

**BIOMEDICAL ENGINEERING
GRADUATE PROGRAM HANDBOOK**
(Revised February 2021)

OVERVIEW

Through the Department of Biomedical Engineering (BME) at the University of Delaware (UD), graduate students can obtain a PhD and/or a MS degree. Students are not admitted directly into the MS program. The MS and PhD programs are built on a common first year core curriculum with advanced curricula that are based on the research the student will perform for their PhD dissertation (or MS thesis, if electing that option). Due to the interdisciplinary nature of Biomedical Engineering, faculty that are affiliated with the BME graduate program come from multiple colleges and departments at UD. PhD and MS students will generally identify a Faculty Advisor from among our program's primary and joint faculty, who will be responsible for defining the student's research responsibilities and for evaluating the student's performance. The PhD and MS degrees will be administered by the BME Program and will be awarded by the College of Engineering.

This multi-disciplinary graduate program builds upon the established biomedical research strength at the University of Delaware, largely within the College of Engineering. It offers academic rigor, as well as flexibility, to meet the needs and interests of students from different backgrounds and of their faculty advisors from different research areas.

ADMISSION REQUIREMENTS

Admission to the BME graduate program is competitive. Those who meet stated requirements are not guaranteed admission, and those who do not meet all the requirements are not necessarily precluded from admission if they offer other appropriate strengths. Applicants to the PhD program in BME should meet the following criteria:

- A bachelor's degree or higher in engineering, physical, or biological sciences from an accredited 4-year college or university with a minimum cumulative GPA of 3.2 on a 4.0 scale.
- Engineering, science, and math courses from the following list, while not required for admission, are highly recommended: Calculus, Differential Equations, Calculus-based Physics, Biology, Physiology, Chemistry, Organic Chemistry, Signal Processing, Statics and Dynamics, Probability and Statistics, and Computer Programming. It is understood that very few applicants will have completed all of these courses, but all provide a foundation that will help with the required courses in the Biomedical Engineering graduate program.
- For international applicants, a TOEFL exam taken within the last 2 years with a minimum score of 563 for the paper-based test and of 84 for the iBT (internet-based test) with a 20 for the iBT speaking component.
- Competitive GRE scores of 155 for quantitative and 308 or higher for Quantitative + Verbal. Questions regarding GRE waivers may be sent to bmeg-info@udel.edu.
- Three letters of recommendation from individuals acquainted with the student and their academic work or from employers or others who have had a supervisory relationship with

the applicant and are able to assess the applicant's potential for success in graduate studies.

- A personal statement (1-2 page) that indicates:
 - The reason for the student's interest in graduate study
 - A discussion of previous research experience and/or industrial experience
 - The student's area(s) of research interest and a list of faculty with whom they would like to work
 - The student's ultimate career objectives.

We encourage applications from students from all backgrounds.

PhD PROGRAM

The PhD program in Biomedical Engineering consists of 39 credits of graduate level course work, inclusive of 9 credits of Doctoral Dissertation research. The program allows for considerable flexibility in course selection. The PhD program also requires completion of a Teaching Aid requirement, the Qualifying Exam, two Research Seminar Symposia presentations, the Candidacy (Proposal) Defense, and the Doctoral Dissertation and Defense.

PhD DEGREE REQUIREMENTS

The table below lists the credit requirements for a PhD degree in BME.

| PhD requirements in Biomedical Engineering: 39 credits total | |
|--|-------------------|
| 4 Core courses | |
| Physiology | 3 credits minimum |
| Advanced Math | 3 credits |
| Statistics | 3 credits |
| Communication | 3 credits |
| 5 Technical electives (minimum), of which at least 1 must be a 600-level or higher BMEG elective | 15 credits |
| Research | 3 credits minimum |
| Doctoral Dissertation | 9 credits maximum |
| Seminar series (3 semesters) | 0 credits |

COURSE REQUIREMENTS

| Core Courses (12 credits) | |
|-----------------------------------|--|
| Physiology (3 credits minimum) | BISC 605 Advanced Mammalian Physiology I [4 cr.] or BISC 606 Advanced Mammalian Physiology II [4 cr.] KAAP 630 Advanced Human Physiology I [3 cr.] or KAAP 631 Advanced Human Physiology II [3 cr.] |

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|------------------------------|---|
| Advanced Math (3 credits) | BMEG 671 Mathematical Physiology |
| Statistics (3 credits) | BMEG 802 Advanced Biomedical Experiment Design & Analysis |
| Communication (3 credits) | BMEG 801 Communication in Biomedical Engineering |

Other classes may be substituted for the approved core courses at the recommendation of the student's Faculty Advisor with the approval of the Graduate Director and Graduate Committee.

