Department of Biomedical Engineering

The Department of Biomedical Engineering offers a Bachelor of Science degree in Biomedical Engineering and a Bachelor of Science degree in Chemical Engineering.

- B.S. degree in Biomedical Engineering (p. 1)
- B.S. degree in Chemical Engineering (p. 4)

Bachelor of Science Degree in Biomedical Engineering

A Bachelor of Science (B.S.) degree in Biomedical Engineering (BME) at UTSA is an interdisciplinary program that combines engineering principles, approaches, and methodologies with biological, chemical and physical sciences in order to define and solve problems in medicine. Students will be trained in the fundamentals of science and engineering and are expected to be able to apply this knowledge to investigate fundamental biomedical engineering questions associated with complex living systems as well as with the diagnosis and treatment of human diseases. A broad understanding of sciences and engineering principles is provided in the first two years of the program, with students having the option to choose one concentration as in-depth focus areas of study in the last two years of the program. Critical thinking and innovative design skills are integrated throughout the program to aid students in developing solutions and in solving biomedical engineering-related problems. Design projects throughout the program and Senior BME Design courses provide students the opportunity to integrate their design, critical thinking and communication skills with the scientific and engineering knowledge they acquired throughout the Biomedical Engineering program. The regulations for this degree comply with the general University regulations (refer to Bachelor’s Degree Regulations (http://catalog.utsa.edu/undergraduate/bachelorsdegereeregulations)).

Admission Requirements

A first-time, full-time freshman admitted as a biomedical engineering major must meet the minimum admission criteria of the College of Engineering. These criteria are:

- Students must meet all UTSA admission requirements;
- Students must have credit for MAT 1214 Calculus I or have completed all necessary prerequisites to enroll in MAT 1214 (through a mathematics placement test or credit for MAT 1093 Precalculus or an equivalent).
- Students must:
  1. have graduated in the top quartile of their high school graduation class, or
  2. have graduated in the second quartile of their high school class and have a combined SAT critical reading and mathematics score of at least 1170 with a minimum mathematics score of 550, or an ACT composite score of at least 24, or
  3. be granted admission into a College of Engineering major by holistic review by the College of Engineering if not meeting the criteria in 1 and 2 above.

All students applying for admission to the Biomedical Engineering program must submit the following supplemental documents to the Department of Biomedical Engineering:

- two (2) letters of recommendation,
- a copy of the transcript, and
- a statement of their interests, professional career goals and how the Biomedical Engineering program will help them achieve those goals.

All transfer students must meet the aforementioned minimum admission requirements for the College of Engineering and the Biomedical Engineering program. Transfer students must also meet the minimum Good Academic Standing Requirements for a Biomedical Engineering Major (see below) in order to be considered for admission to the Biomedical Engineering program. Additionally, transfer students should also have completed at least 15 semester credit hours of mathematics, science, or engineering courses, and have an overall grade point average of a 3.0 or better.

Admissions to the biomedical engineering program is competitive; meeting the aforementioned requirements does not guarantee admission to the program. Admission will be restricted only to the most qualified applicants.

Good Academic Standing Requirements for a Biomedical Engineering Major

All students must be in good academic standing in order to remain in the Biomedical Engineering program. The minimum requirements that a student must satisfy in order to remain in good standing as a biomedical engineering major are stated below:

- A cumulative grade point average (GPA) of at least 3.0 for all coursework (cumulative GPA will be calculated on all courses, including previously attempted or repeated courses).
- An average GPA of at least 3.0 for all science, mathematics and engineering coursework (GPA will be calculated on all courses, including previously attempted or repeated courses).

All students applying for admission must have a minimum cumulative GPA of 2.5 or above and have completed all necessary prerequisites to enroll in MAT 1214 (through a mathematics placement test or credit for MAT 1093 Precalculus or an equivalent). Students who fail to meet the above requirements but have a minimum cumulative GPA of 2.5 or above will be placed on programmatic probation in the following semester. Students who fail to maintain good academic standing after a semester of programmatic probation or who have a cumulative GPA below 2.5 will be deemed to be not in good academic standing as a biomedical engineering major and will be removed from the program.

Education Objectives

The objectives of this program are founded on the belief that engineering principles and understanding of biological and physical sciences are critical to the investigation of fundamental bioengineering questions associated with complex living systems as well as with the diagnosis and treatment of human diseases. As such, the program educational objectives of the UTSA Biomedical Engineering program are to prepare graduates who will be able to:

- contribute positively to the biomedical industries and/or other sectors such as hospitals, government agencies, and academia;
- enhance competence in biomedical engineering by pursuing an advanced or a professional degree; and
- work successfully as a member in a team environment to facilitate biomedical engineering practice.
The minimum number of semester credit hours required for this degree is 125, at least 39 of which must be at the upper-division level. All candidates for this degree must fulfill the Core Curriculum requirements, the General Engineering requirements, and the degree requirements, listed below.

**Core Curriculum Requirements (42 semester credit hours)**

Students seeking the B.S. degree in Biomedical Engineering must fulfill the University Core Curriculum requirements in the same manner as other students. The courses listed below satisfy both major requirements and Core Curriculum requirements; however, if these courses are taken to satisfy both requirements, then students may need to take additional courses in order to meet the minimum number of semester credit hours required for the degree.

MAT 1214 may be used to satisfy the core requirement in Mathematics, as well as one of the General Engineering Requirements. BIO 1404 and PHY 1943 may be used to satisfy the core requirement in Life and Physical Sciences, as well as one of the General Engineering Requirements.

**Core Curriculum Component Area Requirements**

(http://catalog.utsa.edu/undergraduate/bachelorsdegreeregulations/ degerequirements/corecurriculumcomponentareaarequirements)

<table>
<thead>
<tr>
<th>Component Area Requirement</th>
<th>Core Curriculum Component Area Requirements</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Year Experience Requirement</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Communication</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Mathematics</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Life and Physical Sciences</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Language, Philosophy and Culture</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Creative Arts</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>American History</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Government-Political Science</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Social and Behavioral Sciences</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Component Area Option</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td><strong>Total Credit Hours</strong></td>
<td><strong>42</strong></td>
<td></td>
</tr>
</tbody>
</table>

**General Engineering Requirements**

All degree-seeking candidates in engineering must complete the following 22 semester credit hours, as well as the Core Curriculum requirements and major requirements:

<table>
<thead>
<tr>
<th>Course</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHE 1113</td>
<td>3</td>
</tr>
<tr>
<td>EGR 2323</td>
<td>3</td>
</tr>
<tr>
<td>MAT 1214</td>
<td>4</td>
</tr>
<tr>
<td>MAT 1224 or EGR 1324</td>
<td>4</td>
</tr>
<tr>
<td>PHY 1943 &amp; PHY 1951</td>
<td>4</td>
</tr>
<tr>
<td>PHY 1963 &amp; PHY 1971</td>
<td>4</td>
</tr>
<tr>
<td><strong>Total Credit Hours</strong></td>
<td><strong>22</strong></td>
</tr>
</tbody>
</table>

**Biomedical Engineering Requirements**

A. **Core Biomedical Engineering Requirements**

All students majoring in Biomedical Engineering are required to complete 36 semester credit hours in the following Core Biomedical Engineering courses.

