POLICIES AND REGULATIONS

Governing PhD Students in the Department of Biomedical Engineering

2017-2018
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PhD Checklist
POLICIES AND REGULATIONS
FOR PhD STUDENTS
IN BIOMEDICAL ENGINEERING

1. REGISTRATION

All graduate students are matriculated into the Washington University Graduate School ([http://graduateschool.wustl.edu/](http://graduateschool.wustl.edu/)). Registration takes place each semester on dates announced by the University. Detailed instructions for registration plus necessary materials are mailed directly to all graduate students enrolled during the previous semester.

All graduate students pursuing a degree in the department must register each semester until all degree requirements are completed. Students register in courses and/or research units until they have earned the total number of credits required for their degree. PhD students register for nine credits of courses and/or research each semester until 72 credits are completed. After earning the required number of credits and fulfilling the course degree requirements, the student requests registration from their adviser or the Doctoral Student Administrator for one of the following:

LGS GSAS 9000
LGS GSAS 9001

LGS GSAS 9000 - Full-time Graduate Research/Study that indicates the student's full-time engagement in research or academic writing until graduation. Students will be administratively registered in LGS GSAS 9000 based on recommendations from their advisers stating that the students are making satisfactory progress toward their degrees.

LGS GSAS 9001 - During a student's period of regular registration, they may have a need or opportunity to study away from Washington University. Recommendations from departments for students' registration in absentia will be considered by the Graduate School on
a case-by-case basis. If approved by the Graduate School, these students will be registered for LGS GSAS 9001 Full-time Graduate Study in Absentia. Students may be allowed to register for LGS GSAS 9001 for up to four consecutive or non-consecutive fall/spring semesters. Semesters in which a student is registered in absentia are counted as part of the student's program length.

Full-time students registered within the program and making satisfactory academic progress are eligible to receive a stipend, tuition remission, and the health insurance and wellness fee subsidies. Tuition each semester will be calculated based on the number of registered course units.

**Inactive:** Students who have not completed their course requirements but who, because of personal reasons, must suspend their studies may request a leave of absence with the approval of their adviser, the Director of Doctoral Studies and the Graduate School. See the Graduate School website on leaves for further information - http://graduateschool.wustl.edu/current_students/leaves.

Students who fail to register in one of the previously mentioned categories will automatically have their graduate standing revoked. See the Graduate School Bulletin for further information.

2. **ADVISING**

**Academic Adviser:** Each entering graduate student is assigned to the Director of Doctoral Studies as their academic adviser. After students pass their qualifying exams, their academic advisers switch to their thesis research mentor unless they move to a lab outside of BME, in which case the Director of Doctoral Studies will remain their academic adviser.

**Rotation and Research Mentors:** Each PhD student is required to participate in at least one research rotation. A research thesis
completed as part of a Master’s degree at another institution or at Washington University, may count as one rotation. Rotations typically consist of contiguous periods of independent research in a mentor’s laboratory, typically 8-12 weeks of research effort corresponding to 15-20 hours weekly. Rotations serve two primary purposes for students: to inform students in their choice of a doctoral research mentor and research project, and to gain skills and knowledge in the conduct of laboratory research. Each rotation will have a rotation mentor who is an Affiliated Faculty member of the BME department. Please see the department website for current members of the Graduate Group [https://bme.wustl.edu/research/areas/Pages/default.aspx](https://bme.wustl.edu/research/areas/Pages/default.aspx). Within each ‘Research Area’, the Graduate Group-consists of both the ‘Primary’ and ‘Affiliated’ Faculty. The ‘Primary’ faculty are tenured/tenure track BME faculty listed here: [https://bme.wustl.edu/faculty/Pages/default.aspx](https://bme.wustl.edu/faculty/Pages/default.aspx). For the full list of affiliated BME faculty, go to [https://bme.wustl.edu/faculty/Pages/affiliated-faculty.aspx](https://bme.wustl.edu/faculty/Pages/affiliated-faculty.aspx).

Only members of the Graduate Group may be research mentors. The rotation mentor will be responsible for outlining the student’s project, as well as reviewing and approving the student’s report at the end of the rotation. If a PhD student has already been accepted as a continuing student into the research team of a member of the Graduate Group, the student may indicate their commitment through communication with the Director of Doctoral Studies followed by a verification with the thesis research mentor. The student indicating continuing status in a mentor’s laboratory, is eligible to take their Qualifying exam at any point in order to qualify for doctoral candidate status, but no later than June 30 after the end of the first academic year.

