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Summary of Course Requirements for BME Graduate Students – Fall 2007

All New Graduate Students:

BE 790 *Biomedical Engineering Seminar* (0 credits)

During semester of teaching assignment (primarily PhD students):

New Graduate Teaching Fellows:

SC 850 *Graduate Teaching Seminar* (0 credits)

BE 801 Teaching Practicum (4 credits). All GTFs are required to register for BE 801 during the semester of their formal teaching assignment. During the semester that the student teaches, he/she can only register for 8 credits (BE 801 and 4 credits of research). Students are not allowed to take a structured course while they teach unless they receive permission from their research advisor.

New MS/Ph.D. Students (post-bachelor's)

- **BE 791 *Biomedical Engineering Laboratory Rotations***. (Students typically register for 1 credit in fall semester and 2 credits in the spring semester.) NIH Student Trainees – please see page 18
- **BE 505 *Molecular Bioengineering I***. You should plan to take this course the fall of your first year. 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 Graduate Committee.
- **BE 706 *Quantitative Physiology for Engineers***. You should plan to take this course spring of your first year. We generally waive this requirement for students with prior grad-level coverage of physiology. Waivers must be approved by the Graduate Committee.
- **Core curriculum electives:** During the course of your time at BU, you are required to take at least **two** more **courses** chosen from the five BME core curriculum electives. Almost always, these two courses should be taken in the first year to prepare for the BME PhD qualifying exam. These courses include:
 - BE 703 (Numerical Models and Methods in BME, taught in fall);
 - BE 567 (Nonlinear Systems in BME, fall);
 - BE 506 (Molecular Bioengineering II, spring)
 - BE 521 (Continuum Mechanics in BME)
 - BE 747 (Advanced Signals and Systems for BME, spring). We will offer each of these courses every academic year.
- Many new Ph.D. students take a Mathematics course in preparation for the College Mathematics qualifier exam. It is recommended that you review the topics covered on the exam to determine if such a course is needed (see page 2).
- **Four technical electives**, at least two of which are from BME. These choices are made with one's advisor.
- BE 801: Teaching Practicum
- **Research credits:** (BE 900 *Research*; details on page 9).

Post-BS PhD Students must complete 64 total credits (formal courses plus research credits) prior to graduation, earning at least 56 credits at BU.

As of Fall 2005, all post-bachelor's PhD degree students are required to declare a Master of Science degree when they complete the prospectus.

New Post-M.S. Ph.D. Students:

- **BE 505 *Molecular Bioengineering I***. We recommend this course for the fall of your first year. If you have had prior coursework that you feel overlaps substantially with this material, you discuss the possibility of waiving this course requirement with your academic advisor or the department Graduate Chair.
- **BE 706 *Quantitative Physiology for Engineers***. We recommend this course for the spring of your first year. We generally waive this requirement for students with prior grad-level coverage of physiology. Petitions must be approved by the Graduate Committee.
- **Three technical electives** (at least two from BME). Post-MS students should take at least one, and preferably two
- Research courses (BE 900 *Research*; details on page 9).
- BE 801: Teaching Practicum
- **Research credits:** (BE 900 *Research*; details on page 9).

Generally, post-MS students are expected to take a total of five courses. However, at the discretion of the 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.

New M.S. Students:

- The **biology/physiology requirement:** at least one of either BE 505 or BE 706. The rules for waivers are the same as for Ph.D. students.
- One Mathematics elective (see list below). The mathematics requirement can also be satisfied by taking (and passing) the Mathematics Qualifier exam that is administered to PhD candidates in January.
- 1 BME core electives (from courses on the same list as the five PhD core electives): BE506, BE521, BE567, BE 703, BE 747
- 2 graduate-level BME Electives
- 2 technical electives relevant to research field (offered by BME or other departments that are approved by advisor)
- BE 900 – 8 credits

Counting courses taken elsewhere:

Students may “place out” of required courses, if they have taken equivalent courses elsewhere at the graduate level, as long as these 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 706. Students with extensive experience in quantitative molecular biology may receive permission not to take BE 505. This permission must be granted by submitting a petition to the grad 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-B.S. Ph.D. students, 32 for post-M.S. Ph.D. students, 36 for M.S. students) to meet the degree requirements, but it does enable the student to take other electives.

