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Summary of Course Requirements for BME PhD Candidates

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 using the BME petition form (available online).

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

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

Three BME graduate-level electives
Two graduate-level technical electives (may include additional BE coursework)
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 Christen Bailey.
Math Requirement selected from approved list (located in the handbook and online). It is strongly recommended that this be completed during the first year. Both passing the oral qualifier exam and satisfying the math requirement are required in order to achieve PhD candidacy!
Teaching Practicum (BE 801 and BE 802) All PhD students are required to teach two semesters. Typically the first teaching assignment (BE 801) is during the second year and the second assignment (BE 802) is during the third year. BE 801 and BE 802 each count for 4 credits and students require permission of their research advisor if they want to take an additional course during the semester that they are teaching.
BE 900 Research (12 credits)
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. If approved by the student’s advisor and the BME Graduate Committee (using the BME petition form, available online), additional courses that do not necessarily satisfy a program requirement but would be beneficial to the student’s research are allowed.

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 Christen Bailey for details.

Post-MS PhD Students (Post-Master’s):

BE 790 Biomedical Engineering Seminar
BE 791 Biomedical Engineering Laboratory Rotations (Students will register for 1 credit in the fall semester and 2 credits in the spring semester – one credit per rotation)
*QBP fellows perform four lab rotations (1 in the fall, 2 in the spring and 1 in the summer)*
BE 792 Literature Review (spring semester of the first year, 2 credits)
BE 605 Molecular Bioengineering (fall semester of the first year, 4 credits)
If you have had prior coursework that you feel overlaps substantially with this material, you can discuss with the instructor the possibility of waiving this course requirement. Waivers must be approved by the BME Graduate Committee using the BME petition form (available online).

BE 606 Quantitative Physiology for Engineers (spring semester of the first year, 4 credits)
If you have had prior coursework that you feel overlaps substantially with this material, you can discuss with the instructor the possibility of waiving this course requirement. Waivers must be approved by the BME Graduate Committee using the BME petition form (available online).

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. Both passing the oral qualifier exam and satisfying the math requirement are required in order to achieve PhD candidacy! (Potentially may be waived, using the BME petition form, 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 the second assignment (BE 802) is during the third year. BE 801 and BE 802 each count for 4 credits and students require permission of their research advisor if they want to take an additional course during the semester that they are teaching.

BE 900 Research (4 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. If approved by the student’s advisor and the BME Graduate Committee (using the BME petition form, available online), additional courses that do not necessarily satisfy a program requirement but would be beneficial to the student’s research are allowed.

MD/PhD Students:

BE 790 Biomedical Engineering Seminar

BE 791 Biomedical Engineering Laboratory Rotations (Students will register for 1 credit in the fall semester and 2 credits in the spring semester – one credit per rotation)

*QBP fellows 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 the first year, 2 credits)

BE 605 Molecular Bioengineering (fall semester of the first year, 4 credits)
If you have had prior coursework that you feel overlaps substantially with this material, you can discuss with the instructor the possibility of waiving this course requirement. Waivers must be approved by the BME Graduate Committee using the BME petition form (available online).

BE 606 Quantitative Physiology for Engineers (spring semester of the first year, 4 credits)
If you have had prior coursework that you feel overlaps substantially with this material, you can discuss with the instructor the possibility of waiving this course requirement. Waivers must be approved by the BME Graduate Committee using the BME petition form (available online).

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. Both passing the oral qualifier exam and satisfying the math requirement are required in order to achieve PhD candidacy!

Teaching Practicum (BE 801 and BE 802) All PhD students are required to teach two semesters. Typically the first teaching assignment (BE 801) is during the second year and the second assignment (BE 802) is during the third year. BE 801 and BE 802 each count for 4 credits and students require permission of their research advisor if they want to take an additional course during the semester that they are teaching.
**BE 900 Research** (4 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. If approved by the student’s advisor and the BME Graduate Committee (using the BME petition form, available online), additional courses that do not necessarily satisfy a program requirement but would be beneficial to the student’s research are allowed.

