DEPARTMENT OF BIOMEDICAL ENGINEERING AND CHEMICAL ENGINEERING

The Department of Biomedical Engineering and Chemical Engineering offers a Bachelor of Science degree in Biomedical Engineering (BME) and a Bachelor of Science degree in Chemical Engineering (CME). The BME degree is currently accredited by the Accreditation Board for Engineering and Technology (ABET, http://www.abet.org).

Individuals enrolled in the BME degree program are given opportunities to develop a strong background in the engineering, technology and physical and biological sciences to learn the analysis, design, and synthesis tools necessary to function successfully as active participants in new and emerging areas of biosciences, medical devices and healthcare technologies. The Biomedical Engineering and Chemical Engineering department continues to be recognized locally and nationally for the quality of its undergraduate program. BME graduates continue to find positions in industry and are accepted into graduate schools and professional training programs (medicine and dentistry) nationwide.

The BME degree 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 are trained in the fundamentals of science and engineering and expected 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. Students develop a degree of depth by selecting courses in three areas of concentration: 1) Biomechanics; 2) Biomaterials and Tissue Engineering; and 3) Biomedical Imaging and Nanotechnology. 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 Chemical Engineering (CME) program provides high-quality education and training in chemical engineering through rigorous coursework and hands on experience in state-of-the-art laboratories. 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 control; 3) Bioengineering, the emerging area that biology and chemistry interface with bio-systems and healthcare; and 4) Environmental Engineering, the strategic growth area finding resources and environmental solutions for manufacturers and consumers.

- 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 an in-depth focus area 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/bachelorsdegreeregulations/)).

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).

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/bachelorsdegerequlations/degreerequirements/corecurriculumcomponentarearequirements/)

| First Year Experience Requirement | 3 |
| Communication | 6 |
| Mathematics | 3 |
| Life and Physical Sciences | 6 |
| Language, Philosophy and Culture | 3 |
| Creative Arts | 3 |
| American History | 6 |
| Government-Political Science | 6 |
| Social and Behavioral Sciences | 3 |
| Component Area Option | 3 |
| **Total Credit Hours** | 42 |

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:

| CHE 1103 General Chemistry I | 3 |
| EGR 2323 Applied Engineering Analysis I | 3 |
| MAT 1214 Calculus I | 4 |
| MAT 1224 Calculus II | 4 |
| or EGR 1324 Calculus II for Engineers | 4 |
| PHY 1943 Physics for Scientists and Engineers I and Physics for Scientists and Engineers I Laboratory | 4 |
| & PHY 1951 or PHY 1963 & PHY 1971 Physics for Scientists and Engineers II and Physics for Scientists and Engineers II Laboratory | 4 |
| **Total Credit Hours** | 22 |

Gateway Courses

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

| EGR 2323 Applied Engineering Analysis I |  |
| MAT 1214 Calculus I |  |

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.

| BME 1002 Introduction to Biomedical Engineering | 2 |
| BME 2103 Physiology for Biomedical Engineering | 3 |
| BME 2203 Biomechanics I | 3 |
| BME 3003 Biomaterials I | 3 |
| BME 3013 Clinical Internship in Biomedical Engineering | 3 |
| BME 3023 Biomedical Engineering Technology and Product Development | 3 |
| BME 3114 Cellular Biology for Biomedical Engineering | 4 |
| BME 3211 Biomedical Engineering Laboratory I | 1 |
| BME 3303 Bioinstrumentation | 3 |
| BME 3311 Biomedical Engineering Laboratory II | 1 |
| BME 3703 Biotransport Phenomena | 3 |
| BME 3711 Biomedical Engineering Laboratory III | 1 |
| BME 4903 Senior BME Design I | 3 |
| BME 4913 Senior BME Design II | 3 |

B. Other Required Courses

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

| CHE 1113 General Chemistry II | 3 |
| STA 1403 or STA 2303 Applied Probability and Statistics for Engineers | 3 |

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

| BME 3033 Biomedical Engineering Internship |  |
| BME 3043 Biomedical Engineering Research |  |
| BME 3203 Biomechanics II: Cardiovascular |  |
| BME 4203 Biomechanics III |  |
| BME 4213 Tissue Mechanics |  |
| BME 4293 Topics in Biomechanics |  |
| BME 4703 Biomedical Engineering Thermodynamics |  |
BME 4803  Fundamental Computational Bioengineering