List of Courses that meet the Mathematics Requirement for MS Students

Any 500 level or higher mathematics course that is approved by the student’s advisor will satisfy the advanced mathematics requirement. In addition, the following courses from the College of Engineering satisfy the requirement:

ENG EK 500 Probability with Statistical Applications
ENG EK 510 Fourier Transforms
ENG AM 513 Compressible Aerodynamics
ENG AM 515 Vibration of Complex Mechanical Systems
ENG AM 519 Heat Transfer
ENG AM 521 Continuum Mechanics
ENG AM 707 Finite Element Methods in Aerodynamics
ENG AM 709 Turbulent Flows
ENG AM 713 Viscous Flow Theory
ENG BE 567 Nonlinear Systems Dynamics in BME
ENG BE 747 Advanced Signals and Systems Analysis for BME
ENG MN 566 Advanced Engineering Mathematics
ENG MN 710 Dynamic Programming and Stochastic Control
ENG SC 501 Dynamic Systems Theory
ENG SC 505 Stochastic Processes
ENG SC 508 Process Control
ENG SC 512 Digital Signal Processing
ENG SC 533 Introduction to Discrete Mathematics
ENG SC 561 Error Control Codes (normally offered as SC 761)
ENG SC 701 Optimal Control and Advanced Topics in System Theory
ENG SC 710 Dynamic Programming and Stochastic Control
ENG SC 761 Information Theory and Coding

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 (Neuromuscular Research Center, Biomolecular Research Center, Center for Advanced Biotechnology, Center for Advanced Genomic Technology, Center for BioDynamics, and the Hearing Research Center). To find out more about specific research programs of the faculty, pick-up a copy of the current “Faculty Research Interests”, and the “Biomedical Engineering Laboratories” descriptions from the form tree files in the BME Office Extension/Kitchen (ERB 407). You can also visit the web pages for individual faculty members through the department web page. There also are many interesting research opportunities outside the Labs and Centers affiliated with the BME Department, associated Centers and BME full-time faculty. It is normally expected that such arrangements will invoke a BME professor as co-advisor, often with a collaborative relationship between the BME and outside faculty member. Students interested in pursuing their M.S. Thesis or Ph.D. 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 4).

Research Project – A major requirement for either the M.S. or Ph.D. 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 of completing a thesis will be different for Masters and Ph.D. 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. The student’s academic advisor should be able to provide general information about the University, and help the student to complete his/her course registrations for the first year.

Master’s students are expected to choose a research advisor no later than the end of the first semester of matriculation.

Ph.D. students will participate in laboratory rotations, typically three, during the first year (with the rare exception of those matriculating already with a research assistantship). 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. 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.

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 academic faculty member, the student must choose an appropriate academic advisor from among the BME faculty. This academic advisor is expected to be a member of the student’s committee (for M.S. students) and/or a “co-First Reader” (for Ph.D. students). See below for more details.

Who Can Be A Research Advisor – For an M.S. student, any full-time member of the Biomedical Engineering faculty, or any 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 Ph.D. or M.D.) within or outside of Boston University (i.e., from one of the area hospitals) can be accepted by the Graduate Committee to be a student’s principal research advisor as long as the student can identify at least two full-time faculty members within the BME Department to serve as members of the M.S. Thesis Committee.

The Graduate Committee must approve of outside advisors for M.S. students. **Prospective advisors must turn in the following materials to the Graduate Committee:**

- ✓ Up-to-date Curriculum Vitae
- ✓ Contact Information – email, phone number and mailing address
- ✓ Statement of Commitment
- ✓ Description of the General Area of Research in which the student will become involved.

Ph.D track students wishing to have a research advisor who is not a member of the full-time Biomedical Engineering academic faculty must submit a Ph.D. Supervisor Approval Form (available from Rene Smith, Academic Programs Manager) approved by the Biomedical Engineering Graduate Committee. This form should be submitted as soon as the potential advisor is selected, typically at the end of the first year. In addition, the student must identify a full-time Biomedical Engineering academic faculty member to serve as the co-First Reader of the Ph.D. Dissertation. The co-First Reader 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 and their lab rotations to determine what their specific interests are in the field of biomedical engineering and identify the opportunities for funding in a professor's lab. 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 1st.

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 Biomedical Engineering Department is to check the list of current Faculty Research Interests and BME Laboratory and Research Center Descriptions available on the BME website (<http://www/bme.bu.edu>). Ph.D. 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. There are, however, some exceptions to this general rule. A student who is doing a MS Thesis at a company where she/he has done an internship or a student who is in residence as a regular graduate student and paying full tuition may request permission to pursue their research in the lab of a BU faculty member from a different department. If that faculty member has a joint appointment in BME, no additional approval is required.

An MS student who has done an internship or is employed at a company off-site may conduct the thesis research at that site.

An MS student may submit a request for approval of a research co-advisor from outside the BME Department (who does not have a joint appointment in BME), and may do his/her thesis research at the co-advisor's site. The request should be addressed to the BME Graduate Committee and must be approved by the BME thesis co-advisor supervisor. Two necessary conditions for approval of such a request are:

1. The thesis requires facilities that are NOT available in BME.
2. The BME supervisor agrees to ACTIVELY oversee the research activity.

Students are allowed to perform research for the PhD off-campus as well, but the conditions are more stringent. In addition to the two conditions above, PhD students must identify a BME faculty member to serve as co-First Reader. This BME faculty member typically serves as a collaborator (and eventual co-author) in the work. At a minimum, the BME co-advisor must stay well informed and accept responsibility for the engineering content and quality of the work.