TECHNICAL ELECTIVES

Technical Electives can be chosen from courses offered across engineering departments.

| Technical Elective Courses (15 credits minimum) (Choose 5 courses minimum, of which at least one must be a 600-level or higher BMEG Technical Elective) | |
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| BISC 602 | Molecular Biology of Animal Cells |
| BISC 609 | Molecular Biology of the Cell |
| BISC 612 | Advanced Cell Biology |
| BISC 615 | Developmental Biology |
| BISC 625 | Cancer Biology |
| BISC 639 | Developmental Neurobiology |
| BISC 654 | Biochemical Genetics |
| BISC 682 | Bacterial Pathogens: Molecular Mechanisms |
| BISC 690 | Fundamentals of Pharmacology |
| BMEG 640 | Structural Attachments in Biology |
| BMEG 641 | Biomechatronics |
| BMEG 643 | Magnetic Resonance Imaging |
| BMEG 644 | Microscale Biofluid Mechanics |
| BMEG 645 | Material-Human Body Interfaces |
| BMEG 646 | Neuromechanics of Human Motion |
| BMEG 661 | Cell Engineering |
| BMEG 662 | Engineering Biomedical Nanostructures |
| BMEG 663 | Mechanotransduction |
| BMEG 665 | Tissue Biomechanics and Modeling |
| BMEG 679 | Introduction to Medical Imaging Systems |
| CHEG 604 | Probability and Statistics for Engineering Problem Solving |
| CHEG 608 | Introduction to Particle Technology |
| CHEG 617 | Colloid Science and Engineering |
| CHEG 621 | Metabolic Engineering |
| CHEG 624 | Bio-Based Materials |
| CHEG 648 | Biomaterials for Drug and Gene Delivery |

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| CHEG 649 | Molecular Biophysics |
| CHEG 660 | Systems Biology |
| CHEG 825 | Chemical Engineering Thermodynamics |
| CHEG 827 | Chemical Engineering Problems |
| CHEG 828 | Statistical Thermodynamics |
| CHEG 842 | Selected Topics in Biochemical Engineering |
| CHEG 845 | Advanced Transport Phenomena |
| CHEM 641 | Biochemistry |
| CHEM 642 | Biochemistry |
| CHEM 643 | Intermediary Metabolism |
| CHEM 645 | Protein Structure and Function |
| CHEM 646 | DNA-Protein Interactions |
| CHEM 649 | Molecular Biophysics |
| CHEM 684 | Biochemistry of Nucleic Acids |
| CIEG 601 | Introduction to the Finite Element Method |
| CIEG 605 | Intermediate Topics in Finite Element Analysis |
| CISC 636 | Computational Biology and Bioinformatics |
| CISC 642 | Introduction to Computer Vision |
| CISC 681 | Artificial Intelligence |
| CISC 842 | Introduction to Machine Learning |
| CISC 689 | Topics: Artificial Intelligence |
| CISC 844 | Computational Biomedicine |
| CISC 849 | Advanced Topics in Computer Applications |
| CISC 852 | Computer Network Performance |
| ELEG 602 | Advanced Machine Learning |
| ELEG 604 | Digital Imaging and Photography |
| ELEG 630 | Information Theory |
| ELEG 631 | Digital Signal Processing |
| ELEG 634 | Signals and Systems |
| ELEG 679 | Introduction to Medical Imaging Systems |
| ELEG 815 | Analytics I: Statistical Learning |
| KAAP 617 | Biomechanical Lab Instrumentation |
| KAAP 620 | Advanced Human Anatomy |
| KAAP 651 | Neurophysiological Basis of Human Movement |
| MEEG 613 | Nanomaterials and Nanotechnology |
| MEEG 621 | Linear Systems |
| MEEG 628 | Multiscale Modeling of Materials |
| MEEG 651 | Introduction to Microsystems |
| MEEG 671 | Introduction to Robotics |
| MEEG 677 | Introduction to State Estimation |

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| MEEG 682 | Clinical Biomechanics |
| MEEG 683 | Orthopedic Biomechanics |
| MEEG 684 | Biomaterials and Tissue Engineering Applications |
| MEEG 698 | Stochastic Optimal Control |
| MEEG 829 | Applied Nonlinear Control |
| MEEG 833 | Mesosopic CFD Method |
| MEEG 837 | Multiphase Flow and Transport |
| MEEG 841 | Microscale Thermal Transport |
| MEEG 877 | Sensing and Estimation in Robotics |
| MEEG 890 | Nonlinear Programming |
| MEEG 894 | Linear Feedback Control Design |
| MEEG 895 | Game Theory & Mechanism Design |
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| MSEG 630 | Introduction to Science and Engineering of Polymer Systems |
| MSEG 803 | Equilibria in Material Systems |
| MSEG 804 | Kinetics in Material Systems |
| MSEG 817 | Composite Materials |
| MSEG 832 | Principles of Polymerization |
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| NSCI 626 | Advanced Neuroanatomy |
| NSCI 627 | Advanced Neurophysiology |
| NSCI 628 | Advanced Neuropharmacology |
| NSCI 629 | Integrative Neuroscience I |
| NSCI 630 | Integrative Neuroscience II |
| NSCI 632 | Developmental Behavioral Neuroscience |
| NSCI 633 | Neuroplasticity |
| NSCI 634 | Stress and the Brain |
| NSCI 635 | Neuroplasticity |
| NSCI 636 | Seminar in Spatial Cognition |
| NSCI 637 | Behavioral Epigenetics |
| NSCI 638 | Clinical Neuropsychology |
| NSCI 639 | The Emotional Brain |
| NSCI 640 | The Immune System and Behavior |
| NSCI 641 | Hormones and Behavior |
| NSCI 642 | Social Neuroscience |
| NSCI 643 | Body and Space |
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| PSYC 626 | Advanced Neuroanatomy |
| PSYC 627 | Advanced Neurophysiology |
| PSYC 628 | Advanced Neuropharmacology |
| PSYC 642 | Mental Representation and Memory |
| PSYC 653 | Introduction to Functional Magnetic Resonance Imaging |
| PSYC 829 | Advanced Psychopathology |
| PSYC 845 | Childhood Psychopathology |
| PSYC 878 | Hierarchical Linear Modeling |

