

***BME Department***  
***Graduate Student Handbook***



Fall 2013

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### ***Summary of Course Requirements for BME Graduate Students***

Please note: The following courses although offered by the College of Engineering, do not meet the requirement of a technical elective: ME 502, ME 583, ME 584, EK 731. Any other graduate-level ENG course may count. Students may also petition for a course offered outside of ENG to count as a technical elective.

#### **M.Eng Students:**

**Three BME graduate-level** technical electives (preferably in an area of specialization)

**Two ENG graduate-level** technical electives (may include additional BE coursework)

M.Eng students are permitted to substitute a maximum of one 400-level course for a graduate-level elective.

**Math Requirement** selected from approved list (located in the handbook and online)

**Choice of two Technology Leadership Electives** from the list below (8 credits):

ENG ME 502 Intellectual Assets: Creation, Protection, and Commercialization

ENG ME 517 Product Development

ENG ME 525 Technology Ventures

ENG ME 550 Product Supply Chain Design

ENG ME 583 Product Management

ENG ME 584 Manufacturing Strategy

ENG ME 703 Managerial Cost Accounting

ENG EC 518 Project Management for Software-Intensive

ENG EK 731/GSM HM 801 Bench to Bedside – Translating Biomedical Innovation from the Lab to the Marketplace \*

GSM HM 703 Health Sector Issues and Opportunities \*

GSM SI 839 Managing and Leading Innovation\*

GSM SI 852 Starting New Ventures \*

GSM SI 855 Entrepreneurship \*

GSM PL 870 Government, Society and the New Entrepreneur \*

GSM SI 871 Strategies for Bringing Technology to Market \*

\* Requires GSM MG 800 A1 Variable credit if registering for 3 credit course

Students in the M.Eng degree program are required to complete a minimum of **32 credits** of approved coursework. No master's thesis is required.

#### **MS Students:**

**Math Requirement** selected from approved list (located in the handbook and online)

**BE 605 Molecular Bioengineering** or **BE 606 Quantitative Physiology for Engineers**

**BE 790 Biomedical Engineering Seminar**

**Three BME graduate-level electives**

**Two graduate-level technical electives** (may be BE)

**Research** – Eight or more credits of research (BE 900)

Students in the MS degree program are required to complete a minimum of 36 credits and successfully propose and defend an original MS thesis.

### **Post-BS PhD Students (Post-Bachelor's):**

**BE 790 *Biomedical Engineering Seminar***

**BE 791 *Biomedical Engineering Laboratory Rotations*** (Students typically register for 1 credit in fall semester and 2 credits in the spring semester – one credit per rotation) \*NIH Student Trainees perform four lab rotations (1 in the fall semester, 2 in the spring semester and 1 in the summer)\*

**BE 792 *Literature Review*** (spring semester of your first year, 2 credits)

**BE 605 *Molecular Bioengineering*** (fall semester of your 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 BME Graduate Committee.

**BE 606 *Quantitative Physiology for Engineers*** (spring semester of your first year, 4 credits) Waivers of this requirement can be requested by students with prior grad-level coverage of physiology. Waivers must be approved by the BME Graduate Committee.

**Three BME graduate-level electives**

**Two graduate-level technical electives (may be BE)**

**Note:** some courses offered in the College of Engineering relate to product development, and do not qualify as **technical** electives. If in doubt about a course, students should consult with the BME Graduate Program Administrator.

**Math Requirement** selected from approved list (located in the handbook and online). It is strongly recommended that this be completed during the first year.

**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 (typically) 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.

**Research Credits (BE 900 *Research*)**

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

All Post-Bachelor's PhD degree students may declare a Master of Science degree when they complete the prospectus – **THIS IS NOT AUTOMATIC**. Please see the BME Academic Programs Office for details.

### **Post-MS PhD Students:**

**BE 790 *Biomedical Engineering Seminar***

**BE 791 *Biomedical Engineering Laboratory Rotations*** (Students typically register for 1 credit in fall semester and 2 credits in the spring semester – one credit per rotation) \*NIH Student Trainees perform four lab rotations (1 in the fall semester, 2 in the spring semester and 1 in the summer)\*

**BE 792 *Literature Review*** (spring semester of your first year, 2 credits)

**BE 605 *Molecular Bioengineering*** (fall semester of your first year, 4 credits) If you have had prior coursework that substantially overlaps with this material, you can request waiver of this course requirement, to be approved by the BME Associate Chair for Graduate Programs.

**BE 606 *Quantitative Physiology for Engineers*** (spring semester of your first year, 4 credits) A waiver of this requirement can be requested by students with prior graduate-level coverage of physiology. Waivers must be approved by the BME Graduate Committee.

**Two graduate-level electives (at least one BE)** Students will be advised individually about what courses to take, which may depend on the specifics of their MS degree.

**Math Requirement** selected from approved list (located in the handbook and online). It is strongly recommended that this be completed during the first year. (May be waived, by petition, for post-MS students who have taken graduate-level math courses at another school.)

**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 (typically) 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.

**Research Credits** (BE 900, *Research*) (one additional technical elective can substitute for 4 research credits)

Note: There is no “typical” post-master’s PhD. At the discretion of the BME Graduate Committee, 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 (similar to Post-MS PhD students):**

**BE 790** *Biomedical Engineering Seminar*

**BE 791** *Biomedical Engineering Laboratory Rotations* (Students typically register for 1 credit in fall semester and 2 credits in the spring semester – one credit per rotation) NIH Student Trainees perform four lab rotations (1 in the fall semester, 2 in the spring semester and 1 in the summer).

**BE 792** *Literature Review* (spring semester of your first year, 2 credits)

**BE 605** *Molecular Bioengineering* (fall semester of your first year, 4 credits) If you have had prior coursework that substantially overlaps with this material, you can request waiver of this course requirement, to be approved by the BME Associate Chair for Graduate Programs.

**BE 606** *Quantitative Physiology for Engineers* (spring semester of your first year, 4 credits) If you have had prior coursework that substantially overlaps with this material, you can request waiver of this course requirement, to be approved by the BME Associate Chair for Graduate Programs.

**Three graduate-level electives (at least one BE)**

**Math Requirement** selected from approved list (located in the handbook and online). It is strongly recommended that this be completed during the first year.

**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 (typically) 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.

**Research Credits** (BE 900, *Research*) (one additional technical elective can substitute for 4 research credits)

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.

### **All PhD Students (during each semester of teaching assignment):**

**BE 801 and BE 802** *Teaching Practicum I and II* (4 credits). 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 plus 4 credits of BE 900, *Research*). Students may take a structured course while teaching only if they receive permission from their research advisor and file a petition with the BME Graduate Committee chair.

### **Credit for Courses Taken Elsewhere:**

Students may “place out” of required courses, 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 degree. For example, students who have taken a grad-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 petition to the BME Graduate Committee BEFORE the

end of the add/drop period. 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, 36 for MS students) to meet the degree requirements, but it does enable the student to take other electives.

