BU BME Department

Graduate Student Handbook for PhD Candidates

Fall 2019
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Overview of PhD Program Timeline

Typical progress through the BME PhD degree follows the timeline described below.

- Course requirements should be completed as early as possible, typically within the first two years.
- It is highly recommended that the Math Requirement be completed during the first academic year.
- Students complete the required rotation system in the first academic year before choosing a lab to join.
- The Oral Qualifier Exam is taken in early summer (usually June) following the first academic year.
- The Prospectus Defense should be presented by the end of the sixth semester from matriculation.
- PhD students have five years to complete the dissertation after becoming a PhD candidate. Meetings with their committee must occur at least annually following the Prospectus Defense.
- The culmination of the PhD is the dissertation, which consists of both a written PhD Dissertation and an oral Dissertation Defense.

Note that special cases where timelines may deviate from this are described in detail in this handbook.
Summary of Course Requirements for BME PhD Candidates

Post-BS PhD Students (Post-Bachelor’s)

- **BE 790** Biomedical Engineering Seminar
- **BE 791** Biomedical Engineering Laboratory Rotations (Students will register for 1 credit in the fall semester and 2 credits in the spring semester – one credit per rotation)
- **BE 792** Literature Review (spring semester of the first year, 2 credits)
- **BE 605** Molecular Bioengineering (fall semester of the first year, 4 credits)
- If you have had prior coursework that you feel overlaps substantially with this material, you can discuss with the instructor the possibility of waiving this course requirement. Waivers must be approved by the Associate Chair for Graduate Programs using the BME Petition Form.
- **BE 606** Quantitative Physiology for Engineers (spring semester of the first year, 4 credits)
- If you have had prior coursework that you feel overlaps substantially with this material, you can discuss with the instructor the possibility of waiving this course requirement. Waivers must be approved by the Associate Chair for Graduate Programs using the BME Petition Form.

- Three Graduate-Level BME Electives
- Two Graduate-Level Technical Electives (may include additional BME coursework)
- **Note:** Courses related to product development or management do not qualify as technical electives. See note below about other exceptions. If in doubt about a course, students should consult with Christen Bailey.
- **Math Requirement** (selected from approved list included in handbook and available online). It is strongly recommended that this be completed during the first academic year. Both passing the Oral Qualifier Exam and satisfying the math requirement are required in order to achieve PhD candidacy.
- **Teaching Practicum (BE 801 and BE 802)** All PhD students are required to teach two semesters. Typically, the first teaching assignment (BE 801) is during the second year and the second assignment (BE 802) is during the third year. BE 801 and BE 802 each count for 4 credits and students require permission of their research advisor if they want to take an additional course during the semester that they are teaching.
- **BE 900 (Pre-Prospectus)/991 (Post-Prospectus) Research** (minimum of 12 credits)
- If approved by the student’s advisor and the Associate Chair for Graduate Programs (using the BME Petition Form), additional courses that do not necessarily satisfy a program requirement but would be beneficial to the student’s research or career goals are allowed.

Post-Bachelor’s PhD students must complete a minimum of **64 credits** (formal courses plus research credits) prior to graduation, earning at least 56 credits at BU.

Post-MS PhD Students (Post-Master’s)

- **BE 790** Biomedical Engineering Seminar
- **BE 791** Biomedical Engineering Laboratory Rotations (Students will register for 1 credit in the fall semester and 2 credits in the spring semester – one credit per rotation)
- **BE 792** Literature Review (spring semester of the first year, 2 credits)
- **BE 605** Molecular Bioengineering (fall semester of the first year, 4 credits)
- If you have had prior coursework that you feel overlaps substantially with this material, you can discuss with the instructor the possibility of waiving this course requirement. Waivers must be approved by the Associate Chair for Graduate Programs using the BME Petition Form.
- **BE 606** Quantitative Physiology for Engineers (spring semester of the first year, 4 credits)
- If you have had prior coursework that you feel overlaps substantially with this material, you can discuss with the instructor the possibility of waiving this course requirement. Waivers must be approved by the Associate
Chair for Graduate Programs using the BME Petition Form.

- **Two Graduate-Level Technical Electives (at least one BME)** Students will be advised individually about what courses to take, which may depend on the specifics of their MS degree.

- **Note:** Courses related to product development or management do not qualify as technical electives. See note below about other exceptions. If in doubt about a course, students should consult with Christen Bailey.

- **Math Requirement** (selected from approved list included in handbook and available online). It is strongly recommended that this be completed during the first academic year. Both passing the Oral Qualifier Exam and satisfying the math requirement are required in order to achieve PhD candidacy.

- **Teaching Practicum (BE 801 and BE 802)** All PhD students are required to teach two semesters. Typically, the first teaching assignment (BE 801) is during the second year and the second assignment (BE 802) is during the third year. BE 801 and BE 802 each count for 4 credits and students require permission of their research advisor if they want to take an additional course during the semester that they are teaching.

- **BE 900 (Pre-Prospectus)/991 (Post-Prospectus) Research** (minimum of 4 credits)

  - If approved by the student’s advisor and the Associate Chair for Graduate Programs (using the BME Petition Form), additional courses that do not necessarily satisfy a program requirement but would be beneficial to the student’s research or career goals are allowed.

  **Note:** There is no “typical” Post-Master’s PhD. At the discretion of the Associate Chair for Graduate Programs, fewer courses may be allowed, depending on prior coursework. In total, Post-MS students must complete a minimum of 32 credits (comprised of formal courses plus research course credits) at BU.

