Planning Graduate Study in the Department of Biomedical Engineering

Case School of Engineering and Case School of Medicine

Admissions information:
Please contact the BME Admissions Coordinator
bmedept@case.edu

Additional information:
Please visit the department website
bme.case.edu

Graduate Education information:
Please contact the Graduate Education Office
Wickenden 309
(216) 368-4094
bmedept@case.edu

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The Department of Biomedical Engineering at Case Western Reserve University offers Master of Science (MS) and Doctor of Philosophy (Ph.D.) degrees in several varieties, as illustrated in Figure 1. Students entering directly into the BME graduate program with a BS degree can choose to complete a standard “terminal” MS degree, obtain an MS degree on the way to completion of a Ph.D. degree, or directly enter the Ph.D. program. Students entering the BME graduate program with an MS degree can typically proceed directly toward a Ph.D. degree. Students already admitted to medical schools associated with Case can obtain a combined MD/MS degree. Students admitted to the MSTP program in the Case School of Medicine can pursue a combined MD/Ph.D. program. Although there are several versions of the MS and Ph.D. programs, all have the same fundamental requirements and the same high standards.

**Typical timelines and milestones for graduate program in BME**

A typical timeline (with semester-by-semester milestones) for completion of an MS training program is outlined in Figure 2. Note that students enter the program with a wide variety of backgrounds, so this table is provided only as an example.

<table>
<thead>
<tr>
<th>Semester</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semester 1</td>
<td>Discuss choice of courses with academic advisor. Typically register for 9 credit hours consisting of some combination of courses and research credits (EBME 601 or 651).</td>
</tr>
<tr>
<td>Semester 2</td>
<td>Register for some combination of courses and research credits. Submit final Program of Study to GEC.</td>
</tr>
<tr>
<td>Summer</td>
<td>Register for research credits (EBME 601 or 651) only if needed for Program of Study. Otherwise, register for RSCH 650 (MS level summer research) without cost while maintaining fulltime status.</td>
</tr>
<tr>
<td>Semester 3</td>
<td>Register for some combination of courses and research credits appropriate for your Program of Study.</td>
</tr>
<tr>
<td>Semester 4</td>
<td>Complete any remaining course or research requirements. Complete MS research.</td>
</tr>
<tr>
<td>Summer</td>
<td>Complete all MS work (EBME 601 or 651, or RSCH 650) or move on to Ph.D. program.</td>
</tr>
<tr>
<td>Defense</td>
<td>Submit and defend MS thesis or report.</td>
</tr>
</tbody>
</table>

**Figure 2:** Example timeline for completion of MS program.
A typical timeline (with semester-by-semester milestones) for a student entering with a BS degree in engineering to complete a PhD training program is outlined in Figure 3. Again, students enter the program with a wide variety of backgrounds, so this table is provided only as an example. Some students could move through this pathway on an accelerated schedule; rarely should a student move through it slower than shown here.

| Semester 1 | Discuss choice of courses with academic advisor. Typically register for 9 credit hours, consisting of some combination of courses, research credits, and seminar credits, including CBIO 453 (a BME core course) and EBME 570 (a course on professional development). Your advisor may suggest different courses directly relevant to your research and/or research credits. Also, register for departmental seminar EBME 611 (0.5 credit). You could also register for special topic seminar EBME 613, 615, 617, or 619 (0.5 credit). |
| Semester 2 | Register for some combination of courses and research credits. Typically, this semester would include the BME core courses EBME 401 and 402. Also, register for departmental seminar EBME 612 (0.5 credit). You could also register for special topic seminar EBME 614 or 616, 618 or 620 (0.5 credit). Submit preliminary Ph.D. Program of Study. **Submit final PhD Program of Study (POS) to advance to Ph.D. candidacy.** |
| PhD oral exam | It is possible to take the oral portion of the PhD qualifying exam after your second semester if all BME core courses (or equivalents) have been taken. This exam can also be taken one year later. |
| Summer | Register for RSCH 750, a no-cost registration that maintains fulltime status over the summer. |
| Semester 3 | Register for some combination of courses, research credits, and seminar credits. Include BME core courses as needed. |
| Semester 4 | Register for some combination of other courses in POS and research credits. Write and defend research proposal if you have passed the oral exam |
| PhD oral exam | If not taken previously, the oral portion of the PhD qualifying exam should be taken now. If taken previously but not passed, retake now. |
| Summer | Register for RSCH 750. |
| Semester 5 | Register for 9 credit hours in some combination of courses and research credits appropriate to complete your PhD Program of study. |
| Semester 6 | Register for 9 credit hours in some combination of courses and research credits appropriate to complete your PhD Program of study. |
| Summer | Register for appropriate research credits (EBME 701) if needed or RSCH 750 (preferably). **Write and defend Ph.D. proposal.** |
| Semester 7 until finished | Register for 9 credit hours each semester in some combination of courses and research credits until PhD Program of study is completed (at least 12 courses and 18 hours of EBME 701). Note that at least 1 credit hour of EBME 701 registration is required for ALL Fall and Spring semesters, starting from the first semester you register for EBME 701 until the semester in which you defend your Ph.D. |
| **Submit and defend Ph.D. dissertation. Congratulations!** |

**Figure 3:** Example timeline for completion of Ph.D. program.
Policies, Student Advising, and Review of Student Progress

Policies Regarding Graduate Study in BME at Case

M.S. and Ph.D. students should be familiar with requirements and guidelines of the university, the School of Graduate Studies, and the Department of Biomedical Engineering. Many, but not all, of these requirements are described in this document. There are several other useful documents and websites that describe the opportunities and requirements associated with graduate study at Case:

- The “General Bulletin” of the university (currently found at http://bulletin.case.edu/pdf/2012-2013/all-2012-2013.pdf) provides a comprehensive description of university and Case School of Engineering requirements.
- Policies of the School of Graduate studies, along with links to other relevant sites can be found at http://gradstudies.case.edu/new/policies.html.
- Links to a number of important forms can be found at http://gradstudies.case.edu/current/forms.html.
- The “Graduate Student Handbook” issued by the School of Graduate Studies is also a very useful reference that can be found at http://gradstudies.case.edu/webfm_send/100.

Advising

Each student will be assigned an academic advisor who has a primary appointment in the Department of Biomedical Engineering. The academic advisor serves as the primary source of information regarding BME requirements and procedures. In particular, students work with the academic advisor to plan a program of study (POS) that takes into account departmental and university requirements, as well as the student’s research needs and career goals. The academic advisor always serves as the chair of the Guidance Committee. Each student will also have a research advisor with whom they plan and conduct their research project. The research advisor is typically responsible for the financial support of Ph.D. students and some MS students. The academic advisor may also serve as the research advisor, or a student may have a research advisor with a primary appointment outside the BME department. All research advisors must have a Case appointment (regular, secondary or adjunct).

Review of Progress

The primary day-to-day responsibility for monitoring and guiding each student is held by the academic and research advisors. The academic advisor is the primary contact for issues regarding departmental requirements, while the research advisor takes primary responsibility for the research aspects of the student’s training. The student’s Guidance Committee provides feedback and advice on research-related aspects of the student’s program. Overall oversight of student progress is performed by the BME Graduate Education Committee (GEC), which must approve programs of study (both M.S. and Ph.D.) and supervise completion of other degree requirements. Students are expected to meet with the Guidance Committee each semester. Finally, the departmental faculty also reviews the progress of each graduate student once a year. Students who are failing to meet timelines or normal milestones will be contacted by the Chair of the BME department and required to communicate a plan that describes how and when milestones will get back on track.
How to submit material to the Graduate Education Committee

All correspondence with the Graduate Education Committee should be through the Graduate Education Office in Wickenden 310. Written materials pertaining to documentation of meeting departmental requirements should no longer be delivered to the Graduate Coordinator in Wickenden 310 or placed in the GEC mailbox in the main BME office in Wickenden 309. All documentation for the completion of a departmental requirement should now be submitted through the department's Blackboard site. To access the "BME Graduate Students" Community page, log into your Blackboard account. On the top, instead of selecting “Courses”, select “Community”. Then, on the left hand side, select “BME Graduate Students.”

ALL of the departmental requirements from graduation are listed as “Department Requirements”, and have hyperlinks for document submission, complete with required forms when needed.

Do not submit original documents to your advisor or to the GEC chair, SAVE ORIGINALS IN YOUR PERSONAL RECORDS. Points of clarification and simple questions should first be directed to the academic advisor, who can contact the GEC chair if necessary.
Paper-based and online programs of study

The School of Graduate Studies now requires graduate students to submit their programs of study into the Student Information System (SIS) that can be found at http://www.case.edu/erp/sis. This is a requirement of Graduate Studies and must be done in a timely manner to maintain good standing. Please note that this system is IN ADDITION to the paper-based system currently used by the BME department. **It is absolutely essential that all graduate students follow the instructions listed in this document for submitting programs of study to the BME department for consideration by the GEC. The BME department will not authorize graduation and may prevent registration if an acceptable program of study is not submitted in a timely manner.**

M.S. Programs

**General Requirements**

Twenty-seven (27) credit hours (cr. hrs.) are required for the M.S., but more may be required if remediation is needed. Each MS student must complete an MS Program of Study (see Appendix I) that lists the courses taken to fulfill the degree requirements. This Program of Study must be approved by the GEC. The specific courses taken in a standard MS program are largely left to the discretion of the student and their advisor, but should be appropriate for an MS program in BME. For students intending to continue for a Ph.D., the Ph.D. Program of Study will include the courses taken during the MS but is more structured. Students are thus advised to consider the Ph.D. course requirements when setting up the MS Program of Study.