**Courses that Fulfill the BME Math Requirement:**

*Students can choose to take one of the following courses and pass with a B or higher. It is highly recommended to take the math course in the first year.*

**ENG BE 700 Mathematical Methods in Biomedical Engineering** Pre-reqs: None. The goals of this course are two-fold: To present pertinent mathematical concepts for graduate researchers in biomedical engineering, and moreover, to provide students with enough foundations to further explore advanced mathematical topics necessary for their research. The four main themes will be: Probability/statistics, linear algebra, partial differential equations / boundary value problems, and complex variables.

**ENG EC 505 Stochastic Processes** Pre-reqs: ENG EC 401 & CAS MA 142 or equivalent and either ENG EC 381 or ENG EK 500. Introduction to discrete and continuous-time random processes. Correlation and power spectral density functions. Linear systems driven by random processes. Optimum detection and estimation. Bayesian, Weiner and Kalman filtering.

**ENG EK 501 Mathematical Methods I: Linear Algebra and Complex Analysis** Introduction to basic applied mathematics for science and engineering, emphasizing practical methods and unifying geometrical concepts. Topics include linear algebra for real and complex matrices. Quadratic forms, Lagrange multipliers and elementary properties of the rotation group. Vector differential and integral calculus. Complex function theory, singularities and multi-valued functions, contour integration and series expansions. Fourier and Laplace transforms. Elementary methods for solving ordinary linear differential and systems of differential equations with applications to electrical circuits and mechanical structures.

**CAS MA 561 Methods of Applied Mathematics I** Pre-reqs: CAS MA 226 OR CAS MA 231. Derivation and analysis of the classical equations of mathematical physics; heat equation, wave equation, and potential equation. Initial boundary value problems, method of separation of variables, eigenvalue problems, eigenfunction expansions. Fourier analysis. Existence and uniqueness of solution.

**CAS MA 565 Mathematical Models in the Life Sciences** Pre-reqs: CAS MA 226 OR CAS MA 231. 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 PY 501 Mathematical Physics** 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 ME 566 Advanced Engineering Mathematics** Pre-reqs: CAS MA 225 OR CAS MA 226; senior standing, and consent of instructor. Introduces students of engineering to various mathematical techniques which 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. (Formerly ENG MN 566)

**GRS MA 681 Accelerated Introduction to Statistical Methods for Quantitative Research** Pre-reqs: CAS MA 225 & CAS MA 242 or their equivalents. 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.

**Students may petition for a different graduate-level course to count towards the math requirement, subject to approval by the BME Graduate Committee.**

### *Finding a Research Home*

**Research Opportunities in the Department** – Most students choose to do their research with a faculty member from the Biomedical Engineering Department or affiliated research centers (Biomolecular Research Center, Center for Memory and Brain, Center for Nanoscience and Nanobiotechnology, CompNet, Hearing Research Center and the Neuromuscular Research Center). To find out more about specific research programs of the faculty, visit the web pages for individual faculty members through the department website. There also are many interesting research opportunities outside the Labs and Centers affiliated with the BME Department, associated Centers and BME full-time faculty. Such arrangements will require a BME professor as co-advisor with a collaborative relationship between the BME and outside faculty member. Students interested in pursuing their MS Thesis or PhD dissertation under the direction of a supervisor outside the BME Department must have approval from the BME Graduate Committee prior to undertaking the project (refer to page 5 ).

**Research Project** – A major requirement for either the MS or PhD degree is a research-based thesis. Each student is responsible for finding a research project, conducting scientific studies under the guidance of a faculty member, presenting the proposal and results to the general scientific community in a public defense, and finally turning in a thesis to be bound for the library and the BME Department. The specific process for completing a thesis is different for Masters and PhD students, and these processes are described within the respective degree sections that follow.

**Academic vs. Research Advisors** – Each new student is assigned an academic advisor when entering the program. All M.Eng students will be counseled by the academic advisors assigned to the M.Eng program, and students will be notified about their advisor prior to registration. For MS and PhD students, during the first year the academic advisor is often the BME Associate Chair for Graduate Programs. The student's academic advisor can provide general information about the University and help the student to complete his/her course registrations for the first year.

MS students are expected to choose a research advisor no later than the end of the second semester of matriculation.

PhD students will participate in laboratory rotations, typically three, during the first year. This provides the students an opportunity during their first year 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. Please see page 13 for details on lab rotations.

When a student chooses his/her research advisor, that person automatically becomes the student's academic advisor as well. However, if the student's research advisor is not a BME full-time primary or affiliate faculty member, a BME co-advisor is required, and that co-advisor becomes the academic advisor. This academic advisor is expected to be a member of the student's committee (for MS students) and/or a "co-First Reader"

(for PhD students). See below for more details.

**Who Can Be A Research Advisor** – For MS and 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. Other faculty, scientists or researchers (those holding a PhD or MD) within or outside of Boston University (e.g., from one of the area hospitals) can be approved by the Graduate Committee to be a student's principal research advisor if the advisor has an active research collaboration with a primary or affiliated BME faculty member, who will agree to be the student's research co-advisor.

Students should submit a PhD Supervisor Approval Form (available online), to be approved by the BME Graduate Committee. This form should be submitted as soon as the potential advisor is selected (for PhD students, typically at the end of the first academic year). **The following information from prospective advisors should be attached to the approval form:**

- Up-to-date Curriculum Vitae
- Contact Information – email, phone number and mailing address
- Statement of Commitment to provide support for the student's stipend for the duration of the project
- Description of the General Area of Research in which the student will become involved

After approval, and as the thesis project progresses, MS students must identify one additional primary faculty member within the BME Department to serve as another member of the MS Thesis Committee. PhD students must identify two additional BME faculty members for their committees.

The primary BME co-advisor serves as the co-First Reader for the dissertation and is expected to be closely involved as a collaborator in the work, typically serving as co-author on eventual publications.

**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 a professor's lab. PhD students typically connect with their research advisors through the mechanism of their lab rotations. 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 thesis project. All three rotations should be completed by the end of the academic year (with a few exceptions). **RA positions should begin May 1<sup>st</sup>.**

Students can gain information about steps (1) and (2) through coursework, mandatory attendance of seminars in BE 790, informal discussions with faculty and, most importantly, the lab rotations. An easy way to find out what is available in the BME Department is to check the list of current Faculty Research Interests and BME Laboratory and Research Center Descriptions, available on the BME website ([www.bu.edu/bme](http://www.bu.edu/bme)). PhD students explore research project opportunities through their laboratory rotation experience (BE 791), during their first year. Often, scientific posters along the BME corridor walls provide informal and valuable insight into what is going on in the various BME research groups.

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. Don't be shy; they're friendly! 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 him/her 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. How is the lab funded and is there a 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?

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 thesis begins.

**Off-Campus Thesis** – Thesis research is usually carried out in laboratories and centers of BME faculty located on campus. In cases of non-BU advisors (see discussion above regarding approval) the research is often performed off-campus, in the lab of the advisor. There may be special problems that arise due to intellectual property and other conflicts of interest, which must be addressed prior to starting the work. Unusual cases may be referred to Associate Dean of Research and Graduate Programs. Also, in the case of a non-BU advisor, typically, the funding for the Research Assistantship to pay the student’s stipend is transferred to BU through the mechanism of a sub-contract from the advisor’s institution to BU. Contact Matt Barber or the BME Associate Chair for Graduate Programs to initiate arrangement of the sub-contract.

