BIOMEDICAL ENGINEERING, B.S.

Begin Campus: Any Penn State Campus
End Campus: University Park

Program Description
The Biomedical Engineering curriculum emphasizes the continuous integration of classical and modern engineering principles with the life sciences and health care. Biomedical Engineers apply these skills to innovation in the health care industry, basic biological sciences, and the underpinning of medical practice.

Consistent with the mission of Penn State University and the College of Engineering, the Penn State Bachelor of Science program in Biomedical Engineering aims to create world-class engineers who, after graduation, contribute to social and economic development through the application of engineering to the solution of problems in medicine and biology.

What is Biomedical Engineering?
Biomedical engineering is the application of the life sciences, mathematics, and engineering principals to define and solve problems in biology, medicine, healthcare, and other related fields. Biomedical engineers work to design, create, and improve medical devices such as prosthetics, artificial organs and medical imaging devices. They also develop instrumentation, medical information systems, and health management and care delivery systems to improve health care organizations. Many graduates of the biomedical engineering Bachelor of Science program also go on to pursue advanced degrees in medicine, engineering and related fields such as biostatistics, public health, and health administration.

You Might Like This Program If...
- You like applying traditional engineering skills and analysis to understand biological systems.
- You want to emphasize the integration of classical and modern engineering principles with the life sciences and healthcare.
- You are passionate about bridging the gap between medical professionals and the engineering community.

Entrance to Major
This program currently has administrative enrollment controls. Administrative Enrollment Controls are initiated when limitations of space, faculty, or other resources in a major prevent accommodating all students who request them. Students must follow the administrative enrollment controls that are in effect for the semester that they enter the university.

First-Year Students Entering Summer 2019, Fall 2019, Spring 2020
In order to be eligible for entrance to this major, students must satisfy the following requirements:

- 40-59 graded Penn State credits (excludes transfer and AP credits)
- completed with a grade of C or better: CHEM 110, MATH 140, MATH 141, MATH 250 or MATH 251, PHYS 211, PHYS 212
- earned a minimum cumulative grade-point average (GPA) of 3.20

Students Who Entered Prior to Summer 2019
Students who entered the University during Summer 2018, Fall 2018, and Spring 2019 should view the administrative enrollment controls in the archived 2018-19 Undergraduate Bulletin (http://bulletins.psu.edu/archive/2018-19/undergraduate/general-information/academic-information/#administrativeenrollmentcontrolstext). Students who entered the University prior to the summer 2018 semester should view the administrative enrollment controls for the semester that they entered the university (http://advising.psu.edu/entrance-major-requirements) on the Academic Advising Portal.

Degree Requirements
For the Bachelor of Science degree in Biomedical Engineering, a minimum of 130-131 credits are required:

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Education</td>
<td>45</td>
</tr>
<tr>
<td>Requirements for the Major</td>
<td>112-113</td>
</tr>
</tbody>
</table>

27 of the 45 credits for General Education are included in the Requirements for the Major. This includes: 9 credits of GN courses; 6 credits of GQ courses; 3 credits of GS courses; 9 credits of GWS courses.

Students in residence at the Commonwealth campuses may satisfy the course requirements for semesters 1-3. They should then transfer to University Park to begin studies in their major beginning with semester 4.

General Education
Connecting career and curiosity, the General Education curriculum provides the opportunity for students to acquire transferable skills necessary to be successful in the future and to thrive while living in interconnected contexts. General Education aids students in developing intellectual curiosity, a strengthened ability to think, and a deeper sense of aesthetic appreciation. These are requirements for all baccalaureate students and are often partially incorporated into the requirements of a program. For additional information, see the General Education Requirements (http://bulletins.psu.edu/undergraduate/general-education/baccalaureate-degree-general-education-program) section of the Bulletin and consult your academic adviser.

The keystone symbol appears next to the title of any course that is designated as a General Education course. Program requirements may also satisfy General Education requirements and vary for each program.

Foundations (grade of C or better is required.)
- Quantification (GQ): 6 credits
- Writing and Speaking (GWS): 9 credits

Knowledge Domains
- Arts (GA): 6 credits
- Health and Wellness (GHW): 3 credits
- Humanities (GH): 6 credits
- Social and Behavioral Sciences (GS): 6 credits
- Natural Sciences (GN): 9 credits
Integrative Studies (may also complete a Knowledge Domain requirement)
- Inter-Domain or Approved Linked Courses: 6 credits

University Degree Requirements

First Year Engagement
All students enrolled in a college or the Division of Undergraduate Studies at University Park, and the World Campus are required to take 1 to 3 credits of the First-Year Seminar, as specified by their college First-Year Engagement Plan.

