# BIOMEDICAL ENGINEERING, B.S.

## Program Educational Objectives
Graduates of the Biomedical Engineering Program will:

1. Practice in a professional career or pursue an advanced or professional degree in which they are contributing to scientific, professional, and/or local communities through the improvement of human health.
2. Advance their careers by engaging in teamwork, effective communication, and continued learning to expand their professional development and technical understanding.

## Learning Outcomes
1. Ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
2. Ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.
3. Ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgement to draw conclusions.
4. Ability to acquire and apply new knowledge as needed, using appropriate learning strategies.
5. Ability to communicate effectively with a range of audiences.
6. Ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.
7. Ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.

## Academic Standards
### Program GPA
Program GPA requirement policies are described in the College of Engineering and Computing section of this bulletin. For the purpose of these policies, the following courses are used to determine the Program GPA for the Biomedical Engineering B.S. program: all Biomedical Engineering Major courses, all courses used to satisfy a Biomedical Engineering Elective, all courses used to satisfy an Engineering Elective, and ECHE 320 or equivalent.

### Minimum Course Grades
The Biomedical Engineering program requires that a grade of "C" or better be earned in each of the following courses: ENGL 101, MATH 141, MATH 142, MATH 241, MATH 242, BIOL 101, BIOL 101L, CHEM 111, CHEM 111L, CHEM 112, CHEM 112L, CHEM 333, CHEM 334, PHYS 211, PHYS 211L, BMEN 212, BMEN 240, BMEN 263, and BMEN 290.

## Admissions
### Entrance Requirements
Admission requirements and processes for freshman, transfer students, and former students seeking readmission are managed by the Office of Undergraduate Admissions (http://sc.edu/about/offices_and_divisions/undergraduate_admissions/).

Transfer applicants from regionally accredited colleges and universities must have a cumulative 2.75 GPA on a 4.00 scale to enter the College of Engineering and Computing. In addition, transfer applicants for the Aerospace Engineering, Biomedical Engineering, Chemical Engineering, Civil Engineering, Computer Engineering, Electrical Engineering, or Mechanical Engineering majors must also have completed a four-semester-hour calculus course equivalent to MATH 141 with a grade of "C" or better.

Current University of South Carolina students who wish to enter the College of Engineering and Computing, and former students seeking readmission, must have an institutional GPA of 2.50 or better on at least 15 hours earned at UofSC. In addition, such applicants for the Aerospace Engineering, Biomedical Engineering, Chemical Engineering, Civil Engineering, Computer Engineering, Electrical Engineering, or Mechanical Engineering majors must also have completed a four-semester-hour calculus course equivalent to MATH 141 with a grade of "C" or better.

### Degree Requirements (130-142 hours)
See College of Engineering and Computing (https://academicbulletins.sc.edu/undergraduate/engineering-computing/) for progression requirements and special academic opportunities.

### Program of Study

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Carolina Core Requirements</td>
<td>34-46</td>
</tr>
<tr>
<td>2. College Requirements</td>
<td>0</td>
</tr>
<tr>
<td>3. Program Requirements</td>
<td>48</td>
</tr>
<tr>
<td>4. Major Requirements</td>
<td>48</td>
</tr>
</tbody>
</table>

### Founding Documents Requirement
All undergraduate students must take a 3-credit course or its equivalent with a passing grade in the subject areas of History, Political Science, or African American Studies that covers the founding documents including the United States Constitution, the Declaration of Independence, the Emancipation Proclamation and one or more documents that are foundational to the African American Freedom struggle, and a minimum of five essays from the Federalist papers. This course may count as a requirement in any part of the program of study including the Carolina Core, the major, minor or cognate, or as a general elective. Courses that meet this requirement are listed here (https://academicbulletins.sc.edu/undergraduate/founding-document-courses/).

### 1. Carolina Core Requirements (34-46 hours)

**CMW – Effective, Engaged, and Persuasive Communication: Written (6 hours)**

- ENGL 101 must be passed with a grade of C or higher
- ENGL 102
ARP – Analytical Reasoning and Problem Solving (8 hours)
*must be passed with a grade of C or higher

- MATH 141
- MATH 142

SCI – Scientific Literacy (8 hours)
*must be passed with a grade of C or higher

- BIOL 101
- BIOL 101L
- CHEM 111
- CHEM 111L

GFL – Global Citizenship and Multicultural Understanding: Foreign Language (0-6 hours)
Score two or better on foreign language placement test; or complete the 109 and 110 courses in FREN, GERM, LATN or SPAN; or complete the 121 course in another foreign language.