If the off-campus location is an industrial location, there may be special problems that arise due to patents, copyrights and other conflicts of interest, which must be addressed prior to starting the work, particularly if the student receives compensation in a monthly stipend. Unusual cases may be referred to Associate Dean of Research and Graduate Programs, Selim Unlu.

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. Rene Smith (Academic Programs Manager) will provide you with the necessary form to sign.

Staff Directory

BME Graduate Programs Staff

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Master of Science Degree Program Requirements

The requirements for a Master of Science in Biomedical Engineering 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, and two research courses which culminate in a Master's research proposal, a noncredit 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 of six or seven (7) structured courses and 8-12 credits of (2) research. All but one of the structured courses must be at the graduate level (only one course is permitted at the 400-level); four of them are specified by the requirements below. 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. MS students are required to hand in their final program planning sheets at the time of the MS thesis proposal.

The required courses are:

- * 1 graduate-level BME physiology/biology elective (BE 505 Molecular Bioengineering or BE 706 Quantitative Physiology for Engineers (4 credits)
- * Mathematics elective: (4 credits). The mathematics elective may be satisfied either by taking a 500-level or above mathematics course, (see page 2) or by passing the PhD Engineering Mathematics Qualifier exam. (If the math exam is used for the math requirement, one additional elective must be taken to fulfill requirement for seven structured courses.)
- * 1 BME core elective (from the same list as the five PhD core electives): BE506, BE521, BE567, BE 703, BE747
- * 2 technical electives relevant to research field (BME or other)
 - Two graduate-level BME courses (8 credits)

Electives:

At least three (3) approved electives (12 credits) must be taken. Only one course, four (4) credits, from courses at the 400 level can be used toward the M.S. degree. The student is expected to choose electives that most help him/her learn about topics pertaining to the student's research project. 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.

Research and Thesis Course Requirements

The M.S. 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. Final grades for BE 900 level research courses are on a Pass/Fail system.

To register for BE 900, the student should complete a "Petition to Do Independent Coursework" form. The student fills out and signs the form, obtains the signature of the faculty member who has agreed to supervise the student's research, and then takes the form (along with the Registration Form or Drop/Add Form) to Rene Smith, Academic Programs Manager in Room 220 (44 Cummington Street). The appropriate section code for the research advisor will be assigned. Each faculty member has an individual section code, which enables the course grade to be properly recorded. If the student's research advisor is not a full-time academic department faculty member, then the student's academic advisor must sign this form.

M.S. Thesis Committee Membership - After identifying a research advisor and project, each student forms a thesis committee. The M.S. Thesis Committee must have a minimum of three (3) members. Two members must be from the full-time BME academic faculty and one must be from outside the department (BME adjuncts, research faculty and research associates with a Ph.D. and sufficient experience may count as the "outside" member). Any of these three members can be the primary advisor. See "Finding a Research Home" (see page 3) for more on the subject of selecting advisors.

M.S. Thesis Proposal – A brief written proposal (3-5 pages) of the M.S. 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 M.S. 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 should submit the signed approval form and the proposal document (signed by the advisor) to Rene Smith, Academic Programs Manager in ERB 220 (44 Cummington Street). It is expected that the student's thesis committee will meet regularly with the student throughout the remainder of his/her thesis research.

M.S. Thesis – An M.S. Thesis must be written and defended successfully for completion of the M.S. 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 generally not permitted to defend their thesis the same semester in which the proposal was submitted. Students should discuss with their advisors the expected content and length of the written thesis. 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 in the form tree in the Graduate Student Lounge, ERB 407 and online in the BME website. 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, that information, along with a copy of the abstract, must be submitted to the BME Academic Programs Manager (Rene Smith) 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, and is displayed in the BME office for public disclosure. The BME Academic Programs Manager 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 Rene Smith (BME Academic Programs Manager). Ms. Smith will be responsible for obtaining the signature of the Associate Chair for Graduate Studies.

Submission of the Final Thesis – Upon successful defense and final approval of the thesis, the student must deliver to the BME Academic Programs Manager 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.

Rene Smith 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 Rene Smith 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 will be softbound (plastic binder, clear cover and black backing), unless a hardbound copy is specifically requested (either by the students or the committee member). 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.

M.S. Program Completion Time Schedule – It is up to the student and academic advisors to get the project done in a reasonable amount of time for a Master’s thesis. Most students graduate from the M.S. 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 very 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 if they cannot participate because of missed deadlines. A list of deadlines for the M.S. Program is located in the Engineering College Graduate Bulletin, usually on page 2. Copies of this bulletin are available in the Academic Programs Office (ERB 220) and the Graduate Program Office at 48 Cummington Street. Please contact Rene Smith (smithr@bu.edu) if you have any questions about these deadlines.