<table>
<thead>
<tr>
<th>Course</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BME 1002</td>
<td>2</td>
</tr>
<tr>
<td>BME 2103</td>
<td>3</td>
</tr>
<tr>
<td>BME 2203</td>
<td>3</td>
</tr>
<tr>
<td>BME 3003</td>
<td>3</td>
</tr>
<tr>
<td>BME 3013</td>
<td>3</td>
</tr>
<tr>
<td>BME 3023</td>
<td>3</td>
</tr>
<tr>
<td>BME 3114</td>
<td>4</td>
</tr>
<tr>
<td>BME 3211</td>
<td>1</td>
</tr>
<tr>
<td>BME 3303</td>
<td>3</td>
</tr>
<tr>
<td>BME 3311</td>
<td>1</td>
</tr>
<tr>
<td>BME 3703</td>
<td>3</td>
</tr>
<tr>
<td>BME 3711</td>
<td>1</td>
</tr>
<tr>
<td>BME 4903</td>
<td>3</td>
</tr>
<tr>
<td>BME 4913</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total Credit Hours</strong></td>
<td><strong>42</strong></td>
</tr>
</tbody>
</table>

B. **Other Required Courses**

All students majoring in Biomedical Engineering are required to complete 6 semester credit hours in the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHE 1113</td>
<td>3</td>
</tr>
<tr>
<td>STA 1403 or STA 2303</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total Credit Hours</strong></td>
<td><strong>6</strong></td>
</tr>
</tbody>
</table>

C. **Biomedical Engineering Electives**

A minimum of 15 semester credit hours is required to fulfill this requirement. 9 semester credit hours of Biomedical Engineering elective courses must be selected from one of the following three concentrations. The remaining semester credit hours must be selected from other biomedical engineering concentrations to satisfy the Biomedical Engineering electives. Up to 6 semester credit hours of graduate-level biomedical engineering courses may be used to satisfy the Biomedical Engineering electives, with the approval of the advisor, instructor, Graduate Program Director, and Department Chair.

**Biomechanics Concentration**

<table>
<thead>
<tr>
<th>Course</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BME 3033</td>
<td>Biomedical Engineering Internship</td>
</tr>
<tr>
<td>BME 3043</td>
<td>Biomedical Engineering Research</td>
</tr>
<tr>
<td>BME 3203</td>
<td>Biomechanics II: Cardiovascular</td>
</tr>
<tr>
<td>BME 4203</td>
<td>Biomechanics III</td>
</tr>
<tr>
<td>BME 4213</td>
<td>Tissue Mechanics</td>
</tr>
<tr>
<td>BME 4293</td>
<td>Topics in Biomechanics</td>
</tr>
<tr>
<td>BME 4703</td>
<td>Biomedical Engineering Thermodynamics</td>
</tr>
</tbody>
</table>

**Gateway Course**

Students pursuing the B.S. degree in Biomedical Engineering must successfully complete the following Gateway Course with a grade of “C-” or better in no more than two attempts. A student who is unable to successfully complete this courses within two attempts, including dropping the course with a grade of “W” or taking an equivalent course at another institution, will be required to change his or her major.

<table>
<thead>
<tr>
<th>Course</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>EGR 2323</td>
<td>Applied Engineering Analysis I</td>
</tr>
</tbody>
</table>
B.S. in Biomedical Engineering – Recommended Four-Year Academic Plan

<table>
<thead>
<tr>
<th>First Year</th>
<th>Fall</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AIS 1203</td>
<td>Academic Inquiry and Scholarship (core)</td>
<td>3</td>
</tr>
<tr>
<td>BIO 1404</td>
<td>Biosciences I (core)</td>
<td>4</td>
</tr>
<tr>
<td>CHE 1103</td>
<td>General Chemistry I</td>
<td>3</td>
</tr>
<tr>
<td>MAT 1214</td>
<td>Calculus I (core and major)</td>
<td>4</td>
</tr>
<tr>
<td>WRC 1013</td>
<td>Freshman Composition I (Q) (core)</td>
<td>3</td>
</tr>
<tr>
<td>Spring</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BME 1002</td>
<td>Introduction to Biomedical Engineering</td>
<td>2</td>
</tr>
<tr>
<td>CHE 1113</td>
<td>General Chemistry II</td>
<td>3</td>
</tr>
<tr>
<td>MAT 1224</td>
<td>Calculus II</td>
<td>4</td>
</tr>
<tr>
<td>PHY 1943</td>
<td>Physics for Scientists and Engineers I (core and major)</td>
<td>3</td>
</tr>
<tr>
<td>PHY 1951</td>
<td>Physics for Scientists and Engineers I Laboratory</td>
<td>1</td>
</tr>
<tr>
<td>WRC 1023</td>
<td>Freshman Composition II (Q) (core)</td>
<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Second Year</th>
<th>Fall</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BME 2103</td>
<td>Physiology for Biomedical Engineering</td>
<td>3</td>
</tr>
<tr>
<td>EGR 2323</td>
<td>Applied Engineering Analysis I</td>
<td>3</td>
</tr>
<tr>
<td>STA 1403 or 2303</td>
<td>Probability and Statistics for the Biosciences</td>
<td>3</td>
</tr>
<tr>
<td>PHY 1963</td>
<td>Physics for Scientists and Engineers II</td>
<td>3</td>
</tr>
<tr>
<td>PHY 1971</td>
<td>Physics for Scientists and Engineers II Laboratory</td>
<td>1</td>
</tr>
<tr>
<td>Technical elective</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Spring</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BME 2203</td>
<td>Biomechanics I</td>
<td>3</td>
</tr>
<tr>
<td>BME 3003</td>
<td>Biomaterials I</td>
<td>3</td>
</tr>
<tr>
<td>BME 3114</td>
<td>Cellular Biology for Biomedical Engineering</td>
<td>4</td>
</tr>
<tr>
<td>BME 3211</td>
<td>Biomedical Engineering Laboratory I</td>
<td>1</td>
</tr>
<tr>
<td>Technical elective</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Summer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BME 3013</td>
<td>Clinical Internship in Biomedical Engineering</td>
<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Third Year</th>
<th>Fall</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BME 3303</td>
<td>Bioinstrumentation</td>
<td>3</td>
</tr>
<tr>
<td>BME 3311</td>
<td>Biomedical Engineering Laboratory II</td>
<td>1</td>
</tr>
<tr>
<td>POL 1013</td>
<td>Introduction to American Politics (core)</td>
<td>3</td>
</tr>
<tr>
<td>Technical elective</td>
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<td>3</td>
</tr>
<tr>
<td>Upper-division BME elective</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Spring</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Total Credit Hours | 66 |

