

BIOMEDICAL ENGINEERING

Faculty

Professors: James W. Baish, Donna M. Ebenstein (Chair), Eric A. Kennedy, Joseph V. Tranquillo (Associate Provost for Transformative Teaching & Learning)

Associate Professor: Daniel P. Cavanagh

Assistant Professors: Olivia Boerman, Theo Hopper (Teaching), Karlo Malaga

Adjunct: Jove Graham

Mission Statement

The mission of the biomedical engineering department is to foster an inclusive learning community that prepares our students to have the necessary technical and professional skills and empathy to equitably improve human health and well-being in a diverse and rapidly changing world.

To do this, the department offers the following:

- A Bachelor of Science in Biomedical Engineering degree for students seeking a comprehensive education in biomedical engineering.
- A minor in biomedical engineering for students in other engineering disciplines seeking a basic competency in the discipline and enhanced background in the life sciences.
- Elective courses to support the needs of students outside of the major and minor programs.

Program Educational Objectives

The following program educational objectives of the Department of Biomedical Engineering at Bucknell University are broad statements that describe what graduates are expected to attain within a few years of graduation. As graduates will pursue diverse career paths, these objectives are intended to apply to those who pursue technical and professional careers.

- Alumni will experience success in a variety of biomedical engineering-related postgraduate environments or other diverse areas that require technical and/or professional skills.
- Alumni will contribute to their fields or professions.
- Alumni will pursue professional development, including continuing or advanced education, relevant to their career path.

Student Outcomes

Graduates of the program shall demonstrate the following at the time of graduation:

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.

The biomedical engineering program at Bucknell University is accredited by the Engineering Accreditation Commission of ABET, www.abet.org (<https://www.abet.org/>).

Bachelor of Science in Biomedical Engineering

The **Bachelor of Science** in Biomedical Engineering requirements are:

First Year

First Semester	Credits	Second Semester	Credits
ENGR 099		0 BMEG 210	1
ENGR 100		1 BMEG 226	.5
MATH 201		1 MATH 202	1
PHYS 211		1 PHYS 212	1
Foundation Seminar (W1)		1 Elective	1
		4	4.5

Sophomore

First Semester	Credits	Second Semester	Credits
BMEG 250		1 BMEG 205	1
BMEG 409		.5 BMEG 220	.5
MATH 211		1 CHEM 211	1
CHEM 205		1 ENGR 240	1
Elective		1 MATH 212	1
		4.5	4.5

Junior

First Semester	Credits	Second Semester	Credits
BMEG 350		1 BMEG 300	1
BIOL 203		1 BMEG 408	.5
Two Electives		2 BIOL 221	1
		CHEM 230	1
		Elective	1
		4	4.5

Senior

First Semester	Credits	Second Semester	Credits
BMEG 400		1 BMEG 402	1
BMEG 401		1 Three electives	3
Two Electives		2	
		4	4

Five Year

First Semester	Credits	Second Semester	Credits
Four electives		4 Four electives	4
		4	4

Total Credits: 42

The 11 elective courses are distributed as follows:

- Five courses that meet engineering (<https://coursecatalog.bucknell.edu/collegeofengineeringcurricula/curriculaoverview/>) college requirements for general education (<https://coursecatalog.bucknell.edu/collegeofengineeringcurricula/curriculaoverview/>) selected from any of the following: social science courses, arts & humanities courses, university courses, residential college courses or foundation seminars. These five courses must include one course in arts & humanities and one course in social sciences.
- Two approved 200+ level engineering, math or science courses from the list published by the department.
- One approved 300+ level engineering course from the list published by the department.
- One BMEG engineering elective course from the list published by the department.
- Two courses in any department or program of the University provided that the prerequisites are satisfied.

Any of these electives may also count toward other university majors and minors.

Required natural science and math courses (e.g., PHYS, CHEM, BIOL or MATH) and ENGR 240 may also count toward other university majors and minors.

Of all courses in the student's degree program (required and elective courses):

- Three courses in each student's program must fulfill the University writing requirement that includes a W1 course (FOUN or RESC) taken in the first semester and two subsequent W2 courses.

- One course must fulfill the engineering college global perspectives requirement (<https://coursecatalog.bucknell.edu/collegeofengineeringcurricula/curriculaoverview/>), which can be satisfied by a Global Connections course or a foreign language course.