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

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

**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 or previous degree**. For example, students who have taken a graduate-level physiology course may receive permission not to take BE 606. Students with extensive experience in quantitative molecular biology may receive permission not to take BE 605. This permission must be granted by submitting a petition to the BME Graduate Committee **BEFORE** the end of the Add/Drop period to waive the requirement. **Though students may place out of specific course requirements, this does not alter the total number of credits a student must earn at Boston University (56 or more for Post-BS PhD students, 32 for Post-MS PhD students, 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 601 - 604 Mathematical Methods in Biomedical Engineering** Pre-reqs: None. The goals of these modules 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 modules will be: Linear Algebra (Fall 2015), Ordinary Differential Equations (Fall 2015), Partial Differential Equations (Spring 2016) and Intro to Numerical Analysis (Spring 2016). **If using a combination of these courses to meet the math requirement, you are required to take BE 601 (Linear Algebra) and one of the other modules.**


**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


**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 BME Department or affiliated research centers (Biomolecular Research Center, Center for Future Technologies in Cancer Care, 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, please visit the individual faculty member webpages via the BME website. Faculty, scientists or researchers (holding a PhD or MD) within or outside of Boston University can be approved by the BME Graduate Committee using the BME petition form (available online) to be a student’s principal research advisor if they have an active research collaboration with a primary BME faculty member who will agree to be the student’s research co-advisor.
**Research Project** – A major requirement for the PhD degree is a research-based dissertation. Each student is responsible for finding a research project, conducting scientific studies under the guidance of an approved faculty member, presenting the proposal and results to the general scientific community in a public defense and finally turning in a dissertation to be bound for the library and the BME Department.

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

PhD students will participate in laboratory rotations (typically three) during the first year. This provides the students an opportunity to gain exposure to more than one research area and to help in identifying a good match with a research advisor. After finding a lab, the research advisor will be in charge of the student’s research project and will help coordinate the student’s schedule towards fulfilling all of the graduation requirements. **PhD students are expected to choose a research advisor no later than the end of the second semester of matriculation (April 30, 2016 deadline).**

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

**Who Can Be A Research Advisor** – For PhD students, any full-time member of the BME faculty, or any affiliated or adjunct faculty member who has an appointment with the department, is eligible to serve as a research advisor. Other faculty, scientists or researchers (those holding a PhD or MD) within or outside of Boston University can be approved by the BME Graduate Committee to be a student’s principal research advisor if they have an active research collaboration with a primary BME faculty member who will agree to be the student’s research co-advisor. Students should submit a PhD Supervisor Approval form (available online), to be approved by the BME Graduate Committee. This form should be submitted as soon as the potential advisor is selected (April 30, 2016 deadline).

After approval, and as their research project progresses, PhD students must identify two additional primary BME faculty members for their committees.

**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 dissertation research project. All three rotations should be completed by the end of the academic year (unless you are on the QBP fellowship which requires four lab rotations). **RA positions should begin May 1, 2016.**

Students can gain information about steps (1) and (2) through coursework, mandatory attendance of the BE 790 seminar during Fall 2015, informal discussions with faculty and, most importantly, the lab rotations. An easy way to find out what is available is to check the list of current Faculty Research Interests and BME Laboratory and Research Center Descriptions, available on the BME website.
Another valuable way of learning more about specific research opportunities is to speak with other graduate students who are currently working in the BME Department’s various labs. The best measure for learning about working in a specific lab is to make an appointment to speak with the faculty member in charge of a lab you are interested in. Some useful questions to ask 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 the possibility of funds for a new graduate student?
4. What expectations does the faculty member have of graduate students?
5. If the potential advisor has been at BU for at least a few years, does he/she have a strong history of training students in a timely manner? Have his/her students generally been successful?

Once a student finds a research opportunity and has the consent of a faculty member to be his/her advisor, the process of developing a research project begins.

**Off-Campus Research** – Dissertation research is usually carried out in laboratories and centers of BME faculty located on campus. In cases of non-BU advisors (see discussion above regarding required approval) the research is often performed off-campus, in the lab of the principal research 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. 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 (meb@bu.edu) 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. Christen Bailey will provide you with the necessary Patent Policy agreement form to sign at Orientation.

**Doctor of Philosophy Degree Requirements**

All engineering PhD students must adhere to and meet the PhD degree requirements as set forth by the College of Engineering. Additionally, BME PhD students must also meet any specific degree requirements as set forth by the BME Department.