Other Penn State colleges and campuses may require the First-Year Seminar; colleges and campuses that do not require a First-Year Seminar provide students with a first-year engagement experience.

First-year baccalaureate students entering Penn State should consult their academic adviser for these requirements.

Cultures Requirement
6 credits are required and may satisfy other requirements
- United States Cultures: 3 credits
- International Cultures: 3 credits

Writing Across the Curriculum
3 credits required from the college of graduation and likely prescribed as part of major requirements.

Total Minimum Credits
A minimum of 120 degree credits must be earned for a baccalaureate degree. The requirements for some programs may exceed 120 credits. Students should consult with their college or department adviser for information on specific credit requirements.

Quality of Work
Candidates must complete the degree requirements for their major and earn at least a 2.00 grade-point average for all courses completed within their degree program.

Limitations on Source and Time for Credit Acquisition
The college dean or campus chancellor and program faculty may require up to 24 credits of course work in the major to be taken at the location or in the college or program where the degree is earned. Credit used toward degree programs may need to be earned from a particular source or within time constraints (see Senate Policy 83-80 (http://senate.psu.edu/policies-and-rules-for-undergraduate-students/82-00-and-83-00-degree-requirements/#83-80)). For more information, check the Suggested Academic Plan for your intended program.

Requirements for the Major
To graduate, a student enrolled in the major must earn a grade of C or better in each course designated by the major as a C-required course, as specified by Senate Policy 82-44 (http://senate.psu.edu/policies-and-rules-for-undergraduate-students/82-00-and-83-00-degree-requirements/#82-44).

Common Requirements for the Major (All Options)

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>BME 303</td>
<td>Bio-continuum Mechanics</td>
<td>3</td>
</tr>
<tr>
<td>BME 403</td>
<td>Biomedical Instrumentation Laboratory</td>
<td>1</td>
</tr>
<tr>
<td>BME 429</td>
<td>Biomedical Mechanics and Techniques Laboratory</td>
<td>2</td>
</tr>
<tr>
<td>BME 440</td>
<td>Biomedical Engineering Professional Seminar</td>
<td>1</td>
</tr>
<tr>
<td>BME 450</td>
<td>Fundamentals of Cells and Molecules</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 111</td>
<td>Experimental Chemistry I</td>
<td>1</td>
</tr>
<tr>
<td>CHEM 112</td>
<td>Chemical Principles II</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 113</td>
<td>Experimental Chemistry II</td>
<td>1</td>
</tr>
<tr>
<td>EDSGN 100</td>
<td>Introduction to Engineering Design</td>
<td>3</td>
</tr>
<tr>
<td>EMCH 210</td>
<td>Statics and Strength of Materials</td>
<td>5</td>
</tr>
<tr>
<td>MATH 230</td>
<td>Calculus and Vector Analysis</td>
<td>4</td>
</tr>
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</table>

Prescribed Courses: Require a grade of C or better

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
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</thead>
<tbody>
<tr>
<td>BME 201</td>
<td>Fundamentals of Cells and Molecules</td>
<td>3</td>
</tr>
<tr>
<td>BME 301</td>
<td>Analysis of Physiological Systems</td>
<td>4</td>
</tr>
<tr>
<td>BME 313</td>
<td>Thermodynamics for Biomedical Engineering</td>
<td>3</td>
</tr>
<tr>
<td>BME 401</td>
<td>Numerical Simulations in Biomedical Engineering</td>
<td>3</td>
</tr>
<tr>
<td>BME 402</td>
<td>Biomedical Instrumentation and Measurements</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 110</td>
<td>Chemical Principles I</td>
<td>3</td>
</tr>
<tr>
<td>CMPSC 200</td>
<td>Programming for Engineers with MATLAB</td>
<td>3</td>
</tr>
<tr>
<td>ENGL 202C</td>
<td>Effective Writing: Technical Writing</td>
<td>3</td>
</tr>
<tr>
<td>MATH 140</td>
<td>Calculus With Analytic Geometry I</td>
<td>4</td>
</tr>
<tr>
<td>MATH 141</td>
<td>Calculus with Analytic Geometry II</td>
<td>4</td>
</tr>
<tr>
<td>MATH 251</td>
<td>Ordinary and Partial Differential Equations</td>
<td>4</td>
</tr>
<tr>
<td>PHYS 211</td>
<td>General Physics: Mechanics</td>
<td>4</td>
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<tr>
<td>PHYS 212</td>
<td>General Physics: Electricity and Magnetism</td>
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Additional Courses

