

BIOMEDICAL ENGINEERING

Graduate Program Head	Daniel Hayes
Program Code	BME
Campus(es)	University Park (Ph.D., M.S.)
Degrees Conferred	Doctor of Philosophy (Ph.D.) Master of Science (M.S.)
The Graduate Faculty	View (https://secure.gradsch.psu.edu/gpms/?searchType=fac&prog=BME)

The Department of Biomedical Engineering offers Ph.D. and M.S. degree programs consisting of integrated graduate-level training in engineering, the life sciences and the medical sciences. Students graduating from this program will have acquired expertise in the application of engineering principles to fundamental problems in biology, clinical problems in medicine, or in the development of new biomedical instrumentation. They are also expected to produce scholarly work to be published in peer-reviewed journals and presented at scholarly conferences. Graduate curricula and student assessment in biomedical engineering is under the direction of the program chair and a graduate curriculum committee drawn from the faculty in the Biomedical Engineering Department.

Opportunities for specialized research are offered by graduate faculty working on electrical, mechanical, and biophysical properties of biological materials and the application of this knowledge to understanding molecular, cellular, tissue, and organ level processes involved in health and disease. Specific applications include: artificial organs, biomaterials, bioMEMs, nanotechnology, biophotonics, cellular and medical imaging, cardiovascular engineering, cell signaling and protein dynamics, mechanobiology, systems biology, bioinformatics, tissue engineering and regenerative medicine. Extensive computer facilities and specialized equipment are available to support a combination of studies that employ experimental observations and their analysis through mathematical modeling and computer simulations.

Admission Requirements

Applicants apply for admission to the program via the J. Jeffrey and Ann Marie Fox Graduate School application for admission (<https://gradschool.psu.edu/admissions/how-to-apply/>). Requirements listed here are in addition to Graduate Council policies listed under GCAC-300 Admissions Policies (<https://gradschool.psu.edu/graduate-education-policies/>).

Scores from the Graduate Record Examinations (GRE) are not required for admission.

Students with a degree in engineering, physics, or the life sciences from an approved institution are eligible for admission. All students must have a strong background in physics and mathematics. This background should include chemistry, calculus-based physics, and mathematics through calculus and differential equations. Students who lack this background may still be considered for provisional admission (<http://gradschool.psu.edu/graduate-education-policies/gcac/gcac-300/gcac-303-provisional-admission/>) but will have to make up any deficiency early in their graduate program. These remedial courses will be required in addition to the stated graduate program course requirements. Students with a 3.0 (or higher) junior/senior GPA and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces available. Exceptions to the minimum average may be made for students with

special backgrounds, abilities, and interests, at the discretion of the program.

The language of instruction at Penn State is English. English proficiency test scores (TOEFL/IELTS) may be required for international applicants. See GCAC-305 Admission Requirements for International Students (<https://gradschool.psu.edu/graduate-education-policies/gcac/gcac-300/gcac-305-admission-requirements-international-students/>) for more information.

Degree Requirements

Master of Science (M.S.)

Requirements listed here are in addition to Graduate Council policies listed under GCAC-600 Research Degree Policies. (<https://gradschool.psu.edu/graduate-education-policies/>)

A minimum of 30 credits at the 400, 500, 600, or 800 level is required, with at least 24 credits in BME/BIOE at the 500 or 800 level. Students choosing to complete a scholarly paper must complete at least 32 credits, with 18 credits in 500-level courses. Students choosing to complete a thesis must complete a minimum of 30 credits with at least 24 credits at the 500, 600, or 800-level. Students choosing to complete a thesis must also complete at least 6 credits in thesis research (600 or 610).

