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Graduate Study in the Department of Biomedical Engineering

Case School of Engineering and Case School of Medicine



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0. Change Log

This section describes any minor changes that have been made to the Graduate Student Handbook after release of the original document. The purpose of this section is to reduce the need to issue a new version of the handbook after minor changes are made to the program, and to make these changes transparent to students. Graduate students may continue under the guidelines laid out when they first entered the CWRU BME Graduate Program, or adopt all of the changes that have been made since their matriculation. This version of the document applies to all students who have matriculated in or after Fall 2017; students who entered into the program before this date may either use this handbook or refer to earlier versions of the handbook for specific guidelines and forms which pertain to their course of study.

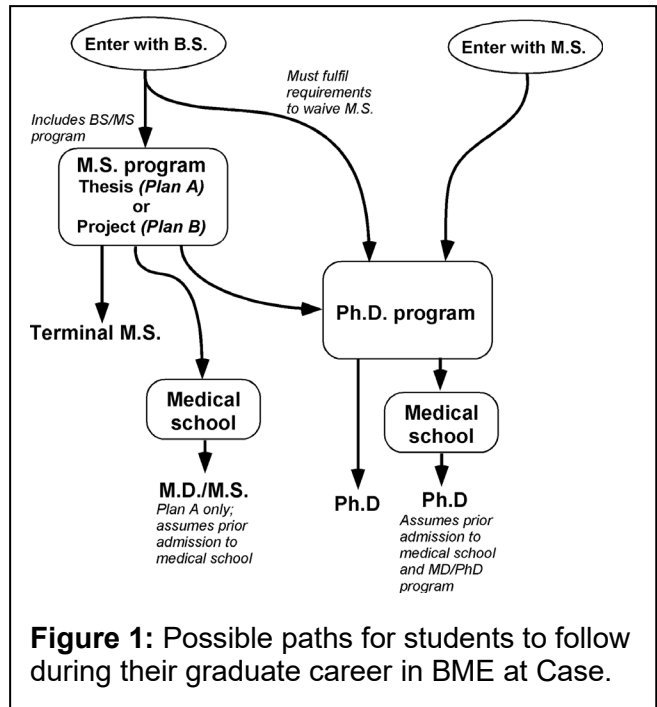
May 4, 2018	Original Document
September 13, 2018	Requirement for GEC representative to be present for R21 proposal eliminated; form changed to reflect responsibility of committee chair to assess R21.
September 13, 2018	Changed the submission deadline for first Program of Study (POS) from end of the first spring semester to <i>end of the Drop/Add period of the first spring semester.</i>
April 10, 2019	Added the requirement for two new grant writing courses; EBME 454 and EBME 515.
April 10, 2019	Added the suggested length of an R21 proposal defense presentation by limited to 20 minutes. This was done to allow appropriate time for the “exam” portion.
April 11, 2019	Updated that stipend to temporarily suspend the tiered stipend system due to the substantial raise in the base salary for students from \$25,000 to \$31,000 starting Fall 2019.
Summer 2019	<ul style="list-style-type: none">- Updated to include name change of CBI 453 to IBMS 453- Include updates on EBME 601 credit and two new grant writing courses
November 2019	<ul style="list-style-type: none">- Requirement to submit a POS removed because of updated SIS platform. Therefore, POS requirement replaced with requirement for Guidance Committee Form.- Students that wish to use graduate credit from another institution for credit towards their PhD at Case, use the Guidance Committee Assignment tab to request for Advanced Standing (come in with an MS completed - up to 18 credits) or to transfer up to 6 credits of graduate work not used for previous degree, upload a syllabus for the course and a note/letter stating which category you would like to waive/reduce the required courses.

- Because of this, we are changing the requirement for advancing to candidacy. Now, you will only need to complete EBME 454 and EBME 570 with a **Passing grade**. Once this is done, either find me in my office or place the form in my mailbox in the main office. Attach or bring with you a copy of your SIS report showing that you completed EBME 454 and EBME 570 with a **Passing grade**.
- December 12, 2019
- In order to take the Oral Qualifying Exam, students must register for EBME 700 for the Summer Term in which they take the exam.
 - In order to take the Research Competency Exam, students must register for EBME 702 for the Term in which they take the exam.
- Fall 2020
- Beginning Fall 2020, the tiered stipend system will be reinstated. Starting Fall 2019, the PhD stipend will be \$31,500; Tier two = \$32,500, and Tier three = \$34,000.
- October 2020
- Students wishing to transfer from the MS to PhD programs before completing the MS degree:
 - Students should complete a minimum 18 credits of graded course work at CWRU, maintain a GPA of at least 3.0 at CWRU, pass EBME PhD Core Courses with B or higher, Pass the Oral PhD Qualifier, and clear demonstration of the ability to perform independent research provided in a letter by PI. Students must be informed of the timing to coordinate when to take the exam. Letter from faculty must include financial support to the student when they enter the PhD program.
- October 2020
- Text was cleaned up throughout for consistency. Changes noted in Red Font
- July 2021
- Changed EBME 602 to EBME 401L (course number change)
 - Beginning Fall 2021, the tiered stipend will be increased by \$500 each. The Ph.D. student stipend will be \$32,000; Tier two = \$33,000, and Tier three = \$34,500.
 - Clarified that Academic Advisor can only chair MS thesis committee if not also the Research Advisor.
 - Clarified that the entire committee MUST PARTICIPATE (in the room or call in) for a thesis defense to be valid for both MS and PhD.
- July 2021 (rev 2)
- Edits to update MS program description and rules

1. Graduate Programs in BME: An Overview

The Department of Biomedical Engineering at Case Western Reserve University offers Master of Science (M.S.) and Doctor of Philosophy (Ph.D.) degrees in several varieties, as illustrated in Figure 1. Although there are several versions of the M.S. and Ph.D. programs, all have the same fundamental requirements.