The general requirements for all PhD students in BME include:

- fulfillment of course requirements
- passing the oral qualifier exam
- Prospectus Defense
- Dissertation Defense

PhD students need to submit a *Program Planning Sheet* (available online) 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.
Oral Qualifier Exam and 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 Oral Qualifier Exam. The Oral Qualifier Exam is taken during the early summer (usually June) following the first academic year in the graduate program. All PhD students are tested on Molecular Bioengineering (BE 605), Quantitative Physiology for Engineers (BE 606) and a third topic in the form of selected research papers to assess fundamental knowledge broadly related to their area of research interest (the student selects their third topic area from a list provided by Christen Bailey). 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 oral 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 Oral Qualifier Exam 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 Oral Qualifier Examination, a student becomes formally accepted to PhD candidacy. A PhD candidate has a maximum of five (5) years after passing the oral 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 using the College of Engineering petition form (available online). 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 (QBP), you will enroll in four laboratory rotations. 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. Students will register for one credit in the fall and two credits in the spring semester, for a total of
three. (1 credit = 1 rotation) The course is graded Pass/Fail.

- Rotations generally last 6-8 weeks. If students are unable to complete two rotations in their second semester, they must request permission from the BME Graduate Committee and Matt Barber to rotate over the summer.
- To do a rotation with a faculty member who does not have a primary or secondary appointment in BME, students must petition and receive permission from the BME Graduate Committee using the BME petition form (available online). QBP fellows must receive permission to do rotations with faculty outside the list of approved labs (see “Training Program in Quantitative Biology and Physiology” section of the handbook). 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. QBP fellows 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 Christen Bailey.

**Prospectus and Dissertation**

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

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

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

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

BME Research faculty may count towards the BME faculty requirement or may also fill the role of a 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 Prospectus Committee constitutes the nucleus of the Final Oral Thesis Examination Committee (Dissertation Defense).

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

**Written Prospectus** – Before undertaking this phase, the student should consult the College's Guide for Writing Theses & Dissertations which is located on the BME website under “Online Forms and Documents”. The Prospectus document should include a signature page, a statement of the problem to be investigated, its background and significance, methods and approach(es) to be followed for its resolution, preliminary results, anticipated timetable for completion and pertinent bibliography. The format is similar to a typical research proposal.

- The 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
- The prospectus should address the anticipated contribution of the work to the body of knowledge and 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, which includes tables and figures but does not include the list of references
- The prospectus should include an up-to-date copy of the student’s curriculum vitae (not part of the 20-page limit)

The PhD Prospectus Defense form (available online) is to be handed in to Christen Bailey two weeks prior to the defense along with the abstract. The student must obtain the committee’s ORIGINAL signatures on this form, which indicate that they have read the Prospectus document and approve that the examination be scheduled. In addition, the student must fill out the top section of this form indicating the title, date, time and location of the Prospectus Defense. The student submits this completed form immediately following the Prospectus Defense examination for approval by the Associate Chair for Graduate Studies.

**Scheduling** – Prior to scheduling the Prospectus Defense, the student must provide a copy of the Prospectus document to all members of the Prospectus Defense Committee. The student must also confirm with the committee members a date, time and location for the examination. Christen Bailey will be responsible for providing publicity for the student’s Prospectus Defense to the BME students and faculty.

**Conduct and Length of the Oral Examination for the Prospectus Defense** – The faculty research advisor should chair the Prospectus Defense, beginning with the introduction of the PhD student and his/her academic background. The student’s presentation should last 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, Prospectus Committee members or the audience may ask questions. The chair should guard against digressions and inappropriate questioning during the presentation. Following a reasonable question period, the student and the audience are dismissed and the Prospectus Committee remains to complete its assessment of the prospectus proposal examination.

**Assessment** – The Prospectus Defense 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 Defense examination. In the case of failure, the Prospectus Committee recommends the appropriate action: a recommendation of failure may include a suggestion that the student re-take the Prospectus Defense exam or that the student be terminated from the PhD program. In the latter case, the student has the option of pursuing an MS or M.Eng degree 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 Defense. This is not automatic and the student needs to complete an MS Program Planning Sheet and apply online for graduation.

If a student’s Prospectus Defense deadline has passed, he/she needs to petition the BME Graduate Committee for an extension, including indicating a timeline for completion of the prospectus.