Non-Thesis (Scholarly Paper) Track

Students choosing to complete a scholarly paper must take the following:

Code	Title	Credits
Required Courses		
9 credits of foundation courses at the BIOE 500-level		9
12 credits of fundamentals and/or applications courses (with a minimum of 3 credits from each category)		12
BIOE 591	Bioengineering Ethics and Professional Development	1
BIOE 590	Colloquium (two 1-credit graduate seminars)	2
BME 429	Biomedical Mechanics and Techniques Laboratory	2
Culminating Experience		
BME 594	Research Topics	6
Total Credits		32

To complete the degree in one year, students are required to take at least one credit of research for each of the three semesters (Fall, Spring, and Summer). A research adviser must be assigned to students in their first semester, as selection and discussion of the student's research topic must begin as soon as possible. Students who need more time to complete the final paper must be allowed to complete the paper, and have it reviewed and approved after the third semester (Summer) has ended. Students are not required to remain in residence while they complete the final paper. However, extensions granted to students in this program must comply with the Graduate Council policy on deferred grades (<https://gradschool.psu.edu/graduate-education-policies/gcac/gcac-400/gcac-401-grading-system/>).

Mentored Projects: By the end of September, a student will identify an adviser. A mentored project assigned by the adviser will be completed and a culminating project using the data as a basis for the scholarly paper will be submitted and evaluated. These projects are completed while enrolled in BME 594.

Thesis Track

For students choosing to complete a thesis, upon entering the program, the student, along with their research adviser, will select an academic advisory committee. Working with this committee, the student will select courses appropriate to their research and their professional goals.

Course expectations are set up so that course work during the semester will require up to half of the students' time with research activities taking up the majority of the time. Summers are generally set aside for full-time research. Beyond the specific course requirements listed below, M.S. students are expected to publish at least one first-author paper based on their research. This is not a requirement for graduation, however.

Students choosing to complete a thesis must take the following:

Code	Title	Credits
Required Courses		
12 credits of lecture- or laboratory-based coursework at the 500-level ¹		12
6 credits of lecture- or laboratory-based coursework at the 400- or 500-level ¹		6
BIOE 591	Bioengineering Ethics and Professional Development	1
1-credit graduate seminar for every semester in attendance		4
Electives²		1
Culminating Experience		
BIOE 600	Thesis Research	6
Total Credits		30

¹ Course work must include at least 6 credits each in bioengineering, life sciences, and technical/quantitative electives.

² Students will select additional course work and research credits from a list of approved electives maintained by the program office, as appropriate, to obtain the total minimum of 30 credits.

The thesis must be accepted by the advisers and/or committee members, the head of the graduate program, and the Graduate School, and the student must pass a thesis defense.

Doctor of Philosophy (Ph.D.)

Requirements listed here are in addition to Graduate Council policies listed under GCAC-600 Research Degree Policies. (<https://gradschool.psu.edu/graduate-education-policies/>)

Upon entering the Ph.D. program, the student will be assigned an academic advisory committee, consisting of three members of the Biomedical Engineering Graduate Faculty (including the adviser). Working with this committee, the student will select courses appropriate to their research and professional goals.

The minimum credit requirements for a Ph.D. in Biomedical Engineering are as follows:

Code	Title	Credits
Required Courses		
6 credits each in Biomedical Engineering, life sciences, and technical/quantitative electives		6
12 credits that are lecture- or laboratory-based (not independent study) and at the 500-level		12
6 credits at the 500-level in courses relevant to their research		6

4 credits in graduate program seminar series (1 credit every semester until passing the comprehensive exam) 4

BIOE 591	Bioengineering Ethics and Professional Development	1
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Total Credits 29

600-level research credits are assigned every semester in attendance. Graduate credits earned at other institutions, including those used toward a degree, may be used to satisfy some of the Ph.D. degree requirements at Penn State, but in these cases, credits are not transferred. Regardless of previous courses taken, every doctoral student must take a minimum of 6 credits at the 500-level at the University Park campus.

Supporting courses are available at University Park in: anatomy, biochemistry, biology, biophysics, chemistry, laboratory animal medicine, materials science, mathematics, physics, physiology, and the engineering departments.

Students who enter the Ph.D. program with a master's degree will work with their Ph.D. committee to determine the suitability of substitutions for courses already taken.

Exams

The Qualifying Exam is the first of three formal exams required for a Ph.D. The exam is taken at the end of the first year of study, typically during the summer following Spring semester. The exam is also given at the end of Fall semester. The purpose of the Qualifying Exam is to ensure that students possess the qualifications expected of a Ph.D. student and have the potential to perform at the high level expected of a Ph.D. biomedical engineer upon completion of the degree. The format of the exam is a written proposal on a research topic different from the student's dissertation project, followed by an oral defense.

