Biomedical Engineering, B.S.Bm.E.

Degree Offered

• Bachelor of Science in Biomedical Engineering (B.S.Bm.E.)

Nature of the Program

The biomedical engineering discipline is among the fastest growing engineering disciplines due to the rapid advancement of medical technologies and treatment and diagnosis strategies; in fact, many are claiming this century as the one that will revolutionize the biological sciences. These advancements will provide immense benefits for society globally. The biomedical engineering curriculum is designed to give graduates a broad background in the areas of biomedical engineering, including biomaterials, biomechanics and biomedical imaging. Students have the ability to design a set of technical electives based on interest and career aspirations. The goal for these electives is to enhance a student’s knowledge in one or more of the focus areas so they can be prepared for graduate school, any professional school, or a job in a specific industry. The Bachelor of Science in Biomedical Engineering program is accredited by the Engineering Accreditation Commission of ABET, https://www.abet.org (https://www.abet.org/).

Program Educational Objectives

• Graduates will be engaged in their professional careers and/or post graduate training as demonstrated by their abilities to identify and solve important biomedical engineering problems, develop and implement new and valuable ideas with potential applications to healthcare, and to engage in lifelong learning opportunities.
• Graduates will be able to work competitively in diverse professional environments as demonstrated by their abilities to work on teams and independently, to provide leadership, and to communicate effectively to a variety of audiences.
• Graduates will behave professionally and ethically, be committed to responsible safety practices, and articulate the societal impact of their work.

Click here to view the Suggested Plan of Study (p. 4)

Curriculum in Biomedical Engineering

General Education Foundations

Please use this link to view a list of courses that meet each GEF requirement. (http://registrar.wvu.edu/gef/)

NOTE: Some major requirements will fulfill specific GEF requirements. Please see the curriculum requirements listed below for details on which GEFs you will need to select.

General Education Foundations

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>F1 - Composition &amp; Rhetoric</td>
<td>3-6</td>
</tr>
<tr>
<td>ENGL 101</td>
<td>Introduction to Composition and Rhetoric</td>
</tr>
<tr>
<td>&amp; ENGL 102</td>
<td>and Composition, Rhetoric, and Research</td>
</tr>
<tr>
<td>or ENGL 103</td>
<td>Accelerated Academic Writing</td>
</tr>
<tr>
<td>F2A/F2B - Science &amp; Technology</td>
<td>4-6</td>
</tr>
<tr>
<td>F3 - Math &amp; Quantitative Reasoning</td>
<td>3-4</td>
</tr>
<tr>
<td>F4 - Society &amp; Connections</td>
<td>3</td>
</tr>
<tr>
<td>F5 - Human Inquiry &amp; the Past</td>
<td>3</td>
</tr>
<tr>
<td>F6 - The Arts &amp; Creativity</td>
<td>3</td>
</tr>
<tr>
<td>F7 - Global Studies &amp; Diversity</td>
<td>3</td>
</tr>
<tr>
<td>F8 - Focus (may be satisfied by completion of a minor, double major, or dual degree)</td>
<td>9</td>
</tr>
<tr>
<td>Total Hours</td>
<td>31-37</td>
</tr>
</tbody>
</table>

Please note that not all of the GEF courses are offered at all campuses. Students should consult with their advisor or academic department regarding the GEF course offerings available at their campus.

Degree Requirements

Students must meet the following criteria to qualify for a Bachelor of Science in Biomedical Engineering degree:

• Complete a minimum of 130 credit hours
• Satisfy WVU's undergraduate degree requirements
• Satisfy Statler College's undergraduate degree requirements (http://catalog.wvu.edu/undergraduate/collegeofengineeringandmineralresources/#policiestext)
Biomedical Engineering, B.S.Bm.E.

- Complete all courses listed in the curriculum requirements with the required minimum grades
- Attain an overall grade point average of 2.25 or better
- Attain a WVU grade point average of 2.25 or better
- Attain a Statler grade point average of 2.25 or better
- A maximum of one math or science courses with a grade of D+, D, or D- may apply towards a Statler College degree
- Complete a survey regarding their academic and professional experiences at WVU, as well as post-graduation job placement or continuing education plans.

