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). Both the BME and CME degrees are currently accredited by the Accreditation Board for Engineering and Technology (ABET, http://www.abet.org).

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. 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. Students are trained in the fundamentals of science and engineering and are 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, Cellular, and Tissue Engineering; and 3) Biomedical Imaging and Data Science. 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) degree program provides high-quality education and training in chemical engineering through rigorous coursework and hands-on experience in state-of-the-art laboratories. Students are required to take two technical electives from any of the following study areas of Chemical Engineering: 1) Petroleum and Energy Systems, a sector with burgeoning industry demand for well-trained individuals; 2) Materials Engineering, an enabling technical field for microelectronics, energy conversion, and process control; 3) Bioengineering, an emerging area in which biology and chemistry interface with bio-systems and healthcare; and 4) Environmental Engineering, a strategic growth area finding resources and environmental solutions for manufacturers and consumers. In addition, students need to take one technical elective from a list of approved advanced chemistry and physics courses. Evidence-based curricular pedagogies are utilized in the CME courses to ensure that our students develop critical thinking, problem-solving, teamwork, and excellent communication skills.

Admission to an Engineering Program

Direct Admission Criteria

Applicants entering UTSA as Freshmen or Freshmen Transfers (fewer than 12 transferable semester credit hours) will be directly admitted to the Biomedical Engineering (BME) or Chemical Engineering (CME) program if they:

- meet all UTSA undergraduate admission requirements,
- qualify for enrollment in MAT 1213 Calculus I, or a higher level mathematics course, and
- are ranked in the top 10 percent of their high school class (no minimum SAT or ACT scores required), or
- are ranked below the top 10 percent of their high school class and have a minimum 1200 SAT or 25 ACT score.

Applicants with SAT scores below 1200 or ACT scores below 25 may be considered for admission by committee review.

Transfer requirements for direct admission to the Biomedical Engineering (BME) or Chemical Engineering (CME) program for students who have earned 12 or more transferable semester credit hours:

- meet all UTSA undergraduate transfer admission requirements, and
- have completed MAT 1213 Calculus I and WRC 1013 Freshman Composition I, or the equivalents, with grades of "C-" or better, and
- meet grade point average requirements:
  - applicants with a transfer grade point average of 3.00 or higher may be granted direct admission to the College,
  - applicants with a transfer grade point average below 3.00 may be granted admission to the College by committee review.

Contact bme@utsa.edu or cme@utsa.edu for information regarding the committee review process.

Applicants who do not meet the Biomedical Engineering and Chemical Engineering department admission requirements will be admitted to the Engineering, Math, and Sciences Studies major in the University College. Students have three semesters to complete Calculus I with a grade of "C-" or better and meet the BME or CME Transfer Requirements.

“C-” Grade Rule

A grade of “C-” or better in any science, engineering, or mathematics course required for an engineering degree or any other course that is a prerequisite to any required Biomedical Engineering (BME), Chemical Engineering (CME), or Engineering (EGR) course indicates satisfactory preparation for further engineering education. Any course assigned a grade below a “C-” must be repeated before enrolling in any course for which it is a prerequisite. This requirement is subject to both the Gateway Course and Three-Attempt Limit rules.

Good Academic Standing in BME and CME

All students must be in good academic standing in order to remain in the Biomedical Engineering or Chemical Engineering programs. The minimum requirement that a student must satisfy in order to remain in good standing as a Biomedical Engineering or Chemical Engineering major is a UTSA grade point average (GPA) of at least 2.5 for all coursework. Students whose GPA falls below 2.5 will be placed on a programmatic probation the following semester. Earning a semester GPA below a 2.5 while on probation, will result in dismissal from the program. In order
to be removed from academic probation, the student must achieve a UTSA grade point average of 2.5 or higher. While on programmatic probation or dismissal, students are not allowed to take any major course requirement. All courses with BME or CME subject code (except BME 1002 and CME 1202) are restricted to students admitted to the major and in good academic standing.

Laptop Program
The laptop program requires that students entering Klesse College programs have their own laptop (notebook) computers and required software. The computer should be upgradeable in order to be of productive use for the duration of the academic program. The laptop specifications may vary per academic program. For further and specific information concerning laptop requirements for each program, please see the Klesse College hardware recommendations website (https://klesse.utsa.edu/student/computer-requirements.html).

- B.S. degree in Biomedical Engineering (p. 2)
- B.S. degree in Chemical Engineering (p. 5)

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/bachelorsdegeregulations/)).

Students 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 Department of Biomedical Engineering and Chemical Engineering continues to be recognized locally and nationally for the quality of its undergraduate program. BME graduates continue to find positions in the industry and are accepted into graduate schools and professional training programs (medicine and dentistry) nationwide.

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 requirement that a student must satisfy to remain in good standing as a biomedical engineering major is having a UTSA grade point average (GPA) of at least 2.5 for all coursework (GPA will be calculated on all courses, including previously attempted or repeated courses).

Students whose GPA falls below 2.5 will be placed on programmatic probation. Students who earn a GPA below 2.5 while on probation will be dismissed from the BME program. In order to be removed from academic probation, students must achieve a UTSA GPA of 2.5 or higher.

Students on programmatic probation or dismissal are not allowed to take any major course requirements.

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:

1. Become professionals with careers in industry, government, healthcare, and/or pursue advanced graduate or professional degrees.
2. Continue their professional development as required for their career advancement.
3. Contribute to the socio-economic development of Texas, the nation, and the world through the professional and ethical practice of engineering.
4. Assume leadership positions in their chosen field.

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 1213 may be used to satisfy the core requirement in Mathematics, as well as one of the General Engineering Requirements. BIO 1203, BIO 1201 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/bachelorsdegeregulations/degerequirements/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:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHE 1103</td>
<td>General Chemistry I</td>
<td>3</td>
</tr>
<tr>
<td>EGR 2302</td>
<td>Linear Algebra for Engineers</td>
<td>2</td>
</tr>
<tr>
<td>EGR 3423</td>
<td>Differential Equations for Engineers</td>
<td>3</td>
</tr>
<tr>
<td>MAT 1213</td>
<td>Calculus I</td>
<td>3</td>
</tr>
<tr>
<td>MAT 1223</td>
<td>Calculus II</td>
<td>3</td>
</tr>
<tr>
<td>or EGR 1333</td>
<td>Calculus II for Engineers</td>
<td>3</td>
</tr>
<tr>
<td>PHY 1943 &amp; PHY 1951</td>
<td>Physics for Scientists and Engineers I and Physics for Scientists and Engineers I Laboratory</td>
<td>4</td>
</tr>
<tr>
<td>PHY 1963 &amp; PHY 1971</td>
<td>Physics for Scientists and Engineers II and Physics for Scientists and Engineers II Laboratory</td>
<td>4</td>
</tr>
</tbody>
</table>

Total Credit Hours 22

**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 course 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 their major.