Each student has maximum of five (5) years from the time of matriculation to complete the requirements for the M.S. 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 M.S. Program to the Ph.D. Program – Often students who enter the M.S. program later decide that they would like to pursue a Ph.D. in Biomedical Engineering. The student must formally apply to the PhD program; however, the M.S. program is designed so that a transition into the Ph.D. program is straightforward, as summarized below:

- An M.S. student wishing to pursue a Ph.D. may apply to the Ph.D. program with the Short Application Form available from the College Graduate Office. MS students accepted into the PhD program will have to pass the PhD math qualifier exam and the BME Department PhD oral qualifier exam, as is required for post-BS PhD candidates. The student may choose to prepare a Ph.D. prospectus rather than a M.S. thesis and take the prospectus defense examination. As of the Fall 2005 semester, 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.)
- If admitted to the PhD program, the student who completed the M.S. degree in Biomedical Engineering requires one additional physiology/biology course, plus the completion of a depth sequence (three cohesive BME electives), to satisfy the curriculum requirements of the doctoral program.
- M.S. students wishing to continue on for a Ph.D. with the intent to extend their M.S. research will be encouraged to modify their M.S. thesis as necessary into a Ph.D. 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 mathematics and departmental written examinations prior to submitting and defending a Ph.D. prospectus. (See PhD requirements below.)

Planning for Graduation – An M.S. student cannot defend his/her thesis and/or graduate the same semester in which the M.S. 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 to the College Graduate Office in order to be eligible for graduation. The deadlines for when this form is to be submitted should be verified in the College Bulletin.

Doctor of Philosophy Degree Requirements

All engineering Ph.D. students must adhere to meet the Ph.D. degree requirements as set forth by the College of Engineering. Those requirements are listed in the *Ph.D. Programs in Engineering Handbook*, which can be obtained from the College Graduate Office. In addition, BME Ph.D. students must 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 Ph.D. requirements are outlined below:

The general requirements for a PhD in BME include: All Ph.D. students must fulfill course requirements, and pass two qualifying examinations: the written exam in applied mathematics and an oral exam in biomedical engineering; an oral defense of the dissertation prospectus; and a final oral examination defending the dissertation are also required. Ph.D. students are expected to become connected with a research laboratory and engaged in goal-oriented research by the end of their first academic year.

All PhD students are required to have one semester of teaching experience as a Graduate Teaching Fellow. This is assigned by the Associate Chair for Graduate Studies, and is usually assigned during the second academic year.

Ph.D. students should submit a Program Planning Sheet to the BME Graduate Committee. This is completed when the student presents their prospectus. A cumulative grade point average of 3.0 must be maintained and not more than one course with a grade lower than B- can be counted towards the degree.

Post-Bachelor's Ph.D. Curriculum Requirements (MS/PhD)

Course Requirements - Post-Bachelor's Ph.D. students must enroll in a minimum total of 16 courses (64 credits prior to graduation.). Students must take a minimum of eight structured courses as listed on page 1, and the remaining credits should be research (BE 900) with a minimum of 16 credits of research. No more than one elective course can be taken at the 400 level: all other courses must be at the graduate level courses. At least seven of the structured courses must be at the graduate level; five of them are specified by the requirements below. 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 attached Program Planning Sheet.

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

Research Credit Requirements – Post-Bachelor Ph.D. students must complete a minimum of 16 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 Ph.D. 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, a minimum of eight additional dissertation research credits are required, which can be satisfied through continued registration for BE 900 (variable credits) until the dissertation is complete.

Post-Master's Ph.D. Curriculum Requirements

Structured Course Requirements – Post-Master's Ph.D. students must complete at least 5 structured courses. Students must also take BE 790 Biomedical Engineering Seminar Series and BE 791 Biomedical Engineering Laboratory Rotation (see page 11). 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 Course Requirements – A minimum of 8 research credits (BE 900) are required for Post-Master's Ph.D. students.

M.D./Ph.D. Curriculum Requirements

MD/PhD students have course requirements that are a hybrid between Post-B.S. and Post-M.S. Ph.D. Students:

- BE 505 *Molecular Bioengineering I*. 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 706 *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.
- Two courses from the five other BME core-curriculum elective courses. (See page 1 for list.) Students should take these courses in the first year, to prepare for the BME qualifying exam.

Elective courses and research credits:

- Three technical electives (at least two from BME). 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 Ph.D.; a minimum of 12 credits must be research credits (BE 900).