- Students entering directly into the BME graduate program *with a BS degree* can choose to complete a standard “terminal” M.S. degree, obtain an M.S. 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 towards 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/PhD program.



1.1. Typical timelines and milestones for graduate program in BME

A typical timeline (with semester-by-semester milestones) for completion of an M.S. 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.

Semester 1	Discuss choice of courses with academic advisor. Typically register for 9 credit hours consisting of some combination of courses and research credits (EBME 651 for Plan A and EBME 695 for Plan B).
Semester 2	Register for some combination of courses and research credits. Submit final Program of Study to GEC.
Summer	Register for research credits (EBME 651 or 695 only if needed for Program of Study. Otherwise, register for RSCH 650 (M.S. level summer research) without cost while maintaining fulltime status.
Semester 3	Register for some combination of courses and research credits appropriate for your Program of Study.
Semester 4	Complete any remaining course or research requirements. Complete M.S. research.
Summer	Complete all M.S. work (EBME 651 or 695, or RSCH 650) or move on to Ph.D. program.
Defense	Submit and defend M.S. thesis or report. Congratulations!

Figure 2: Example timeline for completion of M.S. program.

Semester 1	Discuss choice of courses with academic advisor. Most students register for 9 credits to maintain full time student standing. Note, EBME 651, 695 or 701 can be taken at 1 credit or more to maintain full time standing. Also 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 and/or graduate (whichever is second); thus most students choose to start taking research credits later in their program once most of their classes have been taken. Typically students register for 9 credit hours, consisting of some combination of courses, research credits, and seminar credits, including IBMS 453 (3 credits, a core course for the Ph.D.), EBME 454 (1 credit), EBME 570 (1 credit, a course on professional development), and EBME 601 (pre-candidacy PhD research). EBME 601 counts as breadth credit and reduces the number of didactic classes that are required. Your advisor may suggest different courses directly relevant to your research and/or research credits. Also, you may register for departmental seminar EBME 611 (0.5 credit) and/or a special topic seminar EBME 613, 615, 617, or 619 (0.5 credit).
Semester 2	Most students register for 9 credits to maintain full time student standing (Again, EBME 651, 695 or 701 can be taken at 1 credit or more to maintain full time standing). Register for some combination of courses and research credits. Typically, this semester would include the BME core courses EBME 401D (3 credits), 433 (4 credits), and 602 (1 credit). If your POS has not been approved yet, this is your last chance to register for EBME 601 and reduce the number of courses that you take. 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 Ph.D. Program of Study (POS). When it is accepted, you advance to Ph.D. candidacy allowing you to register for more than 6 credits of EBME 701.
Ph.D. oral exam	The typical course of study involves taking the oral portion of the Ph.D. qualifying exam after your second semester. Eligibility for this exam requires grades of B or better in the EBME core courses (EBME 401D and 433, or their equivalent). <i>This exam can also be taken one year later.</i>
Summer	Register for RSCH 750, a no-cost registration that maintains fulltime status over the summer.
Semester 3	Register for courses, research credits, and seminar credits as detailed in your POS. A guidance committee meetings should be held in this semester. Start preparations to defend R21 proposal. Teaching assistantships (3 are required) typically start in this semester.
Semester 4	Register for courses, research credits, and seminar credits as detailed in your POS. The guidance committee should meet to discuss the student's progress.
Summer	Register for appropriate research credits (EBME 701) if needed or RSCH 750 (preferably). If not taken previously, or not passed previously, Ph.D. qualifying exam should be taken now.
R21 Proposal Exam	Write and defend research proposal if you have passed the oral exam.
Semester 5	Register for courses, research credits, and seminar credits as detailed in your POS. The guidance committee should meet to discuss the student's progress.
Semester 6	Register for courses, research credits, and seminar credits as detailed in your POS. The guidance committee should meet to discuss the student's progress.
Summer	Register for appropriate research credits (EBME 701) if needed or RSCH 750 (preferably).
Semester 7 until finished	Register for courses, research credits, and seminar credits as detailed in your POS until Ph.D. Program of study is completed (at least 12 courses and 18 hours of EBME 701). The guidance committee should meet to discuss the student's progress each semester.
	Submit and defend Ph.D. dissertation. Congratulations!

Figure 3: Example timeline for completion of Ph.D. program.

A typical timeline (with semester-by-semester milestones) for a student entering with a BS degree in engineering to complete a Ph.D. 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.

1.2. 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 provides a comprehensive description of university and Case School of Engineering requirements, currently found at <http://bulletin.case.edu/schoolofengineering/>.
- Policies of the School of Graduate studies, along with links to other relevant sites can be found at <http://bulletin.case.edu/schoolofgraduatestudies/>.
- Links to a number of important forms can be found at <https://case.edu/gradstudies/current-students/forms/>.

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.

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 M.S. 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 and professional development aspects of the student’s program. Students are expected to meet with the Guidance Committee each semester. 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 ensure completion of other degree requirements. Students who are failing to meet timelines or normal milestones will be contacted by the Chair of the BME Graduate Education Committee 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 documentation for the completion of a departmental requirement should be submitted through the department's Canvas site (canvas.case.edu). Do not submit original documents to your advisor or to the GEC chair. ALWAYS SAVE ORIGINALS IN YOUR PERSONAL RECORDS. Points of clarification and simple questions should first be directed to the academic advisor, who can then contact the GEC chair as necessary. Please check Canvas regularly to determine the status of requests and ensure that the documentation has been received and approved.

Programs of study

The School of Graduate Studies now requires graduate students to submit their approved programs of study into the Student Information System (SIS) that can be found at <http://sis.case.edu>. This is a requirement of Graduate Studies and must be done in a timely manner to maintain good standing. This step can be taken by the student after the GEC approves the program of study through Canvas.

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.