The next step toward the Ph.D. degree is the comprehensive exam, which is given when the student has completed all required course work. The comprehensive exam is generally given between the end of the second year and the end of the third year of the Ph.D. program and must take place at least one year prior to the Ph.D. dissertation defense (final oral examination). The exam is intended to evaluate the student's mastery of the major (and if appropriate, minor) field. The Biomedical Engineering Program uses the comprehensive exam as an opportunity to evaluate the Ph.D. student's dissertation proposal. In preparation for the exam, the student must have formed a Ph.D. committee, scheduled an exam time, and prepared a detailed Ph.D. dissertation proposal according to departmental guidelines.

Ph.D. students must have satisfied the English competence and the communication requirement before scheduling the comprehensive exam. This requirement is fulfilled during the oral Qualifying Exam. The Ph.D. committee must meet all Graduate Council requirements (<http://gradschool.psu.edu/graduate-education-policies/gcac/gcac-600/gcac-602-phd-committee-formation/>).

The doctoral candidate who has satisfied all other requirements for the degree will be scheduled to take the final oral examination. According to Biomedical Engineering Program policy, the final oral exam may not be scheduled until at least one year after the comprehensive exam was passed. Every Ph.D. student must meet with their Ph.D. Committee. This meeting is to preview the dissertation structure with the committee and to ensure that the student, adviser, and committee all agree on expectations for the dissertation and defense.

To earn the Ph.D. degree, doctoral candidates must write a dissertation that is accepted by the Ph.D. committee, the head of the graduate program, and the Graduate School, and the student must pass a final oral examination (the dissertation defense).

Minor

A graduate minor is available in any approved graduate major or dual-title program. The default requirements for a graduate minor are stated in Graduate Council policy GCAC-218 Minors (<https://gradschool.psu.edu/graduate-education-policies/gcac/gcac-200/gcac-218-minors/>).

Student Aid

Graduate assistantships available to students in this program and other forms of student aid are described in the Tuition & Funding (<https://gradschool.psu.edu/funding/>) section of the J. Jeffrey and Ann Marie Fox Graduate School's website. Students on graduate assistantships must adhere to the course load limits (<https://gradschool.psu.edu/graduate-education-policies/gsad/gsad-900/gsad-901-graduate-assistants/>) set by the Fox Graduate School.

Courses

Graduate courses carry numbers from 500 to 699 and 800 to 899. Advanced undergraduate courses numbered between 400 and 499 may be used to meet some graduate degree requirements when taken by graduate students. Courses below the 400 level may not. A graduate student may register for or audit these courses in order to make up deficiencies or to fill in gaps in previous education but not to meet requirements for an advanced degree.

Biomedical Engineering (BME) Course List (<https://bulletins.psu.edu/university-course-descriptions/graduate/bme/>)

Learning Outcomes

Master of Science (M.S.)

- Graduates will be able to demonstrate understanding of advanced core principles and methods from selected sub-fields of Biomedical engineering at a depth consistent with their course of study.
- Graduates will be able to apply their knowledge of selected sub-fields of Biomedical engineering to formulate and solve engineering problems.
- Graduates will be able to analyze and synthesize knowledge within the field of Biomedical engineering to extend existing knowledge through a research experience and thesis.
- Graduates will be able to demonstrate proficiency in oral and written communication appropriate to their discipline.
- Graduates will be able to demonstrate an understanding of, and a commitment to, the standards for scholarship and research integrity within Biomedical Engineering.

Doctor of Philosophy (Ph.D.)

- Graduates will be able to demonstrate an understanding of advanced core principles and methods as well as modern research findings from selected sub-fields of Biomedical engineering at a depth appropriate for a Ph.D. candidate.
- Graduates will be able to apply their knowledge of selected sub-fields of Biomedical engineering in formulating and executing a research plan.
- Graduates will be able to demonstrate the ability to analyze and synthesize appropriate literature, to critically review their work in the

context of the literature, and to formulate and defend conclusions based on their research that represent new scholarly contributions.

- Graduates will be able to demonstrate high levels of proficiency in oral and written communication.
- Graduates will be able to demonstrate an understanding of, and a commitment to, the standards for scholarship, professional practice, and research integrity.

Contact

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