**MD/PhD Students**

- **BE 790 Biomedical Engineering Seminar**
- **BE 791 Biomedical Engineering Laboratory Rotations** (Students will register for 1 credit in the fall semester and 2 credits in the spring semester – one credit per rotation)
- **BE 792 Literature Review** (spring semester of the first year, 2 credits)
- **BE 605 Molecular Bioengineering** (fall semester of the first year, 4 credits)

  - If you have had prior coursework that you feel overlaps substantially with this material, you can discuss with the instructor the possibility of waiving this course requirement. Waivers must be approved by the Associate Chair for Graduate Programs using the BME Petition Form.

- **BE 606 Quantitative Physiology for Engineers** (spring semester of the first year, 4 credits)

  - If you have had prior coursework that you feel overlaps substantially with this material, you can discuss with the instructor the possibility of waiving this course requirement. Waivers must be approved by the Associate Chair for Graduate Programs using the BME Petition Form.

- **Three Graduate-Level Technical Electives (at least one BME)**

  - **Note:** Courses related to product development or management do not qualify as technical electives. See note below about other exceptions. If in doubt about a course, students should consult with Christen Bailey.

  - **Math Requirement** (selected from approved list included in handbook and available online). It is strongly recommended that this be completed during the first academic year. Both passing the Oral Qualifier Exam and satisfying the math requirement are required in order to achieve PhD candidacy.

- **Teaching Practicum (BE 801 and BE 802)** All PhD students are required to teach two semesters. Typically, the first teaching assignment (BE 801) is during the second year and the second assignment (BE 802) is during the third year. BE 801 and BE 802 each count for 4 credits and students require permission of their research advisor if they want to take an additional course during the semester that they are teaching.

- **BE 900 (Pre-Prospectus)/991 (Post-Prospectus) Research** (4 credits)

  - If approved by the student’s advisor and the Associate Chair for Graduate Programs (using the BME Petition Form), additional courses that do not necessarily satisfy a program requirement but would be beneficial to the student’s research or career goals are allowed.
MD/PhD students have course requirements that are a hybrid between those of Post-BS and Post-MS PhD students. Students must enroll for a total of 48 credits prior to receiving the PhD degree.

**Required Teaching Practicums for All PhD Students**

**BE 801 and BE 802 Teaching Practicum I and II** (4 credits each) All PhD students assigned to teach for the first time are required to register for BE 801 during the semester of their formal teaching assignment. During the second assignment, students must register for BE 802. During the semester in which the student teaches, he/she may only register for 8 credits (BE 801 or BE 802 plus 4 credits of BE 900/991). Students may take a structured course while teaching only if they receive permission from their research advisor (credit limit would then be 10 – 4 for BE 801 or BE 802, 4 for the course and 2 for BE 900/991).

**Credit for Courses Taken Elsewhere**

Students may “place out” of required courses (but not electives, BE 900 or BE 991), if they have taken equivalent courses elsewhere at the graduate level, as long as those courses were not used to meet the requirements of an undergraduate or previous degree. For example, students who have taken a graduate-level physiology course may receive permission not to take BE 606. Students with extensive experience in quantitative molecular biology may receive permission not to take BE 605. This permission must be granted by submitting a BME Petition Form to BEFORE the end of the ADD/DROP period to waive the requirement. Though students may place out of specific course requirements, this does not alter the total number of credits a student must earn at Boston University (56 or more for Post-BS PhD students, 32 for Post-MS PhD students) to meet the degree requirements.

**Courses that Fulfill the BME Math Requirement**

Students must complete one 4-credit or two 2-credit math courses (BE 601-604) from the list below and pass with a B+ or higher. Students may petition for a different course (500-level or higher) to satisfy the math requirement.


CAS MA 565 Mathematical Models in the Life Sciences  An introduction to mathematical modeling, using applications in the biological sciences. Mathematics includes linear difference and differential equations, and an introduction to nonlinear phenomena and qualitative methods. An elementary knowledge of differential equations and linear algebra is assumed.

CAS MA 579 Numerical Methods for Biological Sciences  An introduction to the use of numerical methods for studying mathematical models of biological systems. Emphasis on the development of these methods; understanding their accuracy, performance, and stability; and their application to the study of biological systems.

CAS MA 684 Applied Multiple Regression and Multivariable Methods Application of multivariate data analytic techniques. Multiple regression and correlation, confounding and interaction, variable selection, categorical predictors and outcomes, logistic regression, factor analysis, MANOVA, discriminant analysis, regression with longitudinal data, repeated measures, ANOVA.

CAS PY 501 Mathematical Physics  An introduction to complex variables and residue calculus, asymptotic methods, and conformal mapping; integral transforms; ordinary and partial differential equations; non-linear equations; integral equations.

ENG BE 567 Nonlinear Systems in Biomedical Engineering  Introduction to nonlinear dynamical systems in biomedical engineering. Qualitative, analytical and computational techniques. Stability, bifurcations, oscillations, multistability, hysteresis, multiple time-scales, chaos. Introduction to experimental data analysis and control techniques. Applications discussed include population dynamics, biochemical systems, genetic circuits, neural oscillators, etc.

NOTE: If students take courses from the BE 601-604 series they must take BE 601 and then either BE 602, BE 603, or BE 604 to satisfy the Math Requirement. Rudimentary programming skills are necessary for these modules.

ENG BE 601 Linear Algebra  The first of four math modules designed to reinforce basic mathematical and computer programming concepts pertinent to graduate research in biomedical engineering. This course will emphasize the five cornerstones of applied linear algebra: Linear combinations, decompositions, orthogonality, metric, and linear transformations. Topics include LU and QR factorizations, finite difference methods for solving partial differential equations (PDEs), least squares, Fourier series and wavelets, solid mechanics, Markov chains, principal component analysis, and signal processing techniques. This course will provide the necessary linear algebra background needed to solve problems in BE 602, 603 and 604.