2. M.S. Programs

2.1. General Requirements

At least thirty (30) credit hours (cr. hrs.) are required for the M.S. Each M.S. student must complete an M.S. Program of Study (see Section 4.1) 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 M.S. program are largely left to the discretion of the student* and their advisor, but should be appropriate for an M.S. 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 M.S., but the Ph.D. Program of Study is more structured. Students are thus advised to consider the Ph.D. course requirements when setting up the M.S. Program of Study if intending to continue on for a Ph.D.

**Students enrolled in the on-line BME-MS program must take EPOM 400: Leadership and interpersonal skills*

**All students in the MS program must have a capstone experience. This is satisfied by doing either a thesis or a project. Students in the course only option must take EBME 471 or 472: BioDesign*

The admission requirements and expectations vary across the different M.S. 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 M.S. students are required to complete at least four graduate-level engineering courses (i.e., 400 level or higher), as approved by their M.S. Guidance Committee and the GEC.

A Program of Study (see Section 4.1) in Biomedical Engineering (BME) should be filed during the student's first semester in an M.S. program. This insures that the student and advisor have devised a plan for the entire M.S. program. Plan A M.S. students should also work with their advisor(s) to assemble an M.S. Guidance Committee consisting of at least three members with Case faculty (including adjunct) appointments. The academic advisor chairs the Committee (if not the research advisor) and must have a primary appointment in BME. The M.S. degree will not be conferred until the final program of study is signed by all guidance committee members and approved by the GEC.

2.2. Description of M.S. Programs

The Case BME department offers several different programs leading to a Master of Science degree in BME. Each is classified as either a 1) thesis option (Plan A) or 2) project option (Plan B) or 3) Course only option (Plan C), and each will be described in more detail below.

Master of Science – Thesis Option (Plan A)

18 hrs of course work + 12 hrs of EBME 651 OR

21 hrs of course work + 9 hrs of EBME 651

Requirement for completion: 30 hrs, written Master's thesis, and thesis defense:

<http://bulletin.case.edu/schoolofgraduatestudies/academicrequirements/>

**NOTE, entire committee MUST PARTICIPATE for a thesis defense to be valid.*

Master of Science – Project-Option (Plan B)

30 hrs of course work (course only option) – available for distance learning and on-line only students

OR

27 hrs of course work and 3 hrs of EBME 695 (project option)

OR

24 hrs of course work and 6 hrs of EBME 695 (project option)

Requirement for completion: 30 hrs [including project](#)

<http://engineering.case.edu/current-students/academic-programs/ms>

Master of Science –Course-Only Option (Plan C)

30 hrs of course work (course only option) – available for distance learning and on-line only students

Students with this option must take a cap-stone course: EBME 471 or 472 or ENGR 600.

Note that for each of these options, up to 3 credit hours may be comprised of seminars in the form of EBME Departmental Seminar (EBME 611/612) or Topic Seminars (EBME 613/614, EBME 615/616, EBME 617/618, and EBME 619/620), each semester of which carries 0.5 credit hours.

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.

2.3. M.S. Strike Policy

In the Fall of 2015, the GEC and full faculty voted to institute a mandatory timeline to meet major departmental requirements beginning in Fall 2016. THIS POLICY IS FOR FULL TIME M.S. [thesis option](#) STUDENTS ONLY.

The policy pertains to completion of the [thesis committee form](#), 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; if a student received three strikes for any one requirement, they will be removed from the M.S. program.

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 required 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 the M.S. program, a student receives three “strikes” for failure to meet the initial and/or GEC-extended milestone for a given requirement, the student will be removed from the M.S. program. Counting of “strikes” is done per requirement and not cumulative across all department requirements. The student AND advisor can petition to the **GEC** and **BME Department Chair** to be re-admitted to the M.S. program should they be removed from the program.

Year	Semester 1	Semester 2	Semester 3
1		Thesis Committee Form	
2	Committee meetings should begin (require a minimum of one per year) (Plan A only)		

For Plan A M.S. students, failure to complete a thesis committee meeting by the last day of classes of the [second semester](#) will result in a strike and a three-month extension before the second strike is issued. Beyond the first required meeting, failure of the committee to meet within a 12-month span will result in a strike and a three-month extension before the second strike is issued.

2.4. M.S. 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 (if applicable), to submit an electronic thesis (if applicable), 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 “Final Certification” <https://canvas.case.edu/courses/1695>. Normally, these 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 these forms must be prepared and submitted well in advance of the planned completion of the M.S. degree. [The form cannot be signed until all the academic requirements have been fulfilled.](#) Please visit:

<http://www.case.edu/provost/gradstudies/current/calendar.html>

to determine the deadlines for applying for graduation, completing your defense [with your entire thesis committee](#), and submitting all materials to Graduate Studies for the semester in which you would like to finish your degree and/or graduate.

2.5. Transfer of Credits

All courses in the M.S. Program of Study must be at the graduate level. Official transfer of graduate courses from other institutions to Case is limited to six (6) semester credit hour ([with minimum GPA of 3.0, or B](#)) (see <http://bulletin.case.edu/schoolofgraduatestudies/academicpolicies/> for more information about these policies). 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.