That Statler GPA is computed based on all work taken at WVU with a subject code within Statler College (BIOM, BMEG, CE, CHE, CPE, CS, CSEE, CYBE, EE, ENGR, IH&S, MAE, MINE, PDA, PNGE, SAFM, SENG) excluding ENGR 140, ENGR 150, and CS 101. The WVU GPA is computed based on all work taken at WVU. The Overall GPA is computed based on all work taken at WVU and transfer work.

## Curriculum Requirements

<table>
<thead>
<tr>
<th>University Requirements</th>
<th>19</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fundamentals of Engineering Requirements</td>
<td>5</td>
</tr>
<tr>
<td>Math and Science Requirements</td>
<td>48</td>
</tr>
<tr>
<td>Biomedical Engineering Program Requirements</td>
<td>58</td>
</tr>
<tr>
<td><strong>Total Hours</strong></td>
<td><strong>130</strong></td>
</tr>
</tbody>
</table>

### University Requirements

- General Education Foundations (GEF) 1, 2, 3, 4, 5, 6, 7, and 8 (31-37 Credits)
- Outstanding GEF Requirements 1, 4, 5, 6, and 7
- **ENGR 191** First-Year Seminar
- **Total Hours** 19

### Fundamentals of Engineering Requirements

- A minimum grade of C- is required in all Fundamentals of Engineering courses.

<table>
<thead>
<tr>
<th>ENGR 101</th>
<th>Engineering Problem Solving 1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHE 102</td>
<td>Introduction to Chemical Engineering</td>
<td>3</td>
</tr>
<tr>
<td>ENGR 102</td>
<td>Engineering Problem-Solving 2</td>
<td>3</td>
</tr>
<tr>
<td>ENGR 103</td>
<td>Introduction to Nanotechnology Design</td>
<td>3</td>
</tr>
<tr>
<td>MAE 102</td>
<td>Introduction to Mechanical and Aerospace Engineering Design</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total Hours</strong></td>
<td><strong>5</strong></td>
<td></td>
</tr>
</tbody>
</table>

### Math and Science Requirements

- A minimum grade of C- is required in all Math and Science courses.

Choose one of the following: 4

<table>
<thead>
<tr>
<th>BIOL 115 &amp; BIOL 116</th>
<th>Principles of Biology and Principles of Biology Laboratory (GEF 8)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 101 &amp; BIOL 102 &amp; BIOL 103 &amp; BIOL 104</td>
<td>General Biology 1 and General Biology 2 and General Biology Laboratory and General Biology Laboratory 1</td>
</tr>
<tr>
<td>BIOL 235 &amp; BMEG 236</td>
<td>Human Physiology and Quantitative Analysis in Human Physiology</td>
</tr>
<tr>
<td><strong>Choose one of the following (GEF 2B):</strong></td>
<td><strong>8</strong></td>
</tr>
<tr>
<td>Course Code</td>
<td>Course Title</td>
</tr>
<tr>
<td>-------------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>CHEM 117 &amp; 117L &amp; CHEM 118 &amp; CHEM 118L</td>
<td>Principles of Chemistry 1 and Principles of Chemistry 2 and Principles of Chemistry 2 - Laboratory</td>
</tr>
<tr>
<td>CHEM 233</td>
<td>Organic Chemistry 1</td>
</tr>
<tr>
<td>CHEM 235</td>
<td>Organic Chemistry Laboratory</td>
</tr>
<tr>
<td>Calculus I (GEF 3):</td>
<td>Calculus 1a with Precalculus and Calculus 1b with Precalculus</td>
</tr>
<tr>
<td>MATH 153 &amp; MATH 154</td>
<td>Calculus 1</td>
</tr>
<tr>
<td>MATH 155</td>
<td>Calculus 2 (GEF 8)</td>
</tr>
<tr>
<td>MATH 156</td>
<td>Multivariable Calculus</td>
</tr>
<tr>
<td>MATH 261</td>
<td>Elementary Differential Equations</td>
</tr>
<tr>
<td>PHYS 111</td>
<td>General Physics (GEF 8)</td>
</tr>
<tr>
<td>PHYS 112</td>
<td>General Physics</td>
</tr>
<tr>
<td>STAT 215 or IENG 213</td>
<td>Introduction to Probability and Statistics ^2</td>
</tr>
</tbody>
</table>