- CC-GFL courses (https://academicbulletins.sc.edu/undergraduate/carolina-core-courses/)

GHS – Global Citizenship and Multicultural Understanding: Historical Thinking (3 hours)

- any CC-GHS course (https://academicbulletins.sc.edu/undergraduate/carolina-core-courses/)

GSS – Global Citizenship and Multicultural Understanding: Social Sciences (3 hours)

- any CC-GSS course (https://academicbulletins.sc.edu/undergraduate/carolina-core-courses/)

AIU – Aesthetic and Interpretive Understanding (3 hours)

- any CC-AIU course (https://academicbulletins.sc.edu/undergraduate/carolina-core-courses/)

CMS – Effective, Engaged, and Persuasive Communication: Spoken Component 1 (0-3 hours)

- any overlay or stand-alone CC-CMS course (https://academicbulletins.sc.edu/undergraduate/carolina-core-courses/)

INF – Information Literacy 1 (0-3 hours)

- any overlay or stand-alone CC-INF course (https://academicbulletins.sc.edu/undergraduate/carolina-core-courses/)

VSR – Values, Ethics, and Social Responsibility 1 (0-3 hours)

- any overlay or stand-alone CC-VSR course (https://academicbulletins.sc.edu/undergraduate/carolina-core-courses/)

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### 2. College Requirements (0 hours)

No college-required courses for this program.

### 3. Program Requirements (48 hours)

#### Supporting Courses (48 hours)

#### Foundational Courses (33 hours)

Complete all of the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 112</td>
<td>General Chemistry II (must be passed with a grade of C or higher)</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 112L</td>
<td>General Chemistry II Lab (must be passed with a grade of C or higher)</td>
<td>1</td>
</tr>
<tr>
<td>CHEM 333</td>
<td>Organic Chemistry I (must be passed with a grade of C or higher)</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 334</td>
<td>Organic Chemistry II (must be passed with a grade of C or higher)</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 550</td>
<td>Biochemistry</td>
<td>3</td>
</tr>
<tr>
<td>or BIOL 541</td>
<td>Biochemistry</td>
<td></td>
</tr>
<tr>
<td>MATH 241</td>
<td>Vector Calculus (must be passed with a grade of C or higher)</td>
<td>3</td>
</tr>
<tr>
<td>MATH 242</td>
<td>Elementary Differential Equations (must be passed with a grade of C or higher)</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 211</td>
<td>Essentials of Physics I (must be passed with a grade of C or higher)</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 211L</td>
<td>Essentials of Physics I Lab (must be passed with a grade of C or higher)</td>
<td>1</td>
</tr>
<tr>
<td>PHYS 212</td>
<td>Essentials of Physics II</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 212L</td>
<td>Essentials of Physics II Lab</td>
<td>1</td>
</tr>
<tr>
<td>STAT 509</td>
<td>Statistics for Engineers</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Select one of the following:</td>
<td></td>
</tr>
<tr>
<td>ECHE 320</td>
<td>Chemical Engineering Fluid Mechanics</td>
<td>3</td>
</tr>
<tr>
<td>ENCP 360</td>
<td>Fluid Mechanics</td>
<td></td>
</tr>
<tr>
<td>EMCH 360</td>
<td>Fluid Mechanics</td>
<td></td>
</tr>
</tbody>
</table>

**Total Credit Hours** 33

#### Biomedical Engineering Electives (6 hours)

Students must take 6 credit hours of Biomedical Engineering electives. Of these 6 credit hours, at most 3 credit hours may come from BMEN 499. Undergraduate courses that may be used to satisfy this requirement are listed below. In addition, BMEN courses numbered 700 and above may be used to satisfy this requirement, provided the student is admitted to an Accelerated Bachelor's/Graduate Program.