2.6. 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 M.S. 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 BS/MS 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. 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 [Scherger](#) 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 4.1 for the 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 M.S. 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 Program of Study (POS) form (Appendix 4.1). 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 695 (Non-Thesis Option) should replace EBME 398 in the fall or spring of the senior year. You should register for EBME 651 or EBME 695 (but NOT EBME 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 695 (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 (Plan A)

21 hrs of course work and 9 hrs of EBME 651 OR

18 hrs of course work and 12 hrs of EBME 651

Requirement for completion: 30 hours, written Master's thesis, and thesis defense

<http://bulletin.case.edu/schoolofgraduatestudies/academicrequirements/>

Students can double count 3 courses (must be at the graduate level)

BS/MS Non-Thesis Options

1. BS/MS Project Option (Plan B)

27 hrs of course work and 3 hrs of EBME 695 OR

24 hrs of course work and 6 hrs of EBME 695

Requirement for Completion: 30 hrs and comprehensive examination

Students can double-count 3 courses (must be at the graduate level)

2. BS-MS Course Only Option (Plan C)

30 hrs of course work

Requirement for Completion: 30 hrs and comprehensive examination

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

12 hrs (4 BME technical Courses)

Requirement for Completion: 30 hrs and a comprehensive examination

Students can double-count 3 courses (only one at the undergraduate level)

2.7. 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 M.S. 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 M.S. 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 M.S. requirements are the same as the rest of the Case School of Engineering Thesis Option M.S. degree, i.e., 30 credit hours including nine to twelve hours of thesis registration (EBME 651). **Please note that only the Thesis Option (Plan A) 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 M.S. 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 M.S. component of the dual degree. **The balance of required formal courses (12-15 hours or 4-5 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)
12-15 hrs (4-5 courses) in biomedical engineering
9-12 hrs of thesis research (EBME 651)

Requirements for Completion: 30 hrs, written Master's thesis, 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.

2.8. MSc Translational Health Technology

This Master's degree in Biomedical Engineering/Translational Health Technology 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 30 credits including a design project.

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

Special Features:

- 26 credit hrs of courses plus 4-hours of project
- Portions available through Distance Learning
- Flexible program to accommodate professionals schedule
- Lock-Step Program. Duration 1 year: August to August
- Projects can be done within the place of work

<http://engineering.case.edu/Translational-Health-Technology>

2.9. Other CSE Masters programs

The **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/> 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> for more information on this program.

3. Ph.D. Programs

3.1. Overview

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 (Medical Sciences Training Program, MD/PhD) program in the Case School of Medicine.

Summary of Ph.D. requirements

- Have a [Guidance Committee Form](#) on file with the Department (in Canvas). ([see section 3.2](#))
- Have a Program of Study online in the SIS system. ([see section 3.3 below](#))
- Complete advance to [candidacy form](#) after completing EBME 570 (Pass) and EBME 454 (A or B) ([see section 4.7 below](#))
- Successfully complete 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.
- Satisfy the BME publication and presentation requirements ([see section 3.7 below](#))
- Complete three teaching assistant (TA) assignments ([see section 3.8 below](#))
- Satisfy the BME Ph.D. residency requirement ([see section 3.9 below](#))
- Pass all components of the Ph.D. Qualification Process specific to your track ([see section 3.10 below](#))
- Apply for graduation well in advance of intended defense date ([see section 3.14 below](#))
- Complete BME Graduation Information Form ([see section 4.3 below](#))
- Obtain required signatures from committee members following a successful final dissertation defense

Tiered Stipend System:

- Ph.D. students start with the base level stipend (Tier 1)
- Once students have completed all course-based classes (i.e. all but EBME 701 and seminar requirements), they are eligible for a stipend increase (move to Tier 2). **Students must petition for review of Tier Level under the Stipend Level Assignment in Canvas.**
- To receive the raise, students must be on pace with all metrics / qualifying exams based on time in program (see below strike policy in Section 3.13).
- Each student is also eligible for a Performance-Based raise (to Tier 3) when the stipulations above are met, **AND** they have:
 - 1) Published a first author paper **and**
 - 2) Either published a second paper with any author standing **or** completed their oral conference presentation requirement for graduation.
- Combined stipend and tuition paid to a student may not exceed the federal cap. If needed, students can reduce salary at any time to take more credits.

- Beginning Fall 2020, the tiered stipend will be reinstated. The Ph.D. student stipend will be \$31,500; Tier two = \$32,500, and Tier three = \$34,000.
- Beginning Fall 2021, the tiered stipend will be increased by \$500 each. The Ph.D. student stipend will be \$32,000; Tier two = \$33,000, and Tier three = \$34,500.

3.2. **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, beginning in the Fall Semester of the student's second year**. To fulfil this requirement, a simple majority of the committee members must be present. It is the student's responsibility to arrange this meeting. The student should also print and bring the Committee Meeting form (see Appendix VI) to this meeting; once signed by all the faculty in attendance, the student should upload this form to Canvas to indicate that a committee meeting has taken place (canvas.case.edu). Do not submit original documents to your advisor or to the GEC chair. ALWAYS SAVE ORIGINALS IN YOUR PERSONAL RECORDS. Please check Canvas regularly to ensure that there are no questions or comments on the documentation that has been submitted.

The Guidance Committee consists of four or more faculty members, all of whom must have Case appointments at a faculty level. The student's academic and research advisors are members of the examination committee. The academic advisor must hold a primary faculty appointment in BME. The research and academic advisor can be the same person. 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.

At least two members of the guidance committee 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 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.

3.3. Program of Study

The Ph.D. Program of Study (POS) requirement has been removed as of Fall 2019 due to an increased capabilities of SIS. Students are able to fulfill the same requirements by selecting courses from prepopulated drop down menus for categorical requirements. Students wishing to take classes not on that list can petition the GEC through Canvas petitions portal. Students wishing to transfer credits from another university should also petition the GEC through Canvas petitions portal. The POS forms are available below ([with guidance](#)).

3.4. Ph.D. Candidacy

A student is advanced to Ph.D. candidacy when:

1. The students complete EBME 454 **with an A or B**, and EBME 570 with Passing grades.
2. Completes the Advance to Candidacy Form, and obtains a signature from the Chair of BME Graduate Education Committee or Department Chair
3. The Ph.D. candidacy form (with the necessary signatures) is the submitted to Graduate Studies by the student to be approved by the Dean of Graduate Studies. See Appendix VII: Ph.D. Advancement to Candidacy Form [\(4.7\) for the form](#).