Total Hours: 48

### Biomedical Engineering Program Requirements

- **BMEG 201**: Introduction to Biomedical Engineering, 3 credits
- **BMEG 203**: Biomedical Engineering Seminar, 1 credit
- **BMEG 310**: Biomedical Imaging, 3 credits
- **BMEG 230**: Numerical Methods in Biomedical Engineering, 3 credits
- **BMEG 311**: Biomaterials, 3 credits
- **BMEG 315**: Transport Phenomena in Biological Systems, 4 credits
- **BMEG 340**: Biomechanics, 3 credits
- **BMEG 321**: Thermodynamics and Kinetics for Biomedical Engineering, 3 credits
- **BMEG 350**: Biomedical Engineering Laboratory, 2 credits
- **BMEG 420**: Biomedical Instrumentation, 3 credits
- **BMEG 421**: Biomedical Engineering Seminar and Journal Club, 1 credit
- **BMEG 455**: Biomedical Senior Design 1 (Fulfills Writing and Communication Skills Requirement), 4 credits
- **BMEG 456**: Biomedical Senior Design 2, 3 credits
- **EE 221**: Introduction to Electrical Engineering, 3 credits
- **EE 222**: Introduction to Electrical Engineering Laboratory, 1 credit

**Technical Electives (18 Credit Hours)**

Science Electives: Choose at least 6 credit hours from the following:

- AGBI 410: Introductory Biochemistry, 6 credits
- AGBI 411: Introductory Biochemistry Laboratory
- AGBI 412: Introduction to Biochemistry Wet Laboratory
- ATTR 218: Gross Anatomy Lab
- BIOC 339: Introduction to Biochemistry
- BIOL 107: Biotechnology and Society
- BIOL 219 & BIOL 220: The Living Cell and The Living Cell Laboratory
- BIOL 302: Biometry
- BIOL 324: Molecular Genetics
- BIOL 325: Molecular Genetics Laboratory
- BIOL 348: Neuroscience 1
- BIOL 349: Neuroscience 2
- CHEM 215 & 215L: Introductory Analytical Chemistry and Introductory Analytical Chemistry Laboratory
- CHEM 234: Organic Chemistry 2
CHEM 236  Organic Chemistry Laboratory 2  
CHEM 310  Instrumental Analysis  
CHEM 335  Methods of Structure Determination  
CHEM 341  Physical Chemistry: Brief Course  
CHEM 462  Biochemistry 2  
CHEM 464  Biochemistry 2 Laboratory  
CHPR 332  Safety Education Principles and Content  
FIS 314  Introduction to Microscopy  
PALM 205  Introduction to Human Anatomy  
PASS 319  Basic Human Anatomy  
PHIL 331  Health Care Ethics  
PHYS 211  Introduction to Mathematical Physics  
PHYS 314  Introductory Modern Physics  
PHYS 321  Optics  

Engineering Electives: Choose at least 9 credit hours from the following:  
BMEG 480  Cellular Machinery  
BMEG 481  Applied Bio-Molecular Modeling  
BMEG 482  Introduction to Tissue Engineering  
BMEG 497  Research  
BMEG 498  Honors Research  
CHE 366  Materials Science  
CHE 461  Polymer Science and Engineering  
CHE 462  Polymer Processing  
CHE 531  Mathematical Methods in Chemical Engineering  
CPE 271  Introduction to Digital Logic Design  
CS 111  Introduction to Data Structures  
EE 223  Electrical Circuits  
EE 251  Digital Electronics  
EE 327  Signals and Systems 1  
EE 328  Signals and Systems Laboratory  
EE 329  Signals and Systems 2  
EE 455  Introduction to Microfabrication  
EE 465  Introduction to Digital Image Processing  
EE 528  Biomedical Microdevices  
IENG 213  Engineering Statistics **  
IENG 360  Human Factors Engineering  
MAE 211  Mechatronics  
MAE 241  Statics  
MAE 242  Dynamics  
MAE 243  Mechanics of Materials  
MAE 343  Intermediate Mechanics of Materials  

Other Elective: Choose at least 3 credit hours from the Science or Engineering Electives  

Total Hours 58  

* Students can choose to take BIOL 117 & BIOL 118 in place of the BIOL 235 & BMEG 236 sequence. Students choosing this path are required to complete an additional credit hour to meet the minimum requirements of 130 total credit hours for the degree.  
** IENG 213 cannot fulfill both the statistics requirement and a technical elective.  