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>EGR 2302</td>
<td>Linear Algebra for Engineers</td>
<td>2</td>
</tr>
</tbody>
</table>

**Biomedical Engineering Requirements**

**A. Core Biomedical Engineering Requirements**

All students majoring in Biomedical Engineering are required to complete 39 semester credit hours in the following Core Biomedical Engineering courses.

<table>
<thead>
<tr>
<th>Code</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>BME 2103</td>
<td>Physiology for Biomedical Engineering</td>
<td>3</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 3013</td>
<td>Clinical Internship in Biomedical Engineering</td>
<td>3</td>
</tr>
<tr>
<td>BME 3023</td>
<td>Biomedical Engineering Technology and Product Development</td>
<td>3</td>
</tr>
<tr>
<td>BME 3113</td>
<td>Cellular Biology for Biomedical Engineering</td>
<td>3</td>
</tr>
<tr>
<td>BME 3121</td>
<td>Cellular Biology for Biomedical Engineering Laboratory</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BME 3211</td>
<td>Biomedical Engineering Laboratory I</td>
<td>1</td>
</tr>
<tr>
<td>BME 3303</td>
<td>Biostatistics</td>
<td>1</td>
</tr>
<tr>
<td>BME 3311</td>
<td>Biomedical Engineering Laboratory II</td>
<td>1</td>
</tr>
<tr>
<td>BME 3373</td>
<td>Modeling and Simulation Using MATLAB</td>
<td>3</td>
</tr>
<tr>
<td>BME 3703</td>
<td>Biotransport Phenomena</td>
<td>3</td>
</tr>
<tr>
<td>BME 3711</td>
<td>Biomedical Engineering Laboratory III</td>
<td>1</td>
</tr>
<tr>
<td>BME 4903</td>
<td>Senior BME Design I</td>
<td>3</td>
</tr>
<tr>
<td>BME 4913</td>
<td>Senior BME Design II</td>
<td>3</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>Code</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHE 1113</td>
<td>General Chemistry II</td>
<td>3</td>
</tr>
<tr>
<td>STA 1403</td>
<td>Probability and Statistics for the Biosciences</td>
<td>3</td>
</tr>
<tr>
<td>or STA 2303</td>
<td>Applied Probability and Statistics for Engineers</td>
<td></td>
</tr>
</tbody>
</table>

**C. Biomedical Engineering Electives**

A minimum of 12 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>Code</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BME 3033</td>
<td>Biomedical Engineering Internship</td>
<td>1</td>
</tr>
<tr>
<td>BME 3041</td>
<td>Biomedical Engineering Research</td>
<td>3</td>
</tr>
<tr>
<td>BME 3042</td>
<td>Biomedical Engineering Research</td>
<td>1</td>
</tr>
<tr>
<td>BME 3043</td>
<td>Biomedical Engineering Research</td>
<td>3</td>
</tr>
<tr>
<td>BME 3203</td>
<td>Biomechanics II</td>
<td>3</td>
</tr>
<tr>
<td>BME 4203</td>
<td>Biomechanics III</td>
<td>3</td>
</tr>
<tr>
<td>BME 4213</td>
<td>Tissue Mechanics</td>
<td>3</td>
</tr>
<tr>
<td>BME 4233</td>
<td>Computational Biomechanics</td>
<td>3</td>
</tr>
<tr>
<td>BME 4923</td>
<td>Orthopaedic Device Design</td>
<td>3</td>
</tr>
<tr>
<td>BME 4283</td>
<td>Impact Biomechanics</td>
<td>3</td>
</tr>
<tr>
<td>BME 4293</td>
<td>Topics in Biomechanics</td>
<td>3</td>
</tr>
<tr>
<td>BME 4463</td>
<td>Cellular Mechanics and Mechanobiology</td>
<td>3</td>
</tr>
</tbody>
</table>

**Biomaterials, Cellular, and Tissue Engineering Concentration**

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BME 3033</td>
<td>Biomedical Engineering Internship</td>
<td>1</td>
</tr>
<tr>
<td>BME 3041</td>
<td>Biomedical Engineering Research</td>
<td>3</td>
</tr>
<tr>
<td>BME 3042</td>
<td>Biomedical Engineering Research</td>
<td>1</td>
</tr>
<tr>
<td>BME 3043</td>
<td>Biomedical Engineering Research</td>
<td>3</td>
</tr>
<tr>
<td>BME 3413</td>
<td>Biocompatibility of Materials: Tissue-Biomechanical Interactions</td>
<td>3</td>
</tr>
<tr>
<td>BME 3503</td>
<td>Nanomaterials and Nanobiotechnology</td>
<td>3</td>
</tr>
<tr>
<td>BME 4213</td>
<td>Tissue Mechanics</td>
<td>3</td>
</tr>
<tr>
<td>BME 4423</td>
<td>Tissue Engineering</td>
<td>3</td>
</tr>
<tr>
<td>BME 4433</td>
<td>Soft Materials</td>
<td>3</td>
</tr>
<tr>
<td>BME 4443</td>
<td>Stem Cell Engineering</td>
<td>3</td>
</tr>
<tr>
<td>BME 4453</td>
<td>Fundamentals to Polymer Science and Engineering with Select Applications</td>
<td>3</td>
</tr>
<tr>
<td>BME 4463</td>
<td>Cellular Mechanics and Mechanobiology</td>
<td>3</td>
</tr>
<tr>
<td>BME 4483</td>
<td>Topics in Biomaterials</td>
<td>3</td>
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</table>
### Biomedical Imaging and Data Science Concentration

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>BME 3033</td>
<td>Biomedical Engineering Internship</td>
</tr>
<tr>
<td>BME 3041</td>
<td>Biomedical Engineering Research</td>
</tr>
<tr>
<td>BME 3042</td>
<td>Biomedical Engineering Research</td>
</tr>
<tr>
<td>BME 3043</td>
<td>Biomedical Engineering Research</td>
</tr>
<tr>
<td>BME 3503</td>
<td>Nanomaterials and Nanobiotechnology</td>
</tr>
<tr>
<td>BME 3803</td>
<td>Programming and Introductory AI for Biomedical Engineering</td>
</tr>
<tr>
<td>BME 3813</td>
<td>Machine and Deep Learning Theory to Solve Biomedical Engineering Problems</td>
</tr>
<tr>
<td>BME 4503</td>
<td>Biosensors</td>
</tr>
<tr>
<td>BME 4603</td>
<td>Biophotonics</td>
</tr>
<tr>
<td>BME 4613</td>
<td>Biomedical Imaging</td>
</tr>
<tr>
<td>BME 4623</td>
<td>Biomedical Optics</td>
</tr>
<tr>
<td>BME 4803</td>
<td>Biomedical Data Science</td>
</tr>
<tr>
<td>BME 4813</td>
<td>Generative Modeling for Biomedical Engineering</td>
</tr>
<tr>
<td>BME 4823</td>
<td>Data Analytics to Support Medical Decision Making</td>
</tr>
</tbody>
</table>