ENG BE 602 Ordinary Differential Equations  This math module will focus on four key ODE concepts: Linear dynamical systems, nonlinear conservative and excitable systems, discrete-time state machines, and generalized Fourier series solutions to Sturm-Liouville problems. Topics include: Filters, enzymatic networks, mechanical models for biomaterials, oscillators and limit cycles, phase-locked loops, nonlinear Leslie matrices, Legendre polynomials, Bessel functions, and a prelude to solving PDE problems associated with heat transfer, diffusion, and electrostatics. Prior exposure to linear algebra (BE 601 or equivalent), and working knowledge of a programming language (Matlab, Python, etc.) is helpful.

ENG BE 603 Partial Differential Equations  This math module will focus on elliptical and parabolic PDEs associated with transport phenomenon problems in biomedical engineering. We will visit four PDE concepts: Separation of variables, integral transform solutions, superposition principles, and numerical approximations using finite-difference schemes. Topics include: 2D and 3D anisotropic Laplace's, Poisson's, and the heat equations in different coordinate systems, Fourier and Laplace transform solutions, 2D ADI methods, Green's functions, and the method of images. Prior exposure to linear algebra (BE 601 or equivalent), ODEs (BE 602 or MA 226 equivalent), Fourier
series, Fourier and Laplace transforms (BE 401 equivalent), and working knowledge of a programming language (Matlab, Python, etc.) is highly recommended.

**ENG BE 604 Statistics and Numerical Methods** This math module will focus on how linear algebra, ODEs, statistics, and signals & systems techniques can be used to interrogate data from biological and engineering experiments. The lecture topics include: Jacobi, Gauss-Seidel, and SOR iterative solvers for large linear systems; Gauss-Newton iterations (nonlinear least-squares); the ANOVA table, multi-factor regression, and intro to the general linear model (GLM); data deconvolution; Monte Carlo, bootstrap, and kernel density estimation. Prior exposure to linear algebra (BE 601 equivalent), basic probability and statistics (BE 200 equivalent), and working knowledge of a programming language (Matlab, Python, etc.) is highly recommended.


**ENG ME 566 Advanced Engineering Mathematics** Introduces students of engineering to various mathematical techniques that are necessary in order to solve practical problems. Topics covered include a review of calculus methods, elements of probability and statistics, linear algebra, transform methods, difference and differential equations, numerical techniques, and mathematical techniques in optimization theory. Examples and case studies focus on applications to several engineering disciplines. The intended audience for this course is advanced seniors and entering MS engineering students who desire strengthening of their fundamental mathematical skills in preparation for advanced studies and research.

**GRS MA 681 Accelerated Introduction to Statistical Methods for Quantitative Research** Introduction to statistical methods relevant to research in the computational sciences. Core topics include probability theory, estimation theory, hypothesis testing, linear models, GLMs, and experimental design. Emphasis on developing a firm conceptual understanding of the statistical paradigm through data analyses.

### Technical Elective Exceptions

**Note:** The following courses, although offered by the College of Engineering, do **not** meet the requirement of a technical elective: BE 795, ME 502, ME 517, ME 518, ME 525, ME 550, ME 583, ME 584, ME 703 and EK 731. SI 839, SI 852, SI 855, SI 871 and PH 825 also do not qualify as a technical elective. Technical electives do not have to be taken within the College of Engineering; hard science courses offered through other BU Colleges may be approved using the [BME Petition Form](#).

### Auditing Courses

An auditor is a student who attends a class to acquire knowledge but not to earn credits or a grade. Audited courses do not count toward completing degree requirements. An auditor may not change his or her status after the fifth week of classes for standard courses. Auditors must attend classes regularly, complete assigned reading,
and participate in discussions, but they are excused from examinations.

Auditors are admitted to a course on a space-available basis and with the approval of the instructor. Auditors are subject to the full tuition and fees of the course.

PhD students who have completed all departmental course requirements are entitled to audit officially one course each semester, excluding Summer Term, without further tuition charge. Students may not audit ENG 900-level, language, physical education, studio or laboratory courses.
Satisfactory Academic Progress Requirement for PhD Students

The College of Engineering is committed to five full years of financial support for graduate students in the College of Engineering PhD program who maintain Satisfactory Academic Progress. This support will be in the form of Teaching Fellowships, Doctoral Research Fellowships (formerly RA’s) or Graduate Fellowships. Funding beyond five years is generally provided (but not guaranteed) to students who are working productively toward the PhD degree. The following achievements are required to maintain Satisfactory Academic Progress:

- Students must complete the required coursework with a B average (GPA of 3.0) or better and pass the Oral Qualifier Exam within the allotted time frames. Thereafter they will need to complete a Prospectus and a Dissertation.

- Students are required to find a research home and funding no later than 12 months after beginning the program. The preponderance of the funding arises from extramural sources such as fellowships, training grants and research funding from grants of individual faculty. Once securing a funded research home, the department guarantees continued funding through the fifth year. Typically, this funding will derive from extramural sources. If bridge resources are required from the department, the department can require that the student be a teaching fellow for the time they are being supported (service appointment).

The inability to find a faculty member willing to serve as a research supervisor by the end of 12 months and with funding is initially interpreted as not making satisfactory progress toward the PhD degree. In rare cases, after the first 12 months a student is able to identify a faculty member willing to serve as a research supervisor but neither the faculty nor the student is able secure extramural funding for the second year. In such a case, this student can petition and request one additional year of funding from departmental resources. Such a request will need to convey to the department Chair that the student has found a research advisor willing to supervise the student and that the advisor and/or student have a concrete plan to secure extramural funding sources following the additional year. Decisions to support this request are at the discretion of the department Chair. If no such funding has emerged after the second year, the student will be deemed as not making satisfactory academic progress and the individual may not be permitted to complete his or her PhD studies.