Qualifying Exams & PhD Candidacy

Applied Mathematics Ph.D. Qualifying Examination –This examination is administered twice each year, in January and April/May, by the College of Engineering Graduate Committee. Students have two chances to pass this exam and are required by the College of Engineering to pass four sections of the exam by the end of their 2nd semester. Once a given section is passed, the student is not required to re-take it. At the discretion of the Departmental Graduate Committee, students may be allowed to gain credit for 1-2 failed sections by taking classes from a specified list. The deadline for completing the math exam requirement may be extended in special cases, as determined by the Graduate Committee on a case-by-case basis for students who are involved in programs that require intensive coursework off-campus during their first year or two (e.g. the MD/PhD program, and the Biomolecular Pharmacology Training program). Students in these programs will be required to take the math exam during the first year that they are primarily located on the Charles River campus (e.g., in the 2nd year for Biomolecular Pharmacology students, and in the 3rd year for MD/PhD students).

Applied Mathematics Ph.D. Qualifying Examination sections:

In this examination, students must select questions from four of the following areas:

1. Fourier Series and Fourier Transforms
2. Ordinary differential equations
3. Linear algebra
4. Vector analysis
5. Partial differential equations
6. Complex variables and series
7. Probability and statistics
8. Discrete mathematics
9. Algorithms

Copies of previous math examinations may be obtained from the College Graduate Office, MEB 204 (48 Cummington St.).

The BME Ph.D. 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. Material in the BME qualifier is tied to the core curriculum. All students are tested in Molecular Bioengineering (BE 505) and Quantitative Physiology (BE706), and choose two additional topics from among the five elective core courses. The qualifier exam is meant to assess the student’s ability to integrate fundamental knowledge from these courses, rather than as a “second final exam” in each topic, relating the knowledge to their area of research interest. The department will provide guidance for students’ preparations for the qualifier exam during the spring semester.

Policy regarding “Conditional 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; a repeat oral exam on all or part of the material; or, in extreme cases, removal from the Ph.D. program.

Conditional Pass: Conditions to be met by the student in order to receive a “Pass” are specified by the examining team, and confirmed by the Associate Chair for Graduate Studies. These may include re-examination on specific topics, requirement to take a specific course (and receive a grade of B+ or better) or serve as a GTF on a specific course, or other such requirement as may be deemed appropriate to correct the perceived deficiency.

Fail: There is no automatic recourse for this outcome. The student may apply to transfer to the M.S. Program, or the student may file a petition to retake the PhD Oral Qualifier exam. If the student submits a petition, it must include an explicit description of circumstances that the student feels led to his/her failing of the exam, and an explanation as to why the student feels he/she would have a reasonable likelihood of passing, given a chance to take the exam a second time. The petition will be reviewed by the BME Graduate Committee, in consultation with the examining committee, and the student will be notified of the decision as soon as possible.

Ph.D. Candidacy – Upon successful completion of all Qualifying Examinations, a student becomes formally accepted to Ph.D. candidacy. A Ph.D. candidate has a maximum of five (5) years to complete all degree requirements for graduate studies. After five years, the Graduate Committee will determine whether or not a candidate may extend his/her participation in the Ph.D. program. In no instance will a student who is not a Ph.D. candidate be allowed to defend a Ph.D. prospectus or completed Ph.D. dissertation.

Lab Rotations

BE 791 Biomedical Engineering Lab Rotations – All Ph.D. students (not already funded by a Research Assistantship) are required to participate in laboratory rotations, and enroll in BE 791 Ph.D. Biomedical Engineering Laboratory Rotation, during their first year in the graduate program. 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 Ph.D. students must register for BE 791 in their first and second semesters of matriculation in BME. Typically, students register for one or two credits in each of the fall and spring semesters, for a total of three. (1 credit = 1 rotation) The course is graded Pass/Fail.
- Ph.D. students usually perform three (3) seven-week rotations during the first two semesters. 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”).
- Students who matriculate into the 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 additional lab rotations (i.e., if the student identifies a BE 900 research advisor in the first lab rotation, then the student may be allowed to petition out of the additional required rotations). The BE 900 research advisor must agree to this.

BE 791 Biomedical Engineering Lab Rotations (cont)

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 Rene Smith (smithr@bu.edu).

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. The BME faculty and Graduate Committee will determine whether the subject is worthy of a dissertation. The student should demonstrate worthy knowledge of and propose how to solve the problem. When sufficient investigation of the topic has been undertaken to believe the subject is worthy of a dissertation, a Dissertation Committee is formed.

Prospectus/Dissertation Committee – By the end of the fifth semester in the program, Ph.D. candidates are required to form a Dissertation Prospectus Committee and present the dissertation prospectus: 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. Each committee must have at least four (4) members: three must be from the College of Engineering full-time academic faculty, two must be from the BME Department's full-time academic faculty, and one must be from a different department or institution. 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 Examination Committee.

If a researcher from outside the University serves on a dissertation committee, a 'Special Service Appointment Form' (available in the form tree located in the Graduate Student Lounge in ERB 407) 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 approved or 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 composition of this committee must be reported to the BME Graduate Programs Office (Rene Smith), prior to scheduling the prospectus defense. In addition, the prospectus defense committee must approve that the Ph.D. prospectus is at a stage appropriate for scheduling the exam via their signature on the Ph.D. Dissertation Prospectus Defense Form.