**Invention and Copyright Agreements** – Students who receive support from sponsored research programs or who make significant use of BU funds and facilities are required to sign the BU Invention and Copyright Agreement. Seek counsel with your faculty advisor about this policy pertaining to intellectual property. A signed form is required before a student can be paid. The BME Graduate Program Administrator will provide you with the necessary form to sign.

### Staff Directory

<b>BME Graduate Programs Staff</b>			
Prof. Catherine Klapperich Associate Chair for Graduate Programs	ERB725	358-0253	<a href="mailto:catherin@bu.edu">catherin@bu.edu</a>
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### ***Master of Engineering (M.Eng) Degree Program Requirements***

The course requirements for a Master of Engineering in Biomedical Engineering (M.Eng) at Boston University are listed on p. 3. The Master of Engineering requires the completion of a 32 credit-hour study program consisting of eight structured courses. All students are required to submit a Program Planning Sheet at the end of their first semester, indicating the eight structured courses they intend to take to fulfill the curriculum requirements. A cumulative grade point average of 3.0 must be maintained. The department permits only four credit hours of C or C+ to be applied toward the degree. Grades of C- or lower are not acceptable.

#### **Structured Course Requirements**

The structured courses must be at the graduate level with the exception that (only) one course is permitted at the 400-level. Each student's complete curriculum, specifying all eight courses, should be developed in consultation with the M.Eng Academic Advisor (for 2012, Prof. Andrew Jackson). Any deviations from the specified course requirements must be approved by the BME Graduate Committee. Non-BME technical electives do not have to be from other Engineering departments; hard science courses from other colleges may be approved upon petition to the BME Graduate Committee. Courses should be pertinent to the student's goals to meet the elective requirements. M.Eng students are required to hand in their final program planning sheets at the time end of their first semester of study. Technical Leadership electives outside of the provided list must be approved by the M.Eng academic advisor.

**M.Eng Program Completion Time Schedule** – It is up to the student to complete the required coursework. Most students graduate from the M.Eng program within 1 year after matriculating. It is important to keep track of the various deadlines that have been established to ensure that students planning to participate in graduation ceremonies are not disappointed by being prevented from participating due to missed deadlines. A list of deadlines for Master's students is located online at <http://www.bu.edu/academics/eng/graduate-program-deadlines/>. Please contact the BME Graduate Program Administrator if you have any questions about these deadlines.

### ***Master of Science Degree Program Requirements***

The requirements for a Master of Science in Biomedical Engineering (MS) at Boston University include course requirements, a thesis proposal, completion of an original thesis and its public defense. Each of these requirements is outlined in the following paragraphs.

The Master of Science program requires the completion of a 36 credit-hour study program: seven structured

courses (see p. 3), and eight credits of research, which culminate in a Master's research proposal, a non-credit research seminar course (BE 790), a thesis and a thesis defense. All students are required to submit a Program Planning Sheet at the time of the thesis proposal, indicating the seven structured courses they intend to take to fulfill the curriculum requirements (see below). A cumulative grade point average of 3.0 must be maintained. The department permits only four credit hours of C or C+ to be applied toward the degree. Grades of C- or lower are not acceptable.

### **Structured Course Requirements**

Students must take a minimum seven (7) structured courses and 8 credits of research. All structured courses must be at the graduate level (500-level and higher). Each student's complete curriculum, specifying all seven courses, should be developed in consultation with the student's advisor and must be approved by the BME Graduate Committee. Electives do not have to be from the Biomedical Engineering Department or from the College of Engineering. Any course that the advisor agrees is pertinent to the student's goals should meet the elective requirements; however, the Graduate Committee Chairman must approve the student's entire study program. MS students are required to hand in their final program planning sheets at the time of the MS thesis proposal.

### **Research and Thesis Course Requirements**

The MS research project proposal and thesis are administered through registration for BE 900. Students must register for a minimum total of eight (8) credits of BE 900 before graduating. Grading of BE 900 *Research* courses are on a Pass/Fail system.

**MS Thesis Committee Membership** – After identifying a research advisor and project, each student forms a thesis committee. The MS Thesis Committee must have a minimum of three (3) members. Two members must be from the primary BME academic faculty, and one must be from outside the department (BME Affiliate faculty, Research faculty and Research Associates with a PhD and sufficient experience may count as the "outside" member). Any of these three members can be the primary advisor. See "*Finding a Research Home*" section for more on the subject of selecting advisors.

**MS Thesis Proposal** – A brief written proposal (3-5 pages) of the MS research project must be submitted and defended no later than the semester before the student defends his/her thesis. It is the student's responsibility to schedule a formal meeting with his/her Thesis Committee members for discussion and approval of the proposal document. The student must present the *MS Proposal* and *Thesis Committee Approval Form* to his/her thesis committee during this meeting. If the proposal is approved, the members of the thesis committee must sign the form, thereby indicating their willingness to participate on the thesis committee. The student must submit the signed approval form and the proposal document (signed by the advisor) to the BME Graduate Program Administrator. It is required that the student's thesis committee meet with the student regularly but at least annually throughout the remainder of his/her thesis research.

**MS Thesis** – An MS Thesis must be written and defended successfully for completion of the MS degree. Note that in order for a student to make full use of the critiques on the proposal offered by his/her committee, students are not permitted to defend the final thesis the same semester in which the proposal was submitted. A full description of the format requirements for the written thesis is included in "*A Guide for the Writers of Dissertations and Theses*". This guide is located on the BME website under "*Online Forms and Documents*". The format described in this guide must be adhered to when writing the thesis. Mugar Library will not accept the thesis if it does not follow the required format!

It is the student's responsibility to confirm a date and time of the presentation with his/her Committee members (*MS Thesis Defense Approval Form* must be completed – this form should include title, abstract, names of committee members and advisor's signatures). Once a date has been confirmed, the date and

location, along with a copy of the Abstract, must be submitted to the BME Graduate Program Administrator at least 8 business days prior to the presentation date. The Abstract must have the names of the student and research advisor listed together with the project title. The BME Graduate Program Administrator will process announcement of the thesis defense to the Biomedical Engineering faculty and graduate students via e-mail.

The format of the defense is not rigid and is decided on by the chair of the defense committee. The student can expect to give a 30-40 minute seminar presenting the results of the completed project. There may be questions during the presentation or after the student has completed the presentation, depending on the decision of the defense committee. The Graduate Committee suggests that the defense be open and that faculty and other graduate students be encouraged to attend.

Following a reasonable question period, the audience is dismissed, so that the committee may ask questions of the student privately; then the student is dismissed and the Committee remains to complete its assessment of the thesis defense. The defense committee must vote unanimously to pass the student. The results are noted on the *Thesis Defense Form* and submitted to the BME Graduate Program Administrator, who will be responsible for obtaining the signature of the Associate Chair for Graduate Affairs.

**Submission of the Final Thesis** – Upon successful defense and final approval of the thesis, the student must deliver to the BME Graduate Program Administrator ALL copies (not bound) of the signed thesis: two copies for the library (in separate manila envelopes), the department copy, one copy for each member of the thesis committee and a copy to be bound for the student. All copies must have original signatures and be delivered to the department.