After joining a laboratory in accordance with the conditions above, students register for research credits each semester and summer they work in that laboratory. If the supervisor feels the student is not making satisfactory progress, the supervisor will provide a four month warning letter (equivalent to a semester or summer). If the progress remains unsatisfactory, the faculty will dismiss the student from their laboratory. The student must then either find an alternative funding source from an individual faculty member or leave the program. After dismissal, the student has one summer or academic semester to find alternative support. During this period, the department is under no obligation to find support for the student but may choose to do so, at the discretion of the department/program leadership.

Any egregious violation of academic or research ethics may result in immediate dismissal from the program at any stage with no opportunity for re-admission.

Academic Standards

The requirements for remaining in good standing are detailed in the College of Engineering Graduate Policy.

College of Engineering GPA Requirement for Awarding Graduate Degrees

Doctoral students must complete all degree program requirements and earn a cumulative grade point average of
at least 3.0 to be awarded a degree. The cumulative grade point average includes all coursework taken after matriculation and all courses completed prior to matriculation submitted in fulfillment of degree requirements.
Finding a Research Home

Required Rotation System

All PhD students are required to participate in laboratory rotations and enroll in BE 791 PhD Biomedical Engineering Laboratory Rotation during their first academic year. During these rotations (typically three), students will become familiar with research activity within departmental laboratories. These rotations will then help students identify the laboratory in which they will perform their research. If you are a participant in an NIH Training Program like QBP, you may have different rotation requirements which will be communicated to trainees directly.

- All PhD students must register for BE 791 in their first and second semesters of matriculation in BME. Students will register for one credit in the fall and two credits in the spring semester, for a total of three. (1 credit = 1 rotation) The course is graded Pass/Fail.
- Rotations generally last 6-8 weeks. If students are unable to complete two rotations in their second semester and/or do not meet the end of April deadline to join a lab, they must request permission from the Associate Chair for Graduate Programs and Christen Bailey to rotate over the summer.
- To do a rotation with a faculty member who does not have a primary or secondary appointment in BME, students must petition and receive permission using the BME Petition Form.
- Students who matriculate into the BME PhD program funded by an external fellowship are not exempt from participation in the rotation system. However, students who matriculate as Doctoral Research Fellows may be allowed to petition out of BE 791. If a student finds a permanent lab position after their second rotation, they can petition for a waiver of the third rotation.

Grades for BE 791 (Pass/Fail only) will be submitted after receipt of 1) a brief summary of the rotation provided by the student and 2) a brief review of the student’s participation by the faculty member. These two items must be submitted via email to Christen Bailey.

Research Opportunities

Most students choose to do their research with a faculty member from the BME Department or affiliated research centers (Biological Design Center, Biomolecular Engineering Research Center, Hearing Research Center, Nanotechnology Innovation Center, Neurophotonics Center, NSF Engineering Research Center in Cellular Metamaterials, Precision Diagnostics Center). To find out more about specific research programs, please visit the individual faculty member webpages.

Research Project

A major requirement for the PhD degree is a research-based dissertation. Each student is responsible for finding a research project, conducting scientific studies under the guidance of an approved faculty member, presenting the Prospectus and results to the general scientific community in a public defense and submitting a dissertation.

Academic vs. Research Advisors

Each new student is assigned an Academic Advisor when entering the program. Incoming PhD students will be notified about their advisor prior to registration by Christen Bailey. The student’s academic advisor can provide general information/guidance and help the student to complete his/her course registration for the first year.

PhD students will participate in laboratory rotations (typically three) during the first year. This provides the
students an opportunity to gain exposure to more than one research area and to help in identifying a good match with a research advisor. After finding a lab, the research advisor will be in charge of the student’s research project and will help coordinate the student’s schedule towards fulfilling all of the graduation requirements. **PhD students, unless requirements differ due to training grant support, are expected to choose a research advisor no later than the end of the second semester of matriculation (end of April deadline).**

When a student chooses his/her research advisor, that person automatically becomes the student’s Academic Advisor as well. However, if the student’s principal research advisor is not a BME full-time primary or affiliated faculty member (but has an active research collaboration with a primary BME faculty member), then a BME co-advisor is required. A primary BME faculty member with an active research collaboration with the off-campus research advisor will become the student’s Academic Advisor and research co-advisor. They are expected to be a member of the student’s committee and a “Co-First Reader”.

**Who Can Be a Research Advisor**

For PhD students, any full-time member of the BME faculty, or any affiliated or adjunct faculty member who has an appointment with the department, is eligible to serve as a research advisor unless otherwise noted. Other faculty, scientists or researchers (those holding a PhD or MD) within or outside of Boston University can be approved to be a student’s principal research advisor if they have an active research collaboration with a primary BME faculty member who will agree to be the student’s research Co-Advisor. Students should submit a [PhD Supervisor Approval form](#), to be approved by the Associate Chair for Graduate Programs. This form should be submitted as soon as the potential advisor is selected.