The choice of a research mentor and an appropriate thesis project will have a profound effect on the career of a PhD student. To aid the PhD student in these decisions, the following procedures are in place:
i. Rotation Preference Sheets
At the start of the academic year, the Graduate Group faculty will be invited to meet entering graduate students to discuss their research programs. It is the responsibility of the student to request the opportunity for a research rotation with the proposed mentor, to determine if there is sufficient overlap in interests, as well as adequate space and resources to support the student throughout the rotation period. For each rotation, the student will submit a Rotation Preference Sheet to the Director of Doctoral Studies identifying his/her first, second, and third choice of the labs in which to do rotations. The Director of Doctoral Studies is available to discuss the process of selecting research rotation mentors during orientation and throughout the first year as students’ progress through their rotations.

ii. Rotation Selection
It is the responsibility of the student to update the Rotation Preference Sheet periodically in consultation with the Director of Doctoral studies and the Doctoral Student Administrator. All grades for each research rotation will be filed by the Director of Doctoral Studies based on communications about research rotation preferences, reports and evaluations.

iii. Rotation requirements
Each student will complete at least one rotation during their first academic year in the program. Rotations consist of contiguous periods of independent research in a mentor’s laboratory, typically 8-12 weeks of research effort corresponding to 15-20 hours weekly. Rotations may coincide with the fall and spring semesters; however, students are encouraged to seek a new rotation upon natural completion of their current research rotation. In practice, students may begin new research rotations at several intervals, but they must consult the Director of Doctoral Studies when doing so. Typically students will spend at least 15-20 hours/week on rotations while classes are in session and at least 40 hours/week when classes are not in session. For each rotation, students will register for three units
of BME 601C 30 that is led by the Director of Doctoral Studies. A rotation report is due at the end of each rotation (see PhD checklist for relevant dates). The rotation report is the primary basis for the grade assigned for the rotation. Because PhD students do not register for courses in the summer, any rotation outside of the fall or spring semester is not taken for credit or as a course.

iv. Selection of a thesis research mentor
At the end of each rotation, the rotation mentor will complete an evaluation of the student. These evaluations will become part of the student’s permanent file and will be considered by the qualifying exam committee during the qualifying examination (see Section 3.3). Students normally complete all rotations and identify a thesis research mentor from amongst their research rotation mentors by the end of the second semester. If this is not practical, students must identify a thesis research mentor by the end of their first 12 months in the PhD program. The student’s thesis research mentor (also called “doctoral adviser”) will usually be one of his/her rotation mentors. The thesis research mentor must be a BME Graduate Group faculty member. The faculty member must agree to be the research mentor through an approval process initiated by the Doctoral Student Administrator. Selecting a research lab for pursuit of doctoral research is a process involving close communication between the proposed mentor and student, and that communication should begin early and be ongoing throughout the research rotation.

At any point, if the student and mentor agree that the student will continue his/her doctoral research in the mentor’s lab beginning January 1 of the first academic year (i.e., the rotation mentor is selected as the thesis research mentor), then the student must inform the Director of Doctoral Studies of his/her intent to do so. In this case, the student should take the qualifying exam at any time when they are ready but no later than June 30 of the first academic year (see PhD checklist for relevant dates).
v. Qualifying Examination Committee
After no less than one complete research rotation, the student may elect to stand for the Qualifying Examination. At that time, the student is to discuss a suggested three-member committee (see Section 3.3) with his/her thesis research mentor via written communication (email is typical). The thesis research mentor will confirm that the composition of the committee conforms to the departmental requirements at the time of signing the qualifying exam form. The student will also collaborate with the thesis research mentor to identify three areas of core knowledge considered essential to pursuit of doctoral research in the mentor’s laboratory. These areas of knowledge will serve, in part, as the basis for questioning during the qualifying examination. The student or the thesis research mentor is then cleared to send an invitation to the committee members to participate in the qualifying examination of the student (see Section 3.3). The committee members must be qualified to examine the quality of the research performed during the chosen rotation. The proposed Qualifying Exam Committee member, the three areas of core knowledge considered essential to pursuit of doctoral research in the mentor’s laboratory and proposed qualifying exam date will be submitted to the Doctoral Student Administrator for approval by the Director of Doctoral Studies. The qualifying exam is typically completed by June 30 after the end of the first academic year in order to transition to doctoral candidate status; the student must stand for the qualifying exam no later than the end of the first 12 months in the program. Completion of the qualifying exam is accompanied by a Qualifying Exam Report Form signed by all committee members indicating the outcome and recommendations for further action. This Qualifying Exam Report Form must be returned to the Doctoral Student Administrator for approval by the Director of Doctoral Studies and submission to the Graduate School.

vi. Thesis Committee
Each PhD student will have a thesis committee approved by the Director of Doctoral Studies that will be chaired by the thesis research mentor. The dissertation (thesis) subject must be approved by a
Research Advisory Committee (also called “Dissertation Defense Committee”), and this approval is obtained by successfully passing the thesis proposal. The Research Advisory Committee monitors the dissertation via a successful dissertation defense. The Research Advisory Committee must follow all guidelines of the Graduate School and consist of five members (the thesis research mentor plus four other members) that meet the following requirements:

Members 1 – 3
   BME ‘Primary’ faculty
   https://bme.wustl.edu/faculty/Pages/default.aspx
   or ‘Affiliated’ faculty
   https://bme.wustl.edu/faculty/Pages/affiliated-faculty.aspx
   *(At least one of the three members must be a primary BME faculty member).*

Member 4
   Faculty inside or outside the BME program (use links above for faculty inside the program).