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMWN 342</td>
<td>Infectious Disease &amp; Immunology for Biomedical Engineers</td>
<td>3</td>
</tr>
<tr>
<td>BMWN 346</td>
<td>Medical Microbiology for Biomedical Engineers</td>
<td>3</td>
</tr>
<tr>
<td>BMWN 389</td>
<td>Special Topics in Biomedical Engineering for Undergraduates</td>
<td>1-3</td>
</tr>
<tr>
<td>BMWN 392</td>
<td>Fundamentals of Biochemical Engineering</td>
<td>3</td>
</tr>
<tr>
<td>BMWN 499</td>
<td>Independent Research</td>
<td>1-3</td>
</tr>
<tr>
<td>BMWN 532</td>
<td>Micro/nanofluids and Lab-on-a-Chip</td>
<td>3</td>
</tr>
<tr>
<td>BMWN 537</td>
<td>Bio Nano/Micro Electro-Mechanical Systems</td>
<td>3</td>
</tr>
<tr>
<td>BMWN 546</td>
<td>Delivery of Bioactive Agents</td>
<td>3</td>
</tr>
<tr>
<td>BMWN 547</td>
<td>Immunoengineering</td>
<td>3</td>
</tr>
</tbody>
</table>

1 Carolina Core Stand Alone or Overlay Eligible Requirements – Overlay-approved courses offer students the option of meeting two Carolina Core components in a single course. A maximum of two overlays is allowed. The total Carolina Core credit hours for this program must add up to a minimum of 34 hours.
Biomedical Engineering Electives, all Engineering Electives and the Engineering office and on its website. Technical Electives include all of acceptable technical electives is maintained in the Biomedical Engineering. Students must take 6 credit hours of technical electives. A listing of acceptable technical electives is maintained in the Biomedical Engineering Program within the Biomedical Engineering Program may be satisfied by any CSCE course at a 200 level and above, as well as any ECHE, ELCT, or EMCH course at a 300 level and above with the following exceptions: CSCE 205, ECHE 310, ECHE 320 and EMCH 360.

Additionally, all courses approved as Biomedical Engineering Electives may be used as an Engineering Elective.

**Engineering Elective (3 hours)**

Students must take 3 credit hours of engineering electives. The engineering elective within the Biomedical Engineering Program may be satisfied by any CSCE course at a 200 level and above, as well as any ECHE, ELCT, or EMCH course at a 300 level and above with the following exceptions: CSCE 205, ECHE 310, ECHE 320 and EMCH 360.

**Technical Electives (6 hours)**

Students must take 6 credit hours of technical electives. A listing of acceptable technical electives is maintained in the Biomedical Engineering office and on its website. Technical Electives include all Biomedical Engineering Electives, all Engineering Electives and the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 102</td>
<td>Biological Principles II</td>
<td>3</td>
</tr>
<tr>
<td>BIOL 102L</td>
<td>Biological Principles II Laboratory</td>
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</tr>
<tr>
<td>BIOL 250</td>
<td>Microbiology</td>
<td>3</td>
</tr>
<tr>
<td>BIOL 250L</td>
<td>Microbiology Laboratory</td>
<td>1</td>
</tr>
<tr>
<td>BIOL 270</td>
<td>Introduction to Environmental Biology</td>
<td>3</td>
</tr>
<tr>
<td>BIOL 270L</td>
<td>Introduction to Environmental Biology Laboratory</td>
<td>1</td>
</tr>
<tr>
<td>BIOL 301</td>
<td>Ecology and Evolution</td>
<td>3</td>
</tr>
<tr>
<td>BIOL 302L</td>
<td>Cell and Molecular Biology Laboratory</td>
<td>1</td>
</tr>
<tr>
<td>BIOL 303</td>
<td>Fundamental Genetics</td>
<td>3</td>
</tr>
<tr>
<td>BIOL 415</td>
<td>Comparative Vertebrate Anatomy</td>
<td>4</td>
</tr>
<tr>
<td>BIOL 460</td>
<td>Advanced Human Physiology</td>
<td>3</td>
</tr>
<tr>
<td>BIOL 505</td>
<td>Developmental Biology</td>
<td>3</td>
</tr>
<tr>
<td>BIOL 530</td>
<td>Histology</td>
<td>4</td>
</tr>
<tr>
<td>BIOL 531/ENHS 661/EPID 661</td>
<td>Parasitology</td>
<td>4</td>
</tr>
<tr>
<td>BIOL 534</td>
<td>Animal Behavior</td>
<td>3</td>
</tr>
<tr>
<td>BIOL 541L</td>
<td>Biochemistry Laboratory</td>
<td>1</td>
</tr>
<tr>
<td>or CHEM 550L</td>
<td>Biochemistry Laboratory</td>
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</tr>
<tr>
<td>BIOL 553</td>
<td>Genomics</td>
<td>3</td>
</tr>
<tr>
<td>BIOL 610</td>
<td>Hallmarks of Cancer</td>
<td>3</td>
</tr>
<tr>
<td>BIOL 612</td>
<td>Virology - Classical and Emerging Concepts</td>
<td>3</td>
</tr>
<tr>
<td>BIOL 620</td>
<td>Immunobiology</td>
<td>3</td>
</tr>
<tr>
<td>BIOL 625</td>
<td>Neurophysiology</td>
<td>4</td>
</tr>
<tr>
<td>BIOL 635</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>BIOL 653</td>
<td>Bioinformatics</td>
<td>3</td>
</tr>
<tr>
<td>BIOL 655</td>
<td>Biotechnology</td>
<td>3</td>
</tr>
<tr>
<td>BIOL 656</td>
<td>Experimental Biotechnology</td>
<td>4</td>
</tr>
<tr>
<td>BIOL 662</td>
<td>Signal Transduction and Pathogenesis</td>
<td>3</td>
</tr>
<tr>
<td>BMEN 548</td>
<td>Cardiovascular System: From Development to Disease</td>
<td>3</td>
</tr>
<tr>
<td>BMEN 565</td>
<td>Advanced Biomechanics</td>
<td>3</td>
</tr>
<tr>
<td>BMEN 572</td>
<td>Tissue Engineering</td>
<td>3</td>
</tr>
<tr>
<td>BMEN 575</td>
<td>Engineering of Soft Materials</td>
<td>3</td>
</tr>
<tr>
<td>BMEN 589</td>
<td>Special Topics in Biomedical Engineering</td>
<td>1-3</td>
</tr>
<tr>
<td>ECHE 430</td>
<td>Chemical Engineering Kinetics</td>
<td>3</td>
</tr>
<tr>
<td>EMCH 580</td>
<td>Mechanics of Solid Biomaterials</td>
<td>3</td>
</tr>
<tr>
<td>EXSC 335</td>
<td>Biomechanics of Human Movement</td>
<td>3</td>
</tr>
</tbody>
</table>