**Finding a Research Advisor and Project**

Occasionally students enter the program with a specific research advisor in mind and may even plan to work on a specific project. The majority of students, however, will utilize the first two semesters to determine what their specific interests are in the field of biomedical engineering and identify the opportunities for funding in potential labs. PhD students typically connect with their research advisors through the lab rotation mechanism. In general, the procedure involves three steps: (1) doing rotations and deciding upon a research area; (2) joining a specific lab; and (3) developing a dissertation research project. All three rotations should be completed by the end of the academic year (exception for QBP fellows who require a fourth rotation – this will discussed directly with trainees). **Doctoral research fellow positions should begin May 1, in the second semester following matriculation.**

Students can gain information about steps (1) and (2) through coursework, mandatory attendance of the BE 790 seminar during the fall semester, informal discussions with faculty and, most importantly, the lab rotations. Another valuable way of learning more about specific research opportunities is to speak with other graduate students who are currently working in the department’s various labs. The best measure for learning about working in a specific lab is to make an appointment to speak with the faculty member in charge of a lab you are interested in. Some useful questions to ask are:

1. What projects are currently going on and what projects are planned for the near future?
2. What background is required to work in the lab?
3. Is there the possibility of funds for a new graduate student?
4. What expectations does the faculty member have of graduate students?
5. If the potential advisor has been at BU for at least a few years, does he/she have a strong history of training students in a timely manner? Have his/her students generally been successful?
6. Are there any opportunities for collaboration with other faculty or labs?
Once a student finds a research opportunity and has the consent of a faculty member to be his/her advisor, the process of developing a research project begins.

**Off-Campus Research**

Dissertation research is usually carried out in laboratories and centers of BME faculty located on campus. In cases of non-BU advisors (see previous section regarding required approval) the research is often performed off-campus, in the lab of the principal research advisor. There may be specific issues that arise due to intellectual property and other conflicts of interest, which must be addressed prior to starting the work. Also, in the case of a non-BU advisor, typically, the funding to pay the student’s stipend is transferred through the mechanism of a sub-contract or billing agreement from the advisor’s institution to BU.

**Invention and Copyright Agreements**

Students who receive support from sponsored research programs or who make significant use of University funds and facilities are required to sign the BU Intellectual Property Policy Agreement. Seek counsel with your faculty advisor about this policy. A signed agreement form is required through PolicyTech before a student can be paid.
Doctor of Philosophy Degree Requirements

All engineering PhD students must adhere to and meet the PhD degree requirements as set forth by the College of Engineering. Additionally, BME PhD students must also meet any specific degree requirements as set forth by the department. The general requirements for all PhD students in BME include:

- Fulfillment of course requirements
- Passing the Oral Qualifier exam
- Prospectus Defense
- Dissertation Defense

PhD students need to submit a Program Planning Sheet for approval by their Academic Advisor (typically also their Research Advisor) and the Associate Chair for Graduate Programs. This is to be completed when the student defends their Prospectus. A cumulative grade point average of 3.0 must be maintained and no course with a grade lower than B- can be counted towards the degree.

Oral Qualifier Exam and PhD Candidacy

Oral Qualifier Exam

The Oral Qualifier Exam is taken during the early summer (usually June) following the first academic year in the graduate program. The exam is based on the student’s ability to read, understand, critically evaluate and discuss scientific papers in an oral examination format. The goals are as follows:

- Assess the student’s command of general core knowledge required for all biomedical engineers
- Assess the ability of the student to integrate knowledge across disciplines, time scales and length scales. In particular, students should be able to integrate principles of molecular bioengineering and quantitative physiology with various topics of research
- Assess the quantitative and mathematical skills of the student
- Assess the ability of the student to verbally communicate ideas and information in a clear, logical and organized fashion
- Assess the ability of the student to handle questions across a range of topics both within and outside the student’s area of interest
- Assess the ability of the student to critically read and understand scientific publications and to place the results of these publications in the context of the broader Biomedical Engineering field

Expectations of Students

Each student will be questioned by three examiners. In general, examiners will be selected so that there will be one examiner with specific expertise in each of the two topics selected by the student, while the third examiner will be more at arms-length from the topic. Scheduling constraints may result in variations on this general goal. We expect that students will:

- Read, understand, and critically evaluate every assigned paper
- Be prepared to answer any questions about the methods, results and conclusions of the main paper(s)
- Understand any key scientific concepts necessary to explain and understand the main paper(s). This includes, but is not limited to, concepts covered in the core curriculum, e.g. BE 605 and BE 606
- Be prepared to derive and/or solve quantitative problems associated with each main paper(s)
· Identify, read, and understand key papers necessary to understand the background and context of the main paper. These background papers are typically included in the citations of the main paper(s)
· Be prepared to discuss alternative approaches and potential follow-up studies
· Justify all answers with reasoned arguments based on established results and data

Assessment

Each examiner completes a grade form upon completion of the examination. The grade forms are evaluated by the BME Graduate Committee. Each student will be assigned a grade of “Pass,” “Partial Pass” or “Fail.” In the event that a student fails all or part of the exam, potential outcomes include remedial coursework or an opportunity for a second oral exam on all or part of the material. In some cases, the student will be given a choice between those two options.

Failure of a second attempt at the qualifier exam: There is no automatic recourse for this outcome. The student may apply to transfer to the MS program or MEng program.

PhD Candidacy

Upon successful completion of the Oral Qualifier Exam and satisfying the math requirement, a student becomes formally accepted to PhD candidacy. A PhD candidate has a maximum of five (5) years to complete all degree requirements for graduate studies. If not completed within five years, the student must petition the department for an extension. The petition should include the following material:

· Major reason(s) for delay
· How those delays have been resolved
· Evidence of research progress
· Detailed timeline and evidence that timeline can be adhered to
· Letter of support from advisor that addresses these issues

The Associate Chair for Graduate Programs will determine whether or not a candidate may extend his/her participation in the PhD program. More than one petition to extend the completion date of degree requirements is rarely approved, so the student should be very sure that they will finish their dissertation by the date they propose on the extension petition.

Prospectus

A research problem is selected after initial discussions between the research advisor and the student. The development of a dissertation topic is typically a cooperative effort between the student and research advisor. Commonly, the advisor initially suggests a problem to be addressed, but the student is expected to contribute ideas and thoughts as to how to approach the problem.