### 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 the list of engineering courses and the remaining 3 semester credit hours chosen from any of the engineering courses or from the list of science courses below.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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</thead>
<tbody>
<tr>
<td>CME 2403</td>
<td>Introduction to Programming for Engineers</td>
</tr>
<tr>
<td>EE 2213</td>
<td>Electric Circuits and Electronics</td>
</tr>
<tr>
<td>EGR 2103</td>
<td>Statics</td>
</tr>
<tr>
<td>EGR 4993</td>
<td>Honors Research</td>
</tr>
<tr>
<td>EGR 2213</td>
<td>Statics and Dynamics</td>
</tr>
<tr>
<td>ME 3293</td>
<td>Thermodynamics I</td>
</tr>
<tr>
<td>ME 3813</td>
<td>Mechanics of Solids</td>
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</table>

### Science Courses

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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</thead>
<tbody>
<tr>
<td>BCH 3303</td>
<td>Essentials of Biochemistry</td>
</tr>
<tr>
<td>BCH 3313</td>
<td>Biochemistry I</td>
</tr>
<tr>
<td>BIO 1223</td>
<td>Biosciences II for Science Majors and Biosciences II Laboratory for Science Majors</td>
</tr>
<tr>
<td>BIO 2313</td>
<td>Genetics</td>
</tr>
<tr>
<td>CHE 2603</td>
<td>Organic Chemistry I</td>
</tr>
<tr>
<td>CHE 3643</td>
<td>Organic Chemistry II</td>
</tr>
<tr>
<td>EGR 2313</td>
<td>Multivariable Calculus and Series for Engineers</td>
</tr>
<tr>
<td>EGR 3323</td>
<td>Applied Engineering Analysis II</td>
</tr>
<tr>
<td>EGR 3713</td>
<td>Engineering Economic Analysis</td>
</tr>
<tr>
<td>MAT 2213</td>
<td>Calculus III</td>
</tr>
<tr>
<td>NDRB 3913</td>
<td>Molecular Biology</td>
</tr>
</tbody>
</table>

### Total Credit Hours

66

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

#### First Year

<table>
<thead>
<tr>
<th>Semester</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td>16</td>
</tr>
<tr>
<td>AIS 1243</td>
<td>AIS: Engineering, Mathematics, and Sciences 3</td>
</tr>
<tr>
<td>BIO 1203</td>
<td>Biosciences I for Science Majors 4</td>
</tr>
<tr>
<td>BME 1002</td>
<td>Introduction to Biomedical Engineering 2</td>
</tr>
<tr>
<td>CHE 1103</td>
<td>General Chemistry I 3</td>
</tr>
<tr>
<td>CHE 1113</td>
<td>General Chemistry II 3</td>
</tr>
<tr>
<td>STA 1403</td>
<td>Probability and Statistics for the Biosciences 3</td>
</tr>
<tr>
<td>STA 2303</td>
<td>Probability and Statistics for the Biosciences 3</td>
</tr>
<tr>
<td>STA 1403</td>
<td>Probability and Statistics for the Biosciences 3</td>
</tr>
<tr>
<td>PHY 1943</td>
<td>Physics for Scientists and Engineers I (core and major) 3</td>
</tr>
<tr>
<td>PHY 1951</td>
<td>Physics for Scientists and Engineers I Laboratory 1</td>
</tr>
<tr>
<td>WRC 1023</td>
<td>Freshman Composition I (core) 3</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Semester</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring</td>
<td>15</td>
</tr>
<tr>
<td>BME 2203</td>
<td>Physiology for Biomedical Engineering 3</td>
</tr>
<tr>
<td>EGR 2302</td>
<td>Linear Algebra for Engineers 2</td>
</tr>
<tr>
<td>EGR 2302</td>
<td>Linear Algebra for Engineers 2</td>
</tr>
<tr>
<td>STA 1403</td>
<td>Probability and Statistics for the Biosciences 3</td>
</tr>
<tr>
<td>STA 2303</td>
<td>Probability and Statistics for Engineers 3</td>
</tr>
<tr>
<td>PHY 1963</td>
<td>Physics for Scientists and Engineers II (core and major) 3</td>
</tr>
<tr>
<td>PHY 1971</td>
<td>Physics for Scientists and Engineers II Laboratory 1</td>
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<tr>
<td>Technical elective 3</td>
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<table>
<thead>
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<tbody>
<tr>
<td>Summer</td>
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<tr>
<td>BME 3003</td>
<td>Biomaterials I 3</td>
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<tr>
<td>BME 3113</td>
<td>Cellular Biology for Biomedical Engineering 3</td>
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<tr>
<td>BME 3121</td>
<td>Cellular Biology for Biomedical Engineering 1</td>
</tr>
<tr>
<td>BME 3211</td>
<td>Biomedical Engineering Laboratory 1</td>
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<tr>
<td>EGR 3423</td>
<td>Differential Equations for Engineers 3</td>
</tr>
</tbody>
</table>

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

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### Total Credit Hours

66
Bachelor of Science Degree in Chemical Engineering

A Bachelor of Science (B.S.) degree in Chemical Engineering (CME) is the newest addition to the Klesse College of Engineering and Integrated Design at The University of Texas at San Antonio. The program, which began welcoming incoming freshman students in the fall of 2017, provides 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 provides high-quality education and training in chemical engineering through structured coursework and hands-on experience in state-of-the-art laboratory facilities. Students are also required to take two technical electives from any of the four following study areas of Chemical Engineering: 1) Petroleum/Energy Engineering, a sector with burgeoning industry demand for well-trained individuals; 2) Materials Engineering, an enabling technical field for microelectronics, energy conversion, and process control; 3) Bioengineering, an emerging area where biology and chemistry interface with bio-systems and healthcare; and 4) Environmental Engineering, a 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.

### Study 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/bachelorsdegreeregulations/].)

### 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 requirement that a student must satisfy in order to remain in good standing as a chemical engineering major is to have a UTSA grade point average (GPA) of at least 2.5 for all coursework. Students whose GPA falls below 2.5 will be placed on programmatic probation the following semester. If you earn a semester GPA below 2.5 while on probation, you will be dismissed from the program. In order to be removed from academic probation, you must achieve a UTSA grade point average of 2.5 or higher.

### Education Objectives

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

1. Succeed in the practice of chemical engineering through chosen careers in industry, government, or in advanced graduate and/or professional studies.
2. Demonstrate leadership in their chosen field.
3. Contribute to the socio-economic development of Texas, the nation, and the world through the ethical practice of engineering.
4. Embrace life-long learning for professional development and career advancement.

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 1213 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 must 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.utexas.edu/undergraduate/bachelorsdegreeregulations/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:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>CHE 1103</td>
<td>General Chemistry I</td>
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<tr>
<td>MAT 1213</td>
<td>Calculus I</td>
<td>3</td>
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<tr>
<td>PHY 1943</td>
<td>Physics for Scientists and Engineers I</td>
<td>4</td>
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<tr>
<td>&amp; PHY 1951</td>
<td>Physics for Scientists and Engineers I Laboratory</td>
<td>4</td>
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<tr>
<td>PHY 1963</td>
<td>Physics for Scientists and Engineers II</td>
<td>4</td>
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<tr>
<td>&amp; PHY 1971</td>
<td>Physics for Scientists and Engineers II Laboratory</td>
<td>4</td>
</tr>
<tr>
<td>MAT 1223</td>
<td>Calculus II</td>
<td>3</td>
</tr>
<tr>
<td>or EGR 1333</td>
<td>Calculus II for Engineers</td>
<td>3</td>
</tr>
<tr>
<td>EGR 2302</td>
<td>Linear Algebra for Engineers</td>
<td>2</td>
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<tr>
<td>EGR 3423</td>
<td>Differential Equations for Engineers</td>
<td>3</td>
</tr>
</tbody>
</table>

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 their major.