**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 3503  Nanomaterials and Nanobiotechnology
- BME 4213  Tissue Mechanics
- BME 4403  Molecular Techniques for Cell-Biomaterials Interactions
- BME 4423  Tissue Engineering
- BME 4483  Topics in Tissue 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

**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 I

MAT 2214  Calculus III

**Total Credit Hours** 66

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

**First Year**

**Fall**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<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 (core)</td>
<td>3</td>
</tr>
</tbody>
</table>

**Spring**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<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 (core)</td>
<td>3</td>
</tr>
</tbody>
</table>

**Second Year**

**Fall**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<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 STA 2303</td>
<td>Probability and Statistics for the Biosciences or Applied Probability and Statistics for Engineers</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>
</tbody>
</table>

**Spring**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<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>
</tbody>
</table>

**Summer**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BME 3013</td>
<td>Clinical Internship in Biomedical Engineering</td>
<td>3</td>
</tr>
</tbody>
</table>

**Credit Hours** 14
The Chemical Engineering program provides high-quality education and training in chemical engineering through structured coursework and hands-on experience in state-of-the-art laboratory facilities. By selecting technical elective courses, students can also develop a degree of depth in one of the four specialized areas of study: 1) Petroleum/Energy Engineering, the sector with burgeoning industry demand for well-trained individuals; 2) Materials Engineering, the enabling technical field for microelectronics, energy conversion, and process control; 3) Bioengineering, the emerging area where biology and chemistry interface with bio-systems and healthcare; and 4) Environmental Engineering, the strategic growth area finding resources and environmental solutions for manufacturers and consumers.

The chemical engineering program prepares graduates with the knowledge and skill sets to capture career opportunities — together, our goal is to make the industry more efficient and our world cleaner and healthier.

Specialization Areas

- Petroleum/Energy Engineering
- Materials Engineering
- Bioengineering
- Environmental Engineering

The regulations for this degree comply with the general regulations of the University (refer to Bachelor’s Degree Regulations (http://catalog.utsa.edu/undergraduate/bachelorsdegree regulations/)).

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:

- A cumulative grade point average (GPA) of at least 3.0 for all coursework (cumulative GPA will be calculated for 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 for 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 at the beginning of 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 not be in good academic standing as a chemical engineering major and will be removed from the program.

Education 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 students will become successful leaders in their profession of choice.

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 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/bachelorsdegerequregulations/degreerequirements/corecurriculumcomponentarearequirements/)

- First Year Experience Requirement 3
- Communication 6
- Mathematics 3
- Life and Physical Sciences 6
- Language, Philosophy and Culture 3
- Creative Arts 3
- American History 6
- Government-Political Science 6
- Social and Behavioral Sciences 3
- Component Area Option 3

Total Credit Hours 42

**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:

- CHE 1103 General Chemistry I 3
- EGR 2323 Applied Engineering Analysis I 3
- MAT 1214 Calculus I 4
- MAT 1224 Calculus II 4
- or EGR 1324 Calculus II for Engineers 4
- PHY 1943 Physics for Scientists and Engineers I 4
- & PHY 1951 and Physics for Scientists and Engineers I Laboratory 4
- PHY 1963 Physics for Scientists and Engineers II 4
- & PHY 1971 and Physics for Scientists and Engineers II Laboratory 4