Most courses in the MS Program of Study must be at the graduate level, i.e., with course numbers of 400 or higher. Students may receive credit for a maximum of three (3) credit hours for 300-level courses taken at Case. Undergraduate level courses from other institutions cannot be included in the Program of Study at Case. Official transfer of graduate courses from other institutions to Case is limited to six (6) semester credit hours for the M.S. For graduate-level courses taken at institutions other than Case, a number of requirements must be met for inclusion in your Program of Study. A petition with the following content should be prepared and submitted to the GEC:

1. A cover page that clearly summarizes what is being requested and what supporting documents are included. If a revised petition is being submitted, clearly describe what issues were raised by the GEC in the original petition and how the revised petition addresses these issues.

2. Proof that the courses taken at another institution were at a graduate level. Only graduate courses from other institutions can be applied towards the M.S. Program of Study. This means that the courses were approved for graduate study at the other institution.

3. Proof that the courses taken at another institution were above and beyond the courses required to graduate with a B.S. degree. This means that all B.S. requirements, including technical elective requirements, were still fulfilled even if these courses were removed from your transcript.

4. A detailed course syllabus that indicates the textbook used (if any) and that includes the number of lectures, the title of all lectures, and the manner in which the course grade was determined.

5. An official transcript from the other institution that lists a letter grade for the course.
Description of MS Programs

The Case BME department offers several different programs leading to a Master of Science degree in BME. Each of these programs will be described in more detail below.

Standard MS Program

Master of Science – Thesis Option
18 hrs of course work + 9 hrs of EBME651
Or
21 hrs of course work + 6 hrs of EBME651
Requirement for completion: 27 hrs and thesis defense
http://bulletin.case.edu/schoolofgraduatestudies/academicrequirements/

Master of Science – Non-Thesis Option
27 hrs of course work (course only option) – available for distance learning students
Or
24 hrs of course work and 3 hrs of EBME601 (project option)
Requirement for completion: 27 hrs and comprehensive examination
http://engineering.case.edu/current-students/academic-programs/ms

The choice between thesis and non-thesis option should be made by the student after consultation with their academic and research advisors. The theses are typically hypothesis driven and research oriented, while the projects are typically more technical or technique-oriented.

BS-MS Program

The BS/MS program is designed to allow highly qualified undergraduate students from the Case BME program to integrate B.S. courses and project work with M.S. courses and research. Nominally, the combined program can be completed in 5 years that includes 3 summers starting after the junior year. The BS/MS program can reduce the time required to receive an MS degree because up to three courses taken during the undergraduate program at Case can be “double counted” towards M.S. requirements and because a research project can begin before the completion of the B.S. degree.

Admission to the B.S./M.S. program is typically open to BME juniors from Case with a grade point average of 3.2 or higher. Students with slightly lower GPA but with significant research experience and a strong faculty champion can petition the GEC for admission. To be most effective, applications to the BS/MS program should be submitted before the end of Spring semester in the junior year. The final deadline for BS/MS admissions is August 1 before the senior year. This will enable the GEC sufficient time to review the application and allow students to make any required changes to their POS for fall semester.

In general the following steps should be taken to apply to the BS/MS program:
A. See Advisor to discuss interests (typically in junior year or earlier).
B. See Dean Anderson the Undergraduate office to discuss intentions.
C. Complete a School of Graduate Studies application and submit to the Graduate Studies office for the program of interest (BME).
D. Complete a planned Program of Study form (must be signed by student, Faculty Advisor, Department Chair, and Dean of Undergraduate Studies). (see Appendix for BS/MS PPOS form).
Additional information for BME students:

1. An eligible BME faculty member (primary or secondary) must agree to serve as the M.S. research advisor and a primary BME faculty member (who might be the same person as the research advisor) must agree to be the academic advisor. **Obtaining this agreement is the responsibility of the applying student.** The BS/MS application must include letters of recommendation from both the research and academic advisor that states that they agree to serve in these roles and that they support the BS/MS application.

2. The BME department does not guarantee financial support during the MS portion of this program. However, the GEC requires students and potential research advisors to discuss and agree to some financial arrangement. **The letter of recommendation from the proposed research advisor must therefore indicate that the issue of financial support has been discussed and that some arrangement has been agreed upon. The details of this arrangement do not need to be included in the letter.**

3. Complete a standard application to the School of Graduate Studies via the online application system.

4. Complete the BS/MS Planned Program of Study (PPOS) form (in Appendix VI or from the BME website bme.case.edu). Make sure to check the “BS/MS” box and to indicate which courses are to be double-counted (by checking the “double count” box next to the relevant courses on the POS).

5. Obtain an approval signature from the School of Undergraduate Studies on the proposed POS prior to submitting the package (below) to the department.

6. Prepare the application package that includes the following:
   - A current transcript
   - The proposed M.S. Program of Study. Make sure that the Program of Study specifies both the academic and research advisors and includes both of their signatures. This form also needs to indicate the courses that are intended to be “double counted”.
     - Only graduate-level courses (400 or higher) can be double counted. This typically means that students should register for 400 level courses to satisfy undergraduate technical electives.
     - It is possible to “double count” three credit hours of EBME 398. To do this, three credit hours of EBME 651 (Thesis Option) or EBME 601 (Non-Thesis Option) should replace EBME 398 in the fall or spring of the senior year. You should register for EBME 651 or EBME 601 (but NOT EMBE 398). However, you must attend the meetings of EBME 398 and also fulfill all of the course requirements for EBME 398.
     - A maximum of nine (9) credit hrs can be double counted. Typically, these are two 3-credit courses (400 level or high) + 3 credits of EBME 651 or EBME 601 (in place of EBME 398).
   - Three (3) reference reports (in sealed envelopes), including letters from your proposed academic and research advisor(s).

7. Submit the proposed POS, transcript, and letters of recommendation to the BME Graduate Coordinator.

No admission decision will be made until the POS is approved by the GEC. After a positive recommendation by the GEC, a letter of conditional admission will be sent. The condition for admission is the submission of GRE scores within 2 months of the completing the B.S.
requirements. The student cannot graduate from the B.S./M.S. program without official GRE scores. This is a BME requirement and not a CSE requirement. Note that it is strongly recommended that students plan to take the GRE exam in the Fall semester of their senior year to be eligible for pre-doctoral fellowships from the National Science Foundation or other sources.

BS-MS Thesis Option
18-hrs of course work and 9-hrs of EBME651
Requirement for completion: 27 hours and thesis defense
http://bulletin.case.edu/schoolofgraduates/studies/academicrequirements/
Students can double count 3 courses (must be at the graduate level)

BS-MS Non-Thesis Options
1. BS-MS Course Only Option
   27-hrs of course work
   Requirement for Completion: 27hrs and comprehensive examination
   Students can double-count 3 courses (must be at the graduate level)

2. BS-MS Project Option
   24-hrs of course work and 3-hrs of EBME601
   Students Can double-count 3 courses (must be at the graduate level)

3. BS-MS Practice Oriented Option
   18 hrs in engineering (5 courses and a capstone projects)
   EPOM 400: Engineering Professionalism
   EPOM 401: Introduction to Business for Engineers
   EPOM 403: Product and Process Design
   EPOM 405: Applied Engineering Statistics (can be double-counted )
   EPOM 407: Engineering Economics and Financial Analysis
   EPOM 409: Master of Engineering Capstone Project
   9 hrs (3 BME technical Courses)
   Graduation requirement: 27 hrs and a comprehensive examination
   Students can double-count 3 courses (only one at the undergraduate level)

MD/MS Program
The MD/MS program is available to qualified medical students from the Case School of Medicine and the Cleveland Clinic Lerner College of Medicine of Case Western Reserve University. Students in this program receive some credit for their medical school studies in completing the MS degree. There are specific admission requirements.

The MD/MS degree is open to Case School of Medicine students in the Cleveland Clinic Lerner College of Medicine (CCLCM) or the University Program (UP), which will award the MD component of the dual degree. An undergraduate degree in engineering is desirable for students entering this program, but other students with an adequate undergraduate preparation (calculus with differential equations, physics, chemistry, and electronic circuits) will be considered. Additional undergraduate courses in instrumentation and signals/systems would be helpful. Students with an insufficient background will be admitted conditionally until they take the remedial undergraduate courses. Remedial courses will not count toward the MS requirements.

Interested students should submit their applications through the BME department, as the department taking responsibility for program management. Students will normally apply to the
program during their first year of medical school. Students should submit their medical school application instead of a separate graduate school application, including MCAT scores instead of GRE scores. The application should include a letter specifying the intended track, the department/major field designation, and a statement of purpose for seeking the combined degree.