Bachelor of Arts/Management for Engineers - Bachelor of Science in Biomedical Engineering

The **Bachelor of Arts/Management for Engineers - Bachelor of Science** in Biomedical Engineering requirements are:

First Year

First Semester	Credits	Second Semester	Credits
ENGR 099		0 BMEG 210	1
ENGR 100		1 BMEG 226	.5
MATH 201		1 MATH 202	1
PHYS 211		1 PHYS 212	1
Foundation Seminar (W1)		1 Elective	1
	4		4.5

Sophomore

First Semester	Credits	Second Semester	Credits
BMEG 250		1 BMEG 205	1
BMEG 409		.5 BMEG 220	.5
MATH 211		1 CHEM 211	1
CHEM 205		1 ENGR 240	1
Elective		1 MATH 212	1
	4.5		4.5

Junior

First Semester	Credits	Second Semester	Credits
BMEG 350		1 BMEG 300	1
BIOL 203		1 BMEG 408	.5
Two Electives		2 BIOL 221	1
		CHEM 230	1
		Elective	1
	4		4.5

Senior

First Semester	Credits	Second Semester	Credits
BMEG 400		1 BMEG 402	1
BMEG 401		1 Three electives	3
Two Electives		2	
	4		4

Total Credits: 34

The 19 elective courses are distributed as follows:

- Eight courses selected to satisfy the major requirements for the Bachelor of Arts/Management for Engineers major.
- Five courses that meet engineering (<https://coursecatalog.bucknell.edu/collegeofengineeringcurricula/curriculaoverview/>)college requirements for general education (<https://coursecatalog.bucknell.edu/collegeofengineeringcurricula/curriculaoverview/>) selected from any of the following: social science courses, arts & humanities courses, university courses, residential college courses or foundation seminars. These five courses must include one course in arts & humanities and one course in social sciences.
- Two approved 200+ level engineering, math or science courses from the list published by the department.
- One approved 300+ level engineering course from the list published by the department.
- One BMEG engineering elective course from the list published by the department.
- Two courses in any department or program of the University provided that the prerequisites are satisfied.
- Courses used to fulfill the General Education (<https://coursecatalog.bucknell.edu/collegeofengineeringcurricula/curriculaoverview/>) requirements for engineering students should also fulfill the College of Arts & Sciences Core Curriculum (CASCC) (<https://coursecatalog.bucknell.edu/>)

collegefartsandsciencescurricula/curriculaoverview/collegecorecurriculum/) requirements for those in the 5-year engineering & liberal arts dual degree program or the Freeman College of Management General Education Curriculum (<https://coursecatalog.bucknell.edu/collegefmanagementcurricula/curriculaoverview/gened/>) requirements for those in the 5-year engineering & management dual degree program

Any of these electives may also count toward other university majors and minors.

Required natural science and math courses (e.g., PHYS, CHEM, BIOL or MATH) and ENGR 240 may also count toward other university majors and minors.

Of all courses in the student's degree program (required and elective courses):

- Three courses in each student's program must fulfill the University writing requirement that includes a W1 course (FOUN or RESC) taken in the first semester and two subsequent W2 courses.
- One course must fulfill the engineering college global perspectives requirement (<https://coursecatalog.bucknell.edu/collegefengineeringcurricula/curriculaoverview/>), which can be satisfied by a Global Connections course or a foreign language course.

Minor in Biomedical Engineering

Engineering students not pursuing the Bachelor of Science in Biomedical Engineering may choose to pursue a **minor** in biomedical engineering. This minor is attained through a judicious use of electives that combine the study of the basic biological sciences with an area of technological interest. To complete the biomedical engineering minor, engineering students must successfully complete at least **five credits** from approved courses as follows. Additional courses may be approved by the biomedical engineering department on a case-by-case basis.

At least two credits from the following list, with at least one having a ¹ designation:

BMEG 425	Patients, Diseases, & Devices ¹	1
BMEG 431	Biomimetic Materials ¹	1
BMEG 437	Tissue Engineering ¹	1
BMEG 441/ECEG 411	Neural Engineering ¹	1
BMEG 451	Biomechanics and Injury Prevention ¹	1
BMEG 463	Medical Imaging ¹	1
BMEG 471/472	Advanced Topics in Biomedical Engineering ¹	1
BMEG 480/481	Biomedical Engineering Project	.5
BMEG 490/491	Biomedical Engineering Research	1
CHEG 452	Bioprocess Engineering	1
CHEG 460	Biomaterials: Materials in Medicine	1
MECH 476	Biomechanics	1

Select remaining credits from the above list or the following:

BIOL 203	Integrated Concepts in Biology Fall	1
BIOL 204	Integrated Concepts in Biology Spring	1
BIOL 221	Human Physiology	1
BIOL 312	Comparative Vertebrate Anatomy	1
BIOL 318	Principles of Physiology	1
BIOL 324	Neurophysiology	1
BIOL 327	Molecular Biology	1
BIOL 328	Endocrinology	1
BIOL 340/CHEM 358	Biochemical Methods	1
BIOL 348	Immunology	1
BIOL 352	Cell Biology	1
BIOL 365	Introduction to Microscopy	1
CHEM 340	Biological Physical Chemistry	1
CHEM 351	Biochemistry I	1
CHEM 352	Biochemistry II	1
CHEM 358/BIOL 340	Biochemical Methods	1

Graduates of the program shall demonstrate the following student outcomes at the time of graduation:

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.