Total Credit Hours 22

**Gateway Courses**

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

- EGR 2323 Applied Engineering Analysis I
- MAT 1214 Calculus I

**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 (38 semester credit hours)**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CME 121</td>
<td>Introduction to Chemical Engineering</td>
<td>1</td>
</tr>
<tr>
<td>CME 2101</td>
<td>Chemical Process Principles</td>
<td>3</td>
</tr>
<tr>
<td>CME 2203</td>
<td>Computational Methods in Chemical Engineering</td>
<td>3</td>
</tr>
<tr>
<td>CME 2301</td>
<td>Chemical Process Safety and Risk Management</td>
<td>1</td>
</tr>
<tr>
<td>CME 3003</td>
<td>Introduction to Materials Science and Engineering</td>
<td>3</td>
</tr>
<tr>
<td>CME 3103</td>
<td>Thermodynamics</td>
<td>3</td>
</tr>
<tr>
<td>CME 3303</td>
<td>Transport Phenomena I</td>
<td>3</td>
</tr>
<tr>
<td>CME 3403</td>
<td>Separation Processes</td>
<td>3</td>
</tr>
<tr>
<td>CME 3503</td>
<td>Kinetics and Reactor Design</td>
<td>3</td>
</tr>
<tr>
<td>CME 3601</td>
<td>Chemical Engineering Laboratory I</td>
<td>1</td>
</tr>
<tr>
<td>CME 3703</td>
<td>Transport Phenomena II</td>
<td>3</td>
</tr>
<tr>
<td>CME 4103</td>
<td>Process Dynamics and Control</td>
<td>3</td>
</tr>
<tr>
<td>CME 4163</td>
<td>Chemical Engineering Design Fundamentals</td>
<td>3</td>
</tr>
<tr>
<td>CME 4201</td>
<td>Chemical Engineering Laboratory II</td>
<td>1</td>
</tr>
<tr>
<td>CME 4264</td>
<td>Plant Design</td>
<td>4</td>
</tr>
</tbody>
</table>

**B. Other required courses (29 semester credit hours)**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHE 1103 &amp; CHE 1121</td>
<td>General Chemistry I and General Chemistry I Laboratory (CHE 1103 also satisfies a General Engineering Requirement)</td>
<td>4</td>
</tr>
<tr>
<td>CHE 1113 &amp; CHE 1131</td>
<td>General Chemistry II and General Chemistry II Laboratory</td>
<td>4</td>
</tr>
<tr>
<td>CHE 2603 &amp; CHE 2612</td>
<td>Organic Chemistry I and Organic Chemistry I Laboratory</td>
<td>5</td>
</tr>
<tr>
<td>CHE 3643</td>
<td>Organic Chemistry II</td>
<td>3</td>
</tr>
<tr>
<td>CHE 3804</td>
<td>Physical Chemistry I and Laboratory</td>
<td>4</td>
</tr>
<tr>
<td>EGR 3323</td>
<td>Applied Engineering Analysis II</td>
<td>3</td>
</tr>
<tr>
<td>EGR 3713</td>
<td>Engineering Economic Analysis</td>
<td>3</td>
</tr>
<tr>
<td>STA 2303</td>
<td>Applied Probability and Statistics for Engineers</td>
<td>3</td>
</tr>
</tbody>
</table>

**C. Prescribed electives (9 semester credit hours)**

A minimum of 9 semester credit hours must be selected from one of the following specializations (based on availability):

**Bioengineering**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CME 2113</td>
<td>Physiology for Chemical Engineering</td>
<td></td>
</tr>
<tr>
<td>BIO 3513</td>
<td>Biochemistry</td>
<td></td>
</tr>
<tr>
<td>CME 2803</td>
<td>Biomechanics I</td>
<td></td>
</tr>
<tr>
<td>CME 3113</td>
<td>Cellular Biology for Chemical Engineering</td>
<td></td>
</tr>
<tr>
<td>CME 3413</td>
<td>Biocompatibility of Materials: Tissue-Biomaterial Interaction</td>
<td></td>
</tr>
<tr>
<td>CME 3503</td>
<td>Kinetics and Reactor Design</td>
<td></td>
</tr>
<tr>
<td>CME 3803</td>
<td>Biomechanics II</td>
<td></td>
</tr>
<tr>
<td>CME 3903</td>
<td>Bioinstrumentation</td>
<td></td>
</tr>
</tbody>
</table>
CME 4513 Selected Topics in Bioengineering

Environmental Engineering
Select three courses from the following:
CE 2633 Environmental Engineering
CE 4633 Water and Wastewater Treatment
CE 4603 Water Resources Engineering
CHE 3464 Descriptive Inorganic Chemistry
CME 4543 Selected Topics in Environmental Engineering
ES 6103 Environmental Assessment

Materials Engineering
Select three courses from the following:
CME 2803 Biomechanics I
CME 3433 Crystal Chemistry of Structure and Properties
CME 3903 Bioinstrumentation
CME 4533 Selected Topics in Materials Science and Engineering
EE 2423 Network Theory
EE 3213 Electromagnetic Engineering
EE 3323 Electronic Devices
or PHY 3313 Materials Physics
EE 4323 Dielectric and Optoelectronic Engineering Laboratory
EE 4523 Introduction to Nanoelectronics
EGR 2103 Statics
ME 3243 Materials Engineering
ME 3813 Mechanics of Solids
PHY 2103 Modern Physics