Member 5
   Faculty (or scholar in private sector or government) outside the BME program.

Additional requirements:
   (i) One of the five members must be from the Washington University School of Medicine (may be in the Graduate Group but not required)
   (ii) Four of the five members must be tenured or tenure-track at Washington University; if tenured/tenure-track at Washington University, he/she must have a doctoral degree and be research active.

Upon completion of the qualifying examination, the student will be invited to submit a Dissertation Defense Committee Form (available at the Graduate School and BME website) to the Director of Doctoral Studies for approval. Following approval, the Form is submitted to the Graduate School. The student can then interact and invite the committee members to participate in his/her Research Advisory or Dissertation Defense Committee. Any subsequent changes to the Research Advisory Committee
involve completing a new Dissertation Defense Committee Form and submitting it to the Director of Doctoral Studies for approval.

3. DOCTOR OF PHILOSOPHY (PHD) DEGREE REQUIREMENTS

3.1 Academic Requirements
Candidates for this degree must complete a total of 72 credits beyond the bachelor’s degree. Of these, a minimum of 36 must be graded graduate coursework and a minimum of 24 must be thesis research (i.e. BME 600). The coursework must fulfill the core curriculum requirement (see Section 4). To be admitted to candidacy, the student must have completed at least 18 credits at Washington University, have an overall GPA greater than 3.0, and pass the qualifying examination as described below. He/she must also have completed the research rotations.

3.2 Research Rotation Reports
Within three weeks of the end of each rotation, the student will submit a document to the rotation mentor satisfying one of the following two options:

(i) Write a report on the research conducted by the student during the rotation. The report should be written in the form of a standard research article and it must include the following: a) student’s name; b) title of report; c) semester/year of the rotation; d) rotation mentor’s name; and e) date of report. This document should be double-spaced. Although there is no page limitation, the report should be concise and paginated. If the project has not been completed, preliminary or partial results are to be described. It is recommended that this document contain the following sections:

Abstract. In one paragraph, summarize the objectives, methods, main results and conclusions.
Introduction: Describe the motivation for and objectives of the research.
Methods. Give the details of the procedures and calculations.
Results. Describe the results of the study, referring to graphs, tables and illustrations by number.

Discussion. List the main findings and put them in the context of previously-published research on the topic. Discuss the meaning and implications of your results, any surprising findings, sources of error, limitations, etc. Support any assertions by referring to specific data or previously-published research.

References. List pertinent articles using appropriate citation formatting.

(ii) If insufficient data exists for a research report, the student may alternatively write a critical review of a published research article selected by the mentor. This journal article should not be a review article and none of the authors can be associated with Washington University. The review should be no longer than 20 pages of double-spaced text (12 point type with one-inch margins), excluding figures. It is recommended that this review contain the following sections:

Questions addressed. Identify the key questions addressed and the reasons for examining them.

Background. Discuss the most significant relevant research that had been published prior to this article.

Critical Appraisal. Discuss the author’s approach and contribution to the solution of the questions listed above. Compare the author’s approach and contribution to those of previous investigators.

Proposal for additional research. In concrete terms, propose research that might be done to extend and (if necessary) improve upon the study.

References. List pertinent additional articles using appropriate citation formatting.

In both cases, the rotation mentor must approve the report by personally emailing the report (including the selected article for option (ii)) to the Doctoral Student Administrator (see PhD checklist for relevant dates). All rotation reports must be submitted prior to the qualifying exam. A grade for the rotation cannot be assigned.
until after the rotation report is submitted to the Doctoral Student Administrator.

3.3 Qualifying Examination:
Because PhD is primarily a research degree, the qualifying examination is designed to assess the candidate’s aptitude for independent research. After the rotation reports have been submitted to the Doctoral Student Administrator, the student will select one of the rotation documents as the basis for the qualifying examination. **The student must have a minimum GPA of 3.00 to stand for the qualifying examination.**

In consultation with the student, the chosen thesis research mentor will select the members of the qualifying examination committee from a list of faculty members suggested by the student at least one month before the end of the last rotation (see PhD checklist). This committee will consist of three faculty members, excluding the research rotation mentor, and shall have at least one primary faculty member of the BME department and two tenured/tenure-track faculty members of Washington University. Approval of the composition of the qualifying examination committee is denoted by completion and signing of the Proposed Qualifying Examination Committee Form.