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| PSYC 879 | Structural Equation Modeling |
| STAT 609 | Regression and Experimental Design |

Courses not on the above Technical Elective list can be substituted with permission of the Faculty Advisor and approval by the Graduate Director. Check for updated lists periodically. For descriptions of technical electives, please refer to the [UD Course Catalog](#).

OTHER COURSE REQUIREMENTS

Seminar Series

Biomedical engineering is an emerging and rapidly expanding field where engineering and biological disciplines converge. To keep up to date with the wide variety of research encompassed by this field, students are required to sign up for and successfully complete 3 semesters of the zero (0) credit BME Seminar Series (BMEG890) during semesters in which the course is offered. Students enrolled in the BME Seminar Series must attend at least 75% of the regularly scheduled departmental seminars in that semester to achieve a passing grade. Attendance will be taken at all regularly scheduled departmental seminars for those students enrolled in the Seminar Series course. Students are encouraged to attend the BME Department's Seminar Series, whether or not they are officially enrolled in the course or not.

Research and Doctoral Dissertation Research Credits

PhD students must complete 27 credit hours of course work (described above), plus at least 3 credit hours of Research (BMEG 868) and 9 credit hours of Doctoral Dissertation research (BMEG 969). Please see the section on Sustaining Status (described below) regarding the policy on BMEG964 Pre-Candidacy Study and BMEG969 Doctoral Dissertation research credits.

Students with Previous Graduate Work

The BME program may waive up to 12 credit hours of required course work for students entering with a master's degree or transfer up to 9 credits for graduate course work performed at another recognized graduate school not leading to degree conferral. Waivers and transfers will only be granted for courses that cover subjects eligible for credit toward a PhD in Biomedical Engineering from the University of Delaware. Requests for credit waiver or course transfers must be initiated by the student before the beginning of their third semester at UD. Waivers and transfer credits must be approved by the Faculty Advisor and the BME Graduate Director and will be contingent on the student's demonstration of satisfactory performance in course work taken at UD.

ADDITIONAL PhD PROGRAM REQUIREMENTS

CHOOSING A FACULTY ADVISOR

Generally, students will be matched to a Faculty Advisor from the list of Biomedical Engineering faculty members (Primary and Joint faculty) participating in the degree program. During the first four months following fall matriculation (September through December), students will be advised

by the Graduate Director (unless a direct match to an advisor is made during the admission process). Unless a direct match to an advisor has been made during admissions, each student will participate in a minimum of two five-week lab rotations during their first semester. Rotations within specific labs will be assigned by the Graduate Committee based upon matriculating student interests and prospective advisor needs and availability. Upon the completion of rotations, the BME Graduate Academic Advisor will request that students provide, by the Monday before Thanksgiving, a confidential and ranked preference of at least two potential research advisors they consent to matching with. Similarly, advisors will submit their confidential ranked preference of rotated students to the Graduate Academic Advisor. The Graduate Committee will then work to match all students to Faculty Advisors within approximately two weeks of the end of rotations.

After matching, the Faculty Advisor will be the primary contact of the student for questions and advice regarding their training and dissertation research throughout the remainder of their program. Each student will develop a plan of study for the program with their Faculty Advisor by the end of the second semester of their first year. Any changes to a student's program of study must be approved by the Faculty Advisor and the BME Graduate Director.

THE QUALIFYING EXAM

The *Qualifying Exam* must be taken in the summer after the first year (and after the successful completion of at least 5 approved courses with a cumulative GPA of 3.00 or better). For students with non-fall matriculation or part-time study, the timing of this exam will be set based on course completion and approval by the Graduate Director.

The purpose of the *Qualifying Exam* is to evaluate the preparation of the student in the areas of i) background knowledge, and methodologies and techniques in their proposed field of research; ii) critical thinking, including the ability to identify gaps in knowledge in their area of research and to describe potential directions of future research to address such gaps; iii) oral and written scientific communication; and lastly; to iv) develop a training and mentoring plan to address any shortcomings identified in this preparation. These criteria will be evaluated through both a *Written Exam* and an *Oral Exam*.

The Written Exam

- The written exam requires the student to prepare a 6-7-page document, following standard NIH or NSF grant formatting rules, covering the following aspects/components:
 1. a *Title*;
 2. an *Abstract* or document *Summary*;
 3. a literature review establishing the *Background and Significance* of their proposed area of research;
 4. a *Summary of Important Methodologies, Measurements, Analyses*, and prior *Findings* in their proposed area of research, together with their *strengths and weaknesses*;
 5. the identification of at least one *Important Gap in the Current Knowledge* with regards to this area of research;
 6. the description of a *Potential Direction of Investigation* that the student could use to address the identified gap in knowledge through their *Future Research*;
 7. and a separate *Works Cited* section (no page limit).