Suggested Plan of Study  

It is important for students to take courses in the order specified in the Plan of Study as much as possible; all prerequisites and concurrent requirements must be observed. A typical B.S.Bm.E degree program that completes degree requirements in four years is as follows.
### Major Learning Outcomes

**BIOMEDICAL ENGINEERING**

Upon graduation, all Bachelors of Science students in Biomedical Engineering will have:

1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
2. An 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. An ability to communicate effectively with a range of audiences
4. An 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
5. An 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
6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.
These outcomes are achieved via rigorous individual courses in all basic areas of biomedical engineering, the natural and life sciences, mathematics, humanities, and social sciences. A flexible electives program allows specialization in areas such as biochemistry, biomechanics, biomaterials, and bioelectronics.

The Chemical and Biomedical Engineering Department uses an outcomes-assessment plan for continuous program improvement. Course work and design projects, in conjunction with yearly interviews provide the measures of learning outcomes. These outcomes-assessment results provide feedback to the faculty to improve teaching and learning processes.

**Academic Policies**

1. Students completing the four 200-level courses (BMEG 201, BMEG 203, BMEG 230, BMEG 236) must attain a 2.25 grade-point average in order to enroll in the 300-level core BMEG courses. Students with a grade-point average greater than or equal to 2.00 can submit a formal appeal of this restriction to the department chair for evaluation by the chair, BMEG curriculum committee, and CBE academic standards committee. No appeals will be considered for students below a 2.00 grade-point average in the four BMEG 200-level courses.

2. Students completing the 300-level core BMEG courses must attain a 2.25 grade-point average in core BMEG courses (BMEG 201, BMEG 203, BMEG 230, BMEG 236, BMEG 310, BMEG 311, BMEG 315, BMEG 321, BMEG 340, and BMEG 350) in order to enroll in 400-level core BMEG courses. No appeals will be considered for students moving from the junior to senior level courses.

3. In order to receive a degree, students must attain a 2.25 grade-point average in all biomedical engineering courses, including biomedical engineering elective and special topics courses. In addition, students may only have a grade of D in three (3) biomedical engineering courses. If a biomedical engineering course is repeated, the last grade received will be used to determine the number of D grades on the transcript.

4. A grade of F in any prerequisite course for a core BMEG course disqualifies the student from taking that core course until the F has been removed.

5. Requests to transfer credit for core biomedical engineering courses must be submitted to the BMEG Undergraduate Curriculum Committee via email to statler-cbe-curriculum@mail.wvu.edu. The course syllabus has to submitted with the transfer request. Please see college guidelines for additional restrictions to transfer credit.

**BMEG 191. First-Year Seminar. 1-3 Hours.**

Engages students in active learning strategies that enable effective transition to college life at WVU. Students will explore school, college and university programs, policies and services relevant to academic success. Provides active learning activities that enable effective transition to the academic environment. Students examine school, college and university programs, policies and services.

**BMEG 201. Introduction to Biomedical Engineering. 3 Hours.**

PR: MATH 156 and CHEM 116 and BIOL 115. An introduction to biomedical engineering principles using foundational resources from molecular and cellular biology and physiology, and relating them to various sub-specialties of biomedical engineering. Concrete examples of applying engineering knowledge to solve problems related to human medicine as well as concrete examples of recent technological breakthroughs.

**BMEG 203. Biomedical Engineering Seminar. 1 Hour.**

PR or CONC: BMEG 201. Discussion of current aspects related to biomedical engineering including on-going research directions, technical, logistical and ethical issues.

**BMEG 230. Numerical Methods in Biomedical Engineering. 3 Hours.**

PR: BMEG 201 and PR or CONC: MATH 251 with a minimum grade of C-. Introduce the integrative set of computational problem solving tools important to biomedical engineers. Through the use of comprehensive homework exercises, relevant examples and extensive case studies, this course will integrate principles and techniques of numerical analysis into biomedical engineering concepts from cellular and molecular systems, to physiological and biomechanical phenomena and tissue systems.

**BMEG 236. Quantitative Analysis in Human Physiology. 2 Hours.**

PR: MATH 156 and CHEM 116 and (BIOL 115 or (BIOL 101 and BIOL 102 and BIOL 103 and BIOL 104)) with a minimum grade of C- in each. Integrate engineering tools and approaches for quantitative measurements related to human physiology, including neural, cardiovascular, respiratory, and muscular systems.

**BMEG 293. Special Topics. 1-6 Hours.**

PR: Consent. Investigation of topics not covered in regularly scheduled courses.