Prospectus Committee

By the end of the sixth semester following matriculation, PhD candidates are required to form a Prospectus Committee and defend a dissertation prospectus. Prospectus is defined as a public oral presentation of the proposal is held to describe the research and demonstrate the student’s preparation.

A Prospectus Defense will be scheduled by the student. The PhD Prospectus Defense Committee must consist of
at least four (4) members:

- Two members must be from the primary BME faculty
- One member must be from the College of Engineering but outside of the BME department (BME Affiliated faculty, Research faculty and Research Associates with a PhD and sufficient experience may count as the “outside” member)
- One member must be from a different department or institution

The student’s Research Advisor (or Academic Advisor and Co-Advisor if Research Advisor isn’t BU faculty) will serve as the Chair of the committee. Membership of the Prospectus Committee constitutes the nucleus of the Final Oral Thesis Examination Committee (Dissertation Defense).

If a researcher from outside the University serves on a PhD student’s committee, a Special Service Appointment Form must be completed and submitted to Christen Bailey for departmental approval. The completed form and a copy of the person’s curriculum vitae, with the Associate Chair for Graduate Programs signature, will then be submitted to the Graduate Programs Office. The Prospectus Committee is charged with assessing the appropriateness of the research problem and the student’s preparation, based on the written proposal and the oral presentation. The Prospectus Committee must approve that the prospectus is at a stage appropriate for scheduling the examination via their signature on the PhD Prospectus Defense Form.

Written Prospectus

Before undertaking this phase, the student should consult the Boston University Libraries Guide for Writing Theses & Dissertations. The prospectus document should include a signature page, a statement of the problem to be investigated, its background and significance, methods and approach(es) to be followed for its resolution, preliminary results, anticipated timetable for completion and pertinent bibliography. The format is similar to a typical research proposal. The student must provide a copy of the prospectus document to all members of the Prospectus Defense Committee two weeks in advance of the scheduled defense.

Prospectus Contents:

- A separate page listing the proposed title, author’s name, research advisor’s name and an abstract of approximately 150 words
- The prospectus should address the anticipated contribution of the work to the body of knowledge and the format may be similar to that of proposals submitted to a Federal Agency (ex. NIH NRSA F31)
- There is a 20 page (single-spaced) limit on the scientific portion of the proposal, which includes tables and figures but does not include the list of references
- The prospectus should include an up-to-date copy of the student’s curriculum vitae (not part of the 20-page limit)

The PhD Prospectus Defense Form is to be handed in to Christen Bailey two weeks prior to the defense along with the abstract (with the top portion filled out). The student must obtain the committee’s ORIGINAL signatures on this form, which indicate that they have reviewed the Prospectus document and approve that the examination be scheduled. Christen Bailey will be responsible for providing publicity for the student’s Prospectus Defense to BME students and faculty and adding the event to the BME calendar. The student should submit this completed form back to Christen Bailey immediately following the Prospectus Defense examination.

Oral Examination for the Prospectus Defense
The faculty research advisor should chair the Prospectus Defense, beginning with the introduction of the PhD student and his/her academic background. The student’s presentation should last approximately 30 minutes. The student should be able to defend his/her knowledge of the mathematical, physical and analytical tools to be used and how they may relate to other areas outside of his/her particular project. During this period, Prospectus Committee members or the audience may ask questions. The Chair should guard against digressions and inappropriate questioning during the presentation. Following a reasonable question period, the student and the audience are dismissed. The Prospectus Committee may wish at this time to ask additional questions of the candidate. Following this, the candidate should be excused and the committee should complete its assessment.

**Assessment**

The Prospectus Committee recommends that the student should **Pass, Fail or Conditionally Pass**. A conditional pass includes additional requirements (e.g., an additional written progress report or additional studies) to be completed no later than one year from the Prospectus Defense examination. In the case of failure, the Prospectus Committee recommends the appropriate action: a recommendation of failure may include a suggestion that the student re-take the Prospectus Defense exam or that the student be terminated from the PhD program. In the latter case, the student has the option of pursuing an MS or MEng degree but must complete all the requirements for that degree.

**Scheduling the Final Oral Examination (Dissertation Defense)**

It is the student’s responsibility for scheduling a date, location and time with all the Dissertation Defense Committee members for the examination. [Conference room reservations](#) can be requested via the BME website.

**Extension Requests**

If a student’s Prospectus Defense deadline has passed, he/she needs to submit an extension request to the Associate Chair for Graduate Programs using the [BME Petition Form](#), including indicating a timeline for completion of the Prospectus.

**Reporting on Student Progress**

The Chair of the Prospectus Committee will complete the Results section on the [PhD Prospectus Defense Form](#). If the student is required to meet certain conditions, those conditions should be listed on a separate sheet and attached to the form. Those conditions should also contain time frames for completion. The Chair then signs the form and forwards it to Christen Bailey (who will be responsible for submitting to the Associate Chair for Graduate Programs for final approval).

Before the Prospectus Defense ends, the committee must indicate on the PhD Prospectus Defense form the date for the next committee meeting (at least once in the next 12 months) and indicate expected milestones for the next post-prospectus committee meeting. Required revisions to the proposal should be completed satisfactorily before a final “Pass” grade is given.

**Responsible Conduct of Research Requirement**

PhD candidates are required to complete the Responsible Conduct of Research (RCR) requirement before they can receive the Post-Prospectus stipend rate increase. Further information is available on the University’s [Responsible Conduct of Research](#) page.
Master of Science Degree upon Prospectus Completion

All Post-Bachelor’s PhD degree students should declare a Master of Science degree when they successfully complete their PhD Prospectus Defense. This is not automatic and the student needs to complete an MS Program Planning Sheet and apply online for graduation.