The MS requirements are the same as the rest of the Case School of Engineering Thesis Option MS degree, i.e., 27 credit hours including nine hours of thesis registration (EBME 651). **Please note that only Thesis Option is available to MS/MD students.** Students must complete the normal MD requirements in either the UP or CCLCM program. Portions of the medical school curriculum earn graded credit toward the MS portion of this degree. Specifically, students in the University Program register for Integrated Biological Science courses (IBIS 401-405), as in the MD/PhD program. Students in the CCLCM Program enroll in the 6-credit IBIS 434 Process of Discovery course in the second year of the CCLCM curriculum. Six credit hours of these medical school courses are applied to the MS component of the dual degree. **The balance of required formal courses (12 hours or 4 courses) must be graduate level engineering concentration courses** that provide rigor and depth in a field of engineering relevant to the area of research. All courses must be listed on the BME Program of Study, which must be submitted and formally approved by the BME Graduate Education Committee and subsequently transmitted to the School of Graduate Studies. The Program of Study must be approved prior to registration for the second engineering course. Students must earn a minimum of a B grade in each graduate engineering course, and have a minimum overall GPA of 3.25.

**Summary of the requirements**

6 hrs Life science courses (medical school curriculum)
12 hrs (4 courses) in biomedical engineering
9 hrs of thesis research (EBME 651)
Graduation requirement: 27 hrs, Thesis defense

http://bme.cwru.edu/Graduate/CurrentStudents

For more detailed information on this program, please see [http://casemed.case.edu/admissions/education/dual_programs.cfm?program_id=11](http://casemed.case.edu/admissions/education/dual_programs.cfm?program_id=11).

**MSc Translational Health Technology**

This Masters degree in Biomedical Engineering is designed to develop expertise in translating biomedical ideas into clinical implementation. This degree can be completed in one year for full time students. It is offered by the Biomedical Engineering department at CWRU, and takes advantage of the large pool of expertise in Biotechnology on the campus of CWRU. It combines aspects of **bioengineering, marketing, entrepreneurship, bioregulatory affairs**, with **ethics** and **experimental design**. The program will require students to take a minimum of 27 credits including a design project.

**Prerequisite:** Biomedical Engineering Degree or equivalent or consent of program director

**Special Features:**
- Eight courses plus 4-hours of project
- Portions available through Distance Learning
- Flexible program to accommodate professionals schedule
- Lock-Step Program. Duration 1year: August to August
- Projects can be done within the place of work
**Other CSE Masters programs**

- **Master of Engineering program** is typically followed by professional engineers who are already employed in industry. This is a practice oriented degree, not a research oriented degree, so course work is emphasized and no thesis is required. Please see [http://www.engineering.case.edu/meng/](http://www.engineering.case.edu/meng/) for more information on this program. Please note that this program is not intended to be used by students ultimately seeking a Ph.D. degree.

- **Master of Engineering and Management (MEM)**. The BME department participates in the MEM program, but this is administered directly by the Case School of Engineering. The Master of Engineering and Management Degree program is designed to meet the needs of industry by offering young engineers the critical skills needed to be successful in an engineering career. Engineering and Business Management do not happen independently in industry. Rather, they are fully integrated into a 42 credit hour program that only takes three semesters to complete. Please see [http://www.mem.case.edu/index.html](http://www.mem.case.edu/index.html) for more information on this program.

**Logistics**

The admission requirements and expectations vary across these programs (see following sections that detail each program), but the following elements are common:

- All applications to these programs are reviewed by the GEC
- All MS students are required to complete at least four graduate-level engineering courses (i.e., 400 level or higher), as approved by their MS Guidance Committee and the GEC.

A preliminary Program of Study (see Appendix I) in Biomedical Engineering (BME) should be filed during the student’s first semester in an MS program. This insures that the student and advisor have devised a plan for the entire MS program. This preliminary POS requires the signature of the academic advisor only. By the end of the student’s second semester, they and their advisor should have assembled an M.S. Guidance Committee consisting of at least three members with Case faculty (including adjunct) appointments. The academic advisor chairs the Committee and must have a primary appointment in BME. A finalized MS POS that includes the signatures of all guidance committee members should be submitted during the second semester. The MS degree will not be conferred until the final program of study is signed by all guidance committee members and approved by the GEC.

**Graduation requirements**

Students should follow the procedures required by the School of Graduate Studies to apply for graduation, to format the hard-copy of the thesis, to submit an electronic thesis, and to supply the necessary forms following the final thesis defense. Part of this package is a set of cards that must be signed by the Guidance Committee and then by the BME department graduate associate chair or chair before submission to Graduate Studies. To obtain the signature of the BME department chair, students must complete the form entitled “BME Graduation Information Form” in Appendix III. Normally, these cards (and other documents) are reviewed by the department’s Academic Staff to ensure that all graduation requirements are met, prior to giving them to the chair.

Note that this must be done well in advance of the planned completion of the MS degree. Please visit [http://www.case.edu/provost/gradstudies/current/calendar.html](http://www.case.edu/provost/gradstudies/current/calendar.html) to determine the
deadlines for applying for graduation, completing your defense, and submitting all materials to Graduate Studies for the semester in which you would like to finish your degree and/or graduate.

Ph.D. Programs

The BME Ph.D. program at Case Western Reserve University can be followed by students in the traditional Ph.D. program or by students in the MSTP program in the Case School of Medicine. These programs are virtually identical, with the only difference being that MSTP students typically substitute physiology courses (IBIS 401, IBIS 402 and IBIS 403) from their medical school curriculum for one BME core course (CBIO 453, 4 cr. hrs), two biology courses in the categorical requirements (6 cr. hrs), and 6 cr hrs. in the breadth requirements.

Summary of Ph.D. requirements:

- Successfully complete GEC-approved Program of Study with a minimum GPA of 3.0 across all courses and a minimum grade of B in each of the BME core courses.
- Pass all of the requirements for Ph.D. Candidacy:
  - Have a GEC-approved Program of Study on file in the BME department and online in the SIS system.
  - Pass all components of the Ph.D. Qualification Process.
- Complete three TA assignments.
- Satisfy the BME Ph.D. residency requirement
- Satisfy the BME publication requirement
- Satisfy the BME presentation requirement
- Complete various administrative requirements:
  - Apply for graduation well in advance of intended defense date
  - Complete BME Graduation Information Form
  - Obtain required signatures from committee members following a successful final dissertation defense.

Tiered Stipend System (beginning Fall 2015)

- Once students have completed all course based classes (i.e. all but EBME 701 and seminar requirements), they are eligible for a stipend increase from $25,000 up to $27,500.
- In order to receive the raise, students must be on pace with all metrics / qualifying exams based on time in program (see below STIKE Policy).
- Additionally, students are only able to take a maximum of 2 credit hours per semester to not exceed the federal cap. (If needed, students can reduce salary at any time to take more credits.)
- Each student is also eligible for a Performance-Based raise when the stipulations above are met, and they have:
  - Published a first author paper and
  - Either published a second paper with any author standing or completed their oral conference presentation requirement for graduation.
- This raise comes with the same credit limit stipulations, and will increase the student’s stipend to $28,192.
STRIKE POLICY

In the Fall of 2013, the GEC and full faculty voted to institute a mandatory timeline to meet major departmental requirements beginning in Fall 2014. The policy pertains to completion of the Program of Study (full POS, negating the preliminary POS), completion of the oral qualifying exam, completion of the R21-style proposal defense, and completion of at least one committee meeting per year. Each requirement should be completed by the below defined timeline. Failure to complete the requirement by the pre-defined deadline results in an automatic “STRIKE” towards expulsion from the program (Three STRIKES AND YOU’RE OUT). When the first “STRIKE” is received, the students will receive official notice from the GEC of the “STRIKE.” At that time, each student will receive a new deadline (defined below per each requirement) of when the second “STRIKE” will be issued if that requirement is not completed. After the second “STRIKE” is issued, the student is allowed to discuss in person with the GEC why the requirements have not been met on time, and potentially given an extension to complete the task before the third and final “STRIKE” is issued. If over the course of a PhD, a student receives 3 “STRIKES” for failure to meet the initial and/or GEC-extended milestone for a given requirement, the student will be removed from the PhD track and placed on the Master’s degree track. Counting of “STRIKES” is done per requirement and not cumulative across all department requirements. The student AND PI can petition to the GEC and CHAIR to be re-admitted to the PhD program.

<table>
<thead>
<tr>
<th>Year</th>
<th>FALL</th>
<th>SPRING</th>
<th>SUMMER</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td>Typical time to complete ORAL</td>
</tr>
<tr>
<td>2</td>
<td>Committee meetings should begin (require a minimum of one per year)</td>
<td></td>
<td>Latest time to completing ORAL</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td>R21 PROPOSAL must be completed</td>
</tr>
</tbody>
</table>

Failure to complete the Full POS by the end of the first Spring term, will result in a two week extension for second “STRIKE”.

Failure to complete a thesis committee meeting by the end of the second Summer term, will result in a three month extension for second “STRIKE”. Beyond the first required meeting, failure to meet within a 12 month span will result in a “STRIKE” and in a three month extension for second “STRIKE”.

Failure to complete the R21-style Proposal exam by the end of the third Summer term, will result in a three month extension for second “STRIKE”.

