BIOMEDICAL ENGINEERING - BACHELOR OF SCIENCE (BSBM)

Biomedical engineering is an exciting, multidisciplinary field that lies at the interface of medicine, biology and engineering. Biomedical engineers use engineering principles to analyze and solve problems in biology and medicine, providing an overall enhancement to healthcare. Biomedical engineers create technology to save lives and improve the quality of life. Much of the equipment in hospitals and clinics across the globe was designed, built and tested by biomedical engineers. At the same time, biomedical engineers employ concepts learned from biology and medicine to generate new (biomimetic) engineering designs in fields such as robotics and artificial intelligence.

Course code for this program is BMEN.

Requirements
Prerequisites and Passing Grades
The minimum passing grade for a course that is a prerequisite or corequisite for another required course is C- (see exception below). If a grade of D+ or lower is received in a course which is a prerequisite to another, the student may not register for the subsequent course and must be repeated until a grade of C- or higher is achieved.

The minimum passing grade for Mechanical Engineering (MCEN) courses in the Biomedical Engineering curriculum that are a prerequisite or corequisite for another required course is a C. If a grade of C- or lower is received in a course which is a prerequisite to another, the student may not register for the subsequent course and must be repeated until a grade of C- or higher is achieved.

The minimum passing grade for a course that is not specifically a prerequisite or corequisite for another required course is D-.

The biomedical engineering program reserves the right to drop students enrolled in BMEN courses who have not met the minimum prerequisite requirements. It is the student's responsibility to communicate with the program if summer coursework and/or transfer credit will be used to meet the prerequisite requirement.

Required Courses and Credits
Required courses in engineering, physical science, and mathematics are interwoven throughout the curriculum to provide a balanced education in the fundamentals of the biomedical engineering profession. The core courses are complemented by technical electives, humanities and social sciences electives (https://www.colorado.edu/engineering-advising/get-your-degree/degree-requirements/humanities-social-sciences-and-writing-requirements/), free electives, and a writing course (https://www.colorado.edu/engineering-advising/get-your-degree/degree-requirements/humanities-social-sciences-and-writing-requirements/), for a total of 128 credits required for the degree.

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>BMEN 1000</td>
<td>Exploring Biomedical Engineering</td>
<td>1</td>
</tr>
<tr>
<td>or AREN 1316</td>
<td>Introduction to Architectural Engineering</td>
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<tr>
<td>or MATH 1300</td>
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<tr>
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<tr>
<td>or MATH 2130</td>
<td>Introduction to Linear Algebra for Non-Mathematics Majors</td>
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<tr>
<td>&amp; MATH 3430</td>
<td>and Ordinary Differential Equations</td>
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Technical Electives
Choose 15 credit hours of technical elective coursework (at least 12 must be upper-division- 6 of which must be BME-Approved Engineering technical electives).

Required Mathematics Courses

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2 For more information, see the College of Engineering & Applied Science (https://www.colorado.edu/engineering-advising/get-your-degree/degree-requirements/humanities-social-sciences-and-writing-requirements/) website.

## Optional Program Tracks

Two distinct tracks are offered for students preparing for medical school:

- **Pre-medical track biomechanics option** ([https://www.colorado.edu/bme/academics/bachelors-program/advising-curriculum/#pre_med_biomechanics_track_sample_curriculum-287](https://www.colorado.edu/bme/academics/bachelors-program/advising-curriculum/#pre_med_biomechanics_track_sample_curriculum-287)): For students interested in going to medical school and are interested in human motion, performance, disabilities, prosthetics or orthopedics.

- **Pre-medical track bioinstrumentation option** ([https://www.colorado.edu/bme/academics/bachelors-program/advising-curriculum/#pre_med_bioinstrumentation_track_sample_curriculum-287](https://www.colorado.edu/bme/academics/bachelors-program/advising-curriculum/#pre_med_bioinstrumentation_track_sample_curriculum-287)): For students interested in going to medical school and are interested in medical devices, such as biosensors and imaging systems, or robotic surgical tools.