BME 4803  Fundamental Computational Bioengineering
BME 3033  Biomedical Engineering Internship
BME 3043  Biomedical Engineering Research
BME 3403  Biomaterials II
BME 3413  Biocompatibility of Materials: Tissue-Biomaterial Interaction
BME 4403  Molecular Techniques for Cell-Biomaterials Interactions
BME 4423  Tissue Engineering
BME 4483  Topics in Biomaterials
BME 4493  Topics in Tissue Engineering
BME 4713  Cellular Engineering
BME 4793  Topics in Cellular Engineering

Biomaterials, Cellular, and Tissue Engineering Concentration

BME 3033  Biomedical Engineering Internship
BME 3043  Biomedical Engineering Research
BME 3403  Biomaterials II
BME 3413  Biocompatibility of Materials: Tissue-Biomaterial Interaction
BME 4403  Molecular Techniques for Cell-Biomaterials Interactions
BME 4423  Tissue Engineering
BME 4483  Topics in Biomaterials
BME 4493  Topics in Tissue Engineering
BME 4713  Cellular Engineering
BME 4793  Topics in Cellular Engineering

Biomaterials, Cellular, and Tissue Engineering Concentration

BME 3033  Biomedical Engineering Internship
BME 3043  Biomedical Engineering Research
BME 3403  Biomaterials II
BME 3413  Biocompatibility of Materials: Tissue-Biomaterial Interaction
BME 4403  Molecular Techniques for Cell-Biomaterials Interactions
BME 4423  Tissue Engineering
BME 4483  Topics in Biomaterials
BME 4493  Topics in Tissue Engineering
BME 4713  Cellular Engineering
BME 4793  Topics in Cellular Engineering

Biomedical Imaging and Nanobiotechnology Concentration

BME 3033  Biomedical Engineering Internship
BME 3043  Biomedical Engineering Research
BME 3503  Nanomaterials and Nanobiotechnology
BME 4503  Biosensors
BME 4603  Biophotonics
BME 4613  Biomedical Imaging
BME 4623  Biomedical Optics

Biomedical Imaging and Nanobiotechnology Concentration

BME 3033  Biomedical Engineering Internship
BME 3043  Biomedical Engineering Research
BME 3503  Nanomaterials and Nanobiotechnology
BME 4503  Biosensors
BME 4603  Biophotonics
BME 4613  Biomedical Imaging
BME 4623  Biomedical Optics

D. Technical Electives
A minimum of 9 semester credit hours of Technical Electives must be completed by all students, with at least 6 semester credit hours chosen from one of the three engineering tracks and the remaining 3 semester credit hours chosen from any of the engineering tracks or from the list of science courses below.

Engineering Track 1

EE 2213  Electric Circuits and Electronics
EGR 3323  Applied Engineering Analysis II
EGR 4993  Honors Research

Engineering Track 2

EGR 2103  Statics
EGR 4993  Honors Research
ME 3293  Thermodynamics I
ME 3813  Mechanics of Solids

Engineering Track 3

EGR 2213  Statics and Dynamics
EGR 3323  Applied Engineering Analysis II
EGR 3713  Engineering Economic Analysis
EGR 4993  Honors Research

Science Courses

BIO 1414  Biosciences II
BIO 2313  Genetics
BIO 3913  Molecular Biology
CHE 2603  Organic Chemistry I
CHE 2612  Organic Chemistry I Laboratory
CHE 3643  Organic Chemistry II
CHE 4303  Biochemistry
MAT 2214  Calculus III

Total Credit Hours 66
The Chemical Engineering program will provide high-quality education and training in chemical engineering through rigorous course and state-of-the-art lab works. By selecting technical elective courses, students can also develop a degree of depth in one of the four specialized areas of study: (1) Petroleum and Energy Systems, the sector with burgeoning industry demand for well-trained individuals; (2) Materials Engineering, the enabling technical field for microelectronics, energy conversion, and process controls; (3) Bioengineering, the emerging area that biochemistry interfaces with bio-systems and healthcare; and (4) Environmental Engineering, the strategic growth area finding resources and environmental solutions for manufactures and for consumers.

The chemical engineering program will prepare the graduates with the knowledge and skill sets to capture career opportunities – together, we will make the industry more efficient and our world cleaner and healthier.

Focus Areas
- Bioengineering
- Environmental Engineering

Bachelor of Science Degree in Chemical Engineering

A Bachelor of Science (B.S.) degree in Chemical Engineering (CME) is the newest addition to the College of Engineering at The University of Texas at San Antonio. The program will welcome incoming freshman students in fall 2017 and will provide an exceptional learning environment and opportunities for discovery at UTSA.

Chemical engineering is unique, as it educates students to use chemistry, physics, biology and mathematics to solve engineering problems related to production, transformation, and utilization of chemicals, materials and energy.

The Chemical Engineering program will provide high-quality education and training in chemical engineering through rigorous course and state-of-the-art lab works. By selecting technical elective courses, students can also develop a degree of depth in one of the four specialized areas of study: (1) Petroleum and Energy Systems, the sector with burgeoning industry demand for well-trained individuals; (2) Materials Engineering, the enabling technical field for microelectronics, energy conversion, and process controls; (3) Bioengineering, the emerging area that biochemistry interfaces with bio-systems and healthcare; and (4) Environmental Engineering, the strategic growth area finding resources and environmental solutions for manufactures and for consumers.

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Admission Requirements

A first-time, full-time freshman admitted as a chemical engineering major must meet the minimum admission criteria of the College of Engineering. These criteria are:

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  1. have graduated in the top quartile of their high school graduation class, or
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- two (2) letters of recommendation,
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Admission to the chemical engineering program is competitive; meeting the aforementioned requirements does not guarantee admission to the program. Admission will be restricted only to the most qualified applicants.