The BME Graduate Program Administrator will assist you in preparation of the Mugar Library *Thesis and Dissertation Filing Form* that the student takes to the library, along with two copies of the thesis. The library also requires an extra copy of the Abstract and title page for record keeping purposes. The student will take the documents to the Thesis/Dissertation Coordinator in the Bibliographic Services Office (Third Floor, Mugar Library). The student must return a signed copy of the filing form to the BME Graduate Program Administrator in order to complete the requirements for graduation.

The Academic Programs Office Staff will coordinate the binding of the additional thesis copies. The copies for the department and the student will be hardbound. The copies for the members of the student's defense committee may be either hardbound or softbound, as requested by the student. The cost for any extra hardbound copies is \$10.00 per copy (BME subsidizes your cost). Theses to be hardbound are sent to an external bindery twice a year (late January and early June). It generally takes six to eight weeks for delivery. Students should be sure to leave a correct forwarding address after graduation so that their hardbound copy of the thesis can be mailed to them.

**MS Program Completion Time Schedule** – It is up to the student and academic advisors to complete the project in a reasonable amount of time for a Master's thesis. Most students graduate from the MS program in 2 to 2.5 years after entering, which usually includes at least one year of full-time work on the research project. It is important to keep track of the numerous deadlines that have been established to insure that students planning to participate in graduation ceremonies are not disappointed by being prevented from participating due to missed deadlines. A list of deadlines for the MS Program is located online at <http://www.bu.edu/academics/eng/graduate-program-deadlines/>. Please contact the BME Graduate Program Administrator if you have any questions about these deadlines.

Each student has a maximum of five (5) years from the time of matriculation to complete the requirements for the MS degree. If a student has still not finished the required courses and research thesis in this time, the student must reapply and be accepted again to the department in order to continue.

**Relation of the MS Program to the PhD Program** – Often students who enter the MS program later decide that they would like to pursue a PhD in Biomedical Engineering. The student must formally apply to the PhD program; however, the MS program is designed so that a transition into the PhD program is straightforward, as summarized below:

- An MS student wishing to pursue a PhD may apply to the PhD program with the *Short Application Form* available from the College Graduate Office. MS students accepted into the PhD program will have to pass the BME PhD oral qualifier exam as is required for all PhD candidates. The student may choose to prepare a PhD Prospectus rather than a MS thesis and take the prospectus defense examination. A student who successfully defends a PhD prospectus will also receive an MS degree. (The post-bachelor PhD candidate needs to apply for the MS degree at the time of the prospectus defense, **IT IS NOT AUTOMATIC**)
- If admitted to the PhD program, the student who completed the MS degree in Biomedical Engineering requires one additional physiology/biology course, BE 792 *Literature Review* plus the completion of two graduate –level electives (at least one BE), to satisfy the curriculum requirements of the doctoral program.
- MS students wishing to continue on for a PhD with the intent to extend their MS research will be encouraged to modify their MS thesis as necessary into a PhD prospectus. If a student wishes to change research topics, then a prospectus appropriate for the new topic will be required. It is important to note that all students must have passed the departmental oral qualifier prior to submitting and defending a PhD prospectus.

**Planning for Graduation** – An MS student cannot defend his/her thesis and/or graduate the same semester in which the MS proposal was submitted. In order to graduate, students must be registered as part or full-time students in the semester in which they complete degree requirements and in the preceding semester. Students must submit a *Diploma Application* (this can be found on the BME website under “Online Forms and Documents”) to the College Graduate Office in order to be eligible for graduation.

### ***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. Those requirements are listed in the *PhD Programs in Engineering Handbook*, which can be found at <http://www.bu.edu/eng/current-students/grad/handbook>. Additionally, BME PhD students must also meet any specific degree requirements as set forth by the BME Department. These requirements may be more stringent than those described in the College Handbook. The BME PhD requirements are outlined below:

The general requirements for all PhD students in BME include:

- fulfillment of course requirements
- passing the oral qualifier exam
- presenting an oral defense of the dissertation prospectus
- oral defense of the dissertation

PhD students are expected to become connected with a research laboratory and engaged in goal-oriented research by the end of their first academic year (April 30<sup>th</sup>).

All PhD students are required to have two semesters of teaching experience. The first semester will take place during the second academic year. The second semester will take place any time after the second year, but typically in the third year.

PhD students need to submit a *Program Planning Sheet* for approval by the BME Graduate Committee. 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.

### ***Post-Bachelor's PhD Curriculum Requirements (MS/PhD)***

**Course Requirements** – Post-Bachelor's PhD students must enroll in a minimum total of 64 credits prior to graduation. Students must take a minimum of eight structured courses and the remaining credits should be Research (BE 900) with a minimum of 12 credits of Research. All courses must be at the graduate level courses (500-level and higher). Each student's complete curriculum, specifying all eight courses, should be developed in consultation with the student's advisor and must be approved by the BME Graduate Committee, via the Post-Bachelor's PhD Program Planning Sheet.

Special course elective requirements apply to students with Photonics Center Fellowships, NIH-QPB Traineeships, Biomaterials Traineeships or Biomolecular Pharmacology Traineeships. Students will be advised individually in these cases.

**Research Credit Requirements** – Post-Bachelor PhD students must complete a minimum of 12 credits of research. The student registers for ENG BE 900 regardless of their stage in their research. Students must register for BE 900 prior to the PhD prospectus defense. The purpose of BE 900 is to ensure that the student has located a primary research advisor and has developed an outline of the research that will lead to the dissertation project. After the student passes the prospectus defense examination and all course requirements are complete, the student should register for a minimum of eight research credits (BE 900) per semester until their credit requirements are met and register for 2 credits each semester thereafter until the dissertation is complete.

### ***Post-Master's PhD Curriculum Requirements***

**Structured Course Requirements** – Post-Master's PhD students must enroll in a minimum of 32 credits prior to graduation. Students must take a minimum of 6 structured courses and the remaining credits should be research (BE 900). One additional technical elective can be substituted for research credit. Students must also take BE 790 *Biomedical Engineering Seminar* and BE 791 *Biomedical Engineering Laboratory Rotation*. Students are allowed to petition to count as many as 3 courses from other institutions toward their requirements. For students who received their MS degree at another institution, the specific course requirements are decided on a case-by-case basis, depending on the equivalence of courses between the two schools.

**Research Credit Requirements** – The minimum number of BE 900 research credits is eight.

### ***MD/PhD Curriculum Requirements***

**MD/PhD students have course requirements that are a hybrid between Post-BS and Post-MS PhD students:**

- BE 605 *Molecular Bioengineering* MD/PhD candidates generally receive equivalency waiver for this course because they have had prior coursework that overlaps substantially with this material, albeit less quantitative.
- BE 606 *Quantitative Physiology for Engineers* As above, MD/PhD candidates generally receive equivalency waiver for this course because they have had prior coursework that overlaps substantially with this material, albeit less quantitative.
- BE 792 *Literature Review*
- Two BE courses. Students should take these courses in the first year, to prepare for the qualifier exam.