Failure to complete the ORAL qualification exam by the end of the second Summer term, will result in a one year extension for second “STRIKE”.

13
Guidance and Examination Committees

Each student must have a Ph.D. Guidance Committee. Normally, the Guidance Committee will also serve as the Examination Committee for the Ph.D. research proposal and final dissertation defense. The Committee should meet formally with the student each semester. In order to fulfill this requirement, a simple majority of the committee members must be present. It is the student’s responsibility to arrange this meeting.

The Guidance Committee consists of four or more faculty members, all of whom must have Case appointments at a faculty level. Both the academic and research advisors are members of the examination committee. The research and academic advisor can be the same person if primary BME faculty. For students with a secondary BME member as a research advisor, the academic advisor must still be a primary BME faculty. As of October 2015, the role of Thesis Committee Chair has been added. The role of the Chair is to lead the formal committee meetings, and meet with the student “regularly” as their advocate. The chair can be the Academic advisor if different from the research advisor, but MUST NOT be the Research Advisor. Finally, the Thesis Committee Chair MUST be a primary BME faculty member. Two members must be BME primary faculty members and at least one member must be from outside the BME department (the external member). The external member of a student’s Ph.D. Guidance and Examination Committee must not have a primary appointment in BME, must have no involvement or immediate interest in the outcome of the student’s research project, and must not be a collaborator with the student’s research advisor on any project. For example, faculty members who are (or are likely to be) paper co-authors, who are co-investigators on the same project funding the student’s work, or who have other research collaborations with the student’s research advisor are not acceptable as external committee members. Faculty members with secondary or adjunct appointments in BME could qualify as external members if the above conditions are met. By signing official academic forms (e.g., POS, research pre-proposal, etc.), the academic advisor, the research advisor, and the external member verify that these conditions are met. Faculty with adjunct appointments at Case may serve as voting committee members. Graduate Studies does permit additional individuals without a Case appointment to serve as Guidance Committee members, but these members cannot vote on the final defense.

A student’s Guidance Committee may be changed if a Committee member can no longer participate or if different faculty expertise is needed. Any changes in the Guidance Committee should be requested by the student in a memo signed by the Academic Advisor and submitted to the GEC. The memo should include a list of the current Committee membership (as appears in the approved Program of Study), a list of the new Committee membership, and the reasons for the change. A revised Program of Study with the signatures of the new guidance committee must be submitted to the GEC.

Program of Study

The Ph.D. Program of Study (POS) is a listing of all courses that are taken by a given student in completing the Ph.D. requirements for the BME department. Specific guidelines for selecting appropriate courses are detailed below. In general, however, these courses should provide appropriate depth and breadth as the basis for current and future research in BME. The Ph.D. POS, prepared in consultation with the student’s academic and research advisors, must be approved by the Guidance Committee, the BME GEC, and the Associate Chair for Graduate Studies. The GEC meets approximately twice per month during the Fall and Spring semesters to review Programs of Study.

A preliminary Ph.D. Program of Study in Biomedical Engineering (BME) is no longer accepted, started June 1, 2015. A finalized Ph.D. program of study that includes the signatures
of all guidance committee members should be submitted before the end of the first spring semester in the program (see above). **It is essential that the final program of study is submitted well before the required number of courses is completed.** Otherwise, additional courses may be required by the GEC to compensate for weaknesses or irregularities in the submitted POS, resulting in additional time to complete the Ph.D. and, potentially, additional tuition costs. The Ph.D. degree will not be conferred until the final program of study is signed by all guidance committee members and approved by the GEC. **See Appendix II for detailed instructions on how to prepare and submit a Ph.D. Program of Study.**

In addition to the 12 cr. hrs of core courses, 24 cr. hrs or more approved courses are required for the Ph.D. A maximum of 3 credit hours at the 300 (undergraduate) level can be used to fulfill engineering concentration requirements, but only if these courses are taken at Case. **Note that undergraduate courses can never be used to fulfill the biomedical sciences or mathematical sciences requirements.** Undergraduate courses from other institutions cannot be included in the Ph.D. POS. Students entering the graduate program from a field other than biomedical engineering or from another university may be required to take more than the 24 cr. hrs minimum. Whether or not this is necessary will be determined by the Ph.D. Guidance Committee and the GEC.

The program of study of all BME Ph.D. students will satisfy ALL of the following requirements:

- A total of at least 5 courses for which the student receives a grade of C or better. Furthermore, a grade of B or higher in each of the core courses is a requirement for Ph.D. Qualification. Note that an overall GPA of at least 3.0 must be achieved to graduate.

- Categorical requirements: At least 5 courses (15 cr. hrs) are required in this category. A student can choose to take either three courses in the "Engineering" category, one in the "Biomedical Science" category, and one in the "Mathematical Science" category, or two courses in the "Engineering" category, two in the "Biomedical Science" category, and one in the "Mathematical Science" category. No double counting is allowed.
  - At least six (6) credit hours in engineering (including BME) that provide more depth for research should be included in the program of study. This requirement typically includes advanced courses in the student’s research area of interest, and may also include specifically approved mathematical or physical science courses. One of the engineering concentration courses could be Case 300-level course. Appendix V lists courses that have typically been used to fulfill the engineering concentration courses in different research areas.
  - At least three (3) credit hours of graduate-level courses in the “biomedical sciences” category are required. EBME 451 may be taken as a biomedical science course. Additional courses in this category could be other biomedical science courses, a biomedical scientific methodology course, a course related to translational research, a course on regulatory affairs, or other courses that clearly provide breadth in the broad area of biomedical research (see appendix for previously approved biomedical science courses). The overall Program of Study must clearly demonstrate adequate depth in an area of biomedical sciences relevant to their research area, demonstrated by including at least one biomedical sciences course that is beyond the introductory graduate level. For students enrolled in the MSTP program, courses in the medical school curriculum typically satisfy the entire biomedical science requirements. No 300-level Case course can
be used to satisfy the Biomedical Sciences requirement. Appendix V lists courses that have typically been approved to fulfill the Biomedical Sciences requirement.

- At least three (3) credit hours of **graduate-level** courses are required whose content is primarily mathematical. The mathematics in these courses must be at a higher level than undergraduate calculus and differential equations. No 300-level Case course (or any undergraduate course from another university) can be used to satisfy this requirement.

**Breath requirements:** Students are required to take at least 3 credit hours of additional courses to meet the Breadth requirements. These courses include the BME Departmental Seminar, the various topic seminars, EBME 570 (Professional Development), EMBE 440 (Translational Research), and IBMS 500 (On Being a Professional Scientist). Seminars count for one half (0.5) credits per semester, and students may apply a total of four credit hours (eight semesters) from a given seminar towards their POS. No more than 8 credit hours in the Breadth requirements may come from seminars. At least one full year of the BME Departmental Seminar and a topic seminar are required, although students are encouraged to continue attending these seminars over the course of their studies. All students are required to take EBME 570.

- Only one class at the 300 level will be accepted as one of the required didactic courses (and only as an engineering concentration course), and a grade of B or better must be achieved in this course for it to be included in the program of study. No classes below the 300 level can be used to satisfy any Ph.D. requirements.

In summary, the following courses or their equivalents must be included in the POS:

- CBIO 453 Cell Biology
- EBME 401 Tissue and Organ Systems Physiology
- EBME 402 Biomedical Transducers
- EBME 611/612 Departmental Seminars
- EBME 613-620 Topic Seminars
- EBME 570 Professional Development
- UNIV 400 Professional Development for Graduate TA's
- EBME 400T/500T/600T Graduate Teaching

**Ph.D. Thesis (research) credits**

A minimum of 18 credit hours of EBME 701 Ph.D. Thesis Research is required to complete the Ph.D. program. After the first registration for EBME 701, continuous registration of at least one credit hour of EBME 701 each semester must be maintained until completion of the Ph.D. degree. Also, please note that once EBME 701 registration begins, Ph.D. students have five consecutive calendar years from the semester of the first credited EBME 701 registration, including leaves of absence, to complete all requirements for the Ph.D.

**Courses Taken at Other Institutions to Fulfill Requirements of the Ph.D. Program of Study**

By Graduate Studies requirements, students must complete a minimum of 18 credit hours of courses at Case if they enter with an MS degree, meaning that up to 18 credit hours of graduate coursework can be applied towards Case BME requirements for a Ph.D. Therefore, official transfer of graduate-level courses from other institutions is limited to eighteen (18) credit hours.
for a Ph.D. Program, with or without an MS degree. However, official transfer of courses is **not** needed to fulfill requirements of the Ph.D. Program of Study and this is not the typical (or recommended) approach. More typically, the GEC will recognize approved graduate work at other universities and reduce your Case requirements accordingly. However, **THESE COURSES MUST BE APPROVED BY THE GEC.** For this purpose, only *graduate* courses taken from other universities can be approved by the GEC. To request incorporation of graduate-level courses from other institutions in the Ph.D. Program of Study, a petition with the following content should be prepared:

1. A cover page that clearly summarizes what is being requested and what supporting documents are included. *If a revised petition is being submitted, clearly describe what issues were raised by the GEC in the original petition and how the revised petition addresses these issues.*
2. Proof that the courses taken at another institution were at a graduate level. Only graduate courses from other institutions can be applied towards the Ph.D. Program of Study. This means that the courses were approved for graduate study at the other institution.
3. Proof that the courses taken at another institution were above and beyond the courses required to graduate with a B.S. degree. This means that all B.S. requirements, including technical elective requirements, were still fulfilled even if these courses were removed from your transcript.
4. A detailed course syllabus that indicates the textbook used (if any) and that includes the number of lectures, the title of all lectures, and the manner in which the course grade was determined. This information is needed for the GEC to appropriately review and approve the course(s).
5. An official transcript from the other institution that lists a letter grade for the course.
6. The course must be consistent with one or more of the course categories (i.e., Engineering Concentration, Biomedical Science, or Mathematical Science).