Petroleum/Energy Engineering
Select three courses from the following:
CME 4423 Rheology
CME 4433 Process Optimization
CME 4523 Selected Topics in Petroleum/Energy Engineering
CME 4433 Process Optimization
EGR 2213 Statics and Dynamics
PHY 2103 Modern Physics

Common Electives
No more than 6 semester credit hours may be applied to any of the above specializations. No more than 3 semester credit hours of Independent Study courses or Research courses may count toward a specialization.
CME 4601 Independent Study
CME 4602 Independent Study
CME 4603 Independent Study
CME 4701 Chemical Engineering Research
CME 4702 Chemical Engineering Research
CME 4703 Chemical Engineering Research
CME 4803 Chemical Engineering Internship

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 and major) 4
WRC 1013 Freshman Composition I (core) 3
Credit Hours 17

Spring
CHE 1113 General Chemistry II 3
CHE 1131 General Chemistry II Laboratory 1
CME 1201 Introduction to Chemical Engineering 1
MAT 1224 Calculus II 4
PHY 1943 Physics for Scientists and Engineers I (core and major) 3
PHY 1951 Physics for Scientists and Engineers I Laboratory 1
WRC 1023 Freshman Composition II (core) 3
Credit Hours 16

Second Year
Fall
CHE 2603 Organic Chemistry I 3
CHE 2612 Organic Chemistry I Laboratory 2
CME 2103 Chemical Process Principles 3
EGR 2323 Applied Engineering Analysis I 3
PHY 1963 Physics for Scientists and Engineers II (core and major) 3
PHY 1971 Physics for Scientists and Engineers II Laboratory 1
Credit Hours 15

Spring
CHE 3643 Organic Chemistry II 3
CME 2301 Chemical Process Safety and Risk Management 1
CME 2203 Computational Methods in Chemical Engineering 3
ECO 2023 Introductory Microeconomics (core) 3
EGR 3323 Applied Engineering Analysis II 3
STA 2303 Applied Probability and Statistics for Engineers 3
Credit Hours 16

Third Year
Fall
CHE 3804 Physical Chemistry I and Laboratory 4
CME 3003 Introduction to Materials Science and Engineering 3
CME 3103 Thermodynamics 3
CME 3303 Transport Phenomena I 3
Biomedical Engineering (BME) Courses

BME 1002. Introduction to Biomedical Engineering. (2-0) 2 Credit Hours.
Prerequisites: A grade of "C" or better, or concurrent enrollment 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. Course Fees: LRE1 $20; STSE $20.

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. (Same as CME 2113.) Generally offered: Fall. Course Fees: LRE1 $20; STSE $30.

BME 2203. Biomechanics I. (3-1) 3 Credit Hours.
Prerequisites: A grade of "C" or better in PHY 1963. Corequisites: BME 3211 and EGR 2323. Introduction to the fundamental engineering mechanics with focus on the human body. This course includes a 3 hour lecture and a 1 hour recitation. (Same as CME 2803. Credit cannot be earned for both BME 2203 and CME 2803.) Generally offered: Spring.
Course Fees: LRE1 $20; STSE $30.

BME 3003. Biomaterials I. (3-1) 3 Credit Hours.
Prerequisites: A grade of "C" or better, or concurrent enrollment in BME 1002 and CHE 1113. 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. Credit cannot be earned for more than one of the following: BME 3003, BME 2403, or CME 3003.) Differential Tuition: $165.

BME 3013. Clinical Internship in Biomedical Engineering. (0-0) 3 Credit Hours.
Prerequisites: A grade of "C" or better in BME 3003 and BME 3114. This course will introduce students to the clinical environment, interacting with clinicians on current clinical problems and engineering approaches. Generally offered: Summer. Differential Tuition: $165.

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.) Differential Tuition: $165.

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. Differential Tuition: $165.

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. Differential Tuition: $55.

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. Differential Tuition: $110.

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. Differential Tuition: $165.