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>CME 2103</td>
<td>Chemical Process Principles</td>
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<tr>
<td>EGR 2302</td>
<td>Linear Algebra for Engineers</td>
<td>2</td>
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</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:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>A. Required Chemical Engineering courses (45 semester credit hours)</td>
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<tr>
<td>CME 1202</td>
<td>Introduction to Chemical Engineering</td>
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<tr>
<td>CME 2103</td>
<td>Chemical Process Principles</td>
<td>3</td>
</tr>
<tr>
<td>CME 2303</td>
<td>Transport Phenomena I</td>
<td>3</td>
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<td>CME 2403</td>
<td>Introduction to Programming for Engineers</td>
<td>3</td>
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<tr>
<td>CME 2503</td>
<td>Thermodynamics I</td>
<td>3</td>
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<tr>
<td>CME 3003</td>
<td>Introduction to Materials Science and</td>
<td>3</td>
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<td>Engineering</td>
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<td>CME 3123</td>
<td>Computational Methods in Chemical</td>
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<td>Engineering</td>
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<td>CME 3203</td>
<td>Thermodynamics II</td>
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<td>CME 3302</td>
<td>Chemical Process Safety and Risk</td>
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<td>Management</td>
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<td>CME 3403</td>
<td>Separation Processes</td>
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<td>CME 3503</td>
<td>Kinetics and Reactor Design</td>
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<td>CME 3601</td>
<td>Chemical Engineering Laboratory I</td>
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<td>CME 3703</td>
<td>Transport Phenomena II</td>
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<td>CME 4103</td>
<td>Process Dynamics and Control</td>
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<td>CME 4163</td>
<td>Chemical Engineering Design</td>
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<tr>
<td>Fundamentals</td>
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<tr>
<td>CME 4201</td>
<td>Chemical Engineering Laboratory II</td>
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<tr>
<td>CME 4263</td>
<td>Plant Design</td>
<td>3</td>
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<tr>
<td>B. Other required courses (25 semester credit hours)</td>
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<tr>
<td>CHE 1103</td>
<td>General Chemistry I and General Chemistry I Laboratory (CHE 1103 also satisfies a General Engineering Requirement)</td>
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<tr>
<td>&amp; CHE 1121</td>
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<tr>
<td>CHE 1113</td>
<td>General Chemistry II and General Chemistry II Laboratory</td>
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<tr>
<td>&amp; CHE 1131</td>
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<tr>
<td>CHE 2603</td>
<td>Organic Chemistry I and Organic Chemistry I Laboratory</td>
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<td>&amp; CHE 2612</td>
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<td>ECO 2023</td>
<td>Introductory Microeconomics</td>
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<td>EGR 2313</td>
<td>Multivariable Calculus and Series for</td>
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<td>Engineers</td>
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<tr>
<td>EGR 3713</td>
<td>Engineering Economic Analysis</td>
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<tr>
<td>STA 2303</td>
<td>Applied Probability and Statistics for</td>
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<tr>
<td>Engineers</td>
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</table>
A minimum of 9 semester credit hours must be selected from any of the following areas of study (based on availability). One of the electives needs to be chosen from the list of advanced chemistry or physics courses.

**Bioengineering**
- BCH 3303 Essentials of Biochemistry
- CME 2113 Physiology for Chemical Engineering
- CME 2803 Biomechanics I
- CME 3113 Cellular Biology for Chemical Engineering
- CME 3413 Biocompatibility of Materials: Tissue-Biomaterial Interaction
- CME 3803 Biomechanics II
- CME 3903 Bioinstrumentation
- CME 4513 Selected Topics in Bioengineering
- CME 4713 Fundamentals to Polymer Science and Engineering with Select Applications

**Environmental Engineering**
- CE 2633 Environmental Engineering
- CE 4603 Water Resources Engineering
- CE 4633 Water and Wastewater Treatment
- CME 4543 Selected Topics in Environmental Engineering
- CME 4723 Heterogeneous Catalysis and Surface Science
- CME 4733 Fundamentals of Interfaces, Nanoparticles, and Other Colloids
- CME 4823 Electrochemistry and Electrochemical Engineering
- ES 6103 Environmental Assessment (with approval)

**Materials Engineering**
- CME 2803 Biomechanics I
- CME 3903 Bioinstrumentation
- CME 4533 Selected Topics in Materials Science and Engineering
- CME 4713 Fundamentals to Polymer Science and Engineering with Select Applications
- CME 4723 Heterogeneous Catalysis and Surface Science
- CME 4733 Fundamentals of Interfaces, Nanoparticles, and Other Colloids
- CME 4823 Electrochemistry and Electrochemical Engineering

**Petroleum/Energy Engineering**
- CME 4433 Process Optimization
- CME 4523 Selected Topics in Petroleum/Energy Engineering
- CME 4723 Heterogeneous Catalysis and Surface Science
- CME 4733 Fundamentals of Interfaces, Nanoparticles, and Other Colloids
- CME 4823 Electrochemistry and Electrochemical Engineering
- EGR 2213 Statics and Dynamics
- PHY 2103 Modern Physics

**Common Electives**
- No more than 3 semester credit hours of Independent Study, Research, or Internship courses may count toward electives.
- CME 4701 Chemical Engineering Research
- CME 4702 Chemical Engineering Research
- CME 4703 Chemical Engineering Research
- CME 4803 Chemical Engineering Internship
- CME 4911 Independent Study
- CME 4912 Independent Study
- CME 4913 Independent Study

**Advanced Chemistry or Physics Elective**
- CHE 2214 Analytical Chemistry
- CHE 3464 Descriptive Inorganic Chemistry
- CHE 3643 Organic Chemistry II
- CHE 3824 Quantum Chemistry and Spectroscopy
- CHE 4513 X-Ray Crystallography
- CHE 4703 Drug Metabolism
- PHY 3203 Classical Mechanics I
- PHY 3313 Materials Physics
- PHY 3453 Lasers: Theory and Applications
- PHY 4623 Nanotechnology
- PHY 4833 Molecular Biophysics

**Total Credit Hours** 79

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

**First Year**

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit Hours</th>
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<td>AIS 1243</td>
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<tr>
<td>CHE 1103</td>
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<td>CHE 1121</td>
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<tr>
<td>EGR 1343</td>
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<tr>
<td>WRC 1013</td>
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<tr>
<td>MAT 1213</td>
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<td><strong>Credit Hours</strong></td>
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<th>Spring</th>
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<tbody>
<tr>
<td>CHE 1113</td>
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<tr>
<td>CHE 1131</td>
<td>1</td>
</tr>
<tr>
<td>CME 1202</td>
<td>2</td>
</tr>
</tbody>
</table>
## Department of Biomedical Engineering and Chemical Engineering

### Biomedical Engineering (BME) Courses

**BME 1002. Introduction to Biomedical Engineering. (2-0) 2 Credit Hours.**
Prerequisite: A grade of "C-" or better, or concurrent enrollment in BIO 1203, BIO 1201, and MAT 1213 (or MAT 1214 in previous catalogs). This course is an introduction to the interdisciplinary field of biomedical engineering. Topics covered include core biomedical engineering areas, fundamental concepts, ethics, professionalism, careers, and technical skills. Generally offered: Spring. Course Fee: LRE1 $20; STSE $25.