**Reporting on Student Progress** – The chair of the Prospectus Defense Committee will complete the “Prospectus Defense Results” section on the PhD Prospectus Defense form. If the student is required to meet certain conditions, those conditions should be listed on a separate sheet and attached to the form. Those conditions should also contain time frames for completion. The chair then signs the form and forwards it to Christen Bailey (who will be responsible for submitting to the Associate Chair for Graduate Studies for final approval). Before the Prospectus Defense ends, the committee must indicate on the PhD Prospectus Defense form the date for the next committee meeting (at least once in the next 12 months) and indicate expected milestones for the next post-prospectus thesis committee meeting. Required revisions to the proposal should be completed satisfactorily before a final “Pass” grade is given. Dissertation committee meetings are to be held on a regular basis in order for the student to report progress and the committee to provide feedback. **As a minimum, committee meetings will be held annually.** The student must forward to his/her committee a written report (*Post-Prospectus Thesis Committee Meeting Report*) detailing progress towards milestones and the next planned steps at least one week before each planned meeting. It is the responsibility of the student to contact the committee members and schedule the committee meetings.

**Responsible Conduct of Research Requirement** – PhD candidates are required to complete the Responsible Conduct of Research (RCR) requirement before they can receive the post-prospectus stipend rate increase.

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

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

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

**Final Oral Examination (Dissertation Defense)** – The PhD Final Oral Examination form is located on the BME website under “Online Forms and Documents”. The Dissertation Defense is a public presentation of the candidate’s dissertation. The presentation should clearly define the problem, describe the method(s) used to solve the problem, report results and establish significance of the results. The purpose 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 (Dissertation Defense) Committee – In preparation for the Dissertation Defense, it is the candidate’s responsibility, in conjunction with that of his/her research advisor, to appoint a Dissertation Defense Committee. This committee usually consists of the faculty members who participated in the Prospectus Defense, and have followed the student’s progress and annual progress meetings.

The committee consists of five (5) readers:

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

If a researcher from outside the University serves on Dissertation Defense 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 Associate Chairman for Graduate Studies’ signature will be submitted to the Graduate Programs Office after receiving departmental approval. This form does not have to be re-submitted if it was approved for the Prospectus Defense.

Christen Bailey will appoint the chair for the Dissertation Defense. It must be a primary BME faculty member on the committee who is not the student’s research or co-advisor.

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

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

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

Assessment – The Dissertation Defense Committee is charged with assessing completeness of the research, contribution to knowledge, and the candidate’s mastery of his/her research area, based on the written dissertation and the oral presentation. Vote may be ballot or voice. A unanimous vote is required for a candidate to pass.
It is the chair’s responsibility to call the candidate back after the Dissertation Defense Committee has reached a decision. The chair will advise the student of the committee’s decision. At this time the candidate will be advised of any changes that must be made to the final title, abstract or dissertation document, with a deadline provided by the Dissertation Defense Committee.

**Reporting** – The 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, the committee members should sign the signature pages of the dissertation. If there is some rework to be done, this is to be noted on the Final Oral Exam form. Dissertation Defense Committee members should sign off on the form but will refrain from signing the signatures page of the dissertation until all conditions have been met.

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

The Associate Chair for Graduate Studies gives final approval on the Final Oral Examination form. The student will then follow the electronic submission guidelines provided by Mugar Library. Christen Bailey will provide departmental electronic approval for the student upon seeing the 1) original signatures page and 2) title page.

Christen Bailey will handle the binding of the additional dissertation copies. The cost for hardbound copies is $10.00 per copy (subsidized by the BME Department). Dissertations to be hardbound are sent to an external bindery once a year (early fall). Students should be sure to leave a correct forwarding address after graduation so that their hardbound copy of the dissertation 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 Requirement be completed during the first two semesters.
- The BME Oral Qualifier Examination is taken in early summer (usually June) following the first academic year. Schedules will be set by the BME Graduate Committee.
- The Prospectus Defense should be presented by the end of the sixth semester from matriculation.
- PhD students have five years to complete the dissertation after becoming a PhD candidate. Meetings with the thesis committee must occur at least annually following the Prospectus Defense, and must be documented by submission of the *Post-Prospectus Thesis Meeting Report* form to Christen Bailey.