Courses

BMEG 205. Bioinstrumentation I. 1 Credit.

Offered Spring Semester Only; Lecture hours:3,Lab:2

Introduction to analog and digital circuits with applications to medicine and biology. Corequisite: MATH 212. Prerequisite: MATH 202. Open to biomedical engineering majors only.

BMEG 210. Fundamentals of Biomedical Engineering. 1 Credit.

Offered Spring Semester Only; Lecture hours:3,Other:2

Introduction to the application of fluid mechanics, mass transfer, instrumentation, mechanics, and societal issues to biomedical problems. Hands-on laboratory experiences integrated with lecture. Prerequisites: MATH 201 and PHYS 211P. Open to biomedical engineering majors only.

BMEG 220. Introduction to Engineering Computing. .5 Credits.

Offered Spring Semester Only; Lecture hours:2,Other:1

Introduction to numerical methods and programming fundamentals. Problems drawn from mathematics, engineering, and biomedical engineering. Corequisite: MATH 212. Not open to students who have taken ENGR 211, ENGR 212, ENGR 214. Open to biomedical engineering majors only.

BMEG 226. Statistical Methods in Biomedical Engineering. .5 Credits.

Offered Spring Semester Only; Lecture hours:2,Lab:1

Introduction to concepts in experimental design and data analysis with application to biomedical engineering, medicine, and biology. Prerequisite: MATH 201. Not open to students who have taken ENGR 215, MATH 216 or MATH 226. Open to biomedical engineering majors only.

BMEG 250. Fundamentals of Biomechanics. 1 Credit.

Offered Fall Semester Only; Lecture hours:3,Lab:2

Application of mechanical analyses to solve biomechanical problems including: equilibrium of rigid bodies, anthropometric analysis, link segment analysis, internal loads, combined loading, failure theory. Prerequisites: PHYS 211 and MATH 201. Not open to students who have taken ENGR 220, ENGR 221 or MECH 220. Open to biomedical engineering majors only.

BMEG 300. Biotransport I. 1 Credit.

Offered Spring Semester Only; Lecture hours:3,Lab:2

First biotransport course. Fluid mechanics principles applied to biological systems and medical devices. Properties of biological fluids, energy and momentum balances, computational modeling. Prerequisite: MATH 212. Not open to students who have taken CHEG 300, ENGR 222, or ENGR 233. Open to biomedical engineering majors only.

BMEG 350. Fundamental of Biomedical Signals and Systems. 1 Credit.

Offered Fall Semester Only; Lecture hours:3,Lab:2

Time and frequency analysis, filter design and feedback control as applied to biomedical signals and systems. Prerequisites: BMEG 205 and MATH 212. Open to biomedical engineering majors only.

BMEG 400. Biotransport II. 1 Credit.

Offered Fall Semester Only; Lecture hours:3,Lab:2

Second biotransport course focusing on the advanced application of fundamental heat and mass transport concepts to biological systems and medical devices. Conduction, convection, thermal properties of materials, mass diffusion, compartmental modeling. Prerequisite: BMEG 300. Open to biomedical engineering majors only.

BMEG 401. Biomedical Engineering Capstone I. 1 Credit.

Offered Fall Semester Only; Lecture hours:3,Lab:2

Senior design course emphasizing the biomedical engineering design process including problem identification and medical motivation, background research, medical regulations and ethics, design and project proposal presentation. Prerequisite: BMEG 408. Open to biomedical engineering majors only.

BMEG 402. Biomedical Engineering Capstone II. 1 Credit.**Offered Spring Semester Only; Lecture hours:3,Lab:2**

Second semester of the biomedical engineering design sequence emphasizing fabrication, instrumentation, testing and evaluation, and final presentation of projects. Prerequisites: BMEG 401. Open to biomedical engineering majors only.

BMEG 408. Medical Device Assessment and Development. .5 Credits.**Offered Spring Semester Only; Lecture hours:2,Other:3**

An examination of medical device design including benchmarking, intellectual property, regulatory pathways, industry standards, project planning, project management, and individual and team professionalism. Topics will be applied to currently marketed medical devices. Prerequisites: BMEG 205. Open to biomedical engineering majors only.

BMEG 409. Fabrication and Experimental Design. .5 Credits.**Offered Fall Semester Only; Lecture hours:2,Other:1**

A hands-on course focusing on skills relevant to biomedical engineers, such as computer-aided design and documentation, fabrication, materials, selection and biocompatibility. Cell culture and experimental design. Class will be a mixture of lectures and hands-on activities. Prerequisite: BMEG 226 or MATH 216. Open to biomedical engineering majors only.

