

# BIOLOGICAL ENGINEERING - BACHELOR OF SCIENCE (BSBE)

Vaccine, therapeutic and antimicrobials development. Genome-engineering for gene therapy and pharmaceutical applications. Tissue engineering directing tissue growth for regenerating cartilage and cardiac muscle using stem cells. Quantum dots for imaging and therapeutics. Nanomaterials for labs-on-a-chip diagnostics. Polymers for drug delivery and in vivo imaging (e.g., detecting cancer). Synthetic biology to redesign organisms for useful purposes. Immunoengineering to create tools which investigate and change the immune system.

Biological engineers at CU Boulder learn the skills necessary to work on these cutting-edge technologies and more. Learn from world-class faculty leveraging innovative, award-winning education practices and hands-on lab experiences. Join the ranks of engineers making an impact in these life-saving fields!

## Requirements

### Prerequisites and Passing Grades

Unless otherwise specified, minimum passing grades for all courses that are prerequisites for other required courses is C-. 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 until the first grade has been raised to a C- or higher. In addition biological engineering and/or CHEN core courses taken in a student's senior year also require a minimum grade of C-, even though they are not prerequisites.

Unless specified otherwise, the minimum passing grade for a course that is not specifically a prerequisite for another required course is D-.

Students may be dropped from courses if they do not meet the minimum prerequisite grade requirements. It is the student's responsibility to communicate with the department if summer coursework and/or transfer credit will be used to meet the prerequisite requirement.

### Course Requirements

#### Required Engineering Courses

A total of 128 credit hours is required.

Code	Title	Credit Hours
CHEN 1310	Introduction to Engineering Computing	3
CHEN 2120	Chemical Engineering Material and Energy Balances	3
BIEN 2810	Biology for Engineers	3
or MCDB 1150	Introduction to Cellular and Molecular Biology	
or EBIO 1220	General Biology 2	
CHEN 3010	Applied Data Analysis	3
CHEN 3200	Chemical Engineering Fluid Mechanics	3
or MCEN 3021	Fluid Mechanics	
CHEN 3210	Chemical Engineering Heat and Mass Transfer	4
CHEN 3320	Chemical Engineering Thermodynamics	3
BIEN 3800	Fundamentals of Biotechnology	3

or MCDB 2150	Principles of Genetics	
CHEN 4090	Undergraduate Seminar	1
BIEN 4520	Biological Process and Product Design	3
CHEN 4521	Physical Chemistry for Engineers	3
BIEN 4530	Biological Engineering Design Project	2
BIEN 4805		3
BIEN 4810		3
or BIEN 4010 & BIEN 4020	Biological Engineering Senior Thesis 1 and Biological Engineering Senior Thesis 2	
BIEN 4820		3
BIEN 4830	Biokinetics and Reactor Design	3
<b>Focus Technical Electives</b>		<b>3</b>
Choose one of the following:		
BIEN 4801	Pharmaceutical Biotechnology	
BIEN 4802	Tissue Engineering	
BIEN 4803	Metabolic Engineering	
BIEN 4804		
BIEN 4806	Immunoengineering	
BIEN 4838	Special Topics in Biological Engineering	

#### Required Mathematics Courses

Code	Title	Credit Hours
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	

#### Required Science Courses

Code	Title	Credit Hours
CHEM 1221	Engineering General Chemistry Lab	1
or CHEM 1134	Laboratory in General Chemistry 2	
CHEN 1201	General Chemistry for Engineers 1 (If a student completes CHEN 1211 instead of CHEN 1201 & CHEN 1203, then student must complete 2 additional credits as Free Electives)	4
or CHEN 1211	Accelerated Chemistry for Engineers	
CHEN 1203	General Chemistry for Engineers 2 (If a student completes CHEN 1211 instead of CHEN 1201 & CHEN 1203, then student must complete 2 additional credits as Free Electives)	2
or CHEN 1211	Accelerated Chemistry for Engineers	

or CHEM 1133	General Chemistry 2	
BCHM 4611	Principles of Biochemistry	3
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
PHYS 1110	General Physics 1	4
or PHYS 1115	General Physics 1 for Majors	

### Humanities, Social Sciences and Writing

Complete the College's Humanities, Social Sciences, and Writing requirements (<https://www.colorado.edu/engineering-advising/get-your-degree/degree-requirements/humanities-social-sciences-and-writing-requirements/>) (18 credits total).