**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 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 BU fellowships (Dean’s, BME, Photonics, etc.) should secure a funded Research Assistantship no later than the end of their first academic year (April 30, 2015). Exceptions to this policy include NIH QBP fellows 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 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 Matt Barber (meb@bu.edu) 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 stipend levels:

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

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. Work on the dissertation project is normally part of an assistant’s assignments. RA’s 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, 2016; Fall RA Contracts must be set up by July 15, 2016; Spring RA Contracts must be set up by December 1, 2015.**

Every Research Assistant (RA) and his/her research sponsor must submit an online funding contract. If the student has any questions on how or why the RA contract is completed, he/she should speak with Christen Bailey. 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’s stipend
- Settling the student’s tuition account by Isabel Tereso in the Graduate Programs Office
- Settling the student’s health insurance payment by Isabel Tereso in the Graduate Programs Office

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

**In order to be paid during the Summer** – Students must register for EK 920S for the Summer I term (0 credits) prior to the start of the summer session. International students must also 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 or dissertation during the summer and graduate in September, then you are required to register for two credits of BE 900S.
**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 (QBP)**

There are two core required courses in quantitative biology and physiology for all QBP fellows 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**

<table>
<thead>
<tr>
<th>Molecular and Genetic Engineering</th>
<th>Cellular-to-Tissue Level Engineering</th>
<th>Tissue-to-Organ Level Engineering</th>
<th>Scale-Independent Analysis/Modeling</th>
<th>Measurement Techniques</th>
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</thead>
<tbody>
<tr>
<td>BE 564: Biophysics of Large Molecules</td>
<td>BE 533: Biorheology</td>
<td>BE 567: Nonlinear Systems in Biomedical Engineering</td>
<td>BE 533: Biorheology</td>
<td>BE 569: Next Generation Sequencing</td>
</tr>
<tr>
<td>BE 768: Biological Data Base Design</td>
<td>BE 771: Introduction to Neuroengineering</td>
<td>BE 727: Principles and Applications of Tissue Engineering</td>
<td>BI 575: Techniques in Cellular/Molecular Neurophysiology</td>
<td></td>
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<tr>
<td>BE 775: Mechanisms &amp; Models of Cellular Regulation</td>
<td>BE 775: Mechanisms &amp; Models of Cellular Regulation</td>
<td>BE 771: Introduction to Neuroengineering</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BE 777: Computational Genomics</td>
<td>BE 780: Brain Machine Interfaces</td>
<td>BE 780: Brain Machine Interfaces</td>
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<tr>
<td>BI 575: Techniques in Cellular/Molecular Neurophysiology</td>
<td>BI 645: Cellular/Molecular Neurophysiology</td>
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<tr>
<td>BI 645: Cellular/Molecular Neurophysiology</td>
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</tbody>
</table>
QBP fellows must select at least one course from 3 of the first 4 columns. This ensures that every fellow 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 fellows must then select a course from column 5 covering measurement techniques. This requirement ensures that every fellow is exposed to experimental methods at some level. Satisfying these selections results in six courses. Fellows then must take two additional electives.

**Satisfying the Requirements for the PhD in BME** – As QBP fellows 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 lab rotations. The rotations must 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 Rotation Areas**