## Premedical Biomechanics Track

For more information, including curriculum requirements, visit the program’s Advising & Curriculum ([https://www.colorado.edu/bme/academics/bachelors-program/advising-curriculum/](https://www.colorado.edu/bme/academics/bachelors-program/advising-curriculum/)) webpage.

### Code 
### Title 
### Credit 

#### Required Biomedical Courses

- **BMEN 1000**: Exploring Biomedical Engineering  
  or **AREN 1316**: Introduction to Architectural Engineering  
  or **ASON 1000**: Introduction to Aerospace Engineering Sciences  
  or **CHEN 1300**: Introduction to Chemical Engineering  
  or **CSCI 1000**: Computer Science as a Field of Work and Study  
  or **CVEN 1317**: Introduction to Civil and Environmental Engineering  
  or **ECEN 1100**: Exploring ECE  
  or **EVEN 1000**: Introduction to Environmental Engineering  

- **BMEN 1025**: Computer-Aided Design & Fabrication  
  or **MCEN 1025**: Computer-Aided Design and Fabrication  

- **BMEN 2000**: Introduction to Biomedical Engineering  
  or **BMEN 2010**: Biomaterials  
  or **BMEN 3010**: Biotransport  

- **BMEN 4010**: Biomedical Engineering Capstone Design I  
  or **BMEN 4020**: Biomedical Engineering Capstone Design II  

- **BMEN 4117**: Anatomy and Physiology for Biomedical Engineering  
  or **MCEN 4117**: Anatomy and Physiology for Engineers  
  or **IPHY 3410**: Human Anatomy  
  & **IPHY 3430**: Human Physiology  

#### Required Mechanics Courses

- **MCEN 2023**: Statics and Structures  
  or **GEEN 2851**: Statics for Engineers  
  or **CVEN 2121**: Analytical Mechanics I  

- **MCEN 2063**: Mechanics of Solids  

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| Code     | Title                                      | Credit 
|----------|--------------------------------------------|--------
| BMEN 1000 | Exploring Biomedical Engineering           | 1      
| AREN 1316 | Introduction to Architectural Engineering  |        
| ASON 1000 | Introduction to Aerospace Engineering Sciences |      
| CHEN 1300 | Introduction to Chemical Engineering       |        
| CSCI 1000 | Computer Science as a Field of Work and Study |     
| CVEN 1317 | Introduction to Civil and Environmental Engineering |     
| ECEN 1100 | Exploring ECE                              |        
| EVEN 1000 | Introduction to Environmental Engineering  |        
| BMEN 1025 | Computer-Aided Design & Fabrication        | 4      
| MCEN 1025 | Computer-Aided Design and Fabrication      |        
| BMEN 2000 | Introduction to Biomedical Engineering     | 3      
| BMEN 2010 | Biomaterials                               | 3      
| BMEN 3010 | Biotransport                               | 3      
| BMEN 4010 | Biomedical Engineering Capstone Design I   | 3      
| BMEN 4020 | Biomedical Engineering Capstone Design II  | 3      
| BMEN 4117 | Anatomy and Physiology for Biomedical Engineering |  
| MCEN 4117 | Anatomy and Physiology for Engineers       |        
| I PHY 3410 | Human Anatomy                             | 3      
| I PHY 3430 | Human Physiology                          | 3      

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1. Choose from the course options listed on the program’s Advising & Curriculum webpage.