As part of the qualifying examination, the student is required to identify three areas of core knowledge that will be essential to the successful completion of his/her doctoral research. These areas of knowledge can be obtained through literature review, independent study, or coursework. It is recommended that these areas of core knowledge be identified in consultation with the thesis research mentor at the beginning of the research rotation although they are not required until the formation of the qualifying examination committee. When the student suggests whom to serve on the qualifying examination committee, he/she should consider those faculty members with expertise in these areas of core knowledge.
After the committee is approved by the thesis research mentor, the student is responsible for scheduling the date and time of the exam with the committee members (allowing 2 hours for the exam). The rotation mentor may attend the exam but cannot ask or answer any questions (except to clarify points of confusion) and cannot vote. Copies of the rotation report to be used for examination are to be distributed to the members of qualifying examination committee by the student at least two weeks before the date of the exam. The committee will review the qualifying examination report along with the student’s transcript and the rotation mentors’ evaluations. Failure to submit the qualifying examination report to the committee two weeks prior to the exam is grounds for cancellation or postponement of the examination at the discretion of the Director of Doctoral Studies. A student whose exam is cancelled automatically fails the qualifying examination.

At the time of standing for the qualifying examination, the student will appear before the qualifying examination committee for an oral examination consisting of a brief presentation by the student and questions by the examining committee. The questions may address any issues directly related to the document or the oral presentation as well as the three areas of core knowledge considered essential to pursuit of doctoral research in the mentor’s laboratory. The student may use visual aids or other devices to present a summary of his/her qualifying exam document, i.e., the selected rotation report.

Considering the performance on the oral examination, the written report, the evaluations from all the rotation mentors, the student’s coursework, and the student’s GPA, the qualifying examination committee will recommend that:

- The student passes the qualifying examination.
- The student must retake the examination.
- The student must successfully pass specified remedial courses or other requirements specified by the committee to pass the qualifying examination.
The student fails the examination and is asked to leave the PhD program.

Conclusion of a qualifying examination is denoted by a Qualifying Examination Report Form indicating one of the above determinations with suggestions for future direction. The form must be signed by all members of the qualifying examination committee, provided to the Doctoral Student Administrator, and approved by the Director of Doctoral Studies for the student’s record.

3.4 Thesis Proposal
Following successful completion of the qualifying examination, the student and thesis research mentor will decide upon a suitable problem whereupon the student will prepare a comprehensive written research proposal that includes a thorough survey of the field, a discussion of those areas needing further research, and a tentative but clear definition of the proposed research. Results of preliminary studies or feasibility studies should be included. This proposal will be submitted to the Research Advisory Committee (i.e., Dissertation Defense Committee, see Section 2.vi) at least two weeks prior to an oral presentation and questions before that committee. This should be completed by the end of the third year in the doctoral program. Completion of the thesis proposal presentation will be denoted by a Pass/Fail/Re-take designation on the Thesis Proposal Report Form signed by the Research Advisory Committee members.

The Research Advisory Committee must be formed and meet shortly after the student passes the qualifying examination in order to be prepared for the thesis proposal. The composition of the Research Advisory Committee may change as the research problem evolves; any changes to the composition of the Research Advisory Committee must be approved by the Director of Doctoral Studies as described in Section 2.vi.

The format of the written proposal will be similar to an NIH research proposal: (1) Specific Aims (1 page) (2) Research Strategy (6-12
pages max, single spaced, 11 point font, 0.5” margins). ‘Specific Aims’ are proposed tasks that address a hypothesis (question) or provide technical milestones. Each specific aim should be broad enough to result in one or more publications if successful. ‘Research Strategy’ should include the following sections: (a) Significance – why is the problem important, what has been done already, what part of the problem will be addressed in the dissertation, (b) Approach – describe in detail experiments/simulations to be performed or devices designed for each specific aim, including preliminary data, which may be unpublished or published by you or your lab, and methods. Ensure that proper controls are performed, and that the number of samples/experiments/simulations is sufficient to answer the question, but not greater than what can be accomplished by one person within a few years. Describe expected outcomes and plans to address pitfalls and complications.

3.5 Mentored Teaching Experience
After passing the qualifying examination but before the thesis defense, PhD students must fulfill a university-wide mentored teaching experience (MTE) in a BME or otherwise approved course. Students are required to have a mentored teaching experience for at least one semester, documented by registering for LGS GSAS 600 Mentored Teaching Experience. This is typically completed during the second year of doctoral training. Students may fulfill this requirement in many ways including

- giving lectures in undergraduate classes
- conducting discussion sessions in undergraduate classes
- conducting recitation sessions in undergraduate classes
- giving lectures in laboratory courses that introduce or interpret the experiments
- conducting help sessions in which the graduate student explains the background and methodology of engineering approaches (involving a lesson plan)
- Holding office hours
- Grading assignments or exams
PhD students are also required to deliver a minimum of four oral presentations at journal clubs, seminar series, scientific conferences, or retreats. Presentations given as part of the MTE, lab meetings, or thesis committee meetings will not satisfy this requirement. The student should document the fulfillment of this requirement and submit it to the thesis research mentor for approval. The approved document should then be submitted to the Doctoral Student Administrator.