<table>
<thead>
<tr>
<th>Molecular/Genetic Labs</th>
<th>Cellular/Tissue Labs</th>
<th>Tissue/Organ Labs</th>
<th>Integrative/Sensory Labs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dennis, Allison</td>
<td>Bigio, Irving</td>
<td>Bigio, Irving</td>
<td>Bigio, Irving</td>
</tr>
<tr>
<td>Erramilli, Shyam</td>
<td>Chen, Christopher</td>
<td>Chen, Christopher</td>
<td>Colburn, Steve</td>
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<td>Goldberg, Bennett</td>
<td>Colburn, Steve</td>
<td>Colburn, Steve</td>
<td>Damiano, Ed</td>
</tr>
<tr>
<td>Grinstaff, Mark</td>
<td>Damiano, Ed</td>
<td>Damiano, Ed</td>
<td>Eichenbaum, Howard</td>
</tr>
<tr>
<td>Khalil, Ahmad</td>
<td>Eichenbaum, Howard</td>
<td>Grinstaff, Mark</td>
<td>Han, Xue</td>
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<tr>
<td>Meller, Amit</td>
<td>Grinstaff, Mark</td>
<td>Han, Xue</td>
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<tr>
<td>Ngo, John</td>
<td>Khalil, Ahmad</td>
<td>Klapperich, Catherine</td>
<td>Lutchen, Kenneth</td>
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<tr>
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<td>Klapperich, Catherine</td>
<td>Lutchen, Kenneth</td>
<td>Ngo, John</td>
</tr>
<tr>
<td>Steffen, Martin</td>
<td>Meller, Amit</td>
<td>Mertz, Jerome</td>
<td>Ritt, Jason</td>
</tr>
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<td>Unlu, Selim</td>
<td>Mertz, Jerome</td>
<td>Morgan, Elise</td>
<td>Sen, Kamal</td>
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<tr>
<td>Wong, Wilson</td>
<td>Morgan, Elise</td>
<td>Nugent, Matthew</td>
<td>Stamenovic, Dimitrije</td>
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<tr>
<td>Zaman, Muhammad</td>
<td>Nugent, Matthew</td>
<td>Ritt, Jason</td>
<td>Stepp, Cara</td>
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<td></td>
<td>Smith, Michael</td>
<td>Sen, Kamal</td>
<td>Suki, Bela</td>
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<tr>
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<td>Smith, Michael</td>
<td>Vaina, Lucia</td>
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<tr>
<td>Steffen, Martin</td>
<td>Stamenovic, Dimitrije</td>
<td>White, John</td>
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<td>Suki, Bela</td>
<td>Stepp, Cara</td>
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<td>Tien, Joe</td>
<td>Suki, Bela</td>
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Please note that this table changes every year as new faculty members arrive. Please consult with the BME Associate Chair for Graduate Studies for any questions regarding laboratory selections.

**Program Cohesion, Retention, Enhancement and Information Flow** – The program cohesion and cultural components include: monthly journal club, invitation and active involvement in annual retreats and participation on our Annual Symposium in Quantitative Biology and Physiology run by and for QBP and TRB fellows. Each trainee beyond their third year in the BME program gives a talk at the symposium. There are also monthly dinners.

**Logistical Information**

**Previous PhD dissertations are available for review in ERB 401. Please do NOT remove these from the room!**

**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 Research Assistants. Christen Bailey will notifying incoming PhD students regarding their individual office assignments and provide a key.

**Computer Resource and Printing Facility** - The BME 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. 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 Christen Bailey and/or the Associate Chair for Graduate Studies.

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/.
# Staff Directory

## BME Graduate Programs Staff

<table>
<thead>
<tr>
<th>Name</th>
<th>Email</th>
</tr>
</thead>
<tbody>
<tr>
<td>Michael Smith</td>
<td><a href="mailto:msmith@bu.edu">msmith@bu.edu</a></td>
</tr>
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<td>Joe Tien</td>
<td><a href="mailto:jtiyen@bu.edu">jtiyen@bu.edu</a></td>
</tr>
<tr>
<td>Christen L. Bailey</td>
<td><a href="mailto:christen@bu.edu">christen@bu.edu</a></td>
</tr>
</tbody>
</table>

## BME Department Staff

<table>
<thead>
<tr>
<th>Name</th>
<th>Email</th>
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<tbody>
<tr>
<td>John White</td>
<td><a href="mailto:jwhite@bu.edu">jwhite@bu.edu</a></td>
</tr>
<tr>
<td>Matthew Barber</td>
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<tr>
<td>Mary-Ellen Palmer</td>
<td><a href="mailto:mepalmer@bu.edu">mepalmer@bu.edu</a></td>
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<tr>
<td>Irene Orzechowski</td>
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<td>Laura Prusaitis</td>
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</tr>
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</tr>
<tr>
<td>Brandon Poli</td>
<td><a href="mailto:pbrandon@bu.edu">pbrandon@bu.edu</a></td>
</tr>
</tbody>
</table>

## College of Engineering Staff

<table>
<thead>
<tr>
<th>Name</th>
<th>Email</th>
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</thead>
<tbody>
<tr>
<td>Kenneth Lutchen</td>
<td><a href="mailto:klutch@bu.edu">klutch@bu.edu</a></td>
</tr>
<tr>
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<td><a href="mailto:sre@bu.edu">sre@bu.edu</a></td>
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<tr>
<td>Catherine Klapperich</td>
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</tr>
<tr>
<td>Linda Hession</td>
<td><a href="mailto:hession@bu.edu">hession@bu.edu</a></td>
</tr>
<tr>
<td>Isabel Tereso</td>
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