Good Academic Standing Requirements for a Chemical Engineering Major

All students must be in good academic standing in order to remain in the Chemical Engineering program. The minimum requirements that a student must satisfy in order to remain in good standing as a chemical engineering major are stated below:

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- Petroleum/Energy Engineering

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• A cumulative grade point average (GPA) of at least 3.0 for all coursework (cumulative GPA will be calculated on all courses, including previously attempted or repeated courses).
• An average GPA of at least 3.0 for all science, mathematics and engineering coursework (GPA will be calculated on all courses, including previously attempted or repeated courses).

Students who fail to meet the above requirements but have a minimum cumulative GPA of 2.5 or above will be placed on programmatic probation in the following semester. Students who fail to maintain good academic standing after a semester of programmatic probation or who have a cumulative GPA below 2.5 will be deemed to be not in good academic standing as a chemical engineering major and will be removed from the program.

Ed ucation Objectives
The Chemical Engineering program is preparing graduates to achieve the following Educational Objectives:

• To have the depth that is necessary to apply chemical engineering principles to practice;
• To have the breadth to pursue a productive career in diverse fields of chemical engineering in a globally competitive economy, and
• To instill professional values such that they will be successful leaders in their profession.

The minimum number of semester credit hours required for this degree is 128, at least 39 of which must be at the upper-division level. All candidates for this degree must fulfill the Core Curriculum requirements, the General Engineering requirements, and the Chemical Engineering requirements, which are listed below.

Core Curriculum Component Area Requirements (42 semester credit hours)

Students seeking the B.S. degree in Chemical Engineering must fulfill the University Core Curriculum requirements in the same manner as other students. The courses listed below satisfy both major requirements and Core Curriculum requirements; however, if these courses are taken to satisfy both requirements, then students may need to take additional courses in order to meet the minimum number of semester credit hours required for the degree.

MAT 1214 may be used to satisfy the core requirement in Mathematics, as well as one of the General Engineering Requirements. PHY 1943 and PHY 1963 may be used to satisfy the core requirement in Life and Physical Sciences, as well as one of the General Engineering Requirements. ECO 2023 may be used to satisfy the core requirement in Social and Behavioral Sciences. EGR 1343 may be used to satisfy the Component Area Option requirement.

Core Curriculum Component Area Requirements (http://catalog.utsa.edu/undergraduate/bachelorsdegeregulations/ degreerequirements/corecurriculumcomponentarequirements)

<table>
<thead>
<tr>
<th>Course Area</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Year Experience Requirement</td>
<td>3</td>
</tr>
<tr>
<td>Communication</td>
<td>6</td>
</tr>
<tr>
<td>Mathematics</td>
<td>3</td>
</tr>
<tr>
<td>Life and Physical Sciences</td>
<td>6</td>
</tr>
<tr>
<td>Language, Philosophy and Culture</td>
<td>3</td>
</tr>
<tr>
<td>Creative Arts</td>
<td>3</td>
</tr>
<tr>
<td>American History</td>
<td>6</td>
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</tbody>
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<table>
<thead>
<tr>
<th>Course Area</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Government-Political Science</td>
<td>6</td>
</tr>
<tr>
<td>Social and Behavioral Sciences</td>
<td>3</td>
</tr>
<tr>
<td>Component Area Option</td>
<td>3</td>
</tr>
<tr>
<td>Total Credit Hours</td>
<td>42</td>
</tr>
</tbody>
</table>

General Engineering Requirements

All degree-seeking candidates in engineering must complete the following 22 semester credit hours, as well as the Core Curriculum requirements and major requirements:

<table>
<thead>
<tr>
<th>Course</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHE 1103</td>
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</tr>
<tr>
<td>EGR 2323</td>
<td>3</td>
</tr>
<tr>
<td>MAT 1214</td>
<td>4</td>
</tr>
<tr>
<td>MAT 1224</td>
<td>4</td>
</tr>
<tr>
<td>PHY 1943</td>
<td>4</td>
</tr>
<tr>
<td>PHY 1951</td>
<td>4</td>
</tr>
<tr>
<td>Total Credit Hours</td>
<td>22</td>
</tr>
</tbody>
</table>

Gateway Course

Students pursuing the B.S. degree in Chemical Engineering must successfully complete the following Gateway Course with a grade of “C-” or better in no more than two attempts. A student who is unable to successfully complete this course within two attempts, including dropping the course with a grade of “W” or taking an equivalent course at another institution, will be required to change his or her major.

<table>
<thead>
<tr>
<th>Course</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>EGR 2323</td>
<td>3</td>
</tr>
</tbody>
</table>

Degree Requirements

Students seeking the B.S. degree in Chemical Engineering must complete the following semester credit hours, as well as the Core Curriculum requirements and General Engineering requirements:

A. Required Chemical Engineering courses

<table>
<thead>
<tr>
<th>Course</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CME 1201</td>
<td>1</td>
</tr>
<tr>
<td>CME 2203</td>
<td>3</td>
</tr>
<tr>
<td>CME 3003</td>
<td>3</td>
</tr>
<tr>
<td>CME 3103</td>
<td>3</td>
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<tr>
<td>CME 3203</td>
<td>3</td>
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<tr>
<td>CME 3303</td>
<td>3</td>
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<tr>
<td>CME 3403</td>
<td>3</td>
</tr>
<tr>
<td>CME 3503</td>
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</tr>
<tr>
<td>CME 3601</td>
<td>1</td>
</tr>
<tr>
<td>CME 4001</td>
<td>1</td>
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<tr>
<td>CME 4103</td>
<td>3</td>
</tr>
<tr>
<td>CME 4163</td>
<td>3</td>
</tr>
<tr>
<td>CME 4201</td>
<td>1</td>
</tr>
<tr>
<td>CME 4264</td>
<td>4</td>
</tr>
</tbody>
</table>

B. Other required courses

<table>
<thead>
<tr>
<th>Course</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>EGR 2323</td>
<td>3</td>
</tr>
</tbody>
</table>
CHE 1103 General Chemistry I 4
& CHE 1121 and General Chemistry I Laboratory (CHE 1103 also satisfies a General Engineering Requirement)

CHE 1113 General Chemistry II 4
& CHE 1131 and General Chemistry II Laboratory

CHE 2603 Organic Chemistry I 5
& CHE 2612 and Organic Chemistry I Laboratory

CHE 3804 Physical Chemistry I and Laboratory 4

EGR 2103 Statics 3

EGR 3323 Applied Engineering Analysis II 3

STA 2303 Applied Probability and Statistics for Engineers 3

C. Prescribed electives
A minimum of 15 semester credit hours is required to fulfill this requirement. Elective courses must be selected from one of the following specializations.

