elements of Mathematical Statistics and Probability Theory	3	Offered most semesters, including summers

Bioengineering (BIOE)

Since biological and medical systems involve complex chemical and physical processes, chemical engineering is a natural professional background for bioengineering applications. Bioengineering is an interdisciplinary field that combines the tools and methods of engineering to address challenges in the health sciences and in basic research. Bioengineers strive to understand biological systems, from molecules to whole organisms, from a quantitative and analytical perspective. Because of this in-depth study, bioengineers are uniquely qualified to work at the interface between living and non-living systems, enhancing our ability to measure, image, repair, or replace physiological substances or processes. Training in bioengineering prepares students for graduate school or industry, and is an excellent preparation for professional programs (medicine, dentistry, nursing, pharmacy). Career opportunities for bioengineers at the undergraduate level include the biosensor, pharmaceutical and medical device industries as well as positions in hospitals, federal labs, and environmental agencies.

Complete 6 credit hours from the following list of Technical Electives.

Course	Title	Hours	Notes
BIOC 423	Introductory Biochemistry	3	Counts for CHEM minor
BIOL 302C	Genetics	3	
BIOL 2305	Microbiology for Health Sciences	3	
BIOL 492/592	Introductory Mathematical Biology	3	
BME 575	Biomechanics	3	
BME 558	Methods of Analysis in Bioengineering	3	
BME 581	Colloidal Nanocrystals for Biomedical Applications	3	
CBE 412/512	Characterization Methods for Nanostructures	3	Fall
CBE 417/517	Applied Biology for Biomedical Engineers	3	
CBE 472/572	Biomaterials Engineering	3	Fall, odd years
CBE 479/579	Tissue Engineering	3	Spring, odd years
CBE 499	Sel T: Chemistry & Physics of Nanoscale	3	Cross-listed with CHEM 471
CBE 499	Sel T: Kinetics of Chemical Processes	3	
CBE 499	Sel T: Protein and Nucleic Acid Engineering	3	
CBE 499	Sel T: Surface & Interfacial Phenomena	3	
CBE 499	Sel T: Synthetic Cells & Organelles	3	
CBE 499	Sel T: Thermodynamics of Biological Systems	3	
CHEM 471	Adv T: Physics of Biomaterials	3	Counts for CHEM minor
CHEM 471	Adv T: Chemistry & Physics of Nanoscale	3	Counts for CHEM minor

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Environmental Engineering (ENEN)

The chemical engineer with a concentration in Environmental Engineering is prepared to enter a field of growing importance. This field deals with treatment of waste to reduce its volume, to recover recyclable resources and to prepare appropriately for long-term disposal. Interesting applications exist in atmospheric discharge control and clean-up, bio-treatable water decontamination, soil remediation, and nuclear byproduct handling. Increasingly, chemical engineers are required to develop new processes to minimize byproduct and waste generation, and achieve higher energy efficiencies.

Complete 6 credit hours from the following list of Technical Electives.

Course	Title	Hours	Notes
CE 335	Environmental and Water Resources Engineering	3	
CE 431/531	Physical-Chemical Water and Wastewater Treatment	3	
CE 433/533	Environmental Microbiology	3	
CE 436/536	Biological Wastewater Treatment	3	
CE 438/538	Sustainable Engineering	3	
EPS 333	Environmental Geology	3	
EPS 415/515	Geochemistry of Natural Waters	3	
EPS 462/562	Hydrogeology	3	
CBE 412/512	Characterization Methods for Nanostructures	3	Fall
CBE 477/577	Electrochemical Engineering	3	Fall, on demand
CBE 499	Sel T: Energy Materials Seminar	2	Must register for Dr. Garzon's CBE 491 to make up the last needed credit hour
CBE 499	Sel T: Energy Production & Processing	3	
CBE 499	Sel T: Kinetics of Chemical Processes	3	
CBE 499	Sel T: Surface & Interfacial Phenomena	3	

Materials Processing (MAPR)

The Materials Processing concentration is designed to add additional emphasis in inorganic materials, polymeric, or biological materials, depending on the students interest. Students who are interested in working in the realm of high technology materials, biomedical materials, or nanotechnology should choose this concentration. These rapidly developing fields are expected to provide many job opportunities in the next decade. New materials are currently being developed whose properties depend strongly on their microstructure, nanostructure and processing history. Materials included in this category are advanced ceramics, polymers, composites, photonics, superconductors, semiconductors, and recording media. This concentration provides flexibility for students interested in inorganic or organic materials technology.