3.5. Didactic Courses Required in the Ph.D. Program of Study

Core Courses

As of Fall 2015 entering class, Ph.D. students are required to take 12 credit hours of core courses:

EBME 401D: Biomedical Instrumentation and Signal Processing (3 cr)

EBME 402: Organ/Tissue Physiology and Systems Modeling (4 cr)

EBME 602: Special Topics (1 cr)

CBIO 453: Cell Biology I (4 cr)

CBIO 453 is typically taken in the Fall semester, and the remaining courses in the Spring semester.

As of Fall 2016 entering class, Ph.D. students are required to take 12 credit hours of core courses:

EBME 401D: Biomedical Instrumentation and Signal Processing (3 cr)

EBME 433: Advanced Topics for Physiological Systems Analysis (4 cr)

EBME 602: Special Topics (1 cr)

CBIO 453: Cell Biology I (4 cr)

CBIO 453 is typically taken in the Fall semester, and the remaining courses in the Spring semester.

While CBIO 453 is a core course, it is not required to be taken prior to the Oral Qualifier Exam.

As of Fall 2017 entering class, Ph.D. students are required to take 11 credit hours of core courses:

EBME 401D: Biomedical Instrumentation and Signal Processing (3 cr)

EBME 433: Advanced Topics for Physiological Systems Analysis (4 cr)

EBME 602: Special Topics (1 cr)

CBIO 453: Cell Biology I (3 cr)

CBIO 453 is typically taken in the Fall semester, and the remaining courses in the Spring semester.

While CBIO 453 is a core course, it is not required to be taken prior to the Oral Qualifier Exam.

As of Fall 2019 entering class, Ph.D. students are required to take 11 credit hours of core courses and two grant writing classes:

EBME 401D: Biomedical Instrumentation and Signal Processing (3 cr)

EBME 433: Advanced Topics for Physiological Systems Analysis (4 cr)

EBME 602 (now EBME 401L): Special Topics (1 cr)

IBMS 453: Cell Biology I (3 cr)

EBME 454: Introduction to Grant and Fellowship Writing (1 cr) – Fall first year

EBME 515: Grant Writing - 2 (2 cr) – Fall second year

IBMS 453 is typically taken in the Fall semester, and the remaining courses in the Spring semester.

While IBMS 453 is a core course, it is not required to be taken prior to the Oral Qualifier Exam.

Exceptions to Core Courses

There are two circumstances under which exceptions to the core courses may be given:

- 1) Students may test out of a core course by taking a core competency exam; see below section 3.10 entitled "Ph.D. Qualification Process."
- 2) Students may petition the GEC to use an alternative class. The alternative course should reflect the same principles of measurement, experimental design, modeling, physiology and/or clinical concepts already in the accepted core course it is intended to replace. The idea is to allow students the flexibility to take courses that focus on an application more aligned with their Ph.D. thesis, while learning the same core concepts. NOTE: students will be held to the same requirements of receiving a B or better in the course and to the same standard on the Ph.D. qualifier exams.

The GEC will review petitions to substitute any of the core courses with a course that covers similar core material, but may be delivered in a subject matter more aligned with the students Ph.D. thesis area. Petitions should be submitted through Canvas (canvas.case.edu) and will be granted on a case by case basis. Do not submit original documents to your advisor or to the GEC chair. ALWAYS SAVE ORIGINALS IN YOUR PERSONAL RECORDS. After submitting your POS, please check Canvas regularly to ensure that there are no questions or comments on the documentation that has been submitted.

Other Courses for the Program of Study

In addition to the 11 cr. hrs of core courses, 25 cr. hrs of approved courses are required for the Ph.D. **Undergraduate courses are typically not allowed, and undergraduate courses can never be used to fulfill the biomedical sciences or statistics/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 25 cr. hrs minimum. Whether or not this is necessary will be determined by the Ph.D. Guidance Committee and the GEC. In general, students are encouraged to craft programs of study that include the smallest number of courses necessary to satisfy all requirements. Once the POS is on file, students must complete all the courses in the program to graduate. There is no penalty for taking more courses than appear on the POS.

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

- Categorical requirements: At least five (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 "Statistics/Mathematical Science" category, or two courses in the "Engineering" category, two in the "Biomedical Science" category, and one in the "Statistics/Mathematical Science" category. No double counting is allowed.
- At least six (6) credit hours in engineering (including BME) that provide depth for research. 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. Appendix V (4.5) 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. 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. 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 CWRU course can be used to satisfy the Biomedical Sciences requirement. Appendix V (4.5) 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 or statistics. The mathematics in these courses must be at a higher level than undergraduate calculus and differential equations. No 300-level CWRU course (or any undergraduate course from another university) can be used to satisfy this requirement. Appendix V (4.5) lists courses that have typically been approved to fulfill the Mathematics requirement.
- Breadth requirements: at least three (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) credit per semester, and students may apply a total of four credit hours (eight semesters) from seminars 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.

Summary of Courses Required for Ph.D.

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

- | | |
|----------------|--|
| • IBMS 453 | Cell Biology |
| • EBME 401D | Biomedical Instrumentation and Signal Processing |
| • EBME 433 | Advanced Topics for Physiological Systems Analysis |
| • EBME 401L | Special Topics |
| • EBME 611/612 | Departmental Seminars |
| • EBME 613~620 | Topic Seminars |
| • EBME 454 | Introduction to Grant and Fellowship Writing |
| • EBME 515 | Grant Writing II |
| • EBME 570 | Professional Development |

- UNIV 400 Professional Development for Graduate TA's
- EBME 400T/500T/600T Graduate Teaching

Typically, IBMS 453, EBME 454, and EBME 570 are taken during the first Fall a student is enrolled. Additionally, EBME 401D, EBME 433, and EBME 401L are taken in the first Spring semester that a student is enrolled. EBME 515 should be taken during the second Fall that the student is enrolled.

Course Performance Required for the Ph.D.