- This document should be formatted as follows:
 - no less than 0.5-inch margins (top, bottom, and sides);
 - single spaced;
 - font no smaller than 11pt;
 - Arial, Georgia, Helvetica, or Palatino Linotype font suggested.
- It is suggested that students dedicate approximately 1/4th to 1/3rd of the written document to (4) the identification of the *Important Gap in the Current Knowledge* and (5) the description of a *Potential Direction of Investigation* that could be used to address this gap in knowledge. Please note, this is not a formal research proposal. However, this will allow the faculty to use the qualifying examination to evaluate the student's critical thinking and research development skills, which will be necessary to successfully complete a PhD in biomedical engineering.
- Correct citation style, conforming to the NIH SF424 guide requirements (<https://grants.nih.gov/grants/how-to-apply-application-guide/forms-e/general-forms-e.pdf>) or NSF Proposal Preparation Instructions (https://www.nsf.gov/pubs/policydocs/pappg20_1/pappg_2.jsp#IIC2diii), and the standards of the student's field of study, should be used throughout.

Students may initiate work on this examination document anytime they wish. However, primary work on this exam document is expected to occur between July 1 and August 1 of the student's first year of graduate study, where the student will be expected to dedicate significant time to its completion. Students must submit the exam document to the Graduate Director in PDF format by August 1. Students are expected to continue to participate in their research activities during the time they are working on their qualifying exams.

Students may consult their advisor, other faculty members, and other students regarding scientific questions during the preparation of this work. However, the written exam must be the student's original and independent work.

Any text or figures used from published sources (including previously published works by the student and/or grant submissions) must be properly cited. Failure to do so constitutes plagiarism.

The written exam will be evaluated by a committee of 3 faculty members chosen by the BME Graduate Committee, including the student's advisor and two other faculty members, one of which must be outside the primary area of the student's research. In the event that a student is co-advised, the committee shall consist of both co-advisors and two other faculty members. A minimum of two of the committee members must be BME faculty members. These committee members will evaluate the written exam to determine whether the student demonstrates (1) an acceptable knowledge of the scientific background and techniques relevant to their topic, and (2) appropriate critical thinking, problem formulation, and written scientific communication skills expected of a student completing the first year of a Biomedical Engineering Ph.D. program.

The Oral Exam

After the written exam has been evaluated, a 75-minute oral exam will be scheduled with the same committee that evaluated the written proposal. *Oral exams* are typically scheduled for the week prior to the start of the Fall Academic Semester, but no sooner than 14-days after the submission of the written exam document. For the oral exam the student should prepare a 15-minute presentation based on their written exam. Following the presentation, there will be one hour for questioning, which will be divided between Q&A relating to the written and oral exam and questions on general biomedical engineering knowledge based on the student's completed core and elective courses.

At the conclusion of the oral exam, the exam committee will provide verbal and written feedback to the student regarding both the written and oral components of the examination. This will allow for a more cohesive and holistic evaluation process.

Possible Examination Outcomes

The Qualifying Exam Committee will submit a recommendation to the Graduate Committee that the student either *Pass* or *Fail* the Qualifying Exam.

A decision of *Pass* means the committee feels that the student's preparation is adequate such that, if suggested additional coursework and mentoring is completed, the student will be able to be successful in independent dissertation-level research. If the committee recommends the student *Pass*, they should also prepare a proposed study and mentoring plan to address any identified areas of weakness or insufficient preparation. This plan shall be submitted to the Graduate Director using the *Study and Mentoring Plan* form within one week of the completion of the oral examination.

A decision of *Fail* means that the committee feels that the student's present areas of weakness and insufficient preparation are significant enough to prevent the student from successfully achieving programmatic milestones necessary to demonstrate and complete independent dissertation-level research, and that these deficiencies cannot be corrected within the timeframe set by the Graduate Program for accomplishing these milestones.

All recommendations by the examination committees will be reviewed and voted upon by the Graduate Committee. The Graduate Director or Graduate Academic Advisor will communicate the approved decision to the student and their (co-)advisor(s) and will provide and retain a written copy of the study and mentoring plan.

Progress made on the study and mentoring plan shall be documented on subsequent Annual Progress Reports, or earlier if specified in the plan. Inadequate progress in the study and mentoring plan recommended by the committee may be grounds for dis-enrollment from the PhD program. If the student Fails, he/she will be dis-enrolled from the PhD program, but may continue in the MS program if they meet all necessary requirements.

DISSERTATION COMMITTEE

As soon as possible, but no more than one year after passing the Qualifying Exam, the student must establish a Dissertation Committee. The Dissertation Committee is selected by the Faculty Advisor and the student and must have a minimum of four members including the advisor and at

least three additional faculty. Three members must have an appointment in BME (Primary, Joint, or Affiliated), at least one member must hold a Voting appointment in BME, and one must be from outside the primary research area of the dissertation topic. Three members must be from the University of Delaware. Using the [Form to Establish Dissertation Committee](#) document, the student must submit a 1-2 page research plan, approved by the proposed dissertation committee, to the Graduate Director. The research plan should contain a brief description of the student's proposed research area including major questions to be addressed, a brief summary of research accomplishments so far, one paragraph justifying the committee composition, and a preliminary timeline for the completion of the degree. The Graduate Director must approve the committee, chair, and research plan. Once the committee has been established, students must complete the **Dissertation Committee Confirmation** form and submit it to the Graduate College. If a student is unable to form their dissertation committee within one year of passing their Qualifying Exam, they must petition the Graduate Director, in writing, for an extension of this deadline, else they risk being designated a Student Not in Academic Compliance (see description below). Any subsequent changes in committee members must be approved by the Graduate Director, and the student must complete the [Request to Change Dissertation or Education Leadership Portfolio Committee](#) form and submit it to the Graduate College.