Written Dissertation Prospectus – Before undertaking this phase, the student should consult the College's Guide for Writing Theses & Dissertations, available from the form tree located in the BME Kitchenette in ERB 407 or in the online form tree. The 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 space) 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 student must submit the following prior to the date of the prospectus defense:

The Ph.D. Dissertation Prospectus Defense Form (available in the form tree located in ERB 407 or in the online form tree) is to be handed in to Rene Smith 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 prospectus proposal and 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. Rene Smith 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 Ph.D. 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 Ph.D. program. In the latter case, the student has the option of pursuing an M.S. degree in Biomedical Engineering, but must complete all the requirements for that degree, including preparing and defending an M.S. thesis (see page 15 to review the procedure for changing to the M.S. program). In some cases, this may simply require some modification of the Ph.D. Prospectus.

As of fall 2005, all post-bachelor’s Ph.D. degree students are required to declare a Master of Science degree when they complete their Ph.D. Prospectus. The student must petition the graduate committee with a plan that is approved by their advisor. In some cases, the Ph.D. prospectus will be sufficient. In other cases, additional conditions set by the advisor and/or graduate committee may need to be fulfilled.

Reporting – The Chair of the Committee will complete the “Prospectus Defense Results” section on the “Ph.D. 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 Academic Programs Manager (who will be responsible for submitting to the Associate Chair for Graduate Studies). A signed copy is sent to the student. Required revisions to the proposal should be completed satisfactorily before a final “Pass” grade is given.

Course Registration After Prospectus Requirement Satisfied – After passing the Prospectus Defense candidates will enroll for a minimum of 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 Ph.D. 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 remaining 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. 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 and the Office of the Vice President. 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 candidate should contact the College Graduate Office or the BME Graduate Programs Administrator for the necessary forms and guidelines. 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. The committee consists of a Defense Chairman plus four (4) readers. A minimum of three committee members must be from the full-time academic faculty of the College; two (2) members must be full-time academic faculty members from the BME Department, and one must be from a completely 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 Academic Programs Manager 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 “Ph.D. Dissertation Defense Abstract” form (available from the BME Academic Programs Manager) to his/her major professor for approval and signature. The College Graduate Office reviews the abstract and notifies the BME Academic Programs Manager (Rene Smith informs the candidate via email) in writing if it is acceptable or needs revision.

At least two weeks prior to the defense date, the candidate must submit the “Ph.D. Final Oral Examination” form to the BME Academic Programs Manager. 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 read 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. The BME Academic Programs Manager will forward the form to Associate Chair for Graduate Affairs for approval and arrange publicity with the College Graduate Office.

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 “Ph.D. 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 Academic Programs Manager 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 Academic Programs Manager 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 a copy of the filing form to the BME Academic Programs Manager, at which time the student will have fulfilled the dissertation requirement for the Ph.D. degree in Biomedical Engineering. The BME Academic Programs Manager will forward the filing form to the College Graduate Office.

The BME Academic Programs Manager 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.

Ph.D. Program Completion Time Schedule –

- Course Requirements should be completed as early as possible. After all credit requirements have been fulfilled, Ph.D. students are allowed to audit one course per semester in order to continue to take advantage of course offerings.
- The COE Qualifying Exam in Applied Mathematics and the BME Qualifying Examination should be taken according to the regulations (see page 10).
- The Dissertation Prospectus should be presented by the end of the fifth semester from matriculation.
- Ph.D. students have five years to complete the dissertation after qualifying. Waivers of these limits may be granted under special circumstances.

Switching from the Ph.D. to the M.S. Program – There are several formal steps that must be followed to facilitate the student's official matriculation into the M.S. program. (NOTE: If you were a Research Assistant, the position is not automatically secured for you.)

The students should take the following steps:

1. The student must formally request (in writing to the Graduate Committee) to matriculate into the M.S. program. This includes providing a written outline of your research interests and intentions during and after your M.S. program.
2. The student must identify with whom you intend to complete your M.S. research (he/she must fill out a "short" M.S. program application form, from the College of Engineering and turn it in by the appropriate deadlines).
3. The intended M.S. research sponsor must submit a letter in writing to the Graduate Committee, providing an outline of the proposed M.S. project and whether he/she is willing to sponsor it.

There are time constraints to ensure that you don't 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, you should declare your interest to them if you plan on switching your academic program for the next semester.

Financial Information

Below is a summary of typical funding sources, tuition coverage and payment schedules for students receiving the following forms of financial aid: Deans Fellowships, Distinguished BME Fellowships, BME NIH Training Fellowships, Photonics and Research Assistantships (RAs)/Graduate Teaching Fellowships (GTF), Biomolecular Pharmacology Training Fellowships, and other specialized Center-based fellowships.