### Technical Electives

General Technical Electives must meet specific requirements (9 credits total). Visit the department's Current Students (<http://www.colorado.edu/chbe/academics/undergraduate-program/current-students/>) webpage and consult the current advising guide.

### Free Electives

3 credits of Free Electives allowed.

## Modified Pathways

### Premed Path

This path is offered for students preparing for medical school. Since biological engineering already requires most of the premed courses, it is a logical choice for students who desire an engineering degree and the opportunity to pursue a medical profession. For information on the premed path, visit the department's current students (<http://www.colorado.edu/chbe/academics/undergraduate-program/current-students/>) webpage and consult the current advising guide.

## Recommended Four-Year Plan of Study

### Year One

Fall Semester		Credit Hours
APPM 1350	Calculus 1 for Engineers	4
CHEM 1201	General Chemistry for Engineers 1	4
CHEM 1300	Introduction to Chemical and Biological Engineering (Optional 1-Credit Technical Elective) <sup>1</sup>	1
CHEM 1310	Introduction to Engineering Computing	3
COEN 1830	Special Topics (Engineering First-Year Seminar)	1
Humanities or Social Science Elective <sup>2</sup>		2
<b>Credit Hours</b>		<b>14</b>
Spring Semester		Credit Hours
APPM 1360	Calculus 2 for Engineers	4
CHEM 1221	Engineering General Chemistry Lab	1
CHEM 1203	General Chemistry for Engineers 2	2
BIEN 2810	Biology for Engineers	3
PHYS 1110	General Physics 1	4
Humanities or Social Science Elective <sup>2</sup>		3
<b>Credit Hours</b>		<b>17</b>

### Year Two

Fall Semester		Credit Hours
APPM 2350	Calculus 3 for Engineers	4
CHEM 3311	Organic Chemistry 1	4
CHEM 3321	Laboratory in Organic Chemistry 1	1
CHEM 2120	Chemical Engineering Material and Energy Balances	3
BIEN 3800 or MCDB 2150	Fundamentals of Biotechnology or Principles of Genetics	3
Free Elective <sup>3</sup>		3
<b>Credit Hours</b>		<b>18</b>

### Spring Semester

APPM 2360	Introduction to Differential Equations with Linear Algebra	4
CHEM 3331	Organic Chemistry 2	4
CHEM 3341	Laboratory in Organic Chemistry 2	1
CHEM 3200	Chemical Engineering Fluid Mechanics	3
CHEM 4090	Undergraduate Seminar	1
CHEM 4521	Physical Chemistry for Engineers	3
<b>Credit Hours</b>		<b>16</b>

### Year Three

Fall Semester		Credit Hours
CHEM 3010	Applied Data Analysis	3
CHEM 3210	Chemical Engineering Heat and Mass Transfer	4
CHEM 3320	Chemical Engineering Thermodynamics	3
College-Approved Writing Course <sup>4</sup>		3
Humanities or Social Science Elective <sup>2</sup>		3
<b>Credit Hours</b>		<b>16</b>

### Spring Semester

BCHM 4611	Principles of Biochemistry	3
BIEN 4820		3
BIEN 4805		3
BIEN 4830	Biokinetics and Reactor Design	3
Technical Elective <sup>1,3</sup>		3
Humanities or Social Science Elective <sup>2</sup>		3
<b>Credit Hours</b>		<b>18</b>

### Year Four

Fall Semester		Credit Hours
BIEN 4520	Biological Process and Product Design	3
BIEN 4810		3
BIEN/CHEM Technical Elective <sup>5</sup>		3
Technical Electives <sup>1,3</sup>		6
<b>Credit Hours</b>		<b>15</b>
Spring Semester		Credit Hours
BIEN 4530	Biological Engineering Design Project	2
BIEN/CHEM Technical Elective <sup>5</sup>		3
Technical Elective <sup>1,3</sup>		3
Focus Technical Elective <sup>6</sup>		3
Humanities or Social Science Elective <sup>2</sup>		3
<b>Credit Hours</b>		<b>14</b>
<b>Total Credit Hours</b>		<b>128</b>