In addition, PhD students must complete the MTE orientation in their second year of doctoral studies and attend two approved workshops conducted by the Teaching Center by the end of their third year of doctoral studies. Documentation of attendance by the Teaching Center will be used to verify this requirement. Information on the teaching training and workshops can be found at http://teachingcenter.wustl.edu/

3.6 Thesis Defense
Upon completion of the thesis, the PhD candidate must present the thesis in a public forum and successfully defend the thesis before a committee consisting of the approved Research Advisory Committee (i.e., the Dissertation Defense Committee) plus additional faculty as required. For PhD candidates, the Title, Scope and Procedure Form (see graduateschool.wustl.edu) must be registered in Graduate School at least six months before the dissertation examination, or by the end of the fourth year, whichever comes first. The dissertation must be approved by the Research Advisory Committee as part of the final examination. For the requirements for the composition of the Research Advisory Committee, please see Section 2.vi.

The student must not stand for the defense until after the acceptance of one paper in a peer-reviewed journal and should not stand for the defense before the submission of a second manuscript to a peer-reviewed journal.
4. COURSE SELECTION

Students formulate their course program in consultation with their academic advisor. A core curriculum is required to be completed by all PhD students. This core curriculum requires:

- One graduate course in the area of life science
- One graduate course in the area of mathematics
- One graduate course in the area of computer science or exemption by proficiency.
- Four BME courses as specified below.

The BME courses of the core curriculum are four courses from the list starting on next page. Other courses may fulfill this requirement and may be added to this list at the discretion of the Director of Doctoral Studies by petition of the student.

Up to six units of BME 601C Research Rotation and/or three units of BME 501 Graduate Seminar may be counted towards the 36 units of graduate coursework required for the PhD degree. Therefore, at least nine graduate courses (about 27 units), including the core curriculum that represents six to seven courses, are required for the PhD degree. Of these nine courses, up to two 400-level courses may be counted towards the coursework requirement (not including independent study courses, journal clubs or seminar-based courses).

Graduate courses may be transferred in (up to 24 units) but must be evaluated and approved by the Director of Doctoral Studies. Up to three units of research rotation credit will be assigned for completion of a thesis at the Master’s level. The evaluation and approval may occur at any time but course transfer does not become official until after one year in residence at Washington University.

Courses that fulfill the BME requirement

BIOL 5146    Principles and Applications of Biological Imaging
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>BIOL 5311</td>
<td>Dynamics in Mesoscopic Molecular Systems</td>
</tr>
<tr>
<td>BIOL 5312</td>
<td>Macromolecular Interactions</td>
</tr>
<tr>
<td>BME 422</td>
<td>Kinetic in Cell Signaling and Metabolism</td>
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<tr>
<td>BME 471</td>
<td>Bioelectric Phenomena</td>
</tr>
<tr>
<td>BME 502</td>
<td>Cardiovascular MRI</td>
</tr>
<tr>
<td>BME 507</td>
<td>Radiological Physics and Dosimetry</td>
</tr>
<tr>
<td>BME 5071</td>
<td>Radiobiology</td>
</tr>
<tr>
<td>BME 5072</td>
<td>Radiation Oncology Physics</td>
</tr>
<tr>
<td>BME 5073</td>
<td>Radiation Protection and Safety</td>
</tr>
<tr>
<td>BME 511</td>
<td>Biotechnology Techniques for Engineers</td>
</tr>
<tr>
<td>BME 521</td>
<td>Kinetics of Receptor-Mediated Processes</td>
</tr>
<tr>
<td>BME 523</td>
<td>Biomaterials Science</td>
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<tr>
<td>BME 524</td>
<td>Tissue Engineering</td>
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<tr>
<td>BME 525</td>
<td>Engineering Aspects of Biotechnology</td>
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<tr>
<td>BME 527</td>
<td>Design of Artificial Organs</td>
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<tr>
<td>BME 533</td>
<td>Biomedical Signal Processing</td>
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<tr>
<td>BME 537</td>
<td>Computational Molecular Biology</td>
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<tr>
<td>BME 541</td>
<td>High Throughput Systems Biology</td>
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<tr>
<td>BME 556</td>
<td>Experimental Methods in Biomechanics</td>
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<tr>
<td>BME 557</td>
<td>Cell and Subcellular Biomechanics</td>
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<tr>
<td>BME 558</td>
<td>Biological Transport</td>
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<tr>
<td>BME 559</td>
<td>Intermediate Biomechanics</td>
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<tr>
<td>BME 5610</td>
<td>Protein Structures and Dynamics</td>
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<tr>
<td>BME 562</td>
<td>Mechanics of Growth and Development</td>
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<tr>
<td>BME 563</td>
<td>Orthopedic Biomechanics – Bones and Joints</td>
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<tr>
<td>BME 564</td>
<td>Orthopedic Biomechanics – Cartilage/Tendon</td>
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<tr>
<td>BME 567</td>
<td>Cardiac Mechanics</td>
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<td>BME 568</td>
<td>Cardiovascular Dynamics</td>
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<tr>
<td>BME 572</td>
<td>Biological Neural Computation</td>
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<tr>
<td>BME 573</td>
<td>Applied Bioelectricity</td>
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<tr>
<td>BME 574</td>
<td>Quantitative Bioelectricity and Cardiac Excitation</td>
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<tr>
<td>BME 575</td>
<td>Molecular Basis of Bioelectrical Excitation</td>
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<td>BME 589</td>
<td>Biological Imaging Technology</td>
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<tr>
<td>BME 5901</td>
<td>Integrative Cardiac Electrophysiology</td>
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<td>BME 5903</td>
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<tr>
<td>BME 5907</td>
<td>Advanced Concepts in Image Science</td>
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<tr>
<td>BME 591</td>
<td>Biomedical Optics I: Principles</td>
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<tr>
<td>BME 5910</td>
<td>Reverse Engineering the Human Brain</td>
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<tr>
<td>BME 5913</td>
<td>Molecular Systems Biology: Computation &amp; Measurements for Understanding Cell Physiology and Disease</td>
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<tr>
<td>BME 592</td>
<td>Biomedical Optics II: Imaging</td>
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<tr>
<td>BME 593</td>
<td>Computational Methods for Inverse Problems</td>
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<td>BME 594</td>
<td>Ultrasound Imaging</td>
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<td>ESE 438</td>
<td>Applied Optics</td>
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<td>ESE 482</td>
<td>Digital Signal Processing</td>
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<td>ESE 588</td>
<td>Quantitative Image Processing</td>
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<tr>
<td>MEMS 5560</td>
<td>Interfaces and Attachments in Natural and Engineered Structures</td>
</tr>
<tr>
<td>MEMS 5607</td>
<td>Introduction to Polymer Science &amp; Engineering</td>
</tr>
<tr>
<td>PSYCH 4450</td>
<td>Functional Neuroimaging Methods</td>
</tr>
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**Courses that fulfill the life science requirement**