Bioengineering
Required foundation courses:
BIO 1404 Biosciences I
BME 3114 Cellular Biology for Biomedical Engineering
Specialization electives. Select three courses from the following:
BIO 3513 Biochemistry
BIO 6513 Drug Development (with approval)
BME 3303 Bioinstrumentation
BME 3503 Nanomaterials and Nanobiotechnology
BME 4423 Tissue Engineering
BME 6223 Transport Processes in Biological Systems (with approval)
CHE 4953 Special Studies in Chemistry
CME 4413 Biochemical Engineering
CME 4511 Biochemical Engineering Laboratory

Environmental Engineering
Required foundation courses:
CE 2633 Environmental Engineering
CE 4633 Water and Wastewater Treatment
Specialization electives. Select three courses from the following:
CE 4603 Water Resources Engineering
CE 4613 Environmental Chemistry
CE 5213 Biological Phenomena in Environmental Engineering (with approval)
CE 5623 Advanced Treatment Processes for Water Quality Control (with approval)
CHE 3464 Descriptive Inorganic Chemistry
CME 4543 Selected Topics in Environmental Engineering

Materials Engineering
Required foundation courses:
CME 3433 Crystal Chemistry of Structure and Properties
EE 3213 Electromagnetic Engineering
Specialization electives. Select three courses from the following:
CHE 3643 Organic Chemistry II
CME 4533 Selected Topics in Materials Science and Engineering
EE 3323 Electronic Devices
or PHY 3313 Materials Physics

EE 4323 Dielectric and Optoelectronic Engineering Laboratory
EE 4523 Introduction to Micro and Nanotechnology
or PHY 4653 Introduction to Micro and Nanotechnology
ME 3244 Materials Engineering and Laboratory
ME 4603 Finite Element Analysis
or ME 4543 Mechatronics
ME 4683 Corrosion Engineering
PHY 4603 Crystallography and Materials Characterization

Petroleum/Energy Engineering
Required foundation courses:
EGR 2213 Statics and Dynamics
ME 3113 Measurements and Instrumentation
Specialization electives. Select three courses from the following:
CHE 3643 Organic Chemistry II
CME 4423 Rheology
CME 4523 Selected Topics in Petroleum and Energy Systems
ME 3323 Mechanical Vibration
ME 4593 Alternative Energy Sources
ME 4653 Oil and Gas Engineering and Reservoir Geomechanics
PHY 4703 Renewable Energy: Solar Energy Convertors

Common Electives
CME 4601 Independent Study
CME 4602 Independent Study
CME 4603 Independent Study

Total Credit Hours 76

B.S. in Chemical Engineering – Recommended Four-Year Academic Plan

First Year
Fall
AIS 1203 Academic Inquiry and Scholarship (core) 3
CHE 1103 General Chemistry I 3
CHE 1121 General Chemistry I Laboratory 1
EGR 1343 The Impact of Modern Technologies on Society (core) 3
MAT 1214 Calculus I (core) 4
WRC 1013 Freshman Composition I (Q) (core) 3

Spring
CHE 1113 General Chemistry II 3
CHE 1131 General Chemistry II Laboratory 1
CME 1201 Introduction to Chemical Engineering 1
ME 3244 Materials Engineering and Laboratory 1
MAT 1224 Calculus II 4
PHY 1943 Physics for Scientists and Engineers I (core) 3
PHY 1951 Physics for Scientists and Engineers I Laboratory 1
WRC 1023 Freshman Composition II (Q) (core) 3

Second Year
Fall
Biomedical Engineering (BME) Courses

BME 1002. Introduction to Biomedical Engineering. (2-0) 2 Credit Hours.
Prerequisites: A grade of "C-" or better in BIO 1404 and MAT 1214. This course is an introduction to the interdisciplinary field of biomedical engineering. Topics covered include core biomedical engineering areas such as Biomechanics, Biomaterials and Bioimaging. Generally offered: Spring.

BME 2103. Physiology for Biomedical Engineering. (3-1) 3 Credit Hours.
Prerequisites: Major in Biomedical Engineering and a grade of "C-" or better in BIO 1404 and MAT 1214. Fundamental principles of general and organs systems physiology, including composition and concentration of cellular and other body fluids, types of transport (e.g., diffusion, membrane transporters), energy (thermodynamics, metabolism), enzymes, feedback control, and membrane potentials with engineering applications and mathematical modeling. This course includes a 3 hour lecture and a 1 hour recitation. Generally offered: Fall.

BME 2203. Biomechanics I. (3-1) 3 Credit Hours.
Prerequisites: A grade of "C-" or better in EGR 2323 and PHY 1963. Corequisite: BME 3211. Introduction to the fundamental engineering mechanics with focus on the human body. This course includes a 3 hour lecture and a 1 hour recitation. Generally offered: Spring.

BME 3003. Biomaterials I. (3-1) 3 Credit Hours.
Prerequisite: A grade of "C-" or better, or concurrent enrollment, in BME 1002. Introduction to the fundamental science of natural and synthetic biomaterials used for repairing human tissues and organs. Topics include crystal structures, phase diagrams, and properties of materials. This course includes a 3-hour lecture and a 1-hour recitation. (Formerly BME 2403. Same as CME 3003. Credit cannot be earned for more than one of the following: BME 3003, BME 2403, or CME 3003).

BME 3013. Clinical Internship in Biomedical Engineering. (0-0) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in BME 3114. This course will introduce students to the clinical environment, interacting with clinicians on current clinical problems and engineering approaches. Generally offered: Summer.

BME 3023. Biomedical Engineering Technology and Product Development. (3-0) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in BME 3303. This course will introduce students to current biomedical technologies and product development. (Formerly BME 3022. Credit cannot be earned for both BME 3023 and BME 3022.).

BME 3033. Biomedical Engineering Internship. (0-0) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in BME 3023. Internship with a biomedical industry. May be repeated for credit but no more than 3 semester credit hours will apply to a bachelor’s degree.

BME 3041. Biomedical Engineering Research. (0-0) 1 Credit Hour.
Prerequisite: Consent of instructor. Advanced laboratory practice and introduction to biomedical engineering research. This course may be counted as one of the courses to satisfy one of the BME tracks. May be repeated for credit but no more than 3 semester credit hours will apply towards a bachelor’s degree in Biomedical Engineering.
BME 3042. Biomedical Engineering Research. (0-0) 2 Credit Hours.
Prerequisite: Consent of instructor. Advanced laboratory practice and introduction to biomedical engineering research. This course may be counted as one of the courses to satisfy one of the BME tracks. May be repeated for credit but no more than 3 semester credit hours will apply towards a bachelor’s degree in Biomedical Engineering.