**Elective Courses and Research Credits:**

Three technical electives (at least two from BME) required. MD/PhD students often receive equivalency credit for a fourth elective, depending on their med school coursework. Students must enroll for a total of 48 credits prior to receiving the PhD; a minimum of 12 credits must be research credits (BE 900).

**Qualifying Exam & PhD Candidacy**

**The BME PhD Oral Qualifying Examination** – Students must demonstrate they have an appropriate level of preparation for doctoral studies and their degree of understanding of fundamental materials by passing the BME Qualifying Examination. The Oral Qualifying Examination is taken during the early summer following the first academic year in the graduate program. All PhD students are tested on *Molecular Bioengineering* (BE 605) and *Quantitative Physiology for Engineers* (BE 606) and a third topic to assess fundamental knowledge broadly related to their area of research interest, chosen by the student from a list to be provided at least one month prior to the exam date. The Oral Qualifier exam will assess the student's ability to integrate the information from the courses and relate the material to broad questions in biomedical engineering. The department will provide guidance for students to prepare for the qualifier exam towards the end of the spring semester.

**Policy Regarding "Partial Pass" and "Fail" Grades for the PhD Oral Qualifier Exam:** Results from the BME qualifier are evaluated by the BME Graduate Committee. 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 the chance to choose 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 M.Eng program.

**PhD Candidacy** – Upon successful completion of the Qualifying Examination, a student becomes formally accepted to PhD candidacy. A PhD candidate has a maximum of five (5) years after passing the qualifier exam to complete all degree requirements for graduate studies. If not completed within five years, the student must petition the College of Engineering Graduate Committee 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 College of Engineering Graduate Committee 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.

**Lab Rotations**

**BE 791 Biomedical Engineering Lab Rotations** – All PhD students (not already funded by a Research Assistantship) 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 Dissertation research. If you are a participant in the NIH Training Program in Quantitative Biology and Physiology, you will enroll in four

laboratory rotations (please see the section devoted to this program). The following is an outline of the administrative issues and policies regarding BE 791:

- All PhD students must register for BE 791 in their first and second semesters of matriculation in BME. Typically, students 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, they can petition the Graduate Committee to be allowed to complete the third rotation during the following 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 from the Graduate Committee. Students in the NIH training program must receive permission to do rotations with faculty outside the list of approved labs (see “*Training Program in Quantitative Biology and Physiology*” section). For students with fellowships in other NIH training programs, other requirements may pertain to rotations, which will be communicated individually.
- **Waivers:** Students who matriculate into the BME PhD program funded by an external fellowship are not exempt from participation in the lab rotation program. However, students who matriculate with a research assistantship 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. NIH QBP Trainees must complete three rotations but can petition for a waiver of the fourth rotation.

Grades for BE 791 (Pass/Fail) 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 advisor. These two items must be submitted via email to the BME Graduate Program Administrator.

### ***Dissertation***

**Dissertation Topic** – A research problem is selected after initial discussions between a department faculty 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 thought as to how to approach the problem.

**Prospectus/Dissertation Committee** – By the end of the sixth semester following matriculation, PhD candidates are required to form a Dissertation 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 Oral Defense Exam will be scheduled by the student. The PhD committee must consist of at least four (4) members: three must be from the College of Engineering tenured or tenure-track faculty, two of whom must be from the BME Department’s primary faculty. At least one member must be from a different department or institution. BME affiliated faculty may count towards the BME department faculty, or may also fill the role of non-BME committee member. The student’s research advisor will be the chairman of the prospectus committee but will not be a voting member of the committee. Membership of the Committee constitutes the nucleus of the Final Oral Thesis Examination Committee.

If a researcher from outside the University serves on a dissertation committee, a *Special Service Appointment Form* (available on the BME website under “Online Forms and Documents”) must be completed. The completed form and a copy of the person’s curriculum vitae, with the BME Associate Chair’s signature will be submitted to the College Graduate Office. The student will be notified in writing if the appointment has been denied.



The Dissertation Committee is charged with assessing the appropriateness of the research problem and the student's preparation, based on the written dissertation proposal and the oral presentation. The prospectus defense committee must approve that the PhD prospectus is at a stage appropriate for scheduling the exam via their signature on the PhD Dissertation Prospectus Defense Form.

**Written Dissertation Prospectus** –Before undertaking this phase, the student should consult the College's Guide for Writing Theses & Dissertations which is located on the BME website under "Online Forms and Documents". The Prospectus (proposal) 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 prospectus should specifically document the anticipated contribution of the work to the body of knowledge.
- A separate page listing the proposed title, author's name, research advisor's name and an abstract of approximately 150 words must be submitted.
- The prospectus should address the anticipated contribution of the work to the body of knowledge. The format must be similar to that of proposals submitted to a Federal Agency.
- There is a 20 page (single-spaced) limit on the scientific portion of the proposal. This includes tables and figures but does not include the list of references. Note that this requirement is more stringent than the College's page limit.
- The prospectus should include an up-to-date copy of the student's curriculum vitae. (not part of the 20-page limit)

The PhD Dissertation Prospectus Defense Form (available on the BME website under "Online Forms and Documents") is to be handed in to the BME Graduate Program Administrator two weeks prior to the defense. The student must obtain the dissertation committee's signatures on this form, which indicate that they have read the Prospectus and approve that the oral exam be scheduled. In addition, the student must fill out the top section of this form indicating the title, date, time and location of the oral proposal defense. The student submits this form along with a copy of the abstract for approval by the Associate Chairman for Graduate Studies.

**Scheduling** – Prior to scheduling the prospectus defense, the student must provide a copy of the Prospectus to all members of the Dissertation Committee. The student must also confirm with the dissertation committee members a date and time for the presentation. The BME Graduate Program Administrator will be responsible for providing adequate publicity for the student's Prospectus Defense.

**Conduct and Length of the Oral Presentation for the prospectus defense** – The faculty research advisor should chair the oral prospectus defense, beginning with the introduction of the PhD student and his/her academic background. The student's presentation should last 20 to 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, 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 and the Committee remains to complete its assessment of the proposal defense.

**Assessment** – The Prospectus Oral Exam Committee recommends that the student should pass, fail, or be given additional requirements (e.g., an additional written progress report or additional studies) to be completed no later than one year from the Prospectus Examination. In the case of failure, the Committee recommends the appropriate action: whatever must be done to a prospectus in case of failure; a

recommendation of failure may include a suggestion that the student be permitted to re-take the oral Prospectus 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 M. Eng degree in Biomedical Engineering but must complete all the requirements for that degree.

As of Fall 2005, all Post-Bachelor's PhD degree students should declare a Master of Science degree when they successfully complete their PhD Prospectus. This is not automatic and the student needs to complete an *MS Program Planning Sheet* and *MS Application for Graduation*. A copy of the prospectus is submitted to the BME Graduate Program Administrator in ERB 220.

If a student's prospectus date has passed, he/she needs to petition the BME Graduate Committee indicating a timeline for completion of the prospectus.