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<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>BIOL 404</td>
<td>Laboratory of Neurophysiology</td>
</tr>
<tr>
<td>BIOL 4071</td>
<td>Developmental Biology</td>
</tr>
<tr>
<td>BIOL 4810</td>
<td>Biochemistry</td>
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<tr>
<td>BIOL 5051</td>
<td>Foundations in Immunology (4 units)</td>
</tr>
<tr>
<td>BIOL 5062</td>
<td>Central Questions in Cell Biology</td>
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<tr>
<td>BIOL 5068</td>
<td>Fundamentals of Molecular Cell Biology</td>
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<tr>
<td>BIOL 5224</td>
<td>Molecular, Cell, and Organ Systems</td>
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<tr>
<td>BIOL 5285</td>
<td>Fundamentals of Mammalian Genetics</td>
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<tr>
<td>BIOL 5319</td>
<td>Molecular Foundations of Medicine</td>
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<tr>
<td>BIOL 5352</td>
<td>Developmental Biology</td>
</tr>
<tr>
<td>BIOL 5357</td>
<td>Chemistry and Physics of Biomolecules</td>
</tr>
<tr>
<td>BIOL 548</td>
<td>Nucleic Acids and Protein Biosynthesis</td>
</tr>
<tr>
<td>BIOL 5488</td>
<td>Genomics</td>
</tr>
<tr>
<td>BIOL 5571</td>
<td>Cellular Neurobiology (4 units)</td>
</tr>
</tbody>
</table>
BIOL 5581  Neural Basis of Acoustic Communication  
BIOL 5651  Neural Systems (6 units)  
BIOL 5663  Neurobiology of Disease  

BME 503A  Cell & Organ Systems  
BME 530A  Molecular Cell Biology for Engineers  
BME 538  Cell Signal Transduction  
BME 5902  Cellular Neurophysiology  
BME 5909  Physiology of the Heart  

Courses that fulfill the mathematics requirement  

BME 5912  Applied Mathematics for Biomedical Sciences  
ESE 502  Mathematics of Modern Eng. II  
ESE 517  Partial Differential Equations  
ESE 520  Probability and Stochastic Processes  
MATH 449  Numerical Applied Mathematics  
PHY501  Methods of Theoretical Physics I  
PHY502  Methods of Theoretical Physics II  
PHY503  Advanced Math Methods for Physicist & Eng. I  
PHY504  Advanced Math Methods for Physicist & Eng. II  

Courses that fulfill the computer science requirement*  

BME 550  Numerical Methods for Computational Modeling in Biomedicine  
CSE 501N  Programming Concepts and Practice  
CSE 502N  Fundamentals of Computer Science  
CSE 504N  Object-oriented Software Development Lab  
CSE 511A  Introduction to Artificial Intelligence
CSE 515T  Bayesian Methods in Machine Learning
CSE 517  Machine Learning
CSE 5411  Advanced Algorithms
CSE 543T  Algorithms for Nonlinear Optimization
CSE 554A  Geometric Computing for Biomedicine
CSE 555  Computational Photography
CSE 559A  Computer Vision
CSE 587A  Algorithms for Computational Biology

MEMS 5515  Numerical Simulation in Solid Mechanics I

* The computer science requirement may also be fulfilled by petition to the Director of Doctoral Studies documenting at least one undergraduate course in computer programming and an example of the original code written by the student.