**BME 2103. Physiology for Biomedical Engineering. (3-1) 3 Credit Hours.**
Prerequisite: Major in Biomedical Engineering and a grade of "C-" or better in BIO 1203 and BIO 1201; completion of or concurrent enrollment in MAT 1213 (or MAT 1214 in previous catalogs). Fundamental principles of general and organ systems physiology, including composition and concentration of cellular and other body fluids, types of transport (e.g., diffusion, membrane transporters), energy (e.g., 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. Credit cannot be earned for both BME 2103 and CME 2113.) Generally offered: Fall. Course Fee: LRE1 $25; STSE $30.

**BME 2203. Biomechanics I. (3-1) 3 Credit Hours.**
Prerequisite: Major in Biomedical Engineering and a grade of "C-" or better in EGR 2302 or EGR 2323 and PHY 1943; completion of or concurrent enrollment in BME 3211 and EGR 3423. Introduction to fundamental engineering mechanics with a 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.). Course Fee: LRE1 $25; STSE $30; DL01 $75.

**BME 3003. Biomaterials I. (3-0) 3 Credit Hours.**
Prerequisites: A grade of "C-" or better 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. (Formerly listed as BME 2403 in previous catalogs. Credit cannot be earned for both BME 3003 and CME 3003.) This course has Differential Tuition. Course fee: DL01 $75.

**BME 3013. Clinical Internship in Biomedical Engineering. (0-0) 3 Credit Hours.**
Prerequisite: A grade of "C-" or better in BME 3113 and BME 3121. This course will introduce students to the clinical environment, interacting with clinicians on current clinical problems, and engineering approaches. Generally offered: Summer. This course has Differential Tuition.

### List of Courses

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<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>MAT 1223</td>
<td>Calculus II</td>
<td>3</td>
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<tr>
<td>WRC 1023</td>
<td>Freshman Composition II (core)</td>
<td>3</td>
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<tr>
<td>CME 4103</td>
<td>Process Dynamics and Control</td>
<td>3</td>
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<tr>
<td>CME 4163</td>
<td>Chemical Engineering Design Fundamentals</td>
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</tr>
<tr>
<td>CME 4201</td>
<td>Chemical Engineering Laboratory II</td>
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</tr>
<tr>
<td>CME 4163</td>
<td>Chemical Engineering Design Fundamentals</td>
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<td>CME 4263</td>
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<td>Separation Processes</td>
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<td>CME 3503</td>
<td>Kinetics and Reactor Design</td>
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<td>ECO 2023</td>
<td>Introductory Microeconomics</td>
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<td>CME 3302</td>
<td>Chemical Process Safety and Risk Management</td>
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<td>CME 4001</td>
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**Total Credit Hours:** 128
BME 3023. Biomedical Engineering Technology and Product Development. (3-0) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in BME 3013 and 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.) This course has Differential Tuition. Course fee: DL01 $75.

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. This course has Differential Tuition.

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. This course has Differential Tuition. Course Fee: LRE1 $25; STSE $10.

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. This course has Differential Tuition.

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. This course has Differential Tuition.

BME 3113. Cellular Biology for Biomedical Engineering. (3-0) 3 Credit Hours.
Prerequisites: Major in Biomedical Engineering and a grade of "C-" or better in BME 2103. Introduction to concepts and principles in cell and molecular biology. Topics include the structure and function of biomolecules, the fundamentals of DNA synthesis and repair, gene expression, cell metabolism, cell signaling, the cytoskeleton, and the cell cycle. (Formerly BME 3114. Same as CME 3113. Credit can only be earned for one of the following: BME 3113, BME 3114, and CME 3113.) This course has Differential Tuition.

BME 3121. Cellular Biology for Biomedical Engineering Laboratory. (0-3) 1 Credit Hour.
Prerequisite: Major in Biomedical Engineering and a grade of "C-" or better in BME 2103; completion of or concurrent enrollment in BME 3113 (formerly BME 3114). This laboratory course is designed to reinforce concepts from BME 3113 (formerly BME 3114) and provide students with the ability to use techniques and procedures commonly used in cell and molecular biology with biomedical engineering applications. This course has Differential Tuition. Course fee: L001 $30.

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. (Same as CME 3803. Credit cannot be earned for both BME 3203 and CME 3803.) Generally offered: Fall. This course has Differential Tuition. Course Fee: DL01 $75.

BME 3211. Biomedical Engineering Laboratory I. (0-4) 1 Credit Hour.
Prerequisite: A grade of "C-" or better in BME 1002; completion of or concurrent enrollment in 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 listed as BME 2211 in previous catalogs. Credit cannot be earned for both BME 3211 and BME 2211.) This course has Differential Tuition. Course Fee: L001 $30.

BME 3303. Bioinstrumentation. (3-1) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in BME 2203. 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. This course has Differential Tuition. Course Fee: DL01 $75.

BME 3311. Biomedical Engineering Laboratory II. (0-4) 1 Credit Hour.
Prerequisite: Completion of or concurrent enrollment in 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. This course has Differential Tuition. Course Fee: L001 $30.

BME 3373. Modeling and Simulation Using MATLAB. (3-0) 3 Credit Hours.
Prerequisite: Junior status with a major in Biomedical Engineering and a grade of "C-" or better in BME 2103, BME 2203, BME 3211, and EGR 3423, or permission by instructor; completion of or concurrent enrollment in BME 3311. Introduction to programming using MATLAB. Topics may include modeling biomedical phenomena, including neuronal action potentials, muscles, the heart and circulatory system, and problem-solving in biomechanics. This course has Differential Tuition.

BME 3413. Biocompatibility of Materials: Tissue-Biomaterial Interactions. (3-0) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in BME 2103, BME 3003, BME 3113, and BME 3211. 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, the mechanisms of cell interactions with extracellular matrix components, and 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 CME 3413 and BME 4423. Credit can only be earned for one of the following: BME 3413, BME 4423, or CME 3413.) Generally offered: Fall. This course has Differential Tuition. Course Fee: DL01 $75.
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") Credit cannot be earned for both BME 3503 and CME 3513. Generally offered: Spring. This course has Differential Tuition. Course fee: DL01 $75.