**Modifications to an Approved Program of Study**

An approved POS can be modified by a petition to the GEC that includes three items:

1. The previously approved POS that will be changed;
2. A revised POS reflecting the changes;
3. A cover memo that describes exactly what changes were made and why they were made. *If this memo is not included, the revised POS will be returned to you and not reviewed.*

The revised POS must have original signatures from all Guidance Committee members, as it will become the official POS once approved.

**Publication and Presentation Requirements**

**Publication requirement**

Ph.D. students are required to publish **ALL** scientific and scholarly results and discoveries resulting from their Ph.D. dissertation research. In fact, it is a requirement of the PhD degree that scholarly research and discovery, as well as communication of the results, be achieved successfully. The thesis is one element of this, as are publication of the results in peer-reviewed scientific journals. At minimum, a Ph.D. student must be the author of at least **THREE** manuscripts submitted for publication to a peer-reviewed journal, and at least **TWO** of these
manuscripts should have the students as the primary author. At the time of completion of the Ph.D., at least TWO manuscripts must be accepted and one must be submitted and, in the opinion of the Guidance Committee, deemed to be publishable. Only manuscripts accepted or submitted while attending Case and based on work completed at Case are acceptable. The application for Ph.D. graduation submitted to the BME chairman must have attached a list of manuscripts submitted, accepted, or published in peer-reviewed archival journals, signed by the academic and research advisor(s). The GEC believes it would be uncommon for a CWRU BME Ph.D. candidate to graduate with only the minimum requirement in publication.

Presentation requirement

The ability to give effective oral presentations that describe research findings and to engage in discussion with research peers and the general public are critical skills for pursuing a successful career as a Ph.D. in Biomedical Engineering. Technical presentations are different in important ways from other public speaking format, and these skills often do not come naturally to many students. As with many of the other aspects of a Ph.D. training program, these skills are best developed through practice. The BME department thus strongly encourages all Ph.D. students to seek out and take advantage of multiple opportunities for presenting their research in public forums. BME Ph.D. students typically have many opportunities to present their work in laboratory meetings, in larger meetings associated with broader research groups in the BME department and elsewhere in the Cleveland community, in their guidance committee meetings, and in their Ph.D. dissertation defense. These are all excellent venues for improving oral presentation skills that prepare our Ph.D. trainees for the ultimate objective of our Ph.D. Presentation Requirement, i.e., giving effective presentations at national and international conferences.

To ensure that all of our Ph.D. graduates obtain the presentation skills necessary for a successful future career, the BME department has instituted the following Presentation Requirement:

The Associate Chair for Graduate Programs in Biomedical Engineering will approve the graduation materials for a Ph.D. trainee when at least one of the following activities is completed and appropriately documented:

1. The Ph.D. trainee gives an oral presentation at a national or international meeting in front of an audience of peers. This is the recommended approach. Please note that the presentation of a poster, although a valuable experience, cannot be used to satisfy the Presentation Requirement. Also note that the BME department will provide each Ph.D. student with up to $250 per year to attend a national or international meeting, with the requirement that the student is a presenter at that meeting (either an oral presentation or a poster).

2. If an oral presentation at a national or international meeting cannot be arranged prior to the Ph.D. dissertation defense, the trainee must submit a petition to the GEC at least three months prior to the planned Ph.D. defense that describes an alternative approach for satisfying the spirit of the Ph.D. Presentation Requirement described in the opening paragraph of this section. This petition should include the following:

   • An explanation for why the student will not be able to give an oral presentation at a national or international meeting prior to their Ph.D. dissertation defense.

   • A description of an equivalent oral presentation experience that will be used as a substitute for a national or international conference presentation. Possible alternatives (other approaches will also be considered):
Presentation in a local forum that is similar to a national or international meeting in terms of being open and public, having a similar presentation format, having an audience with a critical mass of appropriate experts, and including the need to answer audience questions.

Presentation in a local forum that is NOT public but otherwise meets the requirements of a local public forum AND is attended by at least two Ph.D. guidance committee members who attest to its adequacy for fulfilling the Presentation Requirement.

Teaching requirement

The teaching assistant requirement of the Case School of Engineering (CSE) provides PhD students with the opportunity to develop teaching and communication skills that will be useful in a variety of future endeavors. Each PhD student in CSE is required to complete three teaching “experiences,” each involving a commitment of 5-10 hr/week for a semester course. Participants are commonly called “teaching assistants” or TA’s. Students must first register and participate in UNIV 400A, which provides a brief overview of the typical duties and responsibilities for teaching assistants. International students may be required to also participate in UNIV 400B (Professional Development for International Teaching Assistants) and UNIV 400C (International Teaching Assistant Communication Skills). Students should register for EBME 400T, 500T, or 600T (for their first, second, or third experiences, respectively) during the semester that a given teaching experience is scheduled.

Tasks performed by teaching assistants can be quite varied to match the level of experience and knowledge of the student, the student’s future career goals, as well as the needs of the course. Tasks can include grading, constructing homework and exam problems, overseeing laboratories, assisting students during office hours, leading tutorial and review sessions, and even 1-2 lectures.

The assignment of students to specific courses is done by the Faculty TA Organizer (FTO, Professor David Wilson), the Coordinator of Graduate Student Affairs (Ms. Carol Adrine), and the BME Curriculum Committee (a group of senior BME faculty). Well before the semester starts, students and faculty will receive emails specifying the matching process. Students and faculty are urged to respond in a timely fashion so as to streamline the match process. The department continues to try to determine an optimal method of matching students to courses. PhD students are required to TA in two large undergraduate courses. Students will typically not TA before passing the qualifier. Students will TA one or two courses per year. The FTO attempts to honor requests of faculty members for a particular TA. Hence, students are encouraged to dialog with faculty members responsible for classes that they want to TA.

Minimum requirements for a BME PhD student are:

- UNIV 400A Professional Development for Graduate Teaching Assistants (domestic students) or UNIV 400B Professional Development for Graduate Teaching Assistants (international students)
- Optionally international students will take UNIV 402 A, B, or C to hone language skills
- EBME 400T
- EBME 500T
- EBME 600T
Residency Requirement

At some point during their Ph.D. training period, all BME Ph.D. students must be engaged full-time in Ph.D. training activities (independent dissertation research and Ph.D. coursework) for two consecutive semesters. This activity must be primarily conducted on the CWRU campus or in a laboratory at a Case-affiliated institution (University Hospitals, MetroHealth Medical Center, Cleveland VA Medical Center, Cleveland Clinic). “Full-time” ideally means that a Ph.D. student focuses all professional activity on their Ph.D. training program during the two-semester residency period, although a limited amount of outside activity may be permitted. Concurrent employment will be considered on an individual basis by the Graduate Education Committee by petition. This petition should describe how the student will engage in part-time, non-Ph.D. employment and still receive an overall training experience that is equivalent to Ph.D. students who do not have other employment obligations.

Rationale. One of the primary objectives of the BME Ph.D. program is to train students to become independent researchers. The practical aspects of Ph.D. training are, in many respects, similar to an apprenticeship during which the student obtains significant knowledge by direct observation of and interaction with their research advisor and other researchers. Students learn experimental and analytical techniques, troubleshooting, and technical writing skills primarily through regular person interactions with their advisors and colleagues. These regular interactions build interpersonal and research teaming skills that are difficult to obtain in other ways.

In addition to these experiential aspects of PhD. training, independent Ph.D. researchers must learn to develop and defend the hypotheses that drive their work. This requires critical analyses of current knowledge, the ability to think beyond the state of the art, and the ability to convince the research community of the value and feasibility of new ideas. These intangible intellectual skills are best developed through practice, including regular debate and discussion with other researchers in the field and with researchers from other disciplines with different approaches and viewpoints.

The development and execution of a Ph.D. research project of sufficient depth and originality requires an extended period of concentrated, committed activity. The ability of the advisor and guidance committee to evaluate and improve the research skills of a Ph.D. student likewise requires regular, intensive interactions.

Ph.D. Qualification Process

The Ph.D. qualification process for Biomedical Engineering consists of three components:

1. Core competency. To demonstrate an understanding of core BME knowledge, potential Ph.D. students in the Department of Biomedical Engineering must achieve a minimum performance in the topics covered by the graduate BME core curriculum. Specifically, each student must achieve a minimum grade of B in each individual core course.