2. For more information, see the College of Engineering & Applied Science (https://www.colorado.edu/engineering-advising/get-your-degree/degree-requirements/humanities-social-sciences-and-writing-requirements/) website.
CHEN 2810
 Required Biology Courses

BCHM 4611
 Required Mathematics Courses

APPM 2350
 or MATH 2400
 Calculus 3

APPM 2360
 Introduction to Differential Equations

 Required Physics Course

PHYS 1110
 General Physics 1

 or PHYS 1115
 General Physics 1 for Majors

PHYS 1120
 General Physics 2

 or PHYS 1125
 General Physics 2 for Majors

PHYS 1140
 Experimental Physics 1

 Required Computing Courses

CHEN 1310
 Introduction to Engineering Computing

or CSCI 1300
 Computer Science 1: Starting Computing

or ASEN 1320
 Aerospace Computing and Engineering Applications

or ECEN 1310
 C Programming for ECE

Humanities, Social Sciences and Writing

Complete the college's humanities, social sciences and writing requirement as specified 2

Free Electives

Choose at least 2 credit hours of free electives to meet the minimum 128 credit hours required for the bachelor's degree.

Total Credit Hours 128

1. Visit the program’s Advising & Curriculum webpage for options.
2. For more information, see the College of Engineering & Applied Science website.

Premedical Bioinstrumentation Track

For more information, including curriculum requirements, visit the program's Advising & Curriculum (https://www.colorado.edu/bme/academics/bachelors-program/advising-curriculum/) webpage.

Code

Required Biomedical Courses

BMEN 1000
 Exploring Biomedical Engineering

or AREN 1316
 Introduction to Architectural Engineering

or ASEN 1000
 Introduction to Aerospace Engineering Sciences

or CHEN 1300
 Introduction to Chemical Engineering

or CSCI 1000
 Computer Science as a Field of Work and Study

or CVEN 1317
 Introduction to Civil and Environmental Engineering

or ECEN 1100
 Exploring ECE

or EVEN 1000
 Introduction to Environmental Engineering

BMEN 1025
 Computer-Aided Design & Fabrication

or MCEN 1025
 Computer-Aided Design & Fabrication

BMEN 2000
 Introduction to Biomedical Engineering

BMEN 2010
 Biomaterials

BMEN 3010
 Biomechanics

BMEN 3030
 Bioinstrumentation

BMEN 4010
 Biomedical Engineering Capstone Design

BMEN 4020
 Biomedical Engineering Capstone Design

Required Electrical Courses

ECEN 2250
 Introduction to Circuits and Electronics

or ECEN 3010
 Circuits and Electronics for Mechanical Engineers

or GEEN 3010
 Circuits for Engineers

ECEN 2260
 Circuits as Systems

ECEN 2270
 Electronics Design Lab

ECEN 3300
 Linear Systems

or ECEN 3310
 Linear Systems
Technical Electives
Choose 9 credit hours of technical elective coursework (at least 6 must be upper-division- 3 of which must be BME-Approved Engineering technical electives.)

Required Mathematics Courses
APPM 1350 Calculus 1 for Engineers 4
or MATH 1300 Calculus 1
or APPM 1345 Calculus 1 with Algebra, Part B
APPM 1360 Calculus 2 for Engineers 4
or MATH 2300 Calculus 2
APPM 2350 Calculus 3 for Engineers 4
or MATH 2400 Calculus 3
APPM 2360 Introduction to Differential Equations with Linear Algebra 4
or MATH 2130 & MATH 3430 Introduction to Linear Algebra for Non-Mathematics Majors and Ordinary Differential Equations
or MATH 2135 & MATH 3430 Introduction to Linear Algebra for Mathematics Majors and Ordinary Differential Equations

CHEN 3010 Applied Data Analysis 3
or STAT 4000 Statistical Methods and Application I
or GEEN 3853 Data Analysis for Engineers
or MCEN 3047 Data Analysis and Experimental Methods

Required Physics Courses
PHYS 1110 General Physics 1 4
or PHYS 1115 General Physics 1 for Majors
PHYS 1120 General Physics 2 4
or PHYS 1125 General Physics 2 for Majors
PHYS 1140 Experimental Physics 1 1