A grade of B or higher in each of the core courses is a requirement for Ph.D. Qualification. An overall GPA of at least 3.0 must be achieved to graduate.

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

Graduate Studies requires students to complete a minimum of 18 credit hours of courses at CWRU if they enter with an M.S. 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 M.S. 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 BME requirements accordingly. However, THESE COURSES MUST BE APPROVED BY THE GEC, and students must have received an A or B in that course. 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 and submitted through the Canvas system (canvas.case.edu) and will be granted on a case by case basis. Do not submit original documents to your advisor or to the GEC chair. ALWAYS SAVE ORIGINALS IN YOUR PERSONAL RECORDS. After submitting your POS, please check Canvas regularly to ensure that there are no questions or comments on the documentation that has been submitted.

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 category that the course would be used to fulfill (i.e., Engineering Concentration, Biomedical Science, or Statistics/Mathematical Science), and justification for why the course is

consistent this category.

3.6. *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. 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.

3.7. *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. The dissertation is one element of this, as are publications in peer-reviewed scientific journals. At minimum, a Ph.D. student must be an author of at least three (3) manuscripts submitted for publication to a peer-reviewed journal. The student must be primary author on at least two (2) of these manuscripts. At the time of completion of the Ph.D., at least two (2) manuscripts must be accepted for publication 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 during this time are acceptable. The application for Ph.D. graduation submitted to the BME chair must have attached a list of manuscripts submitted, accepted, or published in peer-reviewed archival journals, signed by the academic and research advisor(s).

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 formats, 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 GEC 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. 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. Note that one element necessary for satisfying the presentation requirement is that the audience does not consist primarily of individuals the student has been presenting to informally throughout their career as a graduate student. 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.

3.8. Teaching Requirement

The teaching assistant requirement of the Case School of Engineering (CSE) provides Ph.D. students with the opportunity to develop teaching and communication skills that will be useful in a variety of future endeavors. Each CSE Ph.D. student 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, and third teaching 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 are urged to respond in a timely fashion so as to streamline the match process. Ph.D. students often TA in two large undergraduate courses. Students typically do not TA before passing the qualifier. Students often 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 teaching requirements for a BME Ph.D. 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

3.9. 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.

Note that, in most cases, students substantially exceed this minimum residency requirement.

3.10. 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. **This is only an option if the student has maintained the minimum GPA requirements to avoid academic probation from the School of Graduate Studies.** 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. **Note, neither the department nor the PI are obligated to pay for the same course twice due to the students’ poor performance. Tuition expenses for retaking a class may be at the students’ expense.**

Competency for students who seek to be excused by the GEC from taking one or more of the core courses will be determined in a manner described below, 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 order to assess the competency of students that wish to receive a waiver of core courses, a competency exam may be administered before the start of classes:
- One exam may be administered for each of the three core courses. The exams will be optional for first year graduate students only. The exam will be administered by the faculty. No review on the content of the exam will be provided, but the course syllabus from previous years will be supplied as requested. The exam will be scored Pass/Fail by the faculty administering the exam, and only the results of the exam will be shared, as the exam will be similar in content to final exams for the courses. No retakes or petitions over scoring will be heard.
- If a student passes one or more core competency exams, the student will receive a waiver from the GEC for the courses that were passed. The waiver frees the students from the core course requirement, but not from the equivalent required credit hours – meaning that the student must replace the course with additional course(s) in areas of breadth, engineering, biological science, or mathematics (for example). Any such substitute courses must be approved by the GEC prior to taking the course.

MSTP students are not required to take IBMS 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 core competency as it relates to 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:

In order to take the Oral Qualifying Exam, students must register for EBME 700 for the Summer Term in which they take the exam.

Ph.D. students must also demonstrate the ability to integrate fundamental BME knowledge, and to apply measurement principles and analysis techniques to solve biomedical engineering problems. The breadth of fundamental BME knowledge includes the content of a typical BME undergraduate curriculum such as the that provided by the CWRU BME department. The depth of BME knowledge is set by the CWRU BME graduate core courses. This integrative ability will be assessed during a one-hour oral exam administered by a committee of BME primary faculty. Students who have successfully passed the “core competency” (part 1, minus IBMS 453) requirement are eligible to take 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. If a student does not pass the oral exam on 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 a student does not pass after two opportunities, they will not be permitted to continue in the Ph.D. program.

Students are encouraged to discuss preparation for the exam with their academic advisor and senior students in the department. Practice for the exam is also encouraged utilizing these resources.

All questions about outcomes of the exam should be brought to the Chair of the Ph.D. Oral Qualifier Exam Committee.

3. Research competency—Research Proposal and Defense:

In order to take the Research Competency Exam, students must register for EBME 702 for the Term in which they take the exam.

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, <http://grants.nih.gov/grants/guide/pa-files/PA-10-069.html>, 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 specific aims, innovation, significance, 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. A student will have passed the examination when he/she demonstrates the ability to successfully write and defend a research proposal. The oral presentation (should be ~20 min long) and defense will be administered by the student’s guidance committee. An important role of the committee chair is to ensure that the proposal exam requirements are met, that the proposed research contains both engineering and life sciences content, and to ensure some uniformity of exam difficulty across all students. If a student is judged to have not passed this exam, the committee will provide 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, The entire committee MUST PARTICIPATE (in the room or call in) for an R21 defense to be valid.

3.11. Appeals

As noted above, students will be allowed to attempt each of the three parts of the Ph.D. qualification process twice. ***Students who fail any section of the Ph.D. qualification requirements after both of these tries will not be allowed to continue in the Ph.D. 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 academic and research advisors, 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 for a 3rd attempt will be allowed. The facts of the student’s case will be presented to the entire BME primary faculty by a representative of the GEC. The student’s academic advisor will be given a chance to justify the basis for the appeal. The appeal will only be granted if a 3/4 majority of the entire BME Primary Faculty vote in favor of the appeal. Note that any appeal must be made within 3 months of the notification of failure to the individual requirement.