Complete 6 credit hours from the following list of Technical Electives.

Course	Title	Hours	Notes
CBE 412/512	Characterization Methods for Nanostructures	3	Fall
CBE 477/577	Electrochemical Engineering	3	Fall, on demand
CBE 499	Sel T: Chemistry & Physics of Nanoscale	3	Cross-listed with CHEM 471
CBE 499	Sel T: Energy Materials Seminar	2	Must register for Dr. Garzon's CBE 491 to make up the last needed credit hour
CBE 499	Sel T: Energy Production & Processing	3	
CBE 499	Sel T: Kinetics of Chemical Processes	3	
CBE 499	Sel T: Surface & Interfacial Phenomena	3	
CBE 499	Sel T: Synthetic Cells & Organelles	3	
CHEM 431	Advanced Inorganic Chemistry	3	
CHEM 471	Adv T: Physics of Biomaterials	3	Counts for CHEM minor
CHEM 471	Adv T: Chemistry & Physics of Nanoscale	3	Counts for CHEM minor
CE 302	Mechanics of Materials	3	
EPS 301	Mineralogy/Earth & Planetary Materials	3	Fall
EPS 302L	Mineralogy Laboratory	2	Fall
ME 419/519	Theory, Fabrication, and Characterization of Nano and Microelectromechanical Systems (NEMS/MEMS)	4	

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Semiconductor Manufacturing (SCMF)			
There is an increasing demand for chemical engineers in high technology oriented semiconductor manufacturing companies like Intel, Motorola, IBM, etc. This concentration is designed to prepare the student in the fundamental unit operations used in semiconductor manufacturing (oxidation, diffusion, lithography, plasma etch, CVD, ion implant and metallization) and statistical methods used extensively in the industry to optimize the performance of these unit operations. The continuing revolution occurring in computer technology virtually insures there is a strong future demand for engineers with the background needed for semiconductor manufacturing. The goal of this concentration is to introduce students to the specific chemical engineering tools used in micro-chip fabrication.			
Complete 6 credit hours from the following list of Technical Electives.			
Course	Title	Hours	Notes
CBE 412	Characteristization Methods for Nanostructures	3	Fall
CHEM 311	Physical Chemistry	3	Fall
ECE 371	Materials and Devices	3	Override needed

Additional Notes and Policies:

1. If there is a course you wish to take as a Technical Elective that is not on the approved list for your concentration above, you may petition to get the course reviewed to count PRIOR to beginning the course. Please complete the online School of Engineering Course Substitution App here and provide a justification for why the course you are proposing fits in with your concentration. You academic advisor and the Director of Undergraduate Studies will review your request, and you will be notified of its decision via email.

2. Many CBE 499: Selected Topics courses are offered on demand rather than consistently every year, so keep that in mind when planning your future Technical Electives.

3. Students may work with a CBE faculty member to earn credit for undergraduate research through the course CBE 491: Undergraduate Research. In order to be used as a Technical Elective, CBE 491 must be taken for 3 credit hours and a CBE 491 Waiver Form must be submitted and approved by the CBE Director of Undergraduate Programs prior to taking CBE 491 for Technical Elective credit. Only 3 credit hours of CBE 491 may be applied toward the Technical Elective requirement. Credit for CBE 491 cannot be earned if a student is being paid for their research.

4. The Director of Undergraduate Studies may allow up to 6 credit hours of Technical Electives for students taking required ROTC courses in aerospace or naval science.

5. Undergraduate seniors in their final semester may take a 500-level graduate course to satisfy undergraduate requirements, including Technical Electives. This involves completing a Level Restriction Form through the Registrar's Office.

6. Students who are admitted to the Shared Credit Program are able to take graduate-level courses to satisfy all 6 hours of their Technical Elective requirements.

7. Please speak with your CBE academic advisor to learn more about the above policies or to answer any questions regarding your Technical Electives.