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
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<tbody>
<tr>
<td>CAS 100A</td>
<td>Effective Speech</td>
<td>3</td>
</tr>
<tr>
<td>ECON 102</td>
<td>Introductory Microeconomic Analysis and Policy</td>
<td>3</td>
</tr>
<tr>
<td>ECON 104</td>
<td>Introductory Macroeconomic Analysis and Policy</td>
<td>3</td>
</tr>
<tr>
<td>ENGL 15</td>
<td>Rhetoric and Composition</td>
<td>3</td>
</tr>
<tr>
<td>ENGL 30</td>
<td>Honors Freshman Composition</td>
<td>3</td>
</tr>
<tr>
<td>CAS 100B</td>
<td>Effective Speech</td>
<td>3</td>
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Select one of the following:

<table>
<thead>
<tr>
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<th>Title</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>BIOL 141 &amp; BIOL 142</td>
<td>Introduction to Human Physiology and Physiology Laboratory</td>
<td>4</td>
</tr>
<tr>
<td>BIOL 141 &amp; BIOL 162</td>
<td>Introduction to Human Physiology and Human Anatomy and Physiology I - Laboratory</td>
<td>4</td>
</tr>
<tr>
<td>BIOL 141 &amp; BIOL 164</td>
<td>Introduction to Human Physiology and Human Anatomy and Physiology II - Laboratory</td>
<td>4</td>
</tr>
<tr>
<td>BIOL 240W</td>
<td>Biology: Function and Development of Organisms</td>
<td>4</td>
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</table>

Supporting Courses and Related Areas

Select 3 credits of Science or Engineering Elective courses from departmental list

Requirements for the Option

Biochemical Option (24 credits)

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BME 409</td>
<td>Biofluid Mechanics</td>
<td>3</td>
</tr>
<tr>
<td>BME 413</td>
<td>Mass Transport in Biological Systems</td>
<td>3</td>
</tr>
<tr>
<td>BME 423</td>
<td>Reaction Kinetics of Biological Systems</td>
<td>3</td>
</tr>
</tbody>
</table>

Additional Courses

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 202</td>
<td>Fundamentals of Organic Chemistry I</td>
<td>3</td>
</tr>
</tbody>
</table>
Program Educational Objectives

Three to five years after graduation, we expect our graduates to be:

- employed in industry and government positions which include, but are not limited to, research and development, regulation, manufacturing, quality assurance and sales and marketing, or,
- enrolled in graduate school, continuing education, or other professional development programs related to biomedical sciences and engineering, or,
- enrolled in medical school, dental school, or other health-related professional training programs.

Student Outcomes

Student outcomes describe what students are expected to know and be able to do by the time of graduation. The Biomedical Engineering program is designed to enable students to:

1. Identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
2. 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. Communicate effectively with a range of audiences
4. 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
5. Function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
6. Develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
7. Acquire and apply new knowledge as needed, using appropriate learning strategies.

Academic Advising

The objectives of the university's academic advising program are to help advisees identify and achieve their academic goals, to promote their intellectual discovery, and to encourage students to take advantage of both in-and-out-of-class educational opportunities in order that they become self-directed learners and decision makers.

Both advisers and advisees share responsibility for making the advising relationship succeed. By encouraging their advisees to become engaged in their education, to meet their educational goals, and to develop the habit of learning, advisers assume a significant educational role. The advisee's unit of enrollment will provide each advisee with a primary academic adviser, the information needed to plan the chosen program of study, and referrals to other specialized resources.

READ SENATE POLICY 32-00: ADVISING POLICY (http://senate.psu.edu/policies-and-rules-for-undergraduate-students/32-00-advising-policy)

University Park

Angela Hall
Undergraduate Program Assistant
122H Chemical and Biomedical Engineering Building
University Park, PA 16802
814-863-6614
ajh48@psu.edu
Suggested Academic Plan

The suggested academic plan(s) listed on this page are the plan(s) that are in effect during the 2019-20 academic year. To access previous years’ suggested academic plans, please visit the archive (http://bulletins.psu.edu/undergraduate/archive) to view the appropriate Undergraduate Bulletin edition (Note: the archive only contain suggested academic plans beginning with the 2018-19 edition of the Undergraduate Bulletin).

Biochemical Option - Ending at University Park Campus

The course series listed below provides only one of the many possible ways to move through this curriculum. The University may make changes in policies, procedures, educational offerings, and requirements at any time. This plan should be used in conjunction with your degree audit report. Please consult with a Penn State academic adviser on a regular basis to develop and refine an academic plan that is appropriate for you.