Required Chemistry Courses
CHEN 1201 General Chemistry for Engineers 1 4
or CHEM 1113 General Chemistry 1
or CHEN 1211 Accelerated Chemistry for Engineers
CHEM 1114 Laboratory in General Chemistry 1 1
or CHEM 1221 Engineering General Chemistry Lab
CHEM 1133 General Chemistry 2 4
CHEM 1134 Laboratory in General Chemistry 2 1
CHEM 3311 Organic Chemistry 1 4
CHEM 3321 Laboratory in Organic Chemistry 1 1
CHEM 3331 Organic Chemistry 2 4
CHEM 3341 Laboratory in Organic Chemistry 2 1

Required Biochemistry Course
BCHM 4611 Principles of Biochemistry 3

Required Biology Courses
CHEN 2810 Biology for Engineers 3
or MCDB 1150 Introduction to Cellular and Molecular Biology
or EBIO 1210 & EBIO 1220 General Biology 1 and General Biology 2
MCDB 1161 From Dirt to DNA: Phage Genomics Laboratory I 2
MCDB 2150 Principles of Genetics 3
MCDB 2161 From DNA to Genes, Phage Genomics Laboratory II 2

Required Computing Courses
CHEN 1310 Introduction to Engineering Computing 3
or CSCI 1300 Computer Science 1: Starting Computing
or ASEN 1320 Aerospace Computing and Engineering Applications
or ECEN 1310 C Programming for ECE

Humanities, Social Sciences and Writing
Complete the college's humanities, social sciences and writing requirement as specified

Free Electives
Choose at least 2 credit hours of free electives to meet the minimum 128 credit hours required for the bachelor's degree.

Total Credit Hours 128

1 Choose from the course options listed on the program's Advising & Curriculum webpage.
2 For more information, see the College of Engineering & Applied Science website.

Plan(s) of Study

Year One
Fall Semester
VMEN 1025 Computer-Aided Design & Fabrication 4
APPM 1350 Calculus 1 for Engineers 4
CHEN 1201 General Chemistry for Engineers 1 4
Humansities or Social Science Elective 3

Credit Hours 15

Spring Semester
BMEN 1000 Exploring Biomedical Engineering 1
APPM 1360 Calculus 2 for Engineers 4
CHEN 1203 General Chemistry for Engineers 2 2
CHEM 1221 Engineering General Chemistry Lab 1
CHEN 1310 Introduction to Engineering Computing 3
PHYS 1110 General Physics 1 4

Credit Hours 15

Year Two
Fall Semester
BMEN 2000 Introduction to Biomedical Engineering 3
APPM 2350 Calculus 3 for Engineers 4
CHEN 2810 Biophysics for Engineers 3
PHYS 1120 General Physics 2 4
 Humanities or Social Science Elective 3

Credit Hours 15

Spring Semester
BMEN 2010 Biomaterials 3
APPM 2360 Introduction to Differential Equations with Linear Algebra 4
ECEN 2250 Introduction to Circuits and Electronics 3
MCEN 2023 Statics and Structures 3
PHYS 1140 Experimental Physics 1 1
Humansities or Social Science Elective 3

Credit Hours 17
### Year Three

#### Fall Semester
- **BMEN 3010** Biotransport 3
- **ECEN 2260** Circuits as Systems 3
- **ECEN 2270** Electronics Design Lab 3
- **MCEN 2063** Mechanics of Solids 3
- **Technical Elective** 3

<table>
<thead>
<tr>
<th>Credit Hours</th>
<th>15</th>
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</table>

#### Spring Semester
- **BMEN 3030** Bioinstrumentation 3
- **MCEN 4133** Intro to Tissue Biomechanics 3
- **ECEN 3300** Linear Systems 3
- **Technical Elective** 3
- **Humanities or Social Sciences Elective** 3

<table>
<thead>
<tr>
<th>Credit Hours</th>
<th>18</th>
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</table>