3.12. Transition to new Ph.D. qualification requirements

Students admitted to the BME graduate program will be obligated to fulfill the requirements described in the handbook dated at their matriculation into the program. Students in the BME graduate program when new rules are implemented 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.

3.13. Strike Policy

There are mandatory timelines to meet major departmental requirements. The policy pertains to completion of the Program of Study, completion of the oral qualifying exam, completion of the R21 proposal defense, and completion of at least one committee meeting per semester. Each requirement should be completed by the below defined timeline. Failure to complete the requirement by the pre-defined deadline results in an automatic “strikes” towards expulsion from the program. After three strikes in any one requirement area, the student will be removed from the Ph.D. program.

The first “strikes” results in the student receiving official notice from the GEC of the “strikes.” At that time, the student will receive a new deadline (defined below per each requirement) describing when the second strike will be issued if that requirement is not completed. After the second strike is issued, the student is required to discuss in person with the GEC why the requirements have not been met on time. At this meeting, if justified, the GEC may give an extension to complete the task before the third and final strike is issued. In addition, upon receiving the 2nd strike any student over stipend Tier 1 will be lowered back to stipend Tier 1 until the next semester that the student is back in full compliance with all department requirements. If over the course of a Ph.D., a student receives three “strikes” for failure to meet the initial and/or GEC-extended milestone for a given requirement, the student will be removed from the Ph.D. program. The student AND academic advisor can petition to the BME Department Chair to be re-admitted to the Ph.D. program. Counting of “strikes” is done per requirement and not cumulative across all department requirements; once in good standing for a specific requirement (i.e. committee meetings), the strike count is reset.

Year	FALL	SPRING	SUMMER
1		POS due by end of Drop/Add period	Typical time to take Oral Qualifying Exam
2	Committee meetings begin (require a minimum of one per semester. Meetings are not expected to be longer than an hour)		Typical time to complete R21 Proposal Exam (within one year of passing the Oral Qualifying Exam)

Failure to complete the POS by the ***last day of the Drop/Add period*** of the first Spring term will result in a two-week extension for second strike.

Failure to complete a thesis committee meeting by the last day of classes of the second Fall term will result in a three-month extension before a second strike is issued. Beyond the first required meeting, failure to meet during a semester will result in a strike and in a three month extension prior to receiving a second strike. Note: each time a committee meeting is held, the number of “strikes” for this requirement is reset to zero. The committee meeting requirement is checked at the end of each semester, and strikes for this requirement as issued at this time.

Failure to complete the R21 Proposal exam by the end of the subsequent Summer term (before the first day of classes of the Fall term) after passing the oral qualifier exam will result in a first strike and a three-month extension before receiving a second strike.

Students are expected to take the Oral Qualifying Exam in the first scheduled testing session after passing all EBME core courses with a grade of B or better. Failure to do so will result in a grade of “Fail” for this examination; students will have one additional opportunity to pass this examination.

3.14. 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. 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. 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 the BME Graduation Information Form (see Appendix III, 4.3) must be completed before the BME chair will sign the final authorization for graduation.

***NOTE, the entire committee MUST PARTICIPATE (in the room or call in) for a thesis defense to be valid.**

BME department requirements

The BME Ph.D. requirements listed above are summarized 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
- 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.

4. Appendices - BME Graduate Program Forms and Information

APPENDIX I: INSTRUCTIONS AND FORMS FOR M.S. PROGRAM OF STUDY

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

Appendix III: BME Graduation Information Form

Appendix IV: Additional Graduate Studies Forms

Appendix V: Examples of Courses Previously Approved by GEC

Appendix VI: Canvas form for Committee Meetings or Research Proposal Defense

Appendix VII: Ph.D. Advancement to Candidacy Form

4.1. APPENDIX I: INSTRUCTIONS AND FORMS FOR M.S. PROGRAM OF STUDY

All students need to complete a program of study in SIS. Student enrolled in a thesis option must notify the MS Program director and administrator. They will receive an invitation to join the CWRU canvas BME MS site: <https://canvas.case.edu/courses/1695>. They will be required to fill the following three forms found in the assignment section with a prescribed time indicated above. The form must be uploaded in the same site for review by the program director.

- 1) Thesis committee form
- 2) Committee meeting form
- 3) Graduation form

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

1) First read Sections 3.2 (for structure of the Guidance Committee) and 3.5 (for required courses) and speak with your academic advisor (and research advisor as appropriate) to determine the composition of your Guidance Committee and your plan for coursework. Complete the coursework forms and bring them along with Page 1 for signatures from your Guidance Committee members. If this is a modification of an existing POS, please read Section 3.3 for additional instructions. After the Program of Study is signed by all members of the Guidance Committee, it must be submitted to the BME Graduate Education Committee through Canvas (canvas.case.edu). Do not submit original documents to your advisor or to the GEC chair. ALWAYS SAVE ORIGINALS IN YOUR PERSONAL RECORDS. After submitting your POS, please check Canvas regularly to ensure that there are no questions or comments on the documentation that has been submitted (specifically to ensure that the POS has not been rejected).

HOW TO FILL OUT Page 1 "Ph.D. PROGRAM OF STUDY: GUIDANCE COMMITTEE"

Obtain the approval of the entire completed POS (via signatures) of your academic advisor, your research advisor, your thesis committee chair, 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 new or a revised Program of Study. **Note: Your Program of Study must include the signatures of your Guidance Committee members. 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. If it is difficult to obtain signatures all on the same piece of paper, it is acceptable to submit separate filled out POS forms that, in aggregate, contain all the signatures of your Guidance Committee members.**

HOW TO FILL OUT Page 2 "Ph.D. PROGRAM OF STUDY: LIST OF COURSES"

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 695). 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. When listing your EBME 701 research courses, do your best to distribute the credit hours in the semesters in which you plan to take them such that the GEC can understand your general plan towards graduation. You will not be held to taking each course on this list in the semester it is listed. However, the GEC does pay attention to whether or not the student has carefully thought

about how they will divide their time between research and classroom work through their Ph.D. training period. Note: it is best to include the *minimum* number of courses needed to fulfill all requirements. This list of courses becomes your contract for the course portion of your Ph.D. qualification process. If you list an extra course here and decide not to take it, you will need to petition to have it removed from your POS. It is better to simply leave it off this form at the outset.