Course Registration after Prospectus Requirement is Satisfied

After passing the Prospectus Defense, candidates will enroll for eight credits of BE 991 each semester until the total minimum credit requirement is met (64 credits for Post-BS, 32 credits for Post-MS and 48 credits for MD/PhD). Once the student has fulfilled the total minimum credits requirement, he/she will register for two BE 991 credits each semester until he/she graduates, including in the summer.

Annual Post-Prospectus Committee Meetings

Dissertation Committee meetings are to be held on a regular basis in order for the student to report progress and the committee to provide feedback. As a minimum, committee meetings will be held annually after completion of the Prospectus Exam. The student must forward to his/her committee a written report (Post-Prospectus Thesis Committee Meeting Report) detailing progress towards milestones and the next planned steps at least one week before each planned meeting. It is the responsibility of the student to contact the committee members and schedule the committee meetings.

Dissertation

Dissertation Defense Committee

In preparation for the Dissertation Defense, it is the candidate’s responsibility, in conjunction with that of his/her research advisor, to appoint a Dissertation Defense Committee. This committee usually consists of the faculty members who participated in the Prospectus Defense, and have followed the student’s progress and annual progress meetings.

The committee consists of five (5) readers:

- Two members must be from the primary BME faculty
- One member must be from the College of Engineering but outside of the BME department (BME Affiliated faculty, Research faculty and Research Associates with a PhD and sufficient experience may count as the “outside” member)
- One member must be from a different department or institution
- A fifth member from any of the above categories

If a researcher from outside the University serves on Dissertation Defense Committee, a Special Service Appointment Form must be completed. This form does not have to be re-submitted if it was approved for the Prospectus Defense.

Christen Bailey will appoint the chair for the Dissertation Defense. It must be a primary BME faculty member on
the committee who is not the student’s Research Advisor or Academic Advisor/Co-Advisor.

Written Dissertation

Candidates shall demonstrate their abilities for independent research and scholarship by completing a doctoral dissertation in their field of study. The dissertation will be primarily guided by the First Reader (Research Advisor), with the advice of the other members of the Dissertation Defense Committee. The dissertation should represent original scientific/engineering contributions that are appropriate for publication in a recognized peer-reviewed journal. The dissertation is defended at a presentation open to the entire BU community.

Guidelines for preparing the dissertation and its abstract, according to the requirements of the University Microfilms International, are distributed by Mugar Library to all doctoral candidates and are available on the Resources for BME Graduate Students website. Although students will have an opportunity to make final revisions to the dissertation and abstract after their Final Oral Examination (Dissertation Defense), they should not regard their Final Oral Examination version as a “rough draft”.

Final Oral Examination (Dissertation Defense)

The Dissertation Defense is a public presentation of the candidate’s dissertation. The presentation should clearly define the problem, describe the method(s) used to solve the problem, report results and establish significance of the results. The purpose is to ensure that the dissertation constitutes a worthy contribution to knowledge in the candidate’s field and that the candidate has attained sufficient expertise in his/her field of research specialization.

Scheduling the Final Oral Examination (Dissertation Defense)

It is the student’s responsibility for scheduling a date, location and time with all the Dissertation Defense Committee members for the examination. Conference room reservations can be requested via the BME website.

At least two weeks prior to the Dissertation Defense date, the candidate must submit the PhD Final Oral Examination Form to Christen Bailey. Before submitting this form, the candidate must have provided a copy of the dissertation document to all members of the Final Oral Examination committee and obtained their ORIGINAL signatures on this form indicating 1) that they have been provided a copy of the dissertation and 2) agree that it is ready to be defended. This form must also contain the date, time, location, title and abstract.

Length and Conduct for Oral Dissertation Defense

The faculty Research Advisor or Chair should introduce the candidate and include a brief academic background description. The candidate should restrict the length of the presentation to approximately one hour. During this period, either the Dissertation Defense Committee members or audience may ask questions of clarification. The chair should guard against digression and inappropriate questioning during the presentation. After the presentation, a reasonable period of questioning will follow, and then the audience will be dismissed. The Dissertation Defense Committee may wish at this time to ask additional questions of the candidate. Following this, the candidate should be excused and the committee should complete its assessment.

Assessment

The Dissertation Defense Committee is charged with assessing completeness of the research, contribution to knowledge, and the candidate’s mastery of his/her research area, based on the written dissertation and the oral
presentation. Vote may be ballot or voice. A unanimous vote is required for a candidate to pass.

It is the Chair’s responsibility to call the candidate back after the Dissertation Defense Committee has reached a decision. The Chair will advise the student of the committee’s decision. At this time the candidate will be advised of any changes that must be made to the final title, abstract or dissertation document, with a deadline provided by the Dissertation Defense Committee.

**Reporting**

The PhD Final Oral Examination Form must be completed at the examination, with specific indication of whether the title, abstract and dissertation are acceptable as they stand. If ALL requirements are acceptable, the committee members should sign the signature pages of the dissertation. If there is some rework to be done, this is to be noted on the Final Oral Exam form. Dissertation Defense Committee members should sign off on the form but will refrain from signing the signatures page of the dissertation until all conditions have been met.

**Dissertation Approval and Library Submission**

The signatures of the Dissertation Defense Committee members on the dissertation signatures page, if not given at the Final Oral Examination itself, will indicate final approval of the title, abstract and dissertation. Once signatures have been obtained, the student must submit two (minimum) unbound dissertation copies to Christen Bailey: one copy for the BME Department and one personal copy for the candidate. Copies for the Dissertation Committee are optional and to be submitted for binding at the candidate’s discretion. All copies must have original signatures pages.