- <sup>1</sup> CHEN 1300 is an optional Engineering Technical Elective. If it is taken, one of the Technical Elective courses in this Plan of Study will only require 2 credits (instead of 3 credits).
- <sup>2</sup> Students may choose courses from the list of college-approved humanities and social sciences (HSS) electives (<https://www.colorado.edu/engineering-advising/get-your-degree/degree-requirements/humanities-social-sciences-and-writing-requirements/>).
- <sup>3</sup> General Technical Electives and Free Electives must meet specific requirements. Visit the department's Current Students (<http://www.colorado.edu/chbe/academics/undergraduate-program/current-students/>) webpage and consult the current advising guide.
- <sup>4</sup> Students may choose a course from the list of college-approved writing courses (<https://www.colorado.edu/engineering-advising/get-your-degree/degree-requirements/humanities-social-sciences-and-writing-requirements/>).
- <sup>5</sup> BIEN/CHEN Technical Electives can be any BIEN or CHEN 3000+ course.
- <sup>6</sup> Focus Technical Electives can be any BIEN 4000+ course. These courses will be taught in alternating years and should be taken in the junior or senior year as available.

## Learning Outcomes

### Program Educational Objectives

The department prepares graduates to make significant contributions in many diverse areas. Specifically, within a few years of graduation our graduates will have achieved one or more of the following attributes:

- In their chosen field, be established in a professional career, be pursuing an advanced degree or be seeking advanced certification.
- Be recognized as academic, industrial or entrepreneurial leaders.
- Be successfully working and contributing in a variety of technical fields.
- Be adapting to new technologies and changing professional environments.

### Student Outcomes

Upon graduation, students are expected to be able to:

- 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.

## Bachelor's–Accelerated Master's Degree Program(s)

The bachelor's–accelerated master's (BAM) degree program options offer currently enrolled CU Boulder undergraduate students the opportunity to receive a bachelor's and master's degree in a shorter period of time. Students receive the bachelor's degree first but begin taking graduate coursework as undergraduates (typically in their senior year).

Because some courses are allowed to double count for both the bachelor's and the master's degrees, students receive a master's degree in less time and at a lower cost than if they were to enroll in a stand-alone master's degree program after completion of their baccalaureate degree. In addition, staying at CU Boulder to pursue a bachelor's–accelerated master's program enables students to continue working with their established faculty mentors.

### BS in Biological Engineering, MS in Chemical Engineering

#### Admissions Requirements

In order to gain admission to the BAM program named above, a student must meet the following criteria:

- Have a cumulative GPA of 3.000 or higher.
- Have a minimum GPA of 3.0 in CHEN coursework.
- Have completed CHEN 2120, CHEN 3200, CHEN 3210, CHEN 3320 and CHEN 3010 prerequisite courses with grades of B- in each course.
- Have at least junior class standing.
- Provide a one-page statement of purpose. The statement should describe briefly your past work in the field, including non-course educational experiences, teaching, or other relevant employment, publication, theses, research in progress, other scholarly activities, and your plans for graduate study and a professional career.
- GRE.
- Provide an unofficial transcript.

#### Program Requirements

Students may take up to and including 12 credit hours while in the undergraduate program which can later be used toward the master's degree. However, only six credit hours may be double counted toward the bachelor's degree and the master's degree. Students must apply to graduate with the bachelor's degree, and apply to continue with the master's degree, early in the semester in which the undergraduate requirements will be completed.

### BS in Biological Engineering, Professional MS in Materials Science

#### Admissions Requirements

In order to gain admission to the BAM program named above, a student must meet the following criteria:

- Have a cumulative GPA of 3.25 or higher.
- Completion of the following five CHEN core courses with a minimum grade of B- in each course: CHEN 2120, CHEN 3200, CHEN 3210, CHEN 3320 and CHEN 3010.
- Be enrolled in CHEN 4805.
- Provide an unofficial transcript.

Students with a GPA below 3.25 (but above 3.0, the university minimum standard) may submit a petition with a letter of recommendation from a

professor and a one-page statement of purpose. The statement should briefly describe the student's past work in the field, including any non-course educational experiences or other relevant employment, and the student's plans for graduate study and a professional career.

### **Program Requirements**

Students must declare a track in which to specialize. Students may take up to and including 12 hours while in the undergraduate program that satisfy the specialized track courses and/or the breadth elective courses, which can later be used toward the master's degree. However, only six credit hours may be double counted toward the bachelor's degree and the master's degree. Students must apply to graduate with the bachelor's degree, and apply to continue with the master's degree, early in the semester in which the undergraduate requirements will be completed.

Please see the BAM degree program (<https://www.colorado.edu/chbe/undergraduate-program/undergraduate-opportunities/>) webpage for more information.