Students receiving any form of the financial support listed above are not permitted additional employment without prior written approval from both the student's advisor and the BME Graduate Committee.

Dean's Fellowships are awarded by the Dean of the College of Engineering

Distinguished BME Fellowships are awarded by the Director of the Admissions Committee for BME

BME NIH QBP Training Fellowships are awarded by the Chair of Biomedical Engineering Department

Graduate Teaching Fellowships are awarded and administered by the Biomedical Engineering Department

- Paychecks – Paychecks are available from the BME Office (ERB 403) on the last Friday of the month.
- Continuing fellows (DF, BME Distinguished Fellows, and NIH Trainees) should secure a funded Research Assistantship no later than the end of their first academic year (April 30th). Exceptions to this policy are 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 BME's Financial Manager (Debbie Dolan) regarding the details of subcontracting the Research Assistantship through the University in order to receive GRASP-tuition benefits.

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

- All incoming graduate Research Assistants (MS & Ph.D.) will receive the same monthly stipend.
- The stipend for Research Assistants remains equal until the student passes both Ph.D. qualifying examinations (Math and BME). Upon passing ALL qualifying examinations, 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 sign an RA Contract. Before the beginning of each academic year, you should confirm with your research sponsor as to whether or not he/she plans on continuing to support you. The financial administrator overseeing your sponsor's grant will also sign the RA contract, indicating that there are funds to pay the stipend. RA contracts must be completed using an Excel form that is downloaded from the following link:

<http://www.bu.edu/eng/facforms> . After the form has been properly filled in and signatures obtained, the RA Contract will be approved by the College of Engineering. 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's Financial Manager (Helaine Friedlander).
- Paychecks – Monthly stipend checks are paid at the end of each month and are available from the BME Office (ERB 403). (Direct deposit to your bank account can also be arranged.)
- Tuition – RAs supported full-time by a faculty's sponsored research grant usually receive tuition coverage through the Graduate Research Assistant Scholarship Program (GRASP), and should inquire with the Rene Smith, BMEs Academic Programs Manager, as to whether the Research Assistantship is GRASP-eligible. 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 and the BME Graduate Committee.

Getting Paid Over the Summer – Any student to be paid a summer stipend must either pre-register for the fall or register for EK 920S during the summer (0 credits) prior to the start of the summer session. The exceptions 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 Institute 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 (**BE505: Molecular Bioengineering I** and **BE706: Quantitative Physiology**). Both are required of all BME students as well.

The remaining 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 remaining courses.

TABLE A: QUANTITATIVE AND ENGINEERING BASED BIOLOGY AND PHYSIOLOGY COURSES

Molecular and Genetic Engineering	Cellular-to- Tissue Level Engineering	Tissue- to-Organ Level Engineering	Scale-Independent Analysis / Modeling	Measurement Techniques
BE 506: Molecular Bioengineering II BE 560: Biomolecular Architecture BE 561: DNA and Protein Sequence Analysis <u>BE 567: Nonlinear Dynamics in Biological Systems</u> <u>BE 700: Mechanisms & Models of Cellular Regulation</u> BE 764: Biophysics of Large Molecules BE767: Protein & Genomic Systems Eng. BE 777: Computational Genomics BE 768: Biological Data Base Design BI 645: Cellular / Molecular Neurophysiology BI 575: Techniques in Cellular / Molecular Neurophysiology	BE 523: Mechanics of Biomaterials <u>BE 775: Mechanisms & Models of Cellular Regulation</u> <u>BE 707: Quantitative Studies of Excitable Cells</u> BE 726: Biomaterials & Tissue Eng I BE 727: Biomaterials & Tissue Eng II BE 521 Continuum BioMechanics BE 722 Continuum Biomechanics and Biofluid Dynamics BI 645: Cellular / Molecular Neurophysiology BE 550: Bioelectromechanics <u>BE 567: Nonlinear Dynamics in Biological Systems</u> <u>BE563: Cellular and Molecular Systems Analysis</u>	<u>BE 508: Quantitative Studies of Respiratory and Cardiovascular Systems</u> BE 509: Quantitative Physiology of the Auditory System <u>BE 570: Introduction to Computational Vision</u> BE 710: Neural Plasticity and Perceptual Learning <u>BE 567: Nonlinear Dynamics in Biological Systems</u> BE 726: Biomaterials & Tissue Eng I BE 727: Biomaterials & Tissue Eng II BE 523: Mechanics of Biomaterials BE 521 Continuum BioMechanics BE 722 Continuum Biomechanics and Biofluid Dynamics	<u>BE 567: Nonlinear Dynamics in Biological Systems</u> <u>BE 703: Numerical Methods and Modeling in BME</u> <u>BE 736: Biomedical Transport</u> <u>BE 740: Parameter Estimation and System Identification in BME</u> BE 747: Advanced Signals and Systems for BME MA 565: Math Models in the Life Sciences	BE 523: Mechanics of Biomaterials BE 511: Biomedical Instrumentation BE 512: Biomedical Instrument Design BE 515: Introduction to Medical Imaging BE 537: Biomedical and Biochemical Microsystems BE 726: Biomaterials & Tissue Eng I BE 727: Biomaterials & Tissue Eng II BE 765: Biomedical Optics and Biophotonics BI 575: Techniques in Cellular / Molecular Neurophysiology BE 500: Optical Microscopy of Biological Materials