Additional courses may fulfill the life science, mathematics or computer science requirements, dependent upon your background and at the discretion of the Director of Doctoral Studies with consultation with the thesis research mentor.

The normal load for a PhD student is nine to ten credits per semester. Students will be graded for a three-unit course for each semester on which they engage in research rotations; typically, any three-unit course is expected to require nine total hours per week of course-related activity. In practice, research rotations consist of at least 15-20 hours per week in the laboratory during the period in which classes are in session. This is considered the minimum necessary research activity in order to be successful in the rotation.

Following selection of the thesis research mentor, the student should choose the remaining coursework in consultation with the thesis research mentor.
All PhD degrees awarded by Washington University are awarded through the Graduate School. For additional requirements for the PhD degree, see the Graduate School Bulletin: http://graduateschool.wustl.edu/current_students/degree-requirements

5. FINANCIAL ASSISTANCE

Graduate students pursuing doctoral research in the department will normally receive some form of support for stipend and tuition remission during their enrollment as full-time students. Academic achievements and satisfactory performance in research and other assignments while at Washington University are the primary factors governing continuation of financial assistance. Students who are placed on academic suspension will automatically have their financial assistance canceled, effective with the date of suspension. (For the regulations governing academic probation and suspension, please refer to the Graduate School website, http://graduateschool.wustl.edu/files/graduateschool/imce/revised_approved_policy_on_probation_and_dismissal_for_academic_reasons_5.16.17.pdf)

5.1 Types of Awards
There are four types of financial assistance awards available to graduate students in the department:

a. Fellowships
Fellowships are grants generally providing full tuition plus a stipend.

Fellowship funds may derive from government or private sources. They may be administered by the department or they may be awarded directly to the student by an external agency, e.g., the National Science Foundation. (In the case of NSF, Hertz, DOD, DOE, UNCF or similar fellowships, students must apply directly to the foundation and notify the Doctoral Student Administrator in compliance with the federal guidelines).
b. **Traineeships**
Traineeships may be funded by the School of Engineering & Applied Science or the School of Medicine, administered by the departmental chair, or associated with specialized externally-sponsored training grants. In the latter case, the traineeship has a definite term (9 or 12 months) and is generally renewable depending upon academic performance and continuation of the grant. Holders of such traineeships are normally obliged to follow a course program specified by the particular training grant.

Traineeships funded by the university are normally awarded through a competitive evaluation process. They provide a component of tuition remission per semester plus a stipend. Students must apply directly to the training grant program upon recommendation of the thesis research mentor and must notify the Doctoral Student Administrator of any decision for traineeship support.

c. **Mentored Teaching Experiences**
Mentored teaching experiences are funded by the department. They are normally awarded to students who have expressed an interest in a teaching career and who have acceptable English language skills.

The duties of the assistant to the instructor are similar to the teaching requirement with the following exceptions. An assistant to the instructor normally includes the grading of papers, laboratory reports, and/or laboratory supervision in undergraduate courses. Those requesting a teaching assistantship must apply for the position and applications will be accepted from PhD students, MSc students and post-docs. Matches are made by the Doctoral Student Administrator and assistant to the instructor are responsible to the professors in charge of the various courses and laboratories.

The average time is not to exceed 20 hours per week.
d. Research Assistantships
Research assistantships generally provide a stipend and some tuition from government or industry grants and contracts. They are normally awarded to students who have advanced to candidacy and made a commitment to a particular research area and who, by virtue of their academic background and record, satisfy a particular project’s needs.

Research assistantships may be supplemented by tuition scholarships that may be funded jointly by the School of Engineering & Applied Science and the School of Medicine. Research assistants are responsible to the project director (principal investigator) of the project. (Generally, this same individual eventually assumes the additional role of thesis or dissertation mentor.)

5.2 Outside Employment
Holders of fellowships, traineeships and assistantships are required to devote their 100% effort to graduate studies. They are not permitted to engage in any outside employment without special permission of the Director of Doctoral Studies and the BME Department Chair.

External Professional Activity for Full-Time PhD Students in SEAS
If approved by their thesis research mentor in writing, doctoral students may engage in limited external professional activity. Student groups that provide consulting services are also included, and acceptance of a project through these organizations must be approved by the thesis research mentor and the Director of Doctoral Studies. Any professional activity associated with a faculty member's personal company or affiliated companies must follow all the guidelines and be reviewed by the university's Conflict of Interest Review Committee (CIRC). Any proposed activity outside of the engagement of research must be disclosed before the activity may begin.

It is expected that external professional activity will be conducted in a way that will not interfere with their research as part of the research assistantship, nor impede in any manner progress toward completion
of the doctoral degree. International students will also have to receive approval from the university's Office for International Students and Scholars. The Research Advisory Committee must be informed and routinely updated on all external professional activities. Departments may have additional oversight, guidelines and restrictions for their own doctoral students' involvement in external professional activity.