TEACHING AID REQUIREMENT

The ability to communicate ideas, concepts, and factual information is an essential skill for all PhD graduates, even those who have no interest in an academic career. In recognition of this, all PhD students are required to fulfill a Teaching Aid Requirement for 1 semester that consists of serving as a Teaching Aid. Note that this is different from the Teaching Assistantships offered as financial aid (described in [Financial Aid](#) section). While fulfilling this Teaching Aid Requirement, students are expected to continue being actively involved in their research.

The responsibilities of the Teaching Aid Requirement will be defined by the course instructor and should not exceed 20 hours per week. In general, PhD students should not merely be assigned grading responsibilities. They should have an opportunity to plan and deliver lectures, lead discussion sections and lead laboratory exercises. Direct interaction with course students is highly encouraged.

The University requires that all first time Teaching Aids take a TA orientation class offered by the Center for Teaching and Learning (typically scheduled for prior to the start of their first semester classes). International students must also enroll in the ELIITA ([English Language Institute International Teaching Assistant](#)) program before performing their teaching requirement.

Although the exact timing of these Teaching Aid appointments is flexible, it is highly desirable to complete all teaching responsibilities by the end of the 2nd year, although they can be extended to the 3rd year or later under certain circumstances. The BME Graduate Committee assigns these positions in late Fall (for the upcoming spring semester) and in late Spring or Summer (for the following fall semester). Students are encouraged to submit their preferences for specific positions early to facilitate the process. Although every effort will be made to satisfy these requests, students should recognize that this is not always possible.

CANDIDACY REQUIREMENTS + TRANSITIONING TO SUSTAINING STATUS

To qualify to be a PhD Candidate, students must complete the following:

- a. Complete a one semester Teaching Aid Requirement.
- b. Pass the Qualifying Exam.
- c. Establish a Dissertation Committee.
- d. Complete all coursework; inclusive of 3 credits of BMEG 868 *Research* and 9 credits of BMEG969 *Doctoral Dissertation* (see below).

During the semester that a student is expected to complete the coursework and research credits required for the BME Ph.D. Degree, typically semester four after matriculation, the student can submit their [Doctoral Degree Candidacy Recommendation Form](#) to the Graduate College. This form must be approved and signed by the student's Dissertation committee and the Graduate Director. University policy requires that students must advance to candidacy a minimum of six months prior to the defense of their dissertation.

If a student has registered for, or completed all course requirements in a program of study but has not yet met all of the stipulations for passing into candidacy, the student must maintain full-time registration during the fall and spring semesters in course(s) and/or Pre-Candidacy Study (964) (minimum of 9-credits per semester is considered full-time). Pre-Candidacy Study (964) is graded pass/fail. If the student registered in Pre-Candidacy Study is admitted to candidacy before the end of the free drop/add period of the following semester, their registration in Pre-Candidacy Study (964) for the preceding semester may be changed to the course Doctoral Dissertation (969) and used to fulfill the 9-credit Doctoral Dissertation requirement.

Once a student has completed all credit-bearing coursework required for the BME PhD degree, completed their Teaching Aid requirement, passed the Qualifying Exam, established a Dissertation Committee, and qualified for Candidacy, they will be considered eligible for transitioning to Sustaining Status by the BME Department. Completion of credit-bearing course work includes completion of 9 credits of BMEG969 Doctoral Dissertation.

Once a graduate student has transitioned to Sustaining Status, having completed all requirements for the degree except the submission of their dissertation, the student must maintain matriculation in the BME PhD program during the fall and spring semesters by registering for Doctoral Sustaining (UNIV 999). Additionally, all students must be registered in the semester in which the degree is officially awarded. Sustaining registration is required for summer and winter session only if the degree is awarded at the conclusion of the summer or winter session. Students in sustaining status are considered full time.

GRADUATE STUDENT RESEARCH SYMPOSIUM

Strong scientific communication is a fundamental skill required of successful biomedical engineers. As a means to develop and practice visual and oral communication skills, the BME program supports semi-annual, graduate research symposia. These symposia consist of 3-minute research pitches and 12-minute research talks given by graduate students to the BME Department and invited guests. Each student is required to present at our Research Symposia a minimum of two times before graduation. This includes the presentation of a 3-minute research 'pitch' by the end of their 3rd year of training and a 12-minute research talk by the time of their graduation. It is expected that students in their 2nd and 3rd years of training will present the 3-minute 'pitches', and students in or beyond their 4th year of training will present the 12-minute talks.