If you are starting at a campus other than the one this plan is ending at, please refer here:

http://advising.engr.psu.edu/degree-requirements/academic-plans-by-major.aspx

<table>
<thead>
<tr>
<th>First Year</th>
<th>Credits</th>
<th>Fall</th>
<th>Spring</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 110 (GN) †‡</td>
<td>3</td>
<td>CHEM 112 (GN)</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>CHEM 111 (GN)</td>
<td>1</td>
<td>CHEM 113 (GN)</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>EDSGN 100</td>
<td>3</td>
<td>MATH 141 or 141E (GQ) †‡</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>MATH 140 or 140E (GQ) †‡</td>
<td>4</td>
<td>PHYS 211 (GN, PHYSICS 211L &amp; PHYSICS 211R) †‡</td>
<td>4</td>
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</tr>
<tr>
<td>BME 100 (or First Year Seminar) †</td>
<td>1</td>
<td>ENGL 15, 30, or ESL 15 (GWS) †‡</td>
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</tr>
<tr>
<td>ECON 102 or 104 (GS) †</td>
<td>3</td>
<td>General Education Course †</td>
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<tr>
<td><strong>Total Credits</strong></td>
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<td><strong>18</strong></td>
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<table>
<thead>
<tr>
<th>Second Year</th>
<th>Credits</th>
<th>Fall</th>
<th>Spring</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 141*</td>
<td>3</td>
<td>BME 201*</td>
<td>3</td>
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</tr>
<tr>
<td>BIOL 142†</td>
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<td>CHEM 202 or 210</td>
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<td>EMCH 210</td>
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<td>CMPSC 200</td>
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<td></td>
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<tr>
<td>MATH 251†</td>
<td>4</td>
<td>MATH 230</td>
<td>4</td>
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<tr>
<td>PHYS 212 (PHYSICS 212L &amp; PHYSICS 212R) †‡</td>
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<td>General Education Course †</td>
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<tr>
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<table>
<thead>
<tr>
<th>Third Year</th>
<th>Credits</th>
<th>Fall</th>
<th>Spring</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>BME 301*</td>
<td>4</td>
<td>BME 401*</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>BME 303†</td>
<td>3</td>
<td>BME 402†</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>BME 313‡</td>
<td>3</td>
<td>BME 403</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Related Technical Elective</td>
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<td>BME 409</td>
<td>3</td>
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</tr>
<tr>
<td>General Education Course †</td>
<td>3</td>
<td>BME 413</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>ENGL 202C (GWS) †‡</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td><strong>Total Credits</strong></td>
<td><strong>16</strong></td>
<td><strong>16</strong></td>
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<table>
<thead>
<tr>
<th>Fourth Year</th>
<th>Credits</th>
<th>Fall</th>
<th>Spring</th>
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</thead>
<tbody>
<tr>
<td>BME 429</td>
<td>2</td>
<td>BME 423</td>
<td>3</td>
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<table>
<thead>
<tr>
<th><strong>Credits</strong></th>
<th><strong>Fall</strong></th>
<th><strong>Spring</strong></th>
<th><strong>Credits</strong></th>
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<tbody>
<tr>
<td>16.5</td>
<td>16.5</td>
<td></td>
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</tbody>
</table>

* Course requires a grade of C or better for the major
† Course requires a grade of C or better for General Education
‡ Course is an Entrance to Major requirement
†‡ Course satisfies General Education and degree requirement

University Requirements and General Education Notes:

US and IL are abbreviations used to designate courses that satisfy University Requirements (United States and International Cultures).

W, M, X, and Y are the suffixes at the end of a course number used to designate courses that satisfy University Writing Across the Curriculum requirement.

GWS, GQ, GHW, GN, GA, GH, and GS are abbreviations used to identify General Education program courses. General Education includes Foundations (GWS and GQ) and Knowledge Domains (GHW, GN, GA, GH, GS, and Integrative Studies). Foundations courses (GWS and GQ) require a grade of ‘C’ or better.

Integrative Studies courses are required for the General Education program. N is the suffix at the end of a course number used to designate an Inter-Domain course and Z is the suffix at the end of a course number used to designate a Linked course.

All incoming Schreyer Honors College first-year students at University Park will take ENGL/CAS 137 in the fall semester and ENGL/CAS 138 in the spring semester. These courses carry the GWS designation and replace both ENGL 30 and CAS 100. Each course is 3 credits.

College Note

Students who are interested in medical school should substitute BIOL 240 (4) for BIOL 141 (3) & BIOL 142 (1).

CHEM 210 is required for students who are interested in medical school or who plan to take advanced organic chemistry.