HOW TO FILL OUT Page 3 “Ph.D. Program of Study: Supplementary Information”

- 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 (please see Section 3.5 for more details). 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 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), and the category to which the course would be applied should be included in the petition.

HOW TO FILL OUT Page 4 “Justification of POS Categorical Requirements”

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 (or Statistical) Sciences requirement. ***If you are using a pre-approved course listed in Appendix V below, you may simply list the courses and state that they have been preapproved to satisfy this requirement.***

Courses not on the pre-approved list require more explanation. For each area for which you are proposing to take a non-pre-approved course (i.e. engineering, biomedical sciences, and/or statistics/mathematical sciences) provide a written explanation (1/2 page recommended) of how the proposed course/POS satisfies the *spirit* of the category requirement to provide depth and expertise appropriate for the student’s research area. Many courses contain engineering, biomedical sciences, and statistical/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. For instance, this explanation may include a description of how two mixed-material courses were combined to count as one Engineering Concentration course. As another example, some students may fulfill the Biomedical Sciences requirement in non-standard ways, e.g., the medical school curriculum. Note that statistics/mathematical science courses must contain new and/or advanced mathematical tools beyond those included in an undergraduate BME curriculum. In all cases, the explanation must be logical for the BME graduate program requirements and for your research area in particular.

Approval Process:

- 1) Submit the POS only to Canvas for review (canvas.case.edu) and will be granted on a case by case basis. Do not submit original documents to your advisor or to the GEC chair. ALWAYS

SAVE ORIGINALS IN YOUR PERSONAL RECORDS. After submitting your POS, please check Canvas regularly to ensure that there are no questions or comments on the documentation that has been submitted (specifically to ensure that the POS has not been rejected).

2) If the GEC does not approve your Program of Study, this will be denoted on Canvas. Additionally, 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) After obtaining approval from the GEC, students should submit their program 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 Canvas system currently used by the BME department. Students should not submit to SIS until they have received approval from the BME GEC. Note: it is possible to submit your POS through the SIS system without obtaining approval from the GEC first. ***This is a bad idea.*** When it comes time to graduate, if the GEC does not have a record of approving your POS, you will not graduate even if SIS has your POS on file. So, make sure you first get approval from the BME GEC before uploading your POS through SIS.

CASE WESTERN RESERVE UNIVERSITY
Department of Biomedical Engineering, School of Engineering
Ph.D. GUIDANCE COMMITTEE

Name: _____ Date: _____
Last First Middle

CASE FACULTY/ ADJUNCT

NAME	PRIMARY DEPT	Case BME Position	SIGNATURE
Academic Advisor¹:			
Research Advisor²:			
External Member³:			
Other Members:			
Thesis Committee Chair^{1,4}			

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)

NAME	INSTITUTION	TITLE	SIGNATURE

Approved by:

 Associate Chair of
 Graduate Programs

 Dean

 Date

 Date

M.S.
 Ph.D.

4.3. Appendix III: BME Graduation Information Form

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 Ph.D. dissertation or M.S. thesis:

Student signature: _____

Academic advisor (typed): _____

Academic advisor (signature): _____

Research advisor (typed): _____

Research advisor (signature): _____

4.4. 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

4.5. 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. Pre-Approved Biomedical Science Courses

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

2. Pre-Approved Statistics/Mathematical Science Courses

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

3. Pre-Approved Engineering Courses by Research Discipline

3.1 Biomaterials and Tissue Engineering “Engineering Concentration” Courses

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

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

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. Pre-Approved “Breadth” Courses

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 454	Introduction to Grant and Fellowship Writing
EBME 515	Grant Writing II
EBME 570	Graduate Professional Development for Biomedical Engineers
EBME 440	Translational Research
IBMS 500	On Being a Professional Scientist: The Responsible Conduct of Research

4.6. Appendix VI: Canvas form for Committee Meetings or Research Proposal Defense



EVENT: _____
Indicate R21 Research Proposal Defense or Committee Meeting

STUDENT NAME: _____

ACADEMIC ADVISOR: _____

THESIS COMMITTEE CHAIR: _____

DATE OF EVENT: _____ **PASS/FAIL:** _____

For R21, signatures indicate that the student has met the requirements of:

- Demonstration of sufficient biology/life science content
- Demonstration of sufficient engineering content
- Demonstration of the ability to form and test a hypothesis

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)

Additional Member(s)

Additional Member(s)

Uploaded the signed and completed form in the assignment section on Canvas (canvas.case.edu) for the appropriate event.

4.7. Appendix VII: Ph.D. Advancement to Candidacy Form



Advancement to Candidacy

When a Ph.D. student has successfully passed all examinations and met all departmental requirements, the student is advanced to candidacy and may begin 701 research registration. The School of Graduate Studies must be notified when a student advances to candidacy using this form.

Once registration for 701 research begins, the student must register for at least one (1) credit hour of 701 every semester until graduation.

Name _____ SIS ID Number _____

CWRU Email _____ Phone _____

Department/Program _____

Date of Advancement/Qualifying Exam Passed _____

The above named student has met all departmental requirements to advance to candidacy.

Signatures

Print Name of Research Advisor _____

Research Advisor _____ Date _____

Department Chair/Program Director _____ Date _____

For Graduate Studies Use Only

Date Posted _____ Initials _____