BME 3043. Biomedical Engineering Research. (0-0) 3 Credit Hours.
Prerequisite: Consent of instructor. Advanced laboratory practice and introduction to biomedical engineering research. This course may be counted as one of the courses to satisfy one of the BME tracks. May be repeated for credit but no more than 3 semester credit hours will apply towards a bachelor’s degree in Biomedical Engineering.

BME 3114. Cellular Biology for Biomedical Engineering. (3-4) 4 Credit Hours.
Prerequisites: Major in Biomedical Engineering and a grade of "C-" or better in BME 2103. Introduction to cell structure and function, energy conversions, protein sorting, signaling, cytoskeleton, cell adhesion, cell cycle, and mammalian genetics. A laboratory component will focus on techniques and procedures commonly used in cell and molecular biology with bioengineering applications. This class includes a 3-hour lecture and a 4-hour laboratory. (Formerly BME 2114. Credit cannot be earned for both BME 3114 and BME 2114).

BME 3203. Biomechanics II: Cardiovascular. (3-0) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in BME 2203 and BME 3211. Continuation of fundamental biomechanics to include elasticity, viscoelasticity, deformation, stress analysis, blood flow in the systemic and pulmonary circulation, and fluid-structure interaction. Generally offered: Fall.

BME 3211. Biomedical Engineering Laboratory I. (0-4) 1 Credit Hour.
Prerequisite: A grade of "C-" or better in STA 1403. Corequisite: BME 2203. A biomedical engineering lab in biomechanics and biomaterials. This lab-based course will emphasize on the synthesis and characterization of mechanical properties as well as physical and chemical properties of biomaterials. (Formerly BME 2211. Credit cannot be earned for both BME 3211 and BME 2211).

BME 3303. Bioinstrumentation. (3-1) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in BME 2203. Corequisite: BME 3311. Fundamental principles of bioinstrumentation used in clinical and research measurements will be covered. Topics include: principles of transducer operation, amplifiers and signal processing, recording and display. This course includes a 3 hour lecture and a 1 hour recitation. Generally offered: Fall.

BME 3311. Biomedical Engineering Laboratory II. (0-4) 1 Credit Hour.
Corequisite: BME 3303. A biomedical engineering lab in bioinstrumentation. This course will involve the design and testing of hardware and software for acquiring and analyzing biological signals. Generally offered: Fall.

BME 3403. Biomaterials II. (1-5) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in BME 3003. This course will emphasize materials used in medical applications, including modifications and characterization techniques. This course includes a 1 hour lecture and a 5 hour laboratory.

BME 3413. Biocompatibility of Materials: Tissue-Biomaterial Interaction. (3-0) 3 Credit Hours.
Prerequisites: A grade of "C-" or better in BME 3003 and BME 3114. This course is an introduction to the interactions of cells and tissues with biomaterials. Blood composition and blood-material interactions, responses of the inflammatory and immune systems to biomaterials, the process of wound healing, protein structure and interactions with material surfaces, and the mechanisms of cell interactions with extracellular matrix components as well as cell/tissue responses to implant materials are reviewed in detail. Case studies of cardiovascular and orthopaedic implants are discussed to illustrate that judicious selection of materials is a key aspect of implant design and a crucial choice for the success of various biomedical applications (e.g., in tissue engineering and biotechnology) which require regeneration of tissues. Generally offered: Fall.

BME 3503. Nanomaterials and Nanobiotechnology. (3-0) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in BME 3003. This course will introduce an overview of nanomaterials and nanotechnology development. Topics may include biocompatible nanomaterials, microfabrication, microfluidics, lab-on-a-chip, and applications in biomedical engineering. (Formerly titled "Fundamentals of Nanobiotechnology.") Generally offered: Spring.

BME 3703. Biotransport Phenomena. (3-1) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in BME 3303. Corequisite: BME 3711. This course introduces the concepts of quantitative modeling of biological systems with respect to mass, momentum and energy transport. We will study the use of conservation laws to model cardiopulmonary, renal, and thermal systems of the human physiology, and also apply these principles to design artificial and extracorporeal devices, drug delivery systems for pharmacokinetic analysis. This course includes a 3 hour lecture and a 1 hour recitation. Generally offered: Spring.

BME 3711. Biomedical Engineering Laboratory III. (0-4) 1 Credit Hour.
Corequisite: BME 3703. A biomedical engineering lab in biotransport phenomena. Experiments related to mass, momentum, and energy conservation in biological systems such as measurements of apparent viscosity in microcirculation, oxygen diffusivity and thermal conductivity. Generally offered: Spring.

BME 4203. Biomechanics III. (3-0) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in BME 2203. Topics may include elasticity, viscoelasticity, deformation, stress analysis, strain measurement, and stress and strain in organs. Tissues covered may include heart, blood vessels, cartilage, and bone.

BME 4213. Tissue Mechanics. (3-0) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in BME 2203. Topics may include biomechanics characterization, modeling, and properties of regenerating tissues ranging from bone, cartilage, tendons, ligaments, skin, adipose tissue, nerves, bladder, eye, and pulmonary and cardiovascular tissues.

BME 4293. Topics in Biomechanics. (3-0) 3 Credit Hours.
Prerequisites: Senior status with a major in Biomedical Engineering and a grade of "C-" or better in BME 2203. Specific topics in biomechanics. May be repeated for credit when topics vary, but not more than 6 semester credit hours will apply to a bachelor’s degree.
BME 4403. Molecular Techniques for Cell-Biomaterials Interactions. (2-4) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in BME 3114. Advanced molecular techniques for characterizing cell-biomaterials interactions will be taught. Current understanding of topics in cell receptors and signaling mechanisms with application for biomaterial design will be emphasized. Topics will include receptor-ligand communication, methods of identification and quantification, and pathways involved for cell to material stress response. This course includes a 2 hour lecture and a 4 hour laboratory.

BME 4423. Tissue Engineering. (3-0) 3 Credit Hours.
Prerequisites: A grade of "C-" or better in BME 3003 and BME 3114. This course is an introduction to the current status of practice and advances in tissue engineering. Tissue engineering is the biomedical engineering discipline that applies science and technology to develop replacements for damaged and/or diseased tissues of the body. The course focuses on fundamental aspects of new tissue formation, specifically, cells, biomaterials, biochemical cues and biological stimuli, which are part of the physiological milieu. Applications of the latest advances in current knowledge of the aforementioned aspects in designing and formulating cell-containing constructs composed of natural and/or synthetic biomaterial scaffolds is necessary for successful outcomes in tissue engineering. Examples of applications in bone, cartilage, skin, and vascular tissues are reviewed in detail. Strategies which are used to address current challenges, pursue emerging opportunities and explore new scientific directions are discussed.