CMPSC 200 is required because 300- and 400-level BME courses use MATLAB programming.

The department website lists courses acceptable as Biochemical Electives, Medical Imaging and Device Electives, Biomaterials Electives, Biomechanics Electives, Related Electives, and Science or Engineering Electives.

Students who complete the ROTC Program may substitute 3 ROTC credits for the GHW requirement and 3 ROTC credits for a Science or Engineering Elective.
These courses offered at University Park in Fall semester ONLY:

- BME 301
- BME 303
- BME 313
- BME 440

These courses offered at University Park in Spring semester ONLY:

- BME 201
- BME 401
- BME 402
- BME 403
- BME 409
- BME 413
- BME 423

Biomaterials Option - Ending at University Park Campus

The course series listed below provides only one of the many possible ways to move through this curriculum. The University may make changes in policies, procedures, educational offerings, and requirements at any time. This plan should be used in conjunction with your degree audit (accessible in LionPATH as either an Academic Requirements or What If report). Please consult with a Penn State academic adviser on a regular basis to develop and refine an academic plan that is appropriate for you.

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<thead>
<tr>
<th>First Year</th>
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<th>Spring Credits</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CHEM 110 (GN) *†</td>
<td>3</td>
<td>CHEM 112 (GN)</td>
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<tr>
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<tr>
<td>BME 100 (or First Year Seminar) †</td>
<td>1 ENGL 15, 30, or ESL 15 (GWS) †</td>
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<tr>
<td>ECON 102 or 104 (GS) †</td>
<td>3 General Education Course †</td>
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<td></td>
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<th>Credits</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BIOL 141 *</td>
<td>3</td>
<td>BME 201 *</td>
<td>3</td>
</tr>
<tr>
<td>BIOL 142 †</td>
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<td>EMCH 210</td>
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<tr>
<td>MATH 251 †</td>
<td>4</td>
<td>MATH 230</td>
<td>4</td>
</tr>
<tr>
<td>PHYS 212 (PHYSICS 212L &amp; PHYSICS 212R) †</td>
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| General Education Course (GHW) † | 1.5 |

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• BME 301
• BME 303
• BME 313
• BME 429
• BME 440
• BME 443
• BME 446

These courses offered at University Park in spring semester only:

• BME 201
• BME 401
• BME 402
• BME 403
• BME 409
• BME 450

Biomechanics Option - Ending at University Park Campus

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First Year

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Second Year

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Third Year

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Fourth Year

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<td>Related Technical Elective</td>
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- BME 303
- BME 313
- BME 440

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- BME 401
- BME 402
- BME 403
- BME 409

**Medical Imaging & Devices Option - Ending at University Park Campus**

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<th>Course</th>
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<td>BME 100 (or First Year Seminar) $^*$</td>
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<td>3 MATH 141 or 141E (GQ) $^*$</td>
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- BME 402
- BME 403

**Career Paths**

**Careers**

Medical device development; diagnostic and therapeutic tool design; physiological system modeling for the healthcare and pharmaceutical industries; medical school.

MORE INFORMATION ABOUT POTENTIAL CAREER OPTIONS FOR GRADUATES OF THE BIOMEDICAL ENGINEERING PROGRAM (https://career.engr.psu.edu)

**Opportunities for Graduate Studies**

The biomedical engineering graduate program is a part of the Penn State Intercollege Graduate Degree Program in Bioengineering. The highly flexible, mentored curriculum includes fundamental coursework in bioengineering and a number of ancillary areas including physics, chemistry, biology, materials research, esthesiology, orthopedics and rehabilitation, and more. Our students enjoy state-of-the-art research facilities and an exclusive partnership with the Penn State Hershey Medical Center. The unique landscape of the bioengineering graduate program fosters learning and collaboration among students, engineers, clinicians, and professionals in the biomedical industry.

MORE INFORMATION ABOUT OPPORTUNITIES FOR GRADUATE STUDIES (https://www.bme.psu.edu/students/graduate)

**Professional Resources**

- Biomedical Engineering Society (http://www.bme.psu.edu/students/resources/student-groups.aspx)
- Biomedical Sciences Club

**Accreditation**

The baccalaureate program in Biomedical Engineering is accredited by the Engineering Accreditation Commission of ABET, www.abet.org (https://www.abet.org).

MORE INFORMATION ABOUT ABET ACCREDITATION (https://www.abet.org)

**Contact**

**University Park**

DEPARTMENT OF BIOMEDICAL ENGINEERING
122H Chemical and Biomedical Engineering Building
University Park, PA 16802
814-863-6614
ajh48@psu.edu

https://www.bme.psu.edu/index.aspx