**Course** | **Title** | **Credits** |
<table>
<thead>
<tr>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>BIOL 665</td>
<td>Human Molecular Genetics</td>
<td>3</td>
</tr>
<tr>
<td>BIOL 667</td>
<td>Molecular and Genetic Mechanisms of Disease Pathogenesis</td>
<td>3</td>
</tr>
<tr>
<td>BIOL 690</td>
<td>Ultramicroscopy</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 321</td>
<td>Quantitative Analysis</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 321L</td>
<td>Quantitative Analysis Laboratory</td>
<td>1</td>
</tr>
<tr>
<td>CHEM 322</td>
<td>Analytical Chemistry</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 331L</td>
<td>Essentials of Organic Chemistry Laboratory I</td>
<td>1</td>
</tr>
<tr>
<td>or CHEM 333L</td>
<td>Comprehensive Organic Chemistry Laboratory I</td>
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</tr>
<tr>
<td>CHEM 332L</td>
<td>Essentials of Organic Chemistry Laboratory II</td>
<td>1</td>
</tr>
<tr>
<td>or CHEM 333L</td>
<td>Comprehensive Organic Chemistry Laboratory I</td>
<td></td>
</tr>
<tr>
<td>CHEM 340</td>
<td>Elementary Biophysical Chemistry</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 541</td>
<td>Physical Chemistry</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 542</td>
<td>Physical Chemistry</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 545</td>
<td>Physical Biochemistry</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 550L</td>
<td>Biochemistry Laboratory</td>
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</tr>
<tr>
<td>EXSC 330</td>
<td>Exercise Physiology</td>
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</tr>
<tr>
<td>EXSC 562</td>
<td>Impairments of the Human Motor System</td>
<td>3</td>
</tr>
<tr>
<td>MATH 344</td>
<td>Applied Linear Algebra</td>
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<tr>
<td>or MATH 526</td>
<td>Numerical Linear Algebra</td>
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<tr>
<td>MATH 374</td>
<td>Discrete Structures</td>
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</tr>
<tr>
<td>MATH 520</td>
<td>Ordinary Differential Equations</td>
<td>3</td>
</tr>
<tr>
<td>MATH 524</td>
<td>Nonlinear Optimization</td>
<td>3</td>
</tr>
<tr>
<td>MATH 544</td>
<td>Linear Algebra</td>
<td>3</td>
</tr>
<tr>
<td>MATH 546</td>
<td>Algebraic Structures I</td>
<td>3</td>
</tr>
<tr>
<td>MATH 547</td>
<td>Algebraic Structures II</td>
<td>3</td>
</tr>
<tr>
<td>MATH 550</td>
<td>Vector Analysis</td>
<td>3</td>
</tr>
<tr>
<td>MATH 552</td>
<td>Applied Complex Variables</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 515</td>
<td>Mathematical Physics I</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 516</td>
<td>Mathematical Physics II</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 517</td>
<td>Computational Physics</td>
<td>3</td>
</tr>
<tr>
<td>STAT 516</td>
<td>Statistical Methods II</td>
<td>3</td>
</tr>
<tr>
<td>STAT 518</td>
<td>Nonparametric Statistical Methods</td>
<td>3</td>
</tr>
<tr>
<td>STAT 519</td>
<td>Sampling</td>
<td>3</td>
</tr>
<tr>
<td>STAT/MGSC 520</td>
<td>Forecasting and Time Series</td>
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<tr>
<td>STAT 523</td>
<td>Financial Mathematics II</td>
<td>3</td>
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<tr>
<td>STAT/MGSC 525</td>
<td>Statistical Quality Control</td>
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<tr>
<td>STAT 528</td>
<td>Environmental Statistics</td>
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</tr>
<tr>
<td>STAT 530</td>
<td>Applied Multivariate Statistics and Data Mining</td>
<td>3</td>
</tr>
<tr>
<td>STAT/CSCE 582</td>
<td>Bayesian Networks and Decision Graphs</td>
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<tr>
<td>EMCH 111</td>
<td>Introduction to Computer-Aided Design</td>
<td>3</td>
</tr>
<tr>
<td>CSCE 145</td>
<td>Algorithmic Design I</td>
<td>4</td>
</tr>
<tr>
<td>MGMT 371</td>
<td>Principles of Management</td>
<td>3</td>
</tr>
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</table>