BME 4483. Topics in Biomaterials. (3-0) 3 Credit Hours.
Prerequisites: Senior status with a major in Biomedical Engineering and a grade of "C-" or better in BME 3003. Specific topics in biomaterials. May be repeated for credit when topics vary, but not more than 6 semester credit hours will apply to a bachelor's degree.

BME 4493. Topics in Tissue Engineering. (3-0) 3 Credit Hours.
Prerequisites: Senior status with a major in Biomedical Engineering and a grade of "C-" or better in BME 3003 and BME 3114. Specific topics in tissue engineering. May be repeated for credit when topics vary, but not more than 6 semester credit hours will apply to a bachelor's degree.

BME 4503. Biosensors. (3-0) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in BME 3303. Basics to biological detection and in-depth view of device design and performance analyses. Topics may include optical, electrochemical, acoustic, piezoelectric, and nanobiosensors.

BME 4603. Biophotonics. (3-0) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in EGR 2323. This course will introduce the fundamental principles of biophotonics and will focus on their applications to address critical issues in the frontier of biomedical science and technology. Topics may include fundamentals of light interactions with molecules, cells, and tissues, optical imaging, optical biosensing, flow cytometry, photodynamic therapy, laser tweezers and laser surgery, and nanobiotechnology. Generally offered: Fall.

BME 4613. Biomedical Imaging. (3-0) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in EGR 2323. This course will examine, from a systems perspective, the techniques used in a variety of medical imaging modalities, which include x-ray imaging, computed tomography, magnetic resonance imaging, nuclear medicine, ultrasound imaging, and photoacoustic imaging. The fundamental principles and engineering underlying each imaging modality will be discussed and a performance analysis of each system will be examined.

BME 4623. Biomedical Optics. (3-0) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in EGR 2323. This course will introduce the fundamental principles of modern and classical optics and their applications for biomedical research. State-of-the-art topics on cutting-edge research in the area of optics and lasers in medicine and biology will be covered.

BME 4703. Biomedical Engineering Thermodynamics. (3-1) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in BME 3703. This course is introduces the basics of engineering thermodynamics and applications in biomedical engineering. The course covers first and second laws, properties of pure substances and mixtures, phase rule, phase and chemical equilibria, and an introduction to statistical thermodynamics. This course includes a 3 hour lecture and a 1 hour recitation.

BME 4713. Cellular Engineering. (3-0) 3 Credit Hours.
Prerequisites: A grade of "C-" or better in BME 3114 and EGR 2323. This course focuses on using engineering skills and principles in the analysis and design of cellular functions. The emphasis will be on protein biochemistry, cell metabolism, signaling and adhesion.

BME 4793. Topics in Cellular Engineering. (3-0) 3 Credit Hours.
Prerequisites: Senior status with a major in Biomedical Engineering and a grade of "C-" or better in BME 3114 and EGR 2323. Specific topics in cellular engineering. May be repeated for credit when topics vary, but not more than 6 semester credit hours will apply to a bachelor's degree.

BME 4803. Fundamental Computational Bioengineering. (3-0) 3 Credit Hours.
Prerequisites: Major in Biomedical Engineering and a grade of "C-" or better in BME 3303. This course will include fundamental knowledge and skills of mathematical modeling, computer simulation and visualization, with applications in biomedical engineering.

BME 4903. Senior BME Design I. (3-0) 3 Credit Hours.
Prerequisites: Senior status with a major in Biomedical Engineering and a grade of "C-" or better in BME 3023 and BME 3703. Development of project proposals and presentation of conceptual designs. Industrial collaboration and/or faculty sponsorship of these projects is encouraged.

BME 4913. Senior BME Design II. (3-0) 3 Credit Hours.
Prerequisite: Senior status with a major in Biomedical Engineering and a grade of "C-" or better in BME 4903. Continuation of the development of an instructor-approved design project, testing of the design project, and presentation of the findings. Industrial cooperation or faculty sponsorship of projects is encouraged.

Chemical Engineering (CME) Courses

CME 1201. Introduction to Chemical Engineering. (1-0) 1 Credit Hour.
Prerequisites: A grade of "C-" or better in CHE 1103 and MAT 1214. A broad introduction to chemical engineering research and practice, intended to expose students to wide range of opportunities through research seminars and guest lectures. Topics covered include role and impact of materials in technology and societies. How materials are extracted from the earth, processed, and shaped into products, including discussion of disposal and re-use of materials, are explored.
CME 2203. Computational Methods in Chemical Engineering. (3-1) 3 Credit Hours.
Prerequisite: Completion of or concurrent enrollment in EGR 2323. Introduction to numerical techniques and computational tools essential for chemical engineering including the use of data acquisition and processing, engineering drawing, numerical modeling of linear and differential equations, and presentation tools. Students will learn to use Matlab, Mathematica, LabView, and SolidWorks as part of this course. One hour of problem solving recitation per week.

CME 3003. Introduction to Materials Science and Engineering. (3-0) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in CME 1201. Foundation for understanding the structure and properties of engineering materials such as ceramics, glass, polymers, composites, biomaterials, metals and alloys. An integrated introduction of materials' microstructure, thermodynamic process, and corresponding mechanical, electrical, optical, and magnetic properties. (Same as BME 3303. Credit cannot be earned for both CME 3103 and BME 3003).

CME 3103. Thermodynamics I. (3-1) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in CME 2203. Heat, work, equations of state, thermodynamics systems, control volume, first and second laws of thermodynamics, applications of the laws of thermodynamics, reversible and irreversible processes, and introduction to basic thermodynamic cycles. One hour of problem solving recitation per week. (Same as ME 3293. Credit cannot be earned for both CME 3103 and ME 3293).

CME 3203. Thermodynamics II. (3-0) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in CME 3103. Advanced treatment of chemical and phase equilibria in multicomponent systems including a detailed study of non-ideal solutions. Volumetric properties of fluids. Introduction to statistical thermodynamics.

CME 3303. Transport Phenomena. (3-0) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in CME 2203. Fundamental principles of momentum, energy and mass transport in various processes with exploration of laminar and turbulent flow, heat exchange, and mass diffusion.

CME 3403. Transport Processes. (3-1) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in CME 3303. Design and analysis of heat exchanger and furnaces, fluid metering, mixing, sedimentation, filtration, mass transfer operations; types of equipment used and practical chemical engineering applications. One hour of problem solving recitation per week.