At least two courses must be chosen from the underlined options as these courses place emphasis on quantitative and modeling based laboratory exercises. 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 (eg., 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 Ph.D. 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 (BE505 and BE706) and six more electives. Selecting from Table A as described can easily be done in a fashion to satisfy Ph.D. 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 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 insures that QBP students experience biology over multiple scales, regardless of which laboratory they select for their dissertation topic.

Table B: QBP Laboratory Selections

Molecular/Genetic	Cellular/Tissue	Tissue-Organ/Sensory	Behavioral/Integrative
Biomolecular Engineering Research Center (T. Smith)	Binaural Hearing Lab (Colburn)	Systems Neurobiology (Tsien)	Applied BioDynamics Lab (Collins)
Cellular Regulation Labs (Gardner, Collins, Steffen)	Cell &Tissue Mechanics Labs (Stamenovic, Suki)	Brain & Vision Lab (Vaina)	Systems Neurobiology (Tsien)
Center for Advanced Biotechnology (Collins, Frank-Kamenetskii, Gardner)	Cellular and Subcellular Biomechanics Lab (Dembo, Damiano)	Cochlear Biophysics Lab (Mountain)	Binaural Hearing Lab (Colburn)
Biomolecular Systems Lab (Delisi)	Cellular Regulation Labs (Gardner, Collins)	Visual Information Processing Lab (Passaglia)	Biomedical Optics Lab (Bigio)
Nanobiotechnology and Nanobiosystems (Goldberg, Unlu, Erramilli, Georgiadis, Mohanty, Meller, Grinstaff, Wong, Klapperich)	Cell & Tissue Engineering (Morgan, Tien, Grinstaff, Klapperich, Wong)	Natural Sounds and Neural Coding Lab (Sen)	
Macromolecular Chemistry Lab (Grinstaff)	Micro and Nano Biosystems Labs (Klapperich, Wong)	Pulmonary Bioengineering (Lutchen, Jackson)	Cell &Tissue Mechanics Labs (Suki)
Protein Engineering Lab (Weng)	Neuronal Dynamics and Neuroscience Labs (Eldred)	Cell &Tissue Mechanics Labs (Stamenovic, Suki)	Mathematics BioDynamics Group (Kaper, Kopell)
Structural Bioinformatics Lab (Vajda)	Systems Neurobiology (Tsien)	Olfactory Processing (Wachowiak)	Biocomplexity and Multiscale Biology (Suki, Lutchen)
Systems Neurobiology (Tsien)	Biomedical Optics Lab (Bigio)	Biomedical Optics Lab (Bigio)	
	BioMicroscopy Lab (Mertz)	Biomicroscopy Lab (Mertz)	

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 Symposium run by and for trainees. Each trainee beyond their 3rd year in the BME program gives a talk at the symposium. There are also Bi-Monthly Dinners.

Logistical Information

Graduate Student Offices – Graduate Teaching Fellows are assigned an office by the BME Academic Programs Office. Faculty lab supervisors should provide desk space in their labs for BME Research Assistants. Students should contact Rene Smith at X 7609 or smithr@bu.edu regarding office assignments. Rene is located in ERB 220.

Computer resource and printing facility - The Biomedical Engineering Computational Simulation Facility is a new resource for the department this year. It 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.

BME Lounge – The BME Lounge is located on the second floor of 44 Cummington Street near the elevator. This room contains graduate student mailboxes. In addition to email, this is how most information and forms get distributed to graduate students. If you do not have a mailbox, please notify Rene Smith in ERB 220. The mailing address is: Department of Biomedical Engineering, Boston University, 44 Cummington Street, 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. For additional information, please contact Tara Deans at tdeans@bu.edu.

Graduate Student Concerns – Any matters concerning leave of absences, medical leave of absences or maternity leaves should be discussed with Rene Smith in ERB 220. Rene should be the first point of contact.

BME Kitchenette – There is a small kitchenette (including a refrigerator) that is available for faculty, graduate students and staff in ERB 407 with a very small seating area for eating. 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, or conduct research at the medical center.

BU Shuttle Service – there is a free BU shuttle bus that runs between the Charles River (Main) campus and the Medical School every half hour throughout the year. The route and schedule can be found at <http://www.bu.edu/thebus>