DISSERTATION PROPOSAL

The Dissertation Proposal requires a written proposal outlining the plan of research for the PhD and an oral presentation and defense of this proposal to the Dissertation Committee. The written proposal will follow either a NIH R01 or NSF grant submission format, with length of 10-12 pages, excluding references. A curriculum vita, the most recent Progress Report form, and a graduate-level transcript should also be included with the proposal. All materials should be distributed to the Dissertation Committee at least 2 weeks before the oral proposal. The defense will include a 30 min presentation by the student, followed by a 60 min Q&A discussion. There are no guidelines as to whether the proposal is open or closed to an external audience, and determination of this is left up to the student and advisor(s). The student must complete the Dissertation Proposal within 2 years of the Qualifying Exam. If a student is unable to successfully complete their Dissertation Proposal within two years of passing their Qualifying Exam, they must petition the Graduate Director, in writing, for an extension of this deadline; else they risk being designated a Student Not in Academic Compliance (see description below).

COMPLETING THE PHD

To complete the PhD, students must pass a Dissertation Exam. This exam involves approval of the written dissertation and an oral defense of the dissertation. The oral defense must be scheduled through the BME Department and the UD Graduate College must be notified of the defense using their [online form](#). The written dissertation must be deposited with the BME department for submission to the student's Dissertation Committee at least 2 weeks before the oral defense. The oral presentation will be announced to the University community and open to the public, and will last ~45 min. After questions from the public not to exceed 15 minutes, a closed Q&A session with the Dissertation Committee of 30-60 minutes will follow. The student will be responsible for making corrections to the dissertation document and for meeting all Graduate College deadlines for submission. All paperwork that must be submitted prior to and following the defense of the dissertation and approval of the written dissertation document can be found [online](#). These include the [Advanced Degree Application](#), [Dissertation Defense Notification](#), and the [Dissertation Defense Certification](#) forms. Detailed instructions regarding dissertation style guidelines and dissertation deposition deadlines can be found on the [UD Graduate College website](#).

Department policy is that students must complete the Dissertation Exam within 5 years of the Qualifying Exam (6 years after matriculation) or must petition the Graduate Director, in writing, for an extension of this deadline, else they risk being designated a Student Not in Academic Compliance (see below).

The University also has established [Degree Time Limits](#) for the completion of doctoral program degrees. Students entering a doctoral program without a master's degree are given fourteen consecutive semesters to complete the necessary requirements. For students that require a time extension beyond the fourteen consecutive semesters to complete their degree must request a time limit extension from the University. This requires the student to make the request in writing, have it approved by the student's advisory committee and the chair of the department's graduate committee. The department must then forward the request to the Graduate College, and the Graduate College will determine the student's eligibility for a time extension and will notify the student in writing of its decision to grant an extension of time. Students entering a doctoral program with a master's degree are given ten consecutive semesters to complete the requirements.

MS PROGRAM

The MS program in Biomedical Engineering consists of 30 credits of graduate level course work, including 6 credits of Master's Thesis if electing the Thesis option. The program allows for considerable flexibility in course selection. The MS program with thesis option also requires completion of an approved Master's Thesis. If a student is switching into the MS program after initially being in the PhD program, they must submit a [Change of Major/Concentration or Degree Form](#) to the Graduate College.

The tables below list the credit requirements for a MS degree in BME.

| MS requirements in Biomedical Engineering (Thesis option): 30 credits total | |
|--|---------------------|
| 4 Core courses | |
| Physiology | 3 credits (minimum) |
| Advanced Math | 3 credits |
| Statistics | 3 credits |
| Communication | 3 credits |
| 4 Technical electives (minimum), of which at least 1 must be a 600-level or higher BMEG elective | 12 credits |
| Thesis | 6 credits |

| MS requirements in Biomedical Engineering (non-Thesis option): 30 credits total | |
|--|---------------------|
| 4 Core courses | |
| Physiology | 3 credits (minimum) |
| Advanced Math | 3 credits |
| Statistics | 3 credits |
| Communication | 3 credits |
| 6 Technical electives (minimum), of which at least 1 must be a 600-level or higher BMEG elective | 18 credits |

Course Requirements

| Core Courses (12 credits) | |
|-----------------------------------|--|
| Physiology (3 credits minimum) | BISC 605 Advanced Mammalian Physiology I [4 cr.] or BISC 606 Advanced Mammalian Physiology II [4 cr.] KAAP 630 Advanced Human Physiology I [3 cr.] or KAAP 631 Advanced Human Physiology II [3 cr.] |
| Advanced Math (3 credits) | BMEG 671 Mathematical Physiology |
| Statistics (3 credits) | BMEG 802 Advanced Biomedical Experiment Design & Analysis |

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| Communication (3 credits) | BMEG 801 Communication in Biomedical Engineering |
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Other classes may be substituted for the approved core courses at the recommendation of the Faculty Advisor with the approval of the Graduate Director and Graduate Committee.

Technical Electives

Technical Electives can be chosen from courses offered across engineering departments. Classes may be chosen from the list approved for the PhD program as above, and at least one technical elective must be a 600-level or higher BMEG technical elective. Courses not on the above Technical Elective list can be substituted with permission of the Faculty Advisor and the Graduate Director. Students electing the non-thesis option may use up to 6 credits of BMEG 868 (Research) toward the 18-unit technical elective requirement. Check for updated lists periodically. For descriptions of technical electives, please refer to the [UD Course Catalog](#).