**Reporting on Student Progress** – The Chair of the Committee will complete the “Prospectus Defense Results” section on the *PhD Dissertation 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 the BME Graduate Program Administrator (who will be responsible for submitting to the Associate Chair for Graduate Studies). Before the Prospectus Defense ends, the committee must indicate on the PhD Dissertation Prospectus Defense form the date for the next committee meeting (not to exceed 12 months) and indicate expected milestones for the next thesis committee meeting. Required revisions to the thesis proposal should be completed satisfactorily before a final “Pass” grade is given. Thesis 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 thesis committee meetings will be held annually.** The student must forward to his/her committee a written report (Thesis Progress 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 annual committee meetings.

**Course Registration After Prospectus Requirement Satisfied** – After passing the Prospectus Defense, candidates will enroll for eight (8) credits of Research (BE 900) each semester until the total credit requirement is met (64 credits for post BS, 32 credits for post-MS, 48 credits for MD/PhD ). Once the student has fulfilled the total credits requirement, he/she will register for two (2) research credits (BE 900) each semester until the Dissertation is complete.

**Written PhD 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 (dissertation advisor), with the advice of the other members of the Dissertation 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 is available on the BME website. Although students will have an opportunity to make final revisions to the dissertation and abstract after their Final Oral Examination, they should not regard their Final Oral Examination version as a “rough draft”. In particular, this version of the abstract is the only version circulated by the College to the members of the examining committee. A final version of the abstract is submitted with the definitive version of the dissertation for publication in Dissertation Abstract International.

**Final Oral Examination** – The PhD Final Oral Examination form is located on the BME website under “Online Forms and Documents”. The Final Oral Examination 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 of the Final Oral Examination is to ensure that the dissertation constitutes a worthy contribution to knowledge in the candidate’s field and that the candidate has attained an expertise in his/her field of research specialization.

**Final Oral Examination Committee** – In preparation for the Final Oral Defense, it is the candidate’s responsibility, in conjunction with that of his/her research advisor, to appoint a 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 a Defense Chairman plus four (4) readers. A minimum of three committee members must be from the tenured or tenured-track faculty of the College; two (2) members must be primary faculty members from the BME Department and one must be from a different department or institution. If any Committee member is not a member of the Boston University faculty, a *Request for Special Service Appointment* form needs to be signed and submitted (along with a copy of the person’s curriculum vitae) to the College Graduate Office. (*This form does not have to be re-submitted if it was approved prior to the prospectus defense*)

The BME Graduate Program Administrator will appoint a Chairman for the Dissertation Defense. The student is responsible for arranging a meeting with the Chair and giving the Chair a copy of the dissertation prior to the defense.

**Scheduling the Final Oral Examination** – It is the student’s responsibility for scheduling a preferred date and time with all the Dissertation Committee members for the presentation. ***At least three weeks prior to the proposed date***, the student submits the dissertation abstract along with the *PhD Dissertation Defense Abstract* form (available on the BME website under “Online Forms and Documents”) to his/her major professor for approval and signature. The abstract and form is submitted to the BME Graduate Program Administrator.

***At least two weeks prior to the defense date***, the candidate must submit the *PhD Final Oral Examination* form to the BME Graduate Program Administrator. Before submitting this form, the candidate must have provided a copy of the Dissertation to all members of the Final Oral Examination and obtained their signatures on this form indicating that they have been provided a copy of the dissertation and agree that it is ready to be defended. This form must also contain the proposed date, time, and room location of the defense.

**Conduct and Length of the Final Oral Exam** – No final Oral examination may begin if less than five (5) College approved faculty (including the appointed Chairman) are present. The faculty research advisor or Committee Chairman 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 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 Committee may wish at this time to ask additional questions of the candidate. Following this additional questioning, the candidate should be excused and the Committee should complete its assessment of the Defense and Dissertation.

**Assessment** – The Final Oral Examination 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 Chairman’s responsibility to call the candidate back after the Committee has reached a decision. The

Chairman will advise the student of the Committee's decision. At this time the candidate will be advised of any last minute changes that must be made to the final title, abstract or dissertation document, with a deadline provided by the Committee.

**Reporting** – The College's *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, all Committee members, except the Chair of the defense 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 form. Committee members should sign off on the form but will refrain from signing the approval page of the dissertation until all conditions have been met.

**Final Dissertation Approval and Library Submission** – The signature of the Dissertation Committee members on the dissertation signature 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 the following unbound dissertation copies to the BME Graduate Program Administrator for final approval: two copies for Mugar Library, one copy for the BME Department, one copy for each member of his/her Dissertation Committee and one copy for the candidate. All copies must have original signatures.

The Associate Chairman for Graduate Studies sign-offs on the Final Oral Examination form, indicating departmental approval of the dissertation. The BME Graduate Program Administrator signs the Mugar Library filing form for the student. The student must then take the form, along with two unbound originals of the dissertation, and an extra copy of the title page and abstract, to the Library for dissertation submission. The student must return the pink copy of the filing form to the BME Graduate Program Administrator, at which time the student will have fulfilled the dissertation requirement for the PhD degree in Biomedical Engineering. The BME Graduate Program Administrator will forward the filing form to the College Graduate Office.

The BME Graduate Program Administrator will handle the binding of the additional thesis copies. Copies for the department and the student will be hardbound. The copies for the members of the student's defense committee will be softbound (plastic binder, clear cover and black backing), unless a hardbound copy is specifically requested by the student. The cost for any extra hardbound copies is \$10.00 per copy (subsidized by the BME Department). Theses to be hardbound are sent to an external bindery twice a year (late January and early June). Students should be sure to leave a correct forwarding address after graduation so that their hardbound copy of the thesis can be mailed.

#### **PhD Program Completion Time Schedule –**

- Course requirements should be completed as early as possible. After all credit requirements have been fulfilled, PhD students are permitted to audit one course per semester in order to continue to take advantage of course offerings.
- It is highly recommended that the Math course requirement be completed during the first two semesters.
- The BME Oral Qualifying Examination is taken in early summer following the first academic year. Schedules will be set by the BME Graduate Committee.
- The Dissertation Prospectus should be presented by the end of the sixth semester from matriculation.
- PhD students have five years to complete the dissertation after qualifying (passing the qualifier exam). Meetings with the thesis committee must occur at least annually following the prospectus defense, and must be documented by submission of the *Thesis Progress Report* form to the Graduate Committee. Waivers of these limits may be granted under special circumstances.

**Switching from the PhD to the MS Program** – The steps to be followed to facilitate the student’s official switch from the PhD program into the MS program are listed here. (NOTE: If the student had a Research Assistantship, the position is not, generally, retained.)

1. The student formally requests (in writing to the Graduate Committee) to matriculate into the MS program. This includes providing a written outline of the research plan.
2. The student fills out the *Short MS Program Application* form and identifies the research advisor for the MS project.
3. The intended MS research sponsor submits a letter to the Graduate Committee, providing an outline of the proposed MS project and confirming that he/she is willing to sponsor it.

There are time constraints to ensure that the student does not fall out of full-time student status before entering the Master’s program. Within two weeks of the Graduate Committee’s final decision on any appeals regarding the PhD program, a student should inform the Graduate Chair of his/her plan to switch academic programs for the next semester.