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. Same as CME 3113. Credit can be earned for only one of the following courses: BME 3114, CME 3113, BME 2114, or BIO 3813/BIO 3822.) Differential Tuition: $220.
BME 3203. Biomechanics II: Cardiovascular. (3-0) 3 Credit Hours. 
Prerequisites: 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. (Same as 
CME 3303. Credit cannot be earned for both BME 3203 and CME 3803.) 
Generally offered: Fall. Differential Tuition: $165.

BME 3211. Biomedical Engineering Laboratory I. (0-4) 1 Credit Hour. 
Prerequisite: A grade of "C-" or better in BME 1002. Corequisites: BME 
2203, BME 3003, and either STA 1403 or STA 2303. A biomedical 
engineering lab in biomechanics and biomaterials. This lab-based 
course will emphasize 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.) Differential Tuition: $55.

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. 
(Same as CME 3903. Credit cannot be earned for both BME 3303 and 
CME 3903.) Generally offered: Fall. Differential Tuition: $165.

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. Differential Tuition: $55.

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. Differential Tuition: $165.

(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 orthopedic 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. 
(Formerly as CME 3413. Credit cannot be earned for both BME 3413 and 
CME 3413.) Generally offered: Fall. Differential Tuition: $165.

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") (Same as CME 3513. Credit cannot be earned for both BME 3503 and CME 3513.) Generally offered: Spring. Differential Tuition: $165.

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. Differential Tuition: $165.

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. Differential Tuition: $55.

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. Differential Tuition: $165.

BME 4213. Tissue Mechanics. (3-0) 3 Credit Hours. 
Prerequisite: A grade of "C-" or better in BME 2203. Topics may include 
bioengineering characterization, modeling, and properties of regenerating 
tissues ranging from bone, cartilage, tendons, ligaments, skin, adipose 
tissue, nerves, bladder, eye, and pulmonary and cardiovascular tissues. Differential Tuition: $165.

BME 4283. Impact 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 or consent from the instructor. This course will cover the response of the human organism to impact loading. Topics will include dynamics, kinetics, injury mechanisms of the head, spine, thorax, abdomen, and extremities, human tolerance to impact, anthropomorphic test devices, mathematical models, and human subject testing. Impact scenarios covered will include automotive, aerospace, combat, and sports. Maybe repeated for credit when topics vary, but not more than 6 semester credit hours will apply to a bachelor's degree. Differential Tuition: $165.

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. Differential Tuition: $165.

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. Differential Tuition: $165.
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 biophysical 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. Differential Tuition: $165.

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. Differential Tuition: $165.

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. Differential Tuition: $165.

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. Differential Tuition: $165.

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. Differential Tuition: $165.

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. Differential Tuition: $165.

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. Differential Tuition: $165.

BME 4633. MATLAB for Biomedical Engineering. (3-0) 3 Credit Hours.
Prerequisites: Senior status with a major in Biomedical Engineering and a grade of “C-” or better in BME 2203, or consent from the instructor. This course is an introduction to programming in MATLAB. It covers basic programming concepts as well as MATLAB specific features that a biomedical engineer would need either in industry or research. This includes concepts of correctness, clarity, and efficiency. Maybe repeated for credit when topics vary, but not more than 6 semester credit hours will apply to a bachelor’s degree. Differential Tuition: $165.

BME 4703. Biomedical Engineering Thermodynamics. (3-1) 3 Credit Hours.
Prerequisite: A grade of “C-” or better in BME 3703. 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 biophysical 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. Differential Tuition: $165.

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. Differential Tuition: $165.

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. Differential Tuition: $165.

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. Differential Tuition: $165.

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. Differential Tuition: $165.

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. Differential Tuition: $165.

BME 4923. Orthopaedic Device Design. (3-0) 3 Credit Hours.
Prerequisites: Senior status with a major in Biomedical Engineering and a grade of “C-” or better in BME 2203, or consent from the instructor. This course will educate students about current biomedical technologies and product development. Topics covered will include ideation, concept development, design methodologies, business plan basics, regulatory concepts for medical devices and intellectual property management. Maybe repeated for credit when topics vary, but not more than 6 semester credit hours will apply to a bachelor’s degree. Differential Tuition: $165.
Chemical Engineering (CME) Courses

CME 1201. Introduction to Chemical Engineering. (1-0) 1 Credit Hour.
A broad survey of the practice of chemical engineering, intended to expose students to specialized areas of chemical engineering and potential career paths (e.g., bioengineering, environmental engineering, materials engineering, and petroleum/energy engineering) through discussions and guest lectures. Students will review ethics and safety, and practice technical communication through oral presentations and written assignments. Course Fees: LRE1 $20; STSE $10.