BMEG 425. Patients, Diseases, & Devices. 1 Credit.**Offered Either Fall or Spring; Lecture hours:3,Recitation:1**

Student-driven exploration of the comprehensive patient experience including disease cause and progression, clinical diagnosis and treatments, post-intervention care, and patient personal experiences and decisions. Prerequisite: permission of the instructor.

BMEG 431. Biomimetic Materials. 1 Credit.**Offered Either Fall or Spring; Lecture hours:3,Recitation:1**

Introduction to topics in biomimetics, studying nature as an inspiration for engineering design. Topics include relationships between microstructure and physical properties of natural materials and tissue engineering approaches to biomaterials design. Prerequisite: permission of the instructor. Crosslisted as BMEG 631, MECH 478 and MECH 678.

BMEG 437. Tissue Engineering. 1 Credit.**Offered Either Fall or Spring; Lecture hours:3,Recitation:1**

Course includes foundations of tissue engineering with a survey of current tissue engineering techniques used clinically, commercially and in research. The moral, social and ethical considerations of tissue engineering will be explored. Prerequisite: permission of the instructor.

BMEG 441. Neural Engineering. 1 Credit.**Offered Either Fall or Spring; Lecture hours:3,Recitation:1**

Introduction to neural systems and engineering. Topics include neurophysiology, quantitative neural recording and stimulation models, neural signal acquisition and processing, clinical applications, and current field-wide challenges. Prerequisite: permission of the instructor. Crosslisted as ECEG 411 and ECEG 611.

BMEG 451. Biomechanics and Injury Prevention. 1 Credit.**Offered Either Fall or Spring; Lecture hours:3,Recitation:1**

Survey course for field of biomechanics and research for injury prevention (lowering risk and/or severity). Mixture of lectures, labs, and projects. Prerequisite: permission of the instructor.

BMEG 457. Accident Analysis. .5-1 Credits.**Offered Occasionally; Lecture hours:Varies**

Analysis of vehicle design and performance as it pertains to crashworthiness. Vehicle materials and structure, how vehicles are regulated with an emphasis on occupant safety. Studying the evolution of modern designs to minimize injuries includes reviewing many relevant biomechanics research studies. Crosslisted as MECH 457 and MECH 657.

BMEG 463. Medical Imaging. 1 Credit.**Offered Either Fall or Spring; Lecture hours:3,Recitation:1**

Survey of medical imaging from the perspectives of the underlying physics and technology used to obtain images, software used to manage and manipulate images, and use of images in clinical and scientific practice. The economic, societal, cultural and ethical aspects of imaging will be addressed. Prerequisite: permission of the instructor.

BMEG 471. Advanced Topics in Biomedical Engineering. 1 Credit.**Offered Fall Semester Only; Lecture hours:3,Recitation:1; Repeatable**

Advanced, in-depth course developed from areas of biomedical engineering. Topics will vary. Prerequisite: permission of the instructor. Crosslisted as BMEG 671.

BMEG 472. Advanced Topics in Biomedical Engineering. 1 Credit.**Offered Spring Semester Only; Lecture hours:3,Recitation:1; Repeatable**

Advanced, in-depth course developed from areas of biomedical engineering. Topics will vary. Prerequisite: permission of the instructor. Crosslisted as BMEG 672.

BMEG 480. Biomedical Engineering Project. .5 Credits.**Offered Fall Semester Only; Lecture hours:1,Other:5; Repeatable**

Individual work with a faculty adviser on development, design, or research project beginning with a written plan and culminating with a written or oral presentation. Prerequisite: permission of the instructor.

BMEG 481. Biomedical Engineering Project. .5 Credits.**Offered Spring Semester Only; Lecture hours:1,Other:5; Repeatable**

Individual work with a faculty adviser on development, design, or research project beginning with a written plan and culminating with a written or oral presentation. Prerequisite: permission of the instructor.

BMEG 490. Biomedical Engineering Research. 1 Credit.**Offered Fall Semester Only; Lecture hours:1,Other:10; Repeatable**

Independent study with a faculty adviser on a research or design project. Submit a proposal for group review, conduct the work, and culminate with a written report and an oral presentation before a faculty group. Prerequisite: permission of the instructor.

BMEG 491. Biomedical Engineering Research. 1 Credit.**Offered Spring Semester Only; Lecture hours:1,Other:10; Repeatable**

Independent study with a faculty adviser on a research or design project. Submit a project proposal for group review, conduct the work, and culminate with a written report and an oral presentation before a faculty group. Prerequisite: permission of the instructor.