CME 3433. Crystal Chemistry of Structure and Properties. (3-0) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in CME 3003. Principles of crystal chemistry applied to the relationships of crystallographic structures, compositions, and engineering properties of materials.

CME 3503. Kinetics and Reactor Design. (3-1) 3 Credit Hours.
Prerequisites: A grade of "C-" or better in CHE 3804 and CME 3303. Fundamental principles to the design and analysis of chemical reactors; steady and unsteady state operations; effects of pressure and temperature; heterogeneous catalysis; analysis of transport processes in catalysis; special topics including enzyme catalysis; membrane reactors; microscale reactors. One hour of problem solving recitation per week.

CME 3601. Chemical Engineering Laboratory I. (0-4) 1 Credit Hour.
Prerequisite: Completion of or concurrent enrollment in CME 3503. Basic principles and statistical design of experiments using software tools; Experiments demonstrating key unit operations with emphasis on fluid flow and heat transfer. Written and oral reports required.

CME 4001. Chemical Process Safety and Risk Management. (1-0) 1 Credit Hour.
Prerequisite: A grade of "C-" or better in CME 2203. Application of chemical process safety, risk assessment and management, including hazardous waste disposal and remediation.

CME 4103. Process Dynamics and Control. (3-1) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in CME 3403. Modeling of dynamic processes; Response of uncontrolled systems; Transfer functions; Response and stability of controlled systems; frequency response; Design of feedback controllers; Cascade, feed forward and multivariable control systems; Process Instrumentation; Use of simulators to design feedback controllers. One hour of problem solving recitation per week.

CME 4163. Chemical Engineering Design Fundamentals. (3-2) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in CME 2203. Application of design and economic principles to chemical engineering systems; Analysis of costs of equipment, feedstocks, utilities, and risk assessment; Optimization of equipment design using simulation tools.

CME 4201. Chemical Engineering Laboratory II. (0-4) 1 Credit Hour.
Prerequisite: Completion of or concurrent enrollment in CME 4103. Experiments demonstrating key unit operations with emphasis on mass transfer with and without reactions; process control. Special cases in biochemical and environmental engineering; Written and oral reports required.

CME 4264. Product and Process Design. (2-6) 4 Credit Hours.
Prerequisite: A grade of "C-" or better in CME 4163. Strategic application of technical and economic constraints in the design of a chemical processing plant including most aspects of typical industrial design; Integration of social and sustainability issues including hazardous waste disposal and remediation. Students work in small groups and submit a plant design project report.

CME 4413. Biochemical Engineering. (3-0) 3 Credit Hours.
Prerequisites: A grade of "C-" or better in BIO 1404 and BME 2103. Kinetics of single substrate enzyme kinetics; recombinant DNA technology in microbial and mammalian culture systems; fermentation reactor design and control; protein purification; Introduction to bioinformatics.

CME 4423. Rheology. (3-0) 3 Credit Hours.
Prerequisites: A grade of "C-" or better in EGR 3323 and CME 3403. Advanced topics covering non-Newtonian fluids, multiphase transport and flow through porous media with focus on applications to chemical processing industries.

CME 4511. Biochemical Engineering Laboratory. (0-4) 1 Credit Hour.
Prerequisite: Completion of or concurrent enrollment in CME 4413. Microbial cell culture; cloning, expression and purification of a recombinant protein; operation of fermenter, monitoring, and purification of protein; emphasis on scale-up.
CME 4513. Selected Topics in Bioengineering. (3-0) 3 Credit Hours.
Prerequisites vary with the topic (refer to the course syllabus on Bluebook or contact the instructor). An organized course offering the opportunity for specialized study not normally or not often available as part of the regular course offerings. May be repeated for credit when topics vary, but not more than 6 semester credit hours, regardless of concentration, will apply to a bachelor’s degree.

CME 4523. Selected Topics in Petroleum and Energy Systems. (3-0) 3 Credit Hours.
Prerequisites vary with the topic (refer to the course syllabus on Bluebook or contact the instructor). An organized course offering the opportunity for specialized study not normally or not often available as part of the regular course offerings. May be repeated for credit when topics vary, but not more than 6 semester credit hours, regardless of concentration, will apply to a bachelor’s degree.

CME 4533. Selected Topics in Materials Science and Engineering. (3-0) 3 Credit Hours.
Prerequisites vary with the topic (refer to the course syllabus on Bluebook or contact the instructor). An organized course offering the opportunity for specialized study not normally or not often available as part of the regular course offerings. May be repeated for credit when topics vary, but not more than 6 semester credit hours, regardless of concentration, will apply to a bachelor’s degree.

CME 4543. Selected Topics in Environmental Engineering. (3-0) 3 Credit Hours.
Prerequisites vary with the topic (refer to the course syllabus on Bluebook or contact the instructor). An organized course offering the opportunity for specialized study not normally or not often available as part of the regular course offerings. May be repeated for credit when topics vary, but not more than 6 semester credit hours, regardless of concentration, will apply to a bachelor’s degree.

CME 4553. Selected Topics in Business and Technology Management. (3-0) 3 Credit Hours.
Prerequisites vary with the topic (refer to the course syllabus on Bluebook or contact the instructor). An organized course offering the opportunity for specialized study not normally or not often available as part of the regular course offerings. May be repeated for credit when topics vary, but not more than 6 semester credit hours, regardless of concentration, will apply to a bachelor’s degree.

CME 4601. Independent Study. (0-0) 1 Credit Hour.
Prerequisites: Permission in writing (Independent Study Form available online) from the instructor, the student’s advisor, and the Department. Independent reading, research, discussion, and/or writing under the direction of a faculty member. May be repeated for credit, but not more than 6 semester credit hours of independent study, regardless of the concentration, will apply to a bachelor’s degree.

CME 4602. Independent Study. (0-0) 2 Credit Hours.
Prerequisites: Permission in writing (Independent Study Form available online) from the instructor, the student’s advisor, and the Department. Independent reading, research, discussion, and/or writing under the direction of a faculty member. May be repeated for credit, but not more than 6 semester credit hours of independent study, regardless of the concentration, will apply to a bachelor’s degree.

CME 4603. Independent Study. (0-0) 3 Credit Hours.
Prerequisites: Permission in writing (Independent Study Form available online) from the instructor, the student’s advisor, and the Department. Independent reading, research, discussion, and/or writing under the direction of a faculty member. May be repeated for credit, but not more than 6 semester credit hours of independent study, regardless of the concentration, will apply to a bachelor’s degree.