Choosing a Faculty Advisor

If a student is pursuing a non-thesis option MS, the student will be advised by the Graduate Director, or a BME-affiliated faculty member appointed by the Graduate Director. If a student is pursuing a thesis-option MS, the student will be advised by the BME-affiliated faculty member most directly involved in supervising the thesis research. Students are responsible for identifying potential faculty advisors by meeting with faculty, attending faculty presentations, and attending research group meetings, and/or by participating in research rotations during their first semester in the program. With the consent of both student and advisor, the Graduate Director will match the student to a Faculty Advisor before work is begun on the thesis research.

The Faculty Advisor will be the primary contact of the student for questions and advice on his/her training and thesis research throughout the remainder of the program. The student will develop a plan of study for the program with the Faculty Advisor by the end of the second semester of their first year. Any changes to a student's program of study must be approved by the Faculty Advisor and the BME Graduate Director.

Thesis Committee

Before beginning work on their thesis research, the student must establish a Thesis Committee. The Thesis Committee is selected by the Faculty Advisor and the student, and must have a minimum of three (3) members including the advisor and at least two (2) additional faculty. Two (2) members must have an appointment in BME (Primary, Joint, or Affiliated Faculty), at least one member must hold a Primary or Voting Joint appointment in BME. The student must submit a 1-2 page research plan approved by the committee to the Graduate Director. The research plan should contain a brief description of the student's proposed research area including major questions to be addressed, a brief summary of research accomplishments so far, one paragraph justifying the committee composition, and a preliminary timeline for the completion of the degree. The Graduate Director must approve the committee, and research plan, and any subsequent changes in committee members.

Thesis Submission

To complete the MS with thesis option, students must submit a correctly formatted thesis meeting

the University formatting rules, presenting novel, publishable research that has been reviewed and approved by the student's thesis committee. The thesis committee may, at their discretion, require a formal presentation of the thesis as a condition of approval. The student will be responsible for making corrections to the thesis document and for meeting all Graduate College deadlines for submission. Students must complete the thesis within 5 years of matriculation or must petition the Graduate Director for an extension.

Completing the MS Degree

Once all requirements have been met (including the approved thesis for thesis-option MS students), the student must submit an [Advanced Degree Application](#) to the graduate office. Detailed instructions regarding thesis style guidelines and thesis deposition deadlines can be found on the **UD Graduate College** [website](#).

ACADEMIC STANDING

Academic Load

Full-time students are expected to complete the PhD program in 4-6 years, or the MS program in 2-3 years. The program may be completed over a longer time frame for part-time students. Students must be enrolled in at least 9 credit hours or in sustaining credit to be considered full-time students. Those enrolled for fewer than 9 credit hours are considered part-time students, although students holding assistantships are considered full-time with six credits. Students are expected to take 9 credit hours of course work for the first semester in order to be funded. All graduate students are expected to register for a minimum of three credits, typically research credits, during the summer term but not the winter term. Generally, a maximum load is 12 graduate credit hours in spring and fall; however, additional credit hours may be taken with the approval of the student's adviser and the Office of Graduate and Professional Education.

Annual Progress Report

The student's progress toward their PhD will be monitored annually by the BME Graduate Committee. Before July 1st of each year, the student must submit an annual **Progress Report** form to the Graduate Director that is signed by the Faculty Advisor. This form includes a checklist of course requirements, research accomplishments, self-assessment, individual development plan, advisor feedback, and verifications that programmatic milestones/requirements are completed and annual Dissertation Committee meetings are occurring. Failure to submit the annual progress report on time may result in discontinuation of funding and cancellation of Fall registration until the Progress Report is completed.

Grade Requirements

Only graduate courses completed with a grade of B- or higher will count towards the requirements of the BME program. Students must maintain at least a 3.0 cumulative grade point average to receive the degree. If student does not achieve a B- or higher in a core course, they must retake the course (or any of the optional core courses in that category), and if the retaken grade is below a B, the student will be recommended for dismissal. If student achieves lower than a B- on an elective course, they can retake the course or replace it with another elective course. University of Delaware has a No Replacement policy so both grades of a repeated course are included in the cumulative

GPA and the University requires that this GPA must be over 3.0. However, the cumulative GPA for the courses that lead to the PhD degree only use the higher grade of the repeated course.

Consequences of Unsatisfactory Progress/Being a Student Not in Academic Compliance

The BME Graduate Committee will meet at least once each year to evaluate each student's progress within the BME Graduate Program. As part of this monitoring process, each student must annually submit a **Progress Report** form to the BME Graduate Director before July 1. This form requires that the student meet, at a minimum, once-a-year with their Dissertation committee (in year one, the meeting of the Qualifying Examination committee suffices for this requirement), and that they meet with their advisor to sign-off on their annual progress report. If the advisor indicates that the student progress is deemed to be unsatisfactory, the advisor, in consultation with and through the approval of the student's dissertation committee, will provide details regarding expected remedies and an appropriate timeline for resolving any deficiencies. Continued unsatisfactory progress may be grounds for discontinuation of funding and/or dismissal from the graduate program. If the student continues in failing to make satisfactory progress towards a degree, the committee will recommend suitable action to the BME Graduate Director. Possible actions include (but are not limited to): (i) requirement for additional courses, (ii) suspension of financial support, and (iii) recommendation for dismissal.