#### Year Four

#### Fall Semester
- **BMEN 4010** Biomedical Engineering Capstone Design I 3
- **BMEN 4117** Anatomy and Physiology for Biomedical Engineering 3
- **CHEN 3010** Applied Data Analysis 3
- **Technical Elective** 3
- **College-Approved Writing Course** 3

<table>
<thead>
<tr>
<th>Credit Hours</th>
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</table>

#### Spring Semester
- **BMEN 4020** Biomedical Engineering Capstone Design II 3
- **Technical Elective** 3
- **Technical Elective** 3
- **Humanities or Social Sciences Elective** 3
- **Free Elective** 3

<table>
<thead>
<tr>
<th>Credit Hours</th>
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</thead>
</table>

| Total Credit Hours | 128 |

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### Premedical Biomechanics Track

#### Year One

#### Fall Semester
- **BMEN 1025** Computer-Aided Design & Fabrication 4
- **APPM 1350** Calculus 1 for Engineers 4
- **CHEN 1201** General Chemistry for Engineers 1 4
- **CHEM 1114** Laboratory in General Chemistry 1 1
- **Humanities or Social Sciences Elective** 3

<table>
<thead>
<tr>
<th>Credit Hours</th>
<th>16</th>
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</thead>
</table>

#### Spring Semester
- **BMEN 1000** Exploring Biomedical Engineering 1
- **APPM 1360** Calculus 2 for Engineers 4
- **CHEN 1133** General Chemistry 2 4
- **CHEM 1134** Laboratory in General Chemistry 2 1
- **CHEN 1310** Introduction to Engineering Computing 3
- **PHYS 1110** General Physics 1 4

| Credit Hours | 17 |

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#### Year Two

#### Fall Semester
- **BMEN 2000** Introduction to Biomedical Engineering 3
- **APPM 2350** Calculus 3 for Engineers 4
- **CHEN 2810** Biology for Engineers 3
- **PHYS 1120** General Physics 2 4
- **PHYS 1140** Experimental Physics 1 1
- **Humanities or Social Sciences Elective** 3

| Credit Hours | 18 |

#### Spring Semester
- **BMEN 2010** Biomaterials 3
- **APPM 2360** Introduction to Differential Equations with Linear Algebra 4
- **CHEM 3311** Organic Chemistry 1 4
- **CHEM 3321** Laboratory in Organic Chemistry 1 1
- **MCDB 1161** From Dirt to DNA: Phage Genomics Laboratory I 2
- **MCEN 2023** Statics and Structures 3

| Credit Hours | 17 |

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### Year Three

#### Fall Semester
- **BMEN 3010** Biotransport 3
- **CHEM 3331** Organic Chemistry 2 4
- **CHEM 3341** Laboratory in Organic Chemistry 2 1
- **MCEN 2063** Mechanics of Solids 3
- **Technical Elective** 3

| Credit Hours | 14 |

#### Spring Semester
- **MCDB 2150** Principles of Genetics 3
- **MCDB 2161** From DNA to Genes, Phage Genomics Laboratory II 2
- **MCEN 4133** Intro to Tissue Biomechanics 3
- **Humanities or Social Sciences Elective** 3
- **Humanities or Social Science Elective** 3

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1. Students may choose courses from the list of college-approved humanities and social sciences (HSS) electives (http://www.colorado.edu/engineering/academics/policies/hss/). (https://www.colorado.edu/bme/academics/bachelors-program/advising-curriculum/#pre_med_biomechanics_track_sample_curriculum-287)

2. Students may choose a course from the list of college-approved writing courses (http://www.colorado.edu/engineering/academics/policies/hss/). (https://www.colorado.edu/engineering-advising/get-your-degree/degree-requirements/humanities-social-sciences-and-writing-requirements/)