BME 3703. Biotransport Phenomena. (3-1) 3 Credit Hours.
Prerequisites: A grade of "C-" or better in BME 3303 and BME 3373. 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 apply these principles to design artificial and extracorporeal devices and drug delivery systems for pharmacokinetic analysis. This course includes a 3 hour lecture and a 1 hour recitation. Generally offered: Spring. This course has Differential Tuition.

BME 3711. Biomedical Engineering Laboratory III. (0-4) 1 Credit Hour.
Corequisites: 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. This course has Differential Tuition. Course Fee: L001 $30.

BME 3803. Programming and Introductory AI for Biomedical Engineering. (3-0) 3 Credit Hours.
Prerequisite: Major in Biomedical Engineering and a grade of "C-" or better in BME 1002 and BME 3373. Introduction to the Python language and emerging AI methodology in the context of biomedical applications. Use of Python packages and AI simulations to solve contemporary biomedical engineering problems. This course has Differential Tuition.

BME 3813. Machine and Deep Learning Theory to Solve Biomedical Engineering Problems. (3-0) 3 Credit Hours.
Prerequisite: Major in Biomedical Engineering and a grade of "C-" or better in MAT 1213. This course aims to provide students with the fundamentals of machine and deep learning. The topics include the mathematical derivations that transform these principles into practical algorithms. A course research project provides practical experiences in implementing and adjusting ML and DL frameworks to solve real-world biomedical challenges. This course has Differential Tuition.

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 and strain analysis, stress and strain in tissue and organs, and problem solving and design in biomechanics using statics, mechanics of materials, kinematics, and/or dynamics concepts. This course has Differential Tuition. Course Fees: LRE1 $25; STSE $30.

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. This course has Differential Tuition.

BME 4233. Computational Biomechanics. (3-0) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in BME 2203, BME 3373, and EGR 3423, or consent from the instructor. This course will provide students with practical knowledge and tools to perform biomechanical analysis through computational modeling. The course applies fundamentals of mechanics of material and the methods of computational modeling such as the finite element method (FEM) to model biological systems and biomechanical components and simulate biomechanical phenomena. Examples and problems may be solved analytically and with the use of commercially available FEM software. Some basic knowledge of computer programming is recommended. This course has Differential Tuition.

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. This course has Differential Tuition.

BME 4293. Topics in Biomechanics. (3-0) 3 Credit Hours.
Prerequisite: 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. This course has Differential Tuition. Course Fee: DL01 $75.

BME 4423. Tissue Engineering. (3-0) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in BME 2103, BME 3003, BME 3113, and BME 3121. 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. (Same as BME 3413 and CME 3413. Credit can only be earned for one of the following: BME 3413, BME 4423, or CME 3413.) This course has Differential Tuition. Course Fee: DL01 $75.

BME 4433. Soft Materials. (3-0) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in BME 3003 or CME 3003 and a junior or senior status in the program. A review of specific topics in soft biomaterials with an emphasis on the use of polymer matrices. Aspects of material synthesis and characterization will be addressed, along with their applications in nano- and micro-technologies, drug delivery, biosensing, and tissue engineering. This course has Differential Tuition.

BME 4443. Stem Cell Engineering. (3-0) 3 Credit Hours.
Prerequisite: BME 3003 or CME 3003, BME 3113 (BME 3114 in previous catalogs), BME 3121, and senior status in the program. A review of special topics and recent advancements in stem cell engineering. This course has Differential Tuition.
BME 4453. Fundamentals to Polymer Science and Engineering with Select Applications. (3-0) 3 Credit Hours.
Prerequisite: Major in Biomedical Engineering and a grade of "C-" or better in BME 3003 or equivalent. This course introduces the fundamentals of polymer chemistry and engineering, characterization of polymer properties, and polymer processing. Current applications of polymeric materials in materials engineering and bioengineering are highlighted and discussed in detail. (Same as CME 4713. Credit cannot be earned for both CME 4713 and BME 4453.) This course has Differential Tuition.

BME 4463. Cellular Mechanics and Mechanobiology. (3-0) 3 Credit Hours.
Prerequisite: Major in Biomedical Engineering and a grade of "C-" or better in BME 3113 and BME 3121. The goal of the course will be to teach how cells sense, process, and respond to mechanical forces; and to study how physical forces and changes in cells contribute to development, physiology, and disease. This course has Differential Tuition.

BME 4483. Topics in Biomaterials. (3-0) 3 Credit Hours.
Prerequisite: 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. This course has Differential Tuition. Course Fee: DL01 $75.

BME 4493. Topics in Tissue Engineering. (3-0) 3 Credit Hours.
Prerequisite: Senior status with a major in Biomedical Engineering and a grade of "C-" or better in BME 3003, BME 3113 (BME 3114 in previous catalogs), and BME 3121. 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. This course has Differential Tuition. Course Fee: LRE1 $25; STSE $30.

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. This course has Differential Tuition. Course Fee: LRE1 $25; STSE $30.

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 biomedicine 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. This course has Differential Tuition. Course Fee: DL01 $75.

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. This course has Differential Tuition. Course fee: DL01 $75.

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. This course has Differential Tuition. Course Fee: LRE1 $25; STSE $30.

BME 4713. Cellular Engineering. (3-0) 3 Credit Hours.
Prerequisite: BME 3113 and BME 3121. This course focuses on the engineering of cell function for applications in biomedical engineering. Topics include cell conditioning, genetic engineering and gene therapy, basic principles of stem cell engineering, and translational applications of cell engineering. This course has Differential Tuition. Course Fee: DL01 $75.

BME 4793. Topics in Cellular Engineering. (3-0) 3 Credit Hours.
Prerequisite: Senior status with a major in Biomedical Engineering and a grade of "C-" or better in BME 3113 (BME 3114 in previous catalogs), BME 3121, 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. This course has Differential Tuition. Course Fee: DL01 $75.

BME 4803. Fundamental Computational Bioengineering. (3-0) 3 Credit Hours.
Prerequisite: Major in Biomedical Engineering and a grade of "C-" or better in BME 1002, BME 3373, and BME 3803, or permission from the instructor. This course aims to provide students with the ability to use computational methods to understand and analyze biological data. Topics include a survey of high-throughput biomedical data analysis methods, modeling of signaling pathways, image analysis, and artificial intelligence methods. A course research project provides practical experience in applying computational tools to solve real-world biomedical challenges. This course has Differential Tuition.

BME 4813. Generative Modeling for Biomedical Engineering. (3-0) 3 Credit Hours.
Prerequisite: Major in Biomedical Engineering and a grade of "C-" or better in BME 1002 and BME 3373. This course will introduce new methods in machine learning, bioinformatics, and artificial intelligence that support generative model building to design experiments and predict solutions to biomedical engineering problems. This course has Differential Tuition.

BME 4823. Data Analytics to Support Medical Decision Making. (3-0) 3 Credit Hours.
Prerequisite: Major in Biomedical Engineering and a grade of "C-" or better in STA 1403 or STA 2303, BME 1002, and BME 3373. This course will leverage data science methods to support the development of models to understand complex problems in healthcare and inform decision and policy making. This course has Differential Tuition.