Standards of Student Conduct

All graduate students are subject to University of Delaware [regulations regarding academic honesty](#). Violations of the UD regulations regarding academic honesty or other forms of gross misconduct will be referred to the [Office of Student Conduct](#) may result in immediate dismissal from the Program.

Dismissal

The procedures for dismissal as detailed in the [University Graduate Catalog](#) will be followed. Briefly, the BME Graduate Committee will report its recommendation and reason for dismissal to the BME Graduate Director. They will make a recommendation to the Graduate College, who will decide whether to dismiss the student. The student may appeal this decision to the Graduate College, following the procedures given in the University Catalog.

Graduate Student Grievance Procedure

Students who feel that they have been graded inappropriately or have received what they perceive as an unfair evaluation by a faculty member may file grievances in accordance with University of Delaware [policies](#). Students are encouraged to contact the BME Graduate Director and/or the Chair of the BME Department prior to filing a formal grievance in an effort to resolve the situation informally.

Attendance at Conferences and Professional Meetings

The BME program encourages students to attend conferences and professional meetings. They provide opportunities to meet future employers and colleagues, and can offer specialized training beyond course work.

FINANCIAL AID

Financial Awards

Financial assistance is awarded on a competitive basis to the pool of admitted applicants. The University of Delaware's policies apply to all forms of financial aid. Please refer to the University Policies for Graduate Student Assistantships and Fellowships.

The majority of students in the BME PhD program will be supported on research contracts and grants obtained by their Faculty Advisors. Students pursuing a terminal MS degree are not generally funded by the department, but may be supported on research contracts and grants as deemed appropriate by the PI on those projects. MS students may also be appointed as Teaching Assistants at the discretion of the graduate committee chair. PhD Students on projects without external funding will be provided support (assuming that their progress is satisfactory) through the use of either other program funds or by appointment as a Teaching Assistant. No student will be supported by departmental funds for more than 2 semesters; funds beyond such a commitment must be provided by the Faculty Advisor or by appointment as a Teaching Assistant. In general, funding is not guaranteed beyond five years.

Students in the Biomedical Engineering program may be provided the following graduate assistantships:

- **Research Assistants (RAs)** are generally funded by research grants and contracts provided by external funding agencies. Students should be supported as an RA through their Faculty Advisor's research funds once they are matched (usually following the first full semester of the student's matriculating year). RAships provide full tuition and a stipend.
- **Teaching Assistants (TAs)** are offered for graduate students to perform teaching and other instructional activities. Note that this is different from the Teaching Aid Requirement described in the **Candidacy Requirements** section. The amount of service may vary from week to week, but the average is usually expected to be 20 hours per week. A TA-ship provides full tuition and a stipend. In accordance with University of Delaware regulations, TAs must fulfill the requirements detailed for the Teaching Aid Requirement in the **Candidacy Requirements** section above in order to qualify for this type of assistantships.

Continuation of Financial Aid

Students who are awarded financial aid must maintain satisfactory academic progress with satisfactory performance of assistantship duties (see below). Satisfactory academic progress includes maintaining full-time status and maintaining the grade requirements detailed in the **Satisfactory Progress** section.

The Faculty Advisor will establish the Research Assistant (RA) responsibilities and performance standards. In the event of an unsatisfactory performance by an RA, the Faculty Advisor will notify the BME Graduate Director and the student of the problem in writing. The Advisor will give the student a performance appraisal that lists the specific areas that need improvement and a timeline by which to rectify the situation (typically 1 to 3 months) before the assistantship is terminated.

The director of the course in which the student teaches will establish the Teaching Assistant (TA) responsibilities and performance standards. In the event of an unsatisfactory performance by a TA, the course director will notify the student and the BME Graduate Director in writing detailing the specific areas that need improvement. If the student does not rectify the situation (typically within 2-4 weeks), the BME Graduate Director may recommend termination of the assistantship.

BME PEOPLE

BME Graduate Director

The Associate Director for Graduate Studies in BME chairs the BME Graduate Committee and is called the BME Graduate Director. They will be responsible for the overall implementation, quality and progress of the degree program, and advised by the BME Graduate Committee. They will also act as advisor to students during their first semester, until they have been matched to a Faculty Advisor. The Graduate Director serves as a conduit of communication between the program's students, the BME faculty, administrative staff, the Graduate Committee, and the Department Chair. At the end of the PhD or MS program, the Graduate Director will approve the application for the degree upon verifying that the student has successfully completed the requirements.

BME Graduate Committee

This committee consists of at least five BME-affiliated faculty. It is responsible for 1) recommending student admissions and visits, 2) matching students to research advisors, 3) developing and approving the curriculum, 4) reviewing annual Progress Reports, 5) assigning Qualifying Exam committees, 6) reviewing and approving Dissertation Committee members and chairs, and 7) dealing with petitions for course substitutions.

FORMS

All forms can be accessed at: <http://bme.udel.edu/graduate-program-forms/>

ADDITIONAL GRADUATE STUDENT POLICIES

Additional information regarding University-level graduate student policies can be found in the UD [Graduate Catalog](#), and at the website of the [Graduate College](#).