CME 2103. Chemical Process Principles. (3-0) 3 Credit Hours.
Prerequisites: A grade of "C-" or better in CHE 1113, CME 1201, and MAT 1214. Students will learn basic principles of chemical engineering, including material and energy balances. Course Fees: LRE1 $20; STSE $30.

CME 2113. Physiology for Chemical Engineering. (3-1) 3 Credit Hours.
Prerequisites: A grade of "C-" of better in BIO 1404 and MAT 1214. Fundamental principles of general and organs 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 per week. (Same as BME 2103. Credit cannot be earned for both CME 2113 and BME 2103.) Course Fees: LRE1 $20; STSE $30.

CME 2203. Computational Methods in Chemical Engineering. (3-1) 3 Credit Hours.
Prerequisite: Completion of or concurrent enrollment in EGR 3323. Introduction to numerical techniques and computational tools essential for chemical engineering, including the use of data acquisition and processing, numerical analysis of linear, non-linear, and differential equations. Students will learn to use computer software to aid in their analysis (e.g., Matlab). This course includes a 3 hour lecture and a 1 hour recitation per week. Course Fees: LRE1 $20; STSE $30.

CME 2301. Chemical Process Safety and Risk Management. (1-0) 1 Credit Hour.
Application of chemical process safety, risk assessment and management, including hazardous waste disposal and remediation. (Same as CME 4001. Credit cannot be earned for both CME 2301 and CME 4001.) Course Fees: LRE1 $20; STSE $10.

CME 2803. Biomechanics I. (3-1) 3 Credit Hours.
Prerequisites: A grade of "C" of better in EGR 2323 and PHY 1963. Introduction to fundamental engineering mechanics with focus on the human body. (Same as BME 2203. Credit cannot be earned for both CME 2803 and BME 2203.) Course Fees: LRE1 $20; STSE $30.

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 properties, and corresponding mechanical, electrical, optical, and magnetic properties. (Credit cannot be earned for both CME 3003 and BME 3003.) Differential Tuition: $165.

CME 3103. Thermodynamics. (3-1) 3 Credit Hours.
Prerequisites: A grade of "C-" or better in CME 2103 and completion of or concurrent enrollment in CHE 3804. Heat, work, equations of state, thermodynamic systems, control volume, first and second laws of thermodynamics, applications of the laws of thermodynamics, reversible and irreversible processes, introduction to basic thermodynamic cycles, vapor-liquid equilibria, and non-ideal solutions. One hour of problem solving recitation per week. (Credit cannot be earned for both CME 3103 and ME 3293.) Differential Tuition: $165.

CME 3113. Cellular Biology for Chemical Engineering. (3-0) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in CME 2103. Introduction to cell structure and function, energy conversions, protein sorting, signaling, cytoskeleton, cell adhesion, cell cycle, and mammalian genetics. This class consists of a 3-hour lecture. (Same as BME 3114. Credit cannot be earned for both CME 3113 and CME 3114.) Differential Tuition: $165.

CME 3303. Transport Phenomena I. (3-0) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in CME 2103. This course covers the fundamental of momentum transport, fluid mechanics and fluid unit operations. Topics discussed include fluid statics, fluid properties and fluid flow, overall mass, energy and momentum balances, incompressible and compressible flow in pipes, flow in packed and fluidized beds, pumps, compressors, agitators and nozzles, differential equations of fluid flow, non-Newtonian fluids, potential and creeping flow and boundary layer and turbulent flow. Differential Tuition: $165.

CME 3403. Separation Processes. (3-0) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in CME 3303. This course covers unit operations associated with mass transfer. Topics covered include absorption and stripping, mummification processes, filtration and membrane separations, distillation, liquid-liquid extraction, adsorption and ion exchange, settling, evaporation and drying. Differential Tuition: $165.

CME 3413. Biocompatibility of Materials: Tissue-Biomaterial Interaction. (3-0) 3 Credit Hours.
Prerequisites: A grade of "C-" or better in CME 3003 and CME 3113. 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 orthopedic 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. (Same as BME 3413. Credit cannot be earned for both CME 3413 and BME 3413.) Differential Tuition: $165.