**BMEG 310. Biomedical Imaging. 3 Hours.**

PR: BIOL 117 or BIOL 235. Introduction to biomedical imaging technologies including x-ray planar radiography, computed tomography (CT), nuclear medicine, optical imaging, ultrasound (US) and magnetic resonance imaging (MRI). Focus on physical principles, instrumentation methods, and imaging-related algorithms; medical interpretation of images will also be included to give practical examples of the development and applications of medical imaging.

**BMEG 311. Biomaterials. 3 Hours.**

PR: BMEG 201 and (BIOL 235 or (BIOL 117 and PHYS 111)). Principles of materials science and cell biology underlying the design of medical implants and artificial organs. Properties of living tissue, biocompatibility of polymers, metals, and ceramics; implants for hard and soft tissue.
BMEG 315. Transport Phenomena in Biological Systems. 4 Hours.
PR: (BIOL 235 or BIOL 117) and MATH 261. Develop fundamental relationships for momentum and mass transfer from microscopic and macroscopic balance equations and the application to biological systems that include biochemical reactions, inter-phase transport, and transient phenomena.

BMEG 321. Thermodynamics and Kinetics for Biomedical Engineering. 3 Hours.
PR: BMEG 230 and CHEM 116. Development of thermodynamic principles and their application to biological and biophysical systems. Topics will include first and second law; phase and reaction equilibria, kinetic rate laws and macromolecular thermodynamics.

BMEG 340. Biomechanics. 3 Hours.
PR: (BMEG 201 or MAE 243) and PHYS 111. Introduction to the basic approach of biomechanics and application in musculoskeletal, bone and human motion mechanics problems. Includes kinematics to analyze human motion, biomechanics of bone and skeletal system and biomechanical behavior of fibers.

BMEG 350. Biomedical Engineering Laboratory. 2 Hours.
PR: BMEG 201 and (BIOL 235 or BIOL 117). Measurement and interpretation of data from tissue and materials in the areas of biomaterials, biomechanics, bionanotechnology, and biomedical imaging.

BMEG 393. Special Topics. 1-6 Hours.
PR: Consent. Investigation of topics not covered in regularly scheduled courses.

BMEG 420. Biomedical Instrumentation. 3 Hours.
PR: EE 221. Fundamentals of biomedical instrumentation and devices. Clinical applications of medical instrumentation, sensors, devices, biopotential electrodes and amplifiers, measurement of blood flow, different medical imaging systems, and therapeutic and prosthetic devices.

BMEG 421. Biomedical Engineering Seminar and Journal Club. 1 Hour.
PR: BMEG 203. Introduction to current research and topics pertinent to biomedical engineering through literature review and guest lectures by external and internal speakers.

BMEG 455. Biomedical Senior Design 1. 4 Hours.
PR: BMEG 310 and BMEG 311 and BMEG 315 and BMEG 340. Planning, designing, and reporting solutions to challenging biomedical engineering problems that have clinical implication. Also covers professional topics, including ethics, liability, safety, socio-legal issues.

BMEG 456. Biomedical Senior Design 2. 3 Hours.
PR: BMEG 455. Continuation of BMEG 455.

BMEG 480. Cellular Machinery. 3 Hours.
PR: BIOL 115 or Consent. Fundamental understanding of how a cell operates like a chemical factory; understanding how self-sustaining capacity of the cell’s complex chemical reaction networks and cellular components can be manipulated in a synthetic environment.

BMEG 481. Applied Bio-Molecular Modeling. 3 Hours.
PR: BMEG 201 and MATH 261 and (CHEM 231 or CHEM 233). This course provides an introduction to modern molecular-level computational methods for calculating properties of reaction systems and thermodynamic, transport, and structural properties of materials with a particular focus on biological applications.

BMEG 482. Introduction to Tissue Engineering. 3 Hours.
PR: BMEG 201 and BMEG 311. This course introduces biological principles and engineering fundamentals pertaining to cell behavior and substrate properties. The design and characterization of artificial tissues will be discussed using properties and function of native tissues as a guide.

BMEG 494. Seminar. 1-3 Hours.
PR: Consent. Presentation and discussion of topics of mutual concern to students and faculty.

BMEG 495. Independent Study. 1-6 Hours.

BMEG 496. Senior Thesis. 1-6 Hours.

BMEG 497. Research. 1-6 Hours.

BMEG 498. Honors Research. 1-6 Hours.