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 STA 1403 or STA 2303, BME 1002, and BME 3373. This course will introduce new methods in machine learning, bioinformatics, and artificial intelligence that support generative model building to design experiments and predict solutions to biomedical engineering problems. This course has Differential Tuition.

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 collaboration and/or faculty sponsorship of these projects is encouraged. This course has Differential Tuition.

BME 4933. Topics in Cellular Engineering. (3-0) 3 Credit Hours.
Prerequisite: Senior status with a major in Biomedical Engineering and a grade of "C-" or better in BME 3113 (BME 3114 in previous catalogs), BME 3121, 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. This course has Differential Tuition. Course Fee: DL01 $75.
BME 4923. Orthopaedic Device Design. (3-0) 3 Credit Hours.
Prerequisite: 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.
May be repeated for credit when topics vary, but not more than 6
semester credit hours will apply to a bachelor's degree. This course has
Differential Tuition.

Chemical Engineering (CME) Courses

CME 1202. Introduction to Chemical Engineering. (2-0) 2 Credit Hours.
A broad survey of the practice of chemical engineering, intended
to expose students to various 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 Fee: LRE1 $25; STSE $20.

CME 2103. Chemical Process Principles. (3-0) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in CHE 1113 and MAT 1213 (or MAT
1214 in previous catalogs). Students will first have the opportunity to
learn basic principles of chemical engineering, including temperature,
pressure, pressure head, mass, moles, volume, concentration, density,
time-dependent variables, and buoyancy. They will apply techniques such
as interpolation, linearization, statistical analysis, and Gauss-Jordan
elimination. Students will define system boundaries for closed and
open systems to apply material and energy balances to single units and
multiple unit processes; processes containing recycle loops; non-reactive
and reactive processes; processes with ideal and nonideal gases; and
processes with liquid-liquid equilibrium, solid-vapor equilibrium, and
single and multi-component vapor liquid equilibrium. Students will
have the opportunity to learn the first law of thermodynamics to derive
and apply the general energy balance, mechanical energy balance,
and Bernoulli equation. Students will have the opportunity to learn the
differences between extensive versus intensive variables, and state
functions versus path functions. Students will have the opportunity to
develop an understanding of system and stream energies (enthalpy,
internal energy, potential energy, and kinetic energy) versus energy
transfer terms (heat and work) and apply them to non-reactive and
reactive chemical processes. Course Fee: LRE1 $25; STSE $30; DL01 $75.

CME 2113. Physiology for Chemical Engineering. (3-0) 3 Credit Hours.
Prerequisites: A grade of "C-" of better in BIO 1203 and MAT 1213 (or MAT
1214 in previous catalogs). 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. (Same as BME 2103. Credit cannot be earned for both CME
2113 and BME 2103.) Course Fees: LRE1 $25; STSE $30.

CME 2301. Chemical Process Safety and Risk Management. (1-0) 1
Credit Hour.
(This course is for students in catalogs prior to 2022-2024.) Application
of chemical process safety, risk assessment and management, including
hazardous waste disposal and remediation. (Same as CME 3302 and
CME 4001. Credit cannot be earned for more than one of the following:
CME 2301, CME 3302, and CME 4001.) Course Fees: LRE1 $25; STSE $10.

CME 2303. Transport Phenomena I. (3-1) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in CME 2103 and EGR 3213;
completion of or concurrent enrollment in EGR 3423. This course covers
the fundamentals 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. This course includes a 3-hour lecture and a 1-hour
recitation per week. (Credit cannot be earned for both CME 2303 and CME

CME 2403. Introduction to Programming for Engineers. (3-0) 3 Credit
Hours.
Prerequisite: A grade of "C-" or better in EGR 2302. This course is
designed to provide a foundation in programming. Topics include
data types, the use of variables for storing data, arrays and strings,
mathematical and logical expressions, loops, intro to data structures,
structured program design, file input and output, plotting 2-D and 3-D
data, and application to solving engineering problems. Course Fee: LRE1
$25; STSE $30.

CME 2503. Thermodynamics I. (3-1) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in CME 2103 and EGR 2313.
Thermodynamic analysis and modeling of pure component and constant
concentration systems. Topics include basic thermodynamic variables,
introductory equations of state, first and second laws of thermodynamics
(closed and open systems), reversible and irreversible processes,
thermodynamic cycles, thermodynamic potentials, Maxwell relations,
phase change properties and introduction to statistical thermodynamics.
(Credit cannot be earned for both CME 2503 and CME 3103 or ME 3293.)
This course includes a 3-hour lecture and a 1-hour recitation per week.
Course Fee: LRE1 $25; STSE $30.

CME 2803. Biomechanics I. (3-1) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in EGR 2302 or EGR 2323 and PHY
1943; completion of or concurrent enrollment in EGR 3423. 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 Fee: LRE1 $25; STSE $30; DL01 $75.

CME 3003. Introduction to Materials Science and Engineering. (3-0) 3
Credit Hours.
Prerequisite: A grade of "C-" or better in CME 1202. 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. (Same as BME 3003. Credit cannot be
earned for both CME 3003 and BME 3003.) This course has Differential
Tuition. Course fee: DL01 $75.

CME 3113. Cellular Biology for Chemical Engineering. (3-0) 3 Credit
Hours.
Prerequisite: A grade of "C-" or better in CME 2103. Introduction to
concepts and principles in cell and molecular biology. Topics include
the structure and function of biomolecules, the fundamentals of DNA
synthesis and repair, gene expression, cell metabolism, cell signaling,
the cytoskeleton, and the cell cycle. This class consists of a 3-hour lecture.
(Same as BME 3114 and BME 3113. Credit can only be earned for one
of the following: CME 3113, BME 3114, or BME 3113.) This course has
Differential Tuition. Course fee: DL01 $75.
CME 3123. Computational Methods in Chemical Engineering. (3-1) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in CME 2403; "C-" or better in EGR 2313; "C-" or better in EGR 2302, completion of or concurrent enrollment in EGR 3423. 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 have the opportunity to 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. This course has Differential Tuition.

CME 3203. Thermodynamics II. (3-1) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in CME 2503. Thermodynamic analysis and modeling of pure and multicomponent mixtures with variable concentration. This course focuses mainly on phase and chemical equilibria. Topics covered include thermodynamic properties estimation, equations of state, fugacity, activity coefficient models, phase equilibrium, chemical reactions equilibrium, and intermolecular forces. This course includes a 3-hour lecture and a 1-hour recitation per week. (Credit cannot be earned for both CME 3203 and CME 3103 or ME 3293.) This course has Differential Tuition.

CME 3302. Chemical Process Safety and Risk Management. (2-0) 2 Credit Hours.
Application of process safety and risk assessment and management in the petrochemical and related industries. The Risk Based Process Safety (RBPS) framework is used. Process safety design strategies are incorporated in a team project to complete a Hazard Identification and Risk Analysis (HIRA) for a given petrochemical process. Impact on employees, community, and the environment are addressed. The course includes lectures, guest speakers from industry, and investigation of case studies involving significant process safety events. (Same as CME 2301 and CME 4001. Credit cannot be earned for more than one of the following: CME 2301, CME 3302, and CME 4001.) This course has Differential Tuition.