**4. Major Requirements (48 hours)**

**Major Courses (48 hours)**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMEN 101</td>
<td>Introduction to Biomedical Engineering</td>
<td>3</td>
</tr>
<tr>
<td>BMEN 212</td>
<td>Fundamentals of Biomedical Systems (must be passed with a grade of C or higher)</td>
<td>3</td>
</tr>
</tbody>
</table>
### Major Map

A major map is a layout of required courses in a given program of study, including critical courses and suggested course sequences to ensure a clear path to graduation.

Major maps are only a suggested or recommended sequence of courses required in a program of study. Please contact your academic advisor for assistance in the application of specific coursework to a program of study and course selection and planning for upcoming semesters.

**Biomedical Engineering, B.S.**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMEN 240</td>
<td>Cellular and Molecular Biology with Engineering Applications (must be passed with a grade of C or higher)</td>
<td>4</td>
</tr>
<tr>
<td>BMEN 263</td>
<td>Introduction to Biomechanics (must be passed with a grade of C or higher)</td>
<td>3</td>
</tr>
<tr>
<td>BMEN 271</td>
<td>Introduction to Biomaterials</td>
<td>3</td>
</tr>
<tr>
<td>BMEN 290</td>
<td>Thermodynamics of Biomolecular Systems (must be passed with a grade of C or higher)</td>
<td>3</td>
</tr>
<tr>
<td>BMEN 302</td>
<td>Professional Development and Ethics in Biomedical Engineering</td>
<td>2</td>
</tr>
<tr>
<td>BMEN 321</td>
<td>Biomonitoring and Electrophysiology</td>
<td>3</td>
</tr>
<tr>
<td>BMEN 345</td>
<td>Human Anatomy and Physiology for Biomedical Engineers</td>
<td>4</td>
</tr>
<tr>
<td>BMEN 354</td>
<td>Biotransport</td>
<td>3</td>
</tr>
<tr>
<td>BMEN 363</td>
<td>Biomedical Instrumentation</td>
<td>3</td>
</tr>
<tr>
<td>BMEN 381</td>
<td>Biomedical Engineering Laboratory I</td>
<td>2</td>
</tr>
<tr>
<td>BMEN 382</td>
<td>Biomedical Engineering Laboratory II</td>
<td>2</td>
</tr>
<tr>
<td>BMEN 391</td>
<td>Kinetics in Biomolecular Systems</td>
<td>3</td>
</tr>
<tr>
<td>BMEN 411</td>
<td>Modeling and Simulation of Biomedical Systems</td>
<td>3</td>
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<tr>
<td>BMEN 427</td>
<td>Senior Biomedical Engineering Design I</td>
<td>3</td>
</tr>
<tr>
<td>BMEN 428</td>
<td>Senior Biomedical Engineering Design II</td>
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</tr>
</tbody>
</table>

**Total Credit Hours** 48