Students who do not reach this level of performance after their first time through one or more of the courses will be given one additional opportunity to prove their competency by retaking (officially or unofficially) the course or courses for which they did not receive a grade of B or higher. At the discretion of the relevant core course instructor(s), the student can unofficially audit the course, complete all assignments and exams, and receive an (unofficial)
grade that will be used to determine competency. Alternatively, students can officially retake the course and their grade for this course will be used to determine competency. Students who are not able to meet the core competency performance levels after two attempts will not be permitted to continue in the Ph.D. program.

Competency for students who are excused by the GEC from taking one or more of the core courses will be determined in a manner similar to that described above, except using the final grades from others courses that act as proxies for the core courses that have been waived. Specifically:

- The GEC may waive the requirement to take one or more of the core courses for Ph.D.-bound students with significant previous background in one or more of the topics of the core courses. In this case, a graduate-level course with advanced material related to the topics of the core course that was waived can be substituted for the purposes of Ph.D. qualification. Any such substitute courses must be approved by the GEC prior to taking the course.

- MSTP students are not required to take CBIO 453 in the BME graduate core curriculum, so the grades from IBIS 401, IBIS 402 and IBIS 403 will be used along with the grades from the non-physiology core course (or for substitutes for these courses as described above) for the purposes of Ph.D. qualification.

- If a student receives a grade lower than B for any of these proxy courses, the student will either have to (1) retake the course as described above and receive a grade of B or higher or (2) take the core course that was initially waived and receive a grade of B or higher.

2. Knowledge integration and problem solving - the Oral Qualifying Exam. Potential Ph.D. students must also demonstrate the ability to integrate fundamental BME knowledge across the various topics represented by the graduate core courses, and to apply measurement principles and analysis techniques to solve biomedical engineering problems. This ability will be demonstrated during a one-hour oral exam administered by a committee of faculty representing all of the research areas of the BME department. Students who have successfully passed the “core competency” (part 1) requirement are eligible to participate in this oral exam. The oral exams are scheduled during the period between the end of classes in the Spring semester and the start of classes in the Fall semester. Students are given two opportunities to pass this oral exam. If the student is unable to pass the oral exam in their first attempt, they must submit a remediation plan to the GEC for review and approval that describes the actions they will take to improve their performance in the following year’s oral exam. The remediation plan must be submitted to the GEC within two months of failing the exam. If they do not pass after two opportunities, they will not be permitted to continue in the Ph.D. program.

**Effective Beginning Summer 2015**

- All faculty members that serve on the examination committee will now discuss sensitivity to the possibility of unintentional bias prior to the administration of the exam.

- Before the examination committee releases the results of the exam to the students, the results will be released in person to the faculty. This will happen within two weeks of the final exam being administered, to ensure that the students that take the exam are notified as quickly as possible.

- All questions about the exam should be brought to the Chair of the Committee or the Chair of the Department.
3. **Research competency - Research Proposal and Defense.** The final step in the Ph.D. qualification process is the composition and oral defense of a research proposal in the form of an NIH R21 application.


As described by the NIH website, the R21 mechanism “is intended to encourage exploratory/developmental research by providing support for the early and conceptual stages of project development”. A short, concise proposal written according to this funding mechanism is thus appropriate for a student in the formative stages of his or her research project to acquire the skills for conceiving and writing a research proposal. The research proposal can be hypothesis-driven or design-driven. It should include abstract, narrative, specific aims, research strategy and references. The intent for the written proposal and associated oral presentation and defense is to evaluate the ability of the student to formulate a research problem, to state hypotheses or outline design objectives, to propose a research plan using feasible design, experiment and analysis techniques to either test those hypotheses or achieve the design objectives, and to interpret data. While this proposal will often represent the research ultimately pursued by the student, it is recognized that the details of the proposal and even its goals may evolve significantly over time. Students who have written fellowship proposals are encouraged to use the same concepts in this research proposal, but they should convert the material into the NIH R21 format and should include all of the required components.

It is expected that the preparation of the written proposal will be a mentored activity with the research advisor, while the oral presentation and defense will specifically test the understanding and research capabilities of the student. The oral presentation and defense will be administered by the student’s guidance committee. A GEC representative will participate in the proposal defense. The student should contact the GEC chair **ahead of time** to inform the GEC about the upcoming proposal defense. The GEC member, designated by the GEC chair, should be included when scheduling the proposal defense. The role of the GEC member on the proposal examination is to serve as an unbiased third party and to ensure that the proposal exam requirements are met and the proposed research contains both engineering and life sciences content. The scientific content should be resolved by the committee ahead of time. The GEC representative will write a report to GEC on the student’s performance. This report will specifically include a statement on whether the engineering and life sciences components are fulfilled. In addition to testing the specific information contained in the written proposal, the augmented guidance committee will also test fundamental knowledge within the specific research field of the student. If a student is judged to have not passed this exam, the committee will provide a detailed written critique and the student is expected to defend a revised proposal within 4 months. If the student cannot pass the oral exam associated with this first revised proposal, they will not be permitted to continue in the Ph.D. program.

Students will be eligible to defend their research proposal after they have successfully completed the “core competency” (part 1) and “oral exam” (part 2) components of the Ph.D. qualification process.

*NOTE, a minimum of FOUR voting committee member, and the GEC representative MUST PARTICIPATE (in the room or call in) for an R21 defense to be valid (added October 2015).*

**Appeals**

As noted above, students will be allowed to take each of the three parts of the exam twice. **Students who fail any section of the PhD qualification requirements after both of these**
tries will not be allowed to continue in the PhD portion of the BME graduate program. With this consequence in mind, students and their faculty advisors should design and implement appropriate remediation plans so that the student is confident of their ability to pass the failed section at the second attempt. Remediation is automatic in the “Core competency” component – the student retakes the course(s) for which a grade of B or higher was not achieved. Remediation for the “Research competency” component is also clear – the student will be provided with a critique of their proposal and their oral defense of that proposal and given 4 months to revise and improve the proposal and their ability to defend it. Remediation for the “Knowledge integration and problem solving” component is at the discretion of the student and their faculty advisor, but students are required to submit a formal remediation plan for review and approval by the GEC that acknowledges that the student has only one more opportunity to pass the oral exam.

In very rare, special circumstances an appeal will be allowed, to be reviewed by the entire BME Primary Faculty. In such an appeal, the facts of the student will be presented by a representative of the GEC, and the student’s academic advisor will be given a chance to justify the basis for the appeal. Such an appeal will only be granted after a 3/4 majority vote of the entire BME Primary Faculty. Note that any appeal must be made within 3 months of the notification of failure to the individual requirement.

Transition to new PhD qualification requirements

Students admitted to the BME graduate program after the approval of this document (February 2010) will be obligated to fulfill the new requirements described above.

Students already in the BME graduate program as of February 2010 will be given the option of continuing with the old requirements or adopting the new requirements, but they must adopt one of the two sets of rules in their entirety. That is, a student who received a B in a particular core course but did not pass the written qualifier for that class could adopt the new rules and not have to retake the written qualifier for that class. However, they would have to adopt the new grade-based approach for ALL core courses, and they would have to complete the oral exam and new proposal exam requirements as well.

Ph.D. Candidacy

A student is advanced to Ph.D. candidacy when:
1. The Ph.D. Program of Study is signed by all members of the Guidance Committee and is then approved by the GEC.
2. The PhD candidacy form (with the necessary signatures) is approved by the Dean of Graduate Studies.

The Graduation Process

Graduate Studies requirements

Students should follow the procedures required by the School of Graduate Studies to apply for graduation, to format the hard-copy of the thesis, to submit an electronic thesis, and to supply the necessary forms following the final thesis defense. Please refer to the Graduate Student Handbook from the School of Graduate Studies (http://gradstudies.case.edu/) for information on the scheduling and paperwork associated with the final dissertation defense and graduation. Note that this must be done well in advance of the planned completion of the degree. Please consult the School of Graduate Studies regarding the deadlines for applying for
graduation, completing your defense, and submitting all materials to Graduate Studies for the semester in which you would like to finish your degree and/or graduate.

*Please note that BME Graduation Information Form (see Appendix III) must be completed before the BME chair will sign the final authorization for graduation.*

**BME department requirements**

The BME Ph.D. requirements listed above are restated here:

- Successfully complete GEC-approved Program of Study with a minimum GPA of 3.0 across all courses and a minimum grade of B in each of the BME core courses.
- Pass all of the requirements for Ph.D. candidacy
- Complete three TA assignments
- Satisfy the BME Ph.D. residency requirement
- Satisfy the BME publication requirement
- Satisfy the BME presentation requirement
- Complete various administrative requirements:
  - Apply for graduation well in advance of intended defense date
  - Complete BME Graduation Information Form; the signature of the BME chair authorizing your graduation will not occur if this form is not completed.
  - Obtain required signatures from committee members following a successful final dissertation defense.
Appendices - BME Graduate Program Forms and Information

Appendix I: M.S. Program of Study
Appendix II: Ph.D. Program of Study (revised October 2015)
Appendix III: BME Graduation Information Form
Appendix IV: Additional Graduate Studies Forms
Appendix V: Examples of courses previously approved by the GEC
   1. Biomedical
   2. Mathematical Sciences
   3. Research Ethics
   4. Engineering by Research Discipline
   5. 50/50 Engineering and Biomedical Sciences
   6. Double Count as Mathematical Sciences and Engineering
   7. “Breadth” courses
Appendix VI: Blackboard form for Committee Meetings or Research Proposal Defense (new Spring 2015)
APPENDIX I: INSTRUCTIONS AND FORMS FOR M.S. PROGRAM OF STUDY

1) Check the appropriate box in the top left-hand side of the page to indicate if this is a new or a revised Program of Study.