CME 3403. Separation Processes. (3-0) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in CME 2303 (formerly CME 3303). This course focuses on the application of fundamental thermodynamic and transport phenomena principles to the separation of chemical and biological mixtures. Topics covered include the fundamental principles of select solid-fluid, liquid-liquid, and gas-liquid unit operations and their practical sizing and design. This course has Differential Tuition.

CME 3413. Biocompatibility of Materials: Tissue-Biomeraterial 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.) This course has Differential Tuition.

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. This course has Differential Tuition. Course Fees: LRE1 $25; STSE $30.

CME 3503. Kinetics and Reactor Design. (3-0) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in CME 2303 (formerly 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. This course has Differential Tuition. Course Fee: DL01 $75.

CME 3513. Nanomaterials and Nanobiotechnology. (3-0) 3 Credit Hours.
Prerequisite: 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.) This course has Differential Tuition.

CME 3601. Chemical Engineering Laboratory I. (0-3) 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 reports and oral presentations required. This course has Differential Tuition. Course Fee: L001 $30.

CME 3703. Transport Phenomena II. (3-1) 3 Credit Hours.
Prerequisite: CME 2303 (CME 3303 in previous catalogs) 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. This course includes a 3-hour lecture and a 1-hour recitation per week. This course has Differential Tuition. Course fee: DL01 $75.

CME 3803. Biomechanics II. (3-0) 3 Credit Hours.
Prerequisite: 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.) This course has Differential Tuition. Course fee: DL01 $75.

CME 3903. Bioinstrumentation. (3-1) 3 Credit Hours.
Prerequisite: 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.) This course has Differential Tuition.

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. This course has Differential Tuition. Course Fee: DL01 $75.
CME 4163. Chemical Engineering Design Fundamentals. (3-0) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in CME 3203, CME 3403, CME 3703, and CME 3302. 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") This course has Differential Tuition. Course Fee: DL01 $75.

CME 4201. Chemical Engineering Laboratory II. (0-3) 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. This course has Differential Tuition.

CME 4263. Plant Design. (3-0) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in CME 4163 and completion of or concurrent enrollment in EGR 3713. 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 and Integrated Design-wide symposium. (Same as CME 4264. Credit cannot be earned for both CME 4264 and CME 4263.) This course has Differential Tuition.

CME 4423. Rheology. (3-0) 3 Credit Hours.
Prerequisite: 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. This course has Differential Tuition. Course Fee: DL01 $75; IUCS $45.

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. This course has Differential Tuition.

CME 4513. Selected Topics in Bioengineering. (3-0) 3 Credit Hours.
Prerequisites: May 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 will apply to a bachelor’s degree. This course has Differential Tuition. Course fee: DL01 $75.

CME 4523. Selected Topics in Petroleum/Energy Engineering. (3-0) 3 Credit Hours.
Prerequisites: May 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 will apply to a bachelor’s degree. This course has Differential Tuition. Course fee: DL01 $75.

CME 4533. Selected Topics in Materials Science and Engineering. (3-0) 3 Credit Hours.
Prerequisites: May 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 will apply to a bachelor’s degree. This course has Differential Tuition. Course fee: DL01 $75.

CME 4543. Selected Topics in Environmental Engineering. (3-0) 3 Credit Hours.
Prerequisites: May 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 will apply to a bachelor’s degree. This course has Differential Tuition. Course Fees: LRE1 $25; STSE $30; DL01 $75.

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 4913 or CME 4803 have already been earned. This course has Differential Tuition.

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 4913 or CME 4803 have already been earned. This course has Differential Tuition.

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 4913 or CME 4803 have already been earned. This course has Differential Tuition.

CME 4713. Fundamentals to Polymer Science and Engineering with Select Applications. (3-0) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in CME 3003 or BME 3003. This course introduces the fundamentals of polymer chemistry and engineering, characterization of polymer properties, and polymer processing. Current applications of polymeric materials in materials engineering and bioengineering are highlighted and discussed in detail. (Same as BME 4453. Credit cannot be earned for both CME 4713 and BME 4453.) This course has Differential Tuition.
CME 4723. Heterogeneous Catalysis and Surface Science. (3-0) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in CME 2103, or instructor approval. This course covers the main types of important industrial catalysts and their usage in a variety of applications in energy and fuels, the environment, and sustainability. Catalyst formulations, characterization techniques (temperature-programmed, adsorptive, and spectroscopic), and performance (activity, selectivity, and stability) will be covered. Issues associated with the deactivation of catalysts (sintering, attrition, Ostwald ripening, poisoning, oxidation) and how catalysts can be regenerated will be examined. This course has Differential Tuition.

CME 4733. Fundamentals of Interfaces, Nanoparticles, and Other Colloids. (3-0) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in CME 2503 or ME 3293. This course will cover fundamental and applied aspects of surfaces and interfaces with significant effects on chemical processes, materials, and the environment (including underground systems). It will also establish fundamental relationships between different types of colloids (e.g., emulsions, foams, and nanoparticles) and lay out basic principles needed to control their behavior. This course has Differential Tuition.

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 in the chemical engineering industry. No more than 3 semester credit hours will apply to the bachelor's degree in Chemical Engineering. This course cannot be taken if 3 semester credit hours in CME 4913 or CME 4703 have already been earned. This course has Differential Tuition.

CME 4823. Electrochemistry and Electrochemical Engineering. (3-0) 3 Credit Hours.
Prerequisite: A grade of "C-" or better in CME 2503. This course will teach and apply the fundamentals of electrochemistry to electrochemical reactor analysis and design. Building on a theoretical foundation of thermodynamics, kinetics, and transport processes in electrochemical systems, this course will examine corrosion engineering, electrodeposition, batteries and fuel cells, industrial electrolysis, and electrosynthesis. This course has Differential Tuition.

CME 4911. 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 will apply to a bachelor's degree in Chemical Engineering. This course cannot be taken if 3 semester credit hours in CME 4703 or CME 4803 have already been earned. (Formerly CME 4601. Credit cannot be earned for both CME 4601 and CME 4911.) This course has Differential Tuition.

CME 4912. Independent Study. (0-0) 2 Credit Hours.
Prerequisite: 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 no more than 3 semester credit hours of independent study will apply to a bachelor's degree in Chemical Engineering. This course cannot be taken if 3 semester credit hours in CME 4703 or CME 4803 have already been earned. (Formerly CME 4602. Credit cannot be earned for both CME 4602 and CME 4912.) This course has Differential Tuition.

CME 4913. 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 will apply to a bachelor's degree in Chemical Engineering. This course cannot be taken if 3 semester credit hours in CME 4703 or CME 4803 have already been earned. Formerly CME 4603. Credit cannot be earned for both CME 4603 and CME 4913. This course has Differential Tuition.