3. Nominal curriculum requires a total of 15 Technical Electives, of which at least 12 must be upper-division and include at least 6 Upper-Division BME-Approved Engineering Technical Elective credits. Visit the program’s Advising & Curriculum webpage for options.
**Biomedical Engineering - Bachelor of Science (BSBM)**

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<td>Anatomy and Physiology for Biomedical Engineering</td>
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<tr>
<td>Technical Elective</td>
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<tr>
<td>College-Approved Writing Course</td>
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<tr>
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<th>Credit Hours</th>
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<tbody>
<tr>
<td>BMEN 4020</td>
<td>Biomedical Engineering Capstone Design II</td>
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<tr>
<td>BCHM 4611</td>
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**Total Credit Hours** 128

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1 Students may choose courses from the list of college-approved humanities and social sciences (HSS) electives.

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**Premedical Bioinstrumentation Track**

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<td>BMEN 1025</td>
<td>Computer-Aided Design &amp; Fabrication</td>
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<tr>
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<td>Calculus 1 for Engineers</td>
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<tr>
<td>CHEN 1201</td>
<td>General Chemistry for Engineers</td>
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<td>CHEM 1114</td>
<td>Laboratory in General Chemistry I</td>
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<tr>
<td>Humanities or Social Science Elective</td>
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<tr>
<td>CHEM 1133</td>
<td>General Chemistry 2</td>
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<td>CHEM 1134</td>
<td>Laboratory in General Chemistry 2</td>
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<tr>
<td>CHEN 1310</td>
<td>Introduction to Engineering Computing</td>
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<tr>
<td>PHYS 1110</td>
<td>General Physics 1</td>
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<tr>
<td>BMEN 2000</td>
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</tr>
<tr>
<td>APPM 2350</td>
<td>Calculus 3 for Engineers</td>
</tr>
<tr>
<td>CHEN 2810</td>
<td>Biology for Engineers</td>
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<tr>
<td><strong>Credit Hours</strong></td>
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**Spring Semester**

| CHEN 3010 | Applied Data Analysis | 3 |
| MCDB 2161 | From DNA to Genes, Phage Genomics Laboratory II | 2 |
| Technical Elective | 3 |
| Humanities or Social Science Elective | 3 |
| Free Electives | 3 |
| **Credit Hours** | 14 |

**Total Credit Hours** 128

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1 Students may choose courses from the list of college-approved humanities and social sciences (HSS) electives.
Students may choose a course from the list of college-approved writing courses.

Pre-Med Bioinstrumentation requires a total of 9 technical electives (at least 6 must be upper-division, 3 of which must be BME-Approved Engineering technical electives). Visit the program’s Advising & Curriculum webpage for options.

Learning Outcomes

Program Educational Objectives

The Biomedical Engineering Program at CU Boulder is dedicated to preparing our graduating students for the following achievements within 5–10 years of receiving their undergraduate degrees:

• Professional employment in areas such as the medical device industry, engineering consulting, biomechanics, bioinstrumentation, biomedical imaging, and biotechnology, with promotions and increasing levels of leadership and responsibility over time.
• Completion of graduate studies in biomedical engineering or related fields, with subsequent employment and success in academy, industry, or related professions.
• Completion of medical, veterinary, dental or other professional school, with subsequent success in residency, clinical practice and/or other professional employment.

Learning Outcomes

• Identify, formulate and solve complex engineering problems by applying principles of engineering, science and mathematics.
• 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.
• Communicate effectively with a range of audiences.
• 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.
• Function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks and meet objectives.
• Develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.
• Acquire and apply new knowledge as needed, using appropriate learning strategies.

Biomedical Engineering Specific Criteria

• Applying principles of engineering, biology, human physiology, chemistry, calculus-based physics, mathematics (through differential equations) and statistics.
• Solving biomedical engineering problems, including those associated with the interaction between living and non-living systems.
• Analyzing, modeling, designing and realizing biomedical engineering devices, systems, components or processes.
• Making measurements on and interpreting data from living systems.