2) Fill in your name and the current date.

3) List chronologically **ONLY** those courses necessary for the M.S., including EBME 651 or 601, and BME seminars (EBME 611 and 612).

4) Do not include courses that are unique to the Ph.D. requirements such as Ethics, EBME 400T/500T, 600T, etc.

5) Graduate courses not taken at Case that apply to the M.S. should be listed and accompanied by the documentation described under “M.S. Programs” in the GEC Handbook.

6) After the Program of Study is signed by all members of the Guidance Committee, it must be submitted to the BME Graduate Education Committee mailbox located in Wickenden 319. Do not leave your program of study with your advisor, a member of your Guidance Committee, or a GEC member!

7) If the GEC does not approve your Program of Study, you will receive appropriate instructions for how to revise it. **When submitting a revised program of study, always include a cover page that lists the changes requested by the GEC and includes a point-by-point explanation of exactly what was changed in the POS to implement these changes.**

8) Upon approval by the Graduate Education Committee, the Program of Study is forwarded to the School of Graduate Studies
CASE WESTERN RESERVE UNIVERSITY
Department of Biomedical Engineering, School of Engineering
M.S. Program of Study

Name: ___________________________ Date: _________________

Last          First          Middle

Please check one:  ☐ Thesis Option  ☐ Non-Thesis Option  ☐ B.S./M.S  ☐ M.D./M.S.

<table>
<thead>
<tr>
<th>Semester</th>
<th>Year</th>
<th>Course (number and title)</th>
<th>Credit</th>
<th>Grade</th>
<th>Double Count (BS/MS Only)</th>
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</thead>
<tbody>
<tr>
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</tbody>
</table>

Academic Advisor:

Name (Typed) __________________________ Signature __________________________ Date _________________

Research Advisor: (Must be a Case faculty member)

Name (Typed) __________________________ Signature __________________________ Date _________________

Other Guidance Committee Members (not needed for Preliminary POS): (Indicate institution if not Case. Note that non-Case Faculty members can participate but cannot vote.)

Name (Typed) __________________________ Signature __________________________ Date _________________

Name (Typed) __________________________ Signature __________________________ Date _________________

Name (Typed) __________________________ Signature __________________________ Date _________________

Approved: __________________________ __________________________

Associate Chair of Graduate Programs Dean

Date: ________________ ________________
APPENDIX II: INSTRUCTIONS AND FORMS FOR Ph.D. PROGRAM OF STUDY

Page 1

After the Program of Study forms are all completed, obtain the approval (via signatures) of your academic advisor, your research advisor, and all other Guidance Committee members. Check the appropriate box in the top left-hand side of the page to indicate if this is a preliminary, new, or a revised Program of Study. **Note:** Your final Program of Study must include the signatures of your Guidance Committee. If revisions were required, the Guidance Committee must sign a new form indicating that they have seen and agree to the new Program of Study.

Page 2

List chronologically only courses taken or to be taken at Case for graduate credit beyond the B.S. degree. Do not include Masters Thesis (EBME 651) or Masters Project (EBME 601). Note that the various 0 credit hour courses that must be completed by all students are listed at the bottom of this list. For courses that have been completed, include the grade that you received.

Page 3 (Only form needed for Preliminary POS)

1) List all courses taken at all schools, including Case, to fulfill the Ph.D. course requirements and check the appropriate categories. Do not include any M.S. or Ph.D. research credits. **Do not** include EBME 400T/500T/600T on this page.

2) To request the incorporation of graduate-level courses from other institutions to satisfy requirements of the Ph.D. Program of Study, a petition to the GEC should be submitted along with the POS. This petition should include a cover page that clearly summarizes what is being requested and what supporting documents are included. If a revised petition is being submitted, clearly describe what issues were raised by the GEC in the original petition and how the revised petition addressed these issues. The petition should also include all of the documentation described in the GEC Handbook under “Courses Taken at Other Institutions to Fulfill Requirements of the Ph.D. Program of Study”. The courses to be used from other institutions must be consistent with one or more of the course categories (Engineering Concentration, Biomedical Science, or Mathematical Science).

Pages 4

Students must include short descriptions of how the proposed Program of Study satisfies the **spirit** of the Engineering Concentration requirement, the Biomedical Sciences requirement, and the Mathematical Sciences requirement. Many courses contain engineering, biomedical sciences, and mathematical content in varying amounts, making it difficult in some cases for the GEC to assess your training in each of these categories across your entire Program of Study. These descriptions are your opportunity to explain your choices to the GEC, reducing the number of revisions required to achieve a final approved POS while maintaining maximum flexibility.

1) Provide a written explanation (1/2 page recommended) of how the proposed POS satisfies the **spirit** of the Engineering Concentration requirement to provide depth and expertise appropriate for the student’s research area. In some cases, this explanation may include a description of how two mixed-material courses were combined to count as one Engineering Concentration course. In all cases, the explanation must be logical for the BME graduate program requirements and for your research area in particular.
2) Provide a written explanation (1/2 page recommended) of how the proposed POS satisfies the spirit of the Biomedical Science requirement to provide appropriate experience in basic science disciplines relevant to BME. Furthermore, some students may fulfill the Biomedical Sciences requirement in non-standard ways, e.g., the medical school curriculum. Again, it is possible to compile a single course credit from portions of several different courses, but this must be logical for the BME graduate program requirements and for your research area in particular.

3) Provide a written explanation (1/2 page recommended) of how the proposed POS satisfies the spirit of the Mathematical Science requirement to provide additional breadth in mathematics relevant to BME. Just because a course uses mathematical concepts and tools extensively does not mean that it will satisfy the Mathematical Sciences requirement. The course must contain new and/or advanced mathematical tools beyond those included in an undergraduate BME curriculum. Again, it is possible to compile a single course credit from portions of several different courses, but this must be logical for the BME graduate program requirements and for your research area in particular.

**Approval Process:**
1) Submit the POS only to the Biomedical Engineering Graduate Coordinator for review. The GEC mailbox is located in Room 309, Wickenden Building.

2) If the GEC does not approve your Program of Study, you will receive appropriate instructions for how to revise it. **When submitting a revised program of study, always include a cover page that lists the changes requested by the GEC and includes a point-by-point explanation of exactly what was changed in the POS to implement these changes.**

3) Upon approval by the GEC, your program of study will be submitted to the BME Associate Chair for Graduate Programs for approval.

4) After departmental approval, the BME Department will forward your program of study to Graduate Studies for approval.
## CASE WESTERN RESERVE UNIVERSITY
Department of Biomedical Engineering, School of Engineering

Ph.D. PROGRAM OF STUDY: GUIDANCE COMMITTEE

<table>
<thead>
<tr>
<th>Name:</th>
<th>Date:</th>
</tr>
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<tbody>
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<td>Last</td>
<td>First</td>
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</table>

### CASE FACULTY/ ADJUNCT

<table>
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<th>Case BME Position</th>
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<tr>
<td>Academic Advisor¹:</td>
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<tr>
<td>Research Advisor²:</td>
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<td>External Member³:</td>
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<td>Other Members:</td>
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</tbody>
</table>

**Thesis Committee Chair¹, ⁴**

1. Must be primary BME faculty.
2. Must have primary or adjunct BME appointment.
3. Cannot be directly involved in the project or have ongoing collaborations with the student or advisors.
4. Cannot be Research Advisor.

### Non-Case Faculty (may participate but may not vote)

<table>
<thead>
<tr>
<th>NAME</th>
<th>INSTITUTION</th>
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</table>

Approved by:

_________________________  _______________________
Associate Chair of  
Graduate Programs  Dean

__________  _________
Date  Date
List only courses taken at Case, including at least 18 credit hours of EBME 701:

<table>
<thead>
<tr>
<th>Semester</th>
<th>Year</th>
<th>Course (number and title)</th>
<th>Credit</th>
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<td></td>
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<td>UNIV 400  Professional Dev. Of Grad. TA</td>
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<td>EBME 400T Graduate Teaching/Mentoring I</td>
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<td>EBME 500T Graduate Teaching/Mentoring II</td>
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<td></td>
<td>EBME 600T Graduate Teaching/Mentoring III</td>
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</tbody>
</table>
Ph.D. Program of Study: Supplementary Information

Name: ___________________________ Date: ___________________

Last     First     Middle

Department: ___________________________ Academic Advisor: ___________________________

B.S. in ___________________________ From ___________________________ Date Awarded: __________
M.S. in ___________________________ From ___________________________ Date Awarded: __________

Ph.D. Qualifying Exam Date (actual or expected): ___________________________
Ph.D. Proposal Exam Date (actual or expected): ___________________________
Residence Period of Ph.D. Thesis Research: ___________________________
Specialty area in BME: ___________________________

COURSES

<table>
<thead>
<tr>
<th>Category</th>
<th>Course</th>
<th>Hrs.</th>
<th>Course Title</th>
<th>Total Credits</th>
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<td>Core Courses (12 Hrs.)</td>
<td>CBIO 453</td>
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<td></td>
<td>EBME 401</td>
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<td>EBME 402</td>
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<tr>
<td>Categorical Requirements (15 Hrs. min)</td>
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<td>Engineering</td>
<td>Engineering</td>
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<tr>
<td>Engineering (6 Hrs. min)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Biomedical Science (3 Hrs. min)</td>
<td></td>
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<td></td>
<td>Biology</td>
</tr>
<tr>
<td>Math Science (3 Hrs.)</td>
<td></td>
<td></td>
<td></td>
<td>Math</td>
</tr>
<tr>
<td>Breadth Requirements (9 Hrs. max)</td>
<td>EBME 570</td>
<td>1</td>
<td>Graduate Professional Development for Biomedical Engineers</td>
<td></td>
</tr>
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</table>
Justification of POS Categorical Requirements

Name: ________________________________ Date: __________________

Last             First             Middle

Provide a written explanation of how the proposed Program of Study satisfies the spirit of the three main categories (Engineering Concentration, Biomedical Science, Mathematical Science) of courses in your Program of Study.