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. Differential Tuition: $165.
CME 3503. Kinetics and Reactor Design. (3-0) 3 Credit Hours.
Prerequisites: A grade of "C-" or better in CME 3804 and CME 3303. Fundamental principles to the design and analysis of batch, continuously stirred tank, and fixed bed chemical reactors; steady and unsteady state operations; effects of pressure and temperature; heterogeneous catalysis; analysis of transport processes in catalysis; special topics may include enzyme catalysis; fluid bed reactors; membrane reactors; and microscale reactors. Differential Tuition: $165.

CME 3513. Nanomaterials and Nanobiotechnology. (3-0) 3 Credit Hours.
Prerequisites: A grade of "C-" or better in CME 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. (Same as BME 3503. Credit cannot be earned for both CME 3513 and BME 3503.) Differential Tuition: $165.

CME 3601. Chemical Engineering Laboratory I. (0-4) 1 Credit Hour.
Prerequisites: 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 reports and oral presentations required. Differential Tuition: $55.

CME 3703. Transport Phenomena II. (3-0) 3 Credit Hours.
Prerequisites: CME 3303 or instructor approval. This course focuses on the fundamentals and applications associated with heat and mass transfer. Topics discussed steady state conduction, principles of unsteady state heat transfer, convection, heat transfer coefficients, heat exchangers, radiation, steady state mass transfer, diffusions, convection, mass transfer coefficients, and unsteady state mass transfer. Differential Tuition: $165.

CME 3803. Biomechanics II. (3-0) 3 Credit Hours.
Prerequisites: A grade of "C-" or better in CME 2803. Continuation of fundamental biomechanics to include elasticity, viscoelasticity, deformation, stress analysis, blood flow in the systemic and pulmonary circulation, and fluid-structure interaction. (Same as BME 3203. Credit cannot be earned for both CME 3803 and BME 3203.) Differential Tuition: $165.

CME 3903. Bioinstrumentation. (3-1) 3 Credit Hours.
Prerequisites: A grade of "C-" or better in CME 2803. 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 per week. (Same as BME 3303. Credit cannot be earned for both CME 3903 and BME 3303.) Differential Tuition: $165.

CME 4101. Process Dynamics and Control. (3-1) 3 Credit Hours.
Prerequisites: A grade of "C-" or better in CME 3403. Modeling of dynamic processes; response of uncontrolled systems; controller 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. Differential Tuition: $165.

CME 4163. Chemical Engineering Design Fundamentals. (3-2) 3 Credit Hours.
Prerequisites: A grade of "C-" or better in CME 3103 and CME 3403. 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. Students will be assembled in teams to perform materials and energy balances on their capstone design projects. (Formerly titled Thermodynamics II.) Differential Tuition: $165.

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; hands on experience with process control. Written and oral reports required. Differential Tuition: $55.

CME 4264. Plant Design. (2-6) 4 Credit Hours.
Prerequisites: 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 process safety and environmental impact factors. Students will work in small groups and submit a plant design project report that has a comprehensive design of all equipment included in the plant. Students will present the results of their design in a College of Engineering wide symposium. (Formerly titled Product and Process Design.) Differential Tuition: $220.

CME 4423. Rheology. (3-0) 3 Credit Hours.
Prerequisites: To be determined by the instructor. This course covers the fundamentals of rheology as they apply to the oil and gas industry. Topics covered include crude oil flow rheology, drilling fluids, fluids in completion, crude oil pipelining, and fractal characterization of wax. Differential Tuition: $165.

CME 4433. Process Optimization. (3-0) 3 Credit Hours.
Modern optimization theory, algorithms, and applications for large scale chemical engineering real-world problems. Topics included in the course and prerequisites required for the course will be decided upon by the instructor who teaches the course. Differential tuition: $165.

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 specialization, will apply to a bachelor's degree. Differential Tuition: $165.

CME 4523. Selected Topics in Petroleum/Energy 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 specialization, will apply to a bachelor's degree. Differential Tuition: $165.

CME 4533. Process Optimisation. (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 specialization, will apply to a bachelor's degree. Differential Tuition: $165.

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 specialization, will apply to a bachelor's degree. Differential Tuition: $165.

CME 4633. Process and System Safety III. (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 specialization, will apply to a bachelor's degree. Differential Tuition: $165.