The Associate Chair for Graduate Programs gives final approval on the Final Oral Examination form. The student will then follow the electronic submission guidelines provided by Mugar Library. Christen Bailey will provide departmental electronic approval for the student upon seeing the original signatures page.

Christen Bailey will coordinate the binding with an outside vendor but the student is responsible for printing the copies themselves. The cost for hardbound copies is $10 per copy (subsidized by the department). Dissertations to be hardbound are sent to an external bindery once a year (early fall). Students should be sure to leave a correct forwarding address after graduation so that their hardbound copy can be mailed.
Financial Information

Students receiving any form of financial support for graduate studies are not permitted additional employment without prior written approval from both the student’s advisor and the department.

Stipend Paychecks

All students are expected to have a US bank account. If you elect not to use direct deposit, paychecks can be picked up at the BU Payroll Office at 25 Buick Street on the last Friday of the month.

Doctoral Research Fellows (DRF’s)

This is a compensated service appointment exclusively for PhD students engaged to assist on a research project. A Doctoral Research Fellow is a member of a research group in a laboratory or center. Work on the dissertation project is normally part of this position’s assignments. DRF’s are expected to work full-time, with time allowed for courses during the academic year.

Stipend Levels

The following is an outline of the Biomedical Engineering Department’s policy on stipend levels:

- All incoming PhD students on a fellowship will receive the same monthly stipend at the base rate
- Upon fully passing the Oral Qualifier Exam, PhD candidates will receive a stipend increase of 5% above the current base rate
- PhD candidates will receive an additional 5% increase once 1) they fully pass the Prospectus Defense and 2) complete the Responsible Conduct of Research (RCR) training

Tuition

DRF’s supported full-time by a faculty’s sponsored research grant typically receive full tuition coverage. Eligible DRF’s receive 8 credits of tuition, applicable to their degree, each semester they serve as a DRF during the academic year.

Summer Stipends and Tax Withholding

Students funded on fellowships other than NIH will have FICA taxes withheld from their paychecks during the summer (June, July and August).
University Policies and Resources

Vacation Policy for PhD students
Childbirth and Adoption Accommodation for PhD Students
Sexual Misconduct / Title IX Policy

Equal Opportunity and Nondiscrimination

Complaint Procedures in Cases of Alleged Unlawful Discrimination or Harassment
Disability Accommodation
Equal Opportunity/Affirmative Action Policy
Sexual Misconduct/Title IX Policy
Student Grievance Procedure in Cases of Alleged Disability Discrimination

If you have questions about the policies above, please contact:

Stacey Herman, Director of Graduate Programs Office at smherman@bu.edu or 617-353-9763.

Mental Health Resources

Graduate students have access to mental health resources through the Student Health Services Behavioral Medicine Office. These services are open to all full-time students, including PhD students. To contact the office, call 617-353-3569. They offer help for issues related to stress, anxiety, depression, sleep concerns, attentional issues, and many other topics. They can also refer you to appropriate specialized providers, if necessary. In addition to individual assistance, they offer programming specific to graduate students, such as a weekly graduate student discussion groups.

Clinicians are available 24/7, for daytime emergency triage and phone consultations, as well as mental health emergencies that occur after the clinic is closed. Call 617-353-3569 anytime, 24/7.
Logistical and Contact Information

Graduate Student Offices

New PhD students will be assigned a desk in dedicated BME graduate student offices. Research advisors should provide desk space in their labs for Doctoral Research Fellows. Christen Bailey will notify incoming PhD students regarding their individual office assignments and provide a key.

BME Graduate Student Lounge

The BME Lounge is located on the second floor of 44 Cummington Mall near the elevator. This room contains graduate student mailboxes. The mailing address is: Department of Biomedical Engineering, Boston University, 44 Cummington Mall, Boston, MA 02215.

BME Kitchenette

There is a small kitchenette (including a refrigerator) that is available for faculty, graduate students and staff in ERB 407. A copy machine is available for students.

Getting to the BU Medical School Campus

There is a regular shuttle that travels between Boston University’s Charles River campus and the Medical Campus: Boston University Shuttle (The BUS). The Shuttle runs every 10-30 minutes (depending on the day and time). It is free. Call 877-355-1555 to receive recorded information about The BUS service, including current reports of transportation delays and service interruptions. The closest stop to the BME department is at the corner of Blandford St and Commonwealth Ave. Schedules and real-time bus locations can be found online.

Associate Chair for Graduate Programs

The role of the Associate Chair for Graduate Programs (“Grad Chair”) is to handle issues related to BME graduate students. The Grad Chair works in concert with Christen Bailey and the BME Graduate Committee. Christen Bailey is extremely knowledgeable about detailed program requirements, timelines, and documents and deadlines related to prospectus and PhD defenses. Inquiries related to these issues should go to her.

The Grad Chair can handle big picture or specific issues that come up in the course of graduate study. Examples of big picture issues would be changes to the qualifying exam structure or course requirements. Specific issues that fall within the Grad Chair’s purview include conflicts with a graduate advisor or committee member and petitions for extensions.

The Grad Chair is also involved in recruiting new doctoral students each year during the Open Houses. In addition, the Grad Chair holds cohort meetings with students, such as a mock qualifying exam for first year PhD students and a meeting with third year PhD students about the Prospectus process.

The Graduate Committee works with the Grad Chair on issues related to the BME graduate programs. The Committee consists of BME faculty members and Graduate Student Representatives. The committee oversees course requirements, the qualifying exam process, assessment of qualifying exam performance, and other topics.
<table>
<thead>
<tr>
<th><strong>BME Graduate Programs Administration</strong></th>
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