Engineering Concentration

Biomedical Science

Mathematical Science
Appendix III: BME Graduation Information Form

Please submit this form to the BME department chair when requesting signatures for graduation cards.

Name: _______________________________ Date: ________________

Last First Middle

Post-graduation contact information:

Address: __________________________________________________________________

City: ___________________ State: ____ Zip: ___________________

Telephone: __________________ FAX: ___________________________

E-mail address: __________________

Please list all publications and presentations, including their current status. Include expected publications and presentations that have not yet been submitted. Include additional sheets if needed.

Please list all patents, including expected and pending patents. Include additional sheets if needed.

Provide the full title of the dissertation or thesis:

Student signature: __________________________

Academic advisor (typed): _______________________

Academic advisor (signature): _______________________

Research advisor (typed): _______________________

Research advisor (signature): _______________________

☐ M.S.

☐ Ph.D.
Appendix IV: Additional Graduate Studies Forms

The following forms can be obtained from the School of Graduate Studies website

http://gradstudies.case.edu/current/forms.html

- Advancement to Candidacy
- Arrangement to Resolve an Incomplete
- Drop/Add Form
- Fellowship Course Application
- Notification for Scheduling the Final Oral Exam
- Petition for a Leave of Absence
- Petition for an Extension
- Petition for Course Repeat
- Petition for Transfer of Credit
- Petition for Transfer of Department
- Predoctoral Standing
- Waiver of Registration
Appendix V: Examples of Courses Previously Approved by GEC

Notes:
1. Courses that do not appear in this list can be used to fulfill the various requirements if approved by the GEC.
2. If you are in doubt over whether a course will be accepted in a particular category, submit your Program of Study PRIOR to taking the course. You can thus be confident that the course will not be found at a later date to be ineligible by the GEC.

1. Biomedical Science Courses
(Partial Listing)

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>ANAT 414</td>
<td>Neurological Anatomy</td>
</tr>
<tr>
<td>BIOC 408</td>
<td>Genes and Genetic Engineering</td>
</tr>
<tr>
<td>BIOC 412</td>
<td>Proteins and Enzymes</td>
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<td>BIOC 420</td>
<td>Molecular Genetics of Cancer</td>
</tr>
<tr>
<td>CBIO 454</td>
<td>Cell Biology II</td>
</tr>
<tr>
<td>EBME 425</td>
<td>Tissue Engineering and Regenerative Medicine</td>
</tr>
<tr>
<td>EBME 447</td>
<td>Rehabilitation Medicine for Scientists and Engineers</td>
</tr>
<tr>
<td>EMAE 413</td>
<td>Functional Anatomy</td>
</tr>
<tr>
<td>EBME 451</td>
<td>Molecular and Cellular Physiology</td>
</tr>
<tr>
<td>EBME 462</td>
<td>Cellular and Molecular Imaging</td>
</tr>
<tr>
<td>NEUR 402</td>
<td>Principles of Neural Science</td>
</tr>
<tr>
<td>NEUR 405</td>
<td>Cellular and Molecular Neurobiology (also listed as PATH 425)</td>
</tr>
<tr>
<td>NEUR 425</td>
<td>Stem Cell Biology and Therapeutics (Neuro 430/EBME 430)</td>
</tr>
<tr>
<td>NEUR 473</td>
<td>Introduction to Neurobiology</td>
</tr>
<tr>
<td>PATH 416</td>
<td>Fundamental Immunology</td>
</tr>
<tr>
<td>PATH 510</td>
<td>Basic Pathologic Mechanisms</td>
</tr>
<tr>
<td>PHOL 432</td>
<td>Cell Structure and Function</td>
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<tr>
<td>PHOL 466</td>
<td>Cell Signaling</td>
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<tr>
<td>PHOL 468</td>
<td>Membrane Physiology</td>
</tr>
<tr>
<td>PHOL 514</td>
<td>Cardiovascular Physiology</td>
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<tr>
<td>PHRM 409</td>
<td>Fundamentals in Pharmacology/</td>
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2. Mathematical Science Courses
(Partial Listing)

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<tbody>
<tr>
<td>MATH 431</td>
<td>Introduction to Numerical Analysis I</td>
</tr>
<tr>
<td>MATH 440</td>
<td>Computational Inverse Problems</td>
</tr>
<tr>
<td>MATH 471</td>
<td>Advanced Engineering Mathematics</td>
</tr>
<tr>
<td>MATH 475</td>
<td>Mathematics of Imaging in Industry and Medicine</td>
</tr>
<tr>
<td>EBME 421</td>
<td>Bioelectric Phenomena</td>
</tr>
<tr>
<td>EBME 519</td>
<td>Parameter Estimation for Biomedical Systems</td>
</tr>
<tr>
<td>PHYS 423</td>
<td>Classical Electromagnetism</td>
</tr>
<tr>
<td>STAT 412</td>
<td>Design and Analysis in Engineering and Science</td>
</tr>
<tr>
<td>STAT 425</td>
<td>Data Analysis I</td>
</tr>
<tr>
<td>STAT 433</td>
<td>Uncertainty in Science and Engineering</td>
</tr>
</tbody>
</table>

3. Engineering Courses by Research Discipline
(Partial Listing)
3.1 Biomaterials and Tissue Engineering “Engineering Concentration” Courses
(Partial Listing)

EBME 406 Polymers in Medicine
EBME 416 Biomaterials for Drug Delivery
EBME 426 Nanomedicine
EBME 474 Biotransport Processes
EBME 503 Biomolecular Forces
ECHE 461 Transport Phenomena
ECHE 464 Surfaces and Adsorption
ECHE 466 Colloid Science
EMAC 401 Macromolecular Synthesis
EMAE 401 Mechanics of Continuous Media
EMAC 403 Polymer Physics
EMAC 404 Polymer Engineering
EMAC 410 Polymer Self-Assembly/Nanomaterials
EMAC 570 Functional and Reactive Polymers

3.2 Imaging/Sensors “Engineering Concentration” Courses
(Partial Listing)

EBME 410 Medical Imaging Fundamentals
EBME 413 Biomedical Optics
EBME 431 Physics of Imaging
EBME 460 Advanced Topics in MRI
EBME 461 Biomedical Image Processing and Analysis
EBME 519 Parameter Estimation for Biomedical Systems
EBME 523 Biomedical Sensing
EECS 405 Data Structures & Files
EECS 452 Random Signals
EECS 454 Analysis of Algorithms

3.3 Neural Engineering and Rehabilitation “Engineering Concentration” Courses
(Partial Listing)

EBME 407 Neural Interfacing
EBME 422 Muscles Biomechanics Control
EBME 427 Movement Biomechanics and Rehabilitation
EBME 478 Computational Neuroscience
EBME 507 Motor System Neuroprostheses

4. “Breadth” Courses
(Partial Listing)

EBME 611/612 BME Departmental Seminars
EBME 613/614 Neural Engineering Topic Seminars
EBME 615/616 Imaging Topic Seminars
EBME 617/618 Biomaterials Topic Seminars
EBME 619/620 MetroHealth Cardiovascular Topic Seminars
EBME 570 Graduate Professional Development for Biomedical Engineers
EBME 440 Translational Research
IBMS 500 On Being a Professional Scientist: The Responsible Conduct of Research
Appendix VI: Blackboard form for Committee Meetings or Research Proposal Defense

EVENT: __________________________________________________
Indicate Research Proposal Defense or Committee Meeting

STUDENT NAME: ____________________________________________

ACADEMIC ADVISOR: _______________________________________

THESIS COMMITTEE CHAIR: __________________________________

DATE OF EVENT: ___________________________________________

PASS / FAIL: ______________________________________________
(If applicable)

REQUIRED SIGNATURES (members in attendance only):

__________________________________________________________
Student Research Advisor

__________________________________________________________
Academic Advisor GEC Member (if applicable)

__________________________________________________________
Additional Member(s) Additional Member(s)

__________________________________________________________
Additional Member(s) Additional Member(s)

Uploaded the signed and completed form in the assignment section on Black Board for the appropriate event.