CME 4643. 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 specialization, will apply to a bachelor's degree. Differential Tuition: $165.

CME 4653. 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 specialization, will apply to a bachelor's degree. Differential Tuition: $165.

CME 4663. Selected Topics in Manufacturing and Design. (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 specialization, will apply to a bachelor's degree. Differential Tuition: $165.

CME 4673. Selected Topics in Energy 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 specialization, will apply to a bachelor's degree. Differential Tuition: $165.

CME 4683. Selected Topics in Chemical 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 specialization, will apply to a bachelor's degree. Differential Tuition: $165.

CME 4693. Selected Topics in Chemical 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 specialization, will apply to a bachelor's degree. Differential Tuition: $165.

CME 4703. Selected Topics in Biomedical 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 specialization, will apply to a bachelor's degree. Differential Tuition: $165.

CME 4713. Selected Topics in Medical Devices. (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 specialization, will apply to a bachelor's degree. Differential Tuition: $165.
CME 4601. Independent Study. (0-0) 1 Credit Hour.
Prerequisites: Permission in writing (Independent Study Form available online) from the instructor and the Department Chair. Independent reading, research, discussion, and/or writing under the direction of a faculty member. May be repeated for credit, but not more than 3 semester credit hours of independent study, regardless of the concentration, will apply to a bachelor's degree in Chemical Engineering. This course cannot be taken if 3 semester credit hours in CME 4701-3 have already been earned. Differential Tuition: $55.

CME 4602. Independent Study. (0-0) 2 Credit Hours.
Prerequisites: Permission in writing (Independent Study Form available online) from the instructor and the Department Chair. Independent reading, research, discussion, and/or writing under the direction of a faculty member. May be repeated for credit, but not more than 3 semester credit hours of independent study, regardless of the concentration, will apply to a bachelor's degree in Chemical Engineering. This course cannot be taken if 3 semester credit hours in CME 4701-3 have already been earned. Differential Tuition: $110.

CME 4603. Independent Study. (0-0) 3 Credit Hours.
Prerequisites: Permission in writing (Independent Study Form available online) from the instructor and the Department Chair. Independent reading, research, discussion, and/or writing under the direction of a faculty member. May be repeated for credit, but not more than 3 semester credit hours of independent study, regardless of the concentration, will apply to a bachelor's degree in Chemical Engineering. This course cannot be taken if 3 semester credit hours in CME 4701-3 have already been earned. Differential Tuition: $165.

CME 4701. Chemical Engineering Research. (0-0) 1 Credit Hour.
Prerequisite: Permission in writing (form online) from the instructor, the student's advisor, and the Department Chair. Advanced laboratory practice and introduction to chemical engineering research. This course may be used to satisfy one of the electives for the CME tracks. May be repeated for credit but no more than 3 semester credit hours will apply towards the bachelor's degree in Chemical Engineering. This course cannot be taken if 3 semester credit hours in CME 4601-3 Independent study have already been earned. Differential Tuition: $55.

CME 4702. Chemical Engineering Research. (0-0) 2 Credit Hours.
Prerequisite: Permission in writing (form online) from the instructor, the student's advisor, and the Department Chair. Advanced laboratory practice and introduction to chemical engineering research. This course may be used to satisfy one of the electives for the CME tracks. May be repeated for credit but no more than 3 semester credit hours will apply towards the bachelor's degree in Chemical Engineering. This course cannot be taken if 3 semester credit hours in CME 4601-3 Independent study have already been earned. Differential Tuition: $110.

CME 4703. Chemical Engineering Research. (0-0) 3 Credit Hours.
Prerequisite: Permission in writing (form online) from the instructor, the student's advisor, and the Department Chair. Advanced laboratory practice and introduction to chemical engineering research. This course may be used to satisfy one of the electives for the CME tracks. May be repeated for credit but no more than 3 semester credit hours will apply towards the bachelor's degree in Chemical Engineering. This course cannot be taken if 3 semester credit hours in CME 4601-3 Independent study have already been earned. Differential Tuition: $165.

CME 4803. Chemical Engineering Internship. (0-0) 3 Credit Hours.
Prerequisite: Permission in writing (form online) from the instructor, the student's advisor, and the Department Chair. Internship with a chemical engineering industry. No more than 3 semester credit hours will apply to the bachelor's degree in Chemical Engineering. Differential Tuition: $165.