### ***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 BME Graduate Committee. These forms of financial support include BU Fellowships (Dean’s, BME, Photonics, etc.), Training Grant Fellowships, Research Assistantships (RAs), and other external Fellowships (NSF, NIH, foreign government fellowships, or other foundations)

**Stipend Paychecks** – All students are expected to have a bank account in the U.S. Direct Deposit of payments to your bank account is the norm for most students. 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.

Students with one-academic-year fellowships (Deans Fellowships, BME Distinguished Fellows, Photonics Fellowships, etc.) should secure a funded Research Assistantship no later than the end of their first academic year (April 30<sup>th</sup>). Exceptions to this policy include NIH QBP Trainees who are continuing their lab rotations during the summer.

**Research Assistantships** – Research Assistantships are offered by individual faculty members with sponsored research grants. Students interested in off-campus Research Assistantships should speak with the BME Associate Chair for Graduate Studies for departmental approval (to ensure that the research project is appropriate for Biomedical Engineering and that there is direct involvement of a BME faculty member). Off-campus Research Assistants should also see the BME Financial Manager for the BME Faculty co-advisor regarding the details of subcontracting the Research Assistantship through the University in order to receive tuition benefits.

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

- All incoming graduate Research Assistants (MS & PhD) will receive the same monthly stipend.
- The stipend for Research Assistants remains equal until the student passes the PhD qualifying examination. Upon passing the qualifying examination, graduate Research Assistants will receive a stipend increase of 5% above the current base rate.
- Qualified graduate research assistants will receive an additional 5% increase once they pass the prospectus defense.

A Research Assistant is a member of a research group in a laboratory or center. The position offers close association with members of the faculty and is a very effective arrangement for graduate study. The association and the work with the lab or center usually lead to other opportunities. Work on the thesis/dissertation project is normally part of an assistant's assignments. RAs are expected to work full-time, with time allowed for courses during the academic year. **Summer RA Contracts must be set up by April 1; Fall RA Contracts must be set up by July 15; Spring RA Contracts must be set up by December 1.**

Every Research Assistant (RA) and his/her research sponsor must submit an online contract. If the student has any questions on how or why the RA contract is completed, he/she should speak with the BME Graduate Program Administrator. The financial administrator overseeing your sponsor's grant will also approve the RA contract, indicating that there are funds to pay the stipend. A link to the funding contracts online form is located on the BME website. Contracts are necessary for:

- Setting-up the student on payroll; either by the BME Financial Administrator, or by the grant administrator overseeing the grant that funds the student stipend
- Settling the student's tuition account by the College of Engineering Financial Manager
- Settling the student's health insurance payment (College of Engineering Financial Manager)

**Tuition** – RAs supported full-time by a faculty's sponsored research grant typically receive full tuition coverage through the Graduate Research Assistant Scholarship Program (GRASP). GRASP-eligible RAs receive 8 credits of tuition, applicable to their degree, each semester they serve as an RA during the academic year. Registering for more than eight credits requires written approval from the student's research advisor.

**In order to be paid during the Summer** – Domestic students must register for EK 920S for the Summer I term (0 credits) prior to the start of the summer session. International students must pre-register for the Fall semester, prior to the start of the Summer term. The exception to registering for EK 920S are:

- If you plan to complete your thesis/dissertation during the summer, then you need to register for BE 900.

**Summer Stipends and Tax Withholding** – Students funded on fellowships other than NIH will have FICA taxes withheld from their paychecks during the summer (May, June, July and August).

## ***National Institutes of Health Training Program in Quantitative Biology and Physiology***

There are two core required courses in quantitative biology and physiology for all trainees and each has a laboratory component (**BE 605: Molecular Bioengineering** and **BE 606: Quantitative Physiology**). The additional required courses are in areas of quantitative and engineering-based systems biology and physiology and in measurement techniques. Table A provides an overview of these courses.

**TABLE A: QUANTITATIVE AND ENGINEERING BASED BIOLOGY AND PHYSIOLOGY COURSES**

<b>Molecular and Genetic Engineering</b>	<b>Cellular-to-Tissue Level Engineering</b>	<b>Tissue-to-Organ Level Engineering</b>	<b>Scale-Independent Analysis/Modeling</b>	<b>Measurement Techniques</b>
BE 506: Physical Chemistry of Cell Structure & Machinery	BE 504: Polymers & Soft Materials	BE 508: Quantitative Studies of Respiratory & Cardiovascular Systems	BE 504: Polymers & Soft Materials	BE 511: Biomedical Instrumentation
BE 560: Biomolecular Architecture	BE 521: Continuum Mechanics for Biomedical Engineers	BE 509: Quantitative Physiology of the Auditory System	BE 519: Speech Signal Processing	BE 513: Biological & Environmental Acoustics
BE 562: Computational Biology	BE 530: Structure and Function of the Extracellular Matrix	BE 524: Skeletal Tissue Mechanics	BE 521: Continuum Mechanics for Biomedical Engineers	BE 515: Introduction to Medical Imaging
BE 567: Nonlinear Systems in Biomedical Engineering	BE 533: Biorheology	BE 567: Nonlinear Systems in Biomedical Engineering	BE 533: Biorheology	BE 517: Optical Microscopy of Biological Materials
BE 564: Biophysics of Large Molecules	BE 535: Cell Mechanics	BE 570: Introduction to Computational Vision	BE 567: Nonlinear Systems in Biomedical Engineering	BE 569: Next Generation Sequencing
BE 566: DNA Structure and Function	BE 567: Nonlinear Systems in Biomedical Engineering	BE 575: Introduction to Neuroengineering	BE 703: Numerical Methods & Modeling in BME	BE 570: Introduction to Computational Vision
BE 705: Single Molecule Approaches for Biophysics & Bioengineering— Fundamentals and Applications	BE 575: Introduction to Neuroengineering	BE 575: Introduction to Neuroengineering	BE 740: Parameter Estimation & System Identification in BME	BE 726: Fundamentals of Biomaterials
BE 745: Nanomedicine	BE 707: Quantitative Studies of Excitable Cells	BE 710: Neural Plasticity & Perceptual Learning	BE 747: Advanced Signals & Systems for BME	BE 727: Principles and Applications of Tissue Engineering
BE 767: Protein & Genomic Systems Engineering	BE 726: Fundamentals of Biomaterials	BE 726: Fundamentals of Biomaterials	MA 565: Math Models in the Life Sciences	BE 765: Biomedical Optics & Biophotonics
BE 768: Biological Data Base Design	BE 727: Principles and Applications of Tissue Engineering	BE 727: Principles and Applications of Tissue Engineering		BE 773: Advanced Optical Microscopy
BE 775: Mechanisms & Models of Cellular Regulation	BE 775: Mechanisms & Models of Cellular Regulation	BE 788: Soft Tissue Biomechanics		BI 575: Techniques in Cellular/Molecular Neurophysiology
BE 777: Computational Genomics	BI 645: Cellular/Molecular Neurophysiology			
BI 575: Techniques in Cellular/Molecular Neurophysiology				
BI 645: Cellular/Molecular Neurophysiology				

Trainees must select at least one course from 3 of the first 4 columns. This ensures that every trainee takes at least two courses synthesizing a quantitative and systems approach at two distinct scales of biology (e.g., molecular-cell, cell-tissue, or tissue-organ) and a third course either at the third biological scale or a course (from Column 4) that cuts across multiple scales. Finally, all trainees must then select a course from Column 5 covering measurement techniques. This requirement ensures that every trainee is exposed to experimental methods at some level. Satisfying these selections results in 6 courses. Trainees then must take 2 additional free electives.

**Satisfying the Requirements for the PhD in BME** – As QBP trainees select their courses they must be cognizant of the general course requirements for all BME students. These requirements consist of the same two required core courses from above (BE 605 and BE 606) and six more electives. Selecting from Table A as described can easily be done in a fashion to satisfy PhD requirements in BME also.

**Rotation and Mentor Selection** – Students must perform a minimum of three and are encouraged to perform four laboratory rotations. The rotations must be in the laboratories listed in Table B (below) which span four levels of biology and physiology inclusive of a level termed “behavioral or integrative”. Students must select from at least three distinct laboratories and ensure these selections cover at least three distinct columns. Moreover, note that several laboratories are listed in multiple columns. This occurs because these faculty members are engaged in research projects that span several biological levels. Students must show that a rotation in a lab for a particular column engaged the student in experiences associated with that column’s theme. This rotation system ensures that QBP students experience biology over multiple scales, regardless of which laboratory they select for their dissertation topic.

**Table B: QBP Laboratory Selections (check for updates)**

<b>Molecular/Genetic</b>	<b>Cellular/Tissue</b>	<b>Tissue/Organ</b>	<b>Integrative/Sensory</b>
Cellular Regulation Labs (Collins, Steffen)	Binaural Hearing Lab (Colburn)	Neuroscience Labs (Eldred, Sen, Colburn, Han, Mountain, Ritt)	Applied BioDynamics Lab (Collins)
Laboratory for Molecular and Cellular Dynamics (Zaman)	Cell & Tissue Mechanics Labs (Stamenovic, Suki, Damiano)	Brain & Vision Lab (Vaina)	Cell & Tissue Mechanics Labs (Stamenovic, Suki, Damiano)
Applied BioDynamics Lab (Collins)	Cellular and Subcellular Biomechanics Labs (Stamenovic, Damiano)	Auditory Biophysics & Simulation Lab (Mountain)	Binaural Hearing Lab (Colburn)
Nanobiotechnology and Nanobiosystems (Goldberg, Unlu, Erramilli, Meller)	Cellular Regulation Labs (Collins, Steffen)	Neural Information Processing Lab (Ritt)	Biomedical Optics Lab (Bigio)
Macromolecular Chemistry Lab (Grinstaff)	Cell & Tissue Engineering Labs (Morgan, Tien, Grinstaff, Klapperich, Wong, Zaman, M. Smith, Nugent)	Natural Sounds and Neural Coding Lab (Sen)	Brain & Vision Lab (Vaina)
Matrix Mechanotransduction Lab (M. Smith)	Micro and Nano Biosystems Labs (Klapperich, Wong)	Pulmonary Bioengineering (Lutchen)	Mathematics BioDynamics Group (Kopell)
Single Molecule Biophysics & Nano-Biotechnology Lab (Meller)	Single Molecule Biophysics & Nano-Biotechnology Lab (Meller)	Cell & Tissue Mechanics Labs (Stamenovic, Suki, Damiano)	Biocomplexity and Multiscale Biology (Suki, Lutchen)
	Matrix Mechanotransduction Lab (M. Smith)	Cell & Tissue Engineering Labs (Morgan, Tien, Grinstaff, Klapperich, Wong, Zaman, M. Smith, Nugent)	Brain, Behavior and Cognition (Eichenbaum)



	Laboratory for Molecular and Cellular Dynamics (Zaman)	Biomedical Optics Lab (Bigio)	Neuroscience Labs (Eldred, Sen, Colburn, Mountain, Ritt, Han)
	Biomedical Optics Lab (Bigio)		
	Brain & Vision Lab (Vaina)	Biomicroscopy Lab (Mertz)	
	Brain, Behavior and Cognition (Eichenbaum)		
	Biomicroscopy Lab (Mertz)		

Please note that this table changes every year as new faculty members arrive. Please consult with the BME Associate Chair for Graduate Programs for any questions regarding laboratory selections.

**Program Cohesion, Retention, Enhancement and Information Flow** – The program cohesion and cultural components include: monthly journal club, common office space for trainees, invitation and active involvement in annual retreats, and participation on our Annual Fall Symposium in Quantitative Biology and Physiology run by and for trainees. Each trainee beyond their 3<sup>rd</sup> year in the BME program gives a talk at the symposium. There are also monthly dinners.

### **Logistical Information**

**Previous MS & PhD theses are available for review in ERB 401. Please do NOT remove the theses from ERB 401!**

**Graduate Student Offices** – New PhD students will be assigned a desk in dedicated BME graduate student offices. Faculty lab supervisors should provide desk space in their labs for BME Research Assistants. Students should contact the BME Graduate Program Administrator regarding office assignments.

**Computer Resource and Printing Facility** - The Biomedical Engineering Computational Simulation Facility consists of two classrooms containing 56 workstations, as well as a machine room containing a server farm and two 16GB RAM, ccNUMA Linux supercomputers. All machines are running BU's own 64-bit distribution of Linux on the AMD64 Opteron architecture, and are tied together with Sun Grid Engine software for a total of 230 processors available to parallel compute jobs at any time. System enhancements and new GPU-based parallel computing resources are coming on line, for ever-growing capabilities.

**Email** – BME utilizes electronic mail as a medium for official communication. Please be sure to check your **BU** email account on a daily basis for important information, and make sure that your account is not filled up.

**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. In addition to email, this is how some information and forms get distributed to graduate students. If you do not have a mailbox, please notify the BME Graduate Program Administrator. The mailing address is: *Department of Biomedical Engineering, Boston University, 44 Cummington Mall, Boston, MA 02215.*

**Women in BME** - Women in BME started in the fall of 2005 for women graduate students to gain greater access to women mentors and to help guide us in making some of the bigger life decisions (i.e. applying for postdoctoral positions, jobs, discussing family issues, etc.) While there are a handful of other avenues for graduate women to find mentors, there is something unique about having a mentor in our own program. The Women in BME hosts book club meetings throughout the academic year.

**Graduate Student Concerns** – Any matters concerning leave of absences, medical leave of absences or

maternity leaves should be discussed with the BME Graduate Program Administrator, who should be the first point of contact. The Associate Chair for Graduate Programs is also a resource.

**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. Please see the work-study student at the front desk in ERB 403 for instructions.

**Getting to the BU Medical School Campus** – BME students often take courses or attend lectures at the BU School of Medicine campus, which is located at 80 E. Concord Street in Boston. A number of students also conduct research at the medical center. Traveling between Boston University’s Charles River campus and the Medical Campus is now easy thanks to the enhanced **Boston University Shuttle (The BUS)** service. The Shuttle runs every 10-30 minutes (depending on the day and time) and makes it a snap for the BU community to access the many resources, programs, and activities throughout the University. 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 at <http://www.bu.edu/thebus/>.