5.3 Time Off
Graduate students receiving awards are expected to commit themselves fully to their studies and research regardless of whether classes are in session. Intersession periods listed in the University Academic Calendar denote times when classes are not in session. Graduate students in residence should, however, utilize these periods to further their studies and research. Intersession periods are not time off for graduate students receiving a stipend and students are expected to learn full time on research during these periods.

Students on full stipend are permitted to stop their studies and research for a maximum of two weeks during the calendar year. In addition, students are permitted to take the university scheduled holidays. Additional time off can be arranged but must be approved ahead of time by the research mentor (once selected) or the Director of Doctoral Studies (before the selection of a research mentor). Absences of research assistants must be scheduled so as not to impede the progress of an ongoing research project and should be cleared with the research mentor.

6. OTHER POLICIES

6.1 Seminars
Each year the department sponsors or participates in a series of seminars by visiting lecturers or Washington University faculty and students. All full-time graduate students are required to enroll in BME 501 Graduate Seminar, which is a pass/fail course carrying zero or one unit (BME 501 for 0 unit and BME 501C for 1 credit). A passing
grade is required for each semester for all full-time students and is earned by regular attendance at these events. Up to three units of BME 501 Graduate Seminar may be counted towards the 36 units of graduate coursework required for the PhD degree. For one unit of credit, the student must also submit to the Doctoral Student Administrator a two-page critique of a research paper (not a review article) written by one of the seminar speakers. This critique will be reviewed and graded by the Director of Doctoral Studies. First year students should take BME 501 for zero unit until they find a research lab for thesis research.

6.2 Secretarial Service
Department secretaries do not generally provide clerical services to graduate students except in connection with scheduled courses, student groups, and sponsored research projects.

6.3 Copying Service
Graduate students may not charge copying services to the department or a research project without prior authorization. Personal copies can be charged to a student’s personal account. The cost of copying dissertations is considered a personal obligation.
This is a compilation of policies and regulations applicable to the graduate students in the Department of Biomedical Engineering. Students should also become familiar with the general regulations of the Graduate School of Arts & Sciences as described in the school’s website at http://artsci.wustl.edu/GSAS and School of Engineering & Applied Science as described in the school’s web site: engineering.wustl.edu

Department of Biomedical Engineering
Washington University in St. Louis
Whitaker Hall
One Brookings Drive, Campus Box 1097
St. Louis, MO 63130-4899

**Director of Doctoral Studies**
Jin-Yu Shao, PhD
Whitaker Hall 290E
314-935-7467
E-Mail: shao@wustl.edu

**Doctoral Student Administrator**
Suesy Seel
Whitaker Hall 300D
314-935-2720
E-mail: susanseel@wustl.edu
## PhD Checklist

<table>
<thead>
<tr>
<th>Completed</th>
<th>Item</th>
<th>Due Date</th>
<th>Submit to</th>
</tr>
</thead>
<tbody>
<tr>
<td>_________</td>
<td>Rotation Preference Form</td>
<td>Friday first week of classes</td>
<td>Director of Doctoral Studies</td>
</tr>
<tr>
<td>_________</td>
<td>1st Rotation Report <em>(signed by mentor)</em></td>
<td>Dec 15 or 2 weeks after end of rotation</td>
<td>Doctoral Student Administrator</td>
</tr>
<tr>
<td>_________</td>
<td>2nd Rotation Report *(optional) <em>(signed by mentor)</em></td>
<td>May 15 or 2 weeks after end of rotation</td>
<td>Doctoral Student Administrator</td>
</tr>
<tr>
<td>_________</td>
<td>3rd Rotation Report *(optional) <em>(signed by mentor)</em></td>
<td>Aug 1 or 2 weeks after end of rotation</td>
<td>Doctoral Student Administrator</td>
</tr>
<tr>
<td>_________</td>
<td><strong>Submit First Year Progress Update form each semester.</strong></td>
<td>1 rotation – Dec 1</td>
<td>Doctoral Student Administrator</td>
</tr>
<tr>
<td>_________</td>
<td><strong>Schedule exam as soon as your committee is approved by research mentor</strong></td>
<td>2 rotations – April 1</td>
<td>Doctoral Student Administrator</td>
</tr>
<tr>
<td>_________</td>
<td>3 rotations - July 1</td>
<td>3 rotations - July 1</td>
<td>Doctoral Student Administrator</td>
</tr>
<tr>
<td>_________</td>
<td>Rotation report for qualifying examination</td>
<td>2 weeks prior to exam date</td>
<td>Qualifying Exam Committee</td>
</tr>
<tr>
<td>_________</td>
<td>Qualifying Exam Completed</td>
<td>1 or 2 rotations –</td>
<td>Doctoral Student Administrator</td>
</tr>
<tr>
<td>_________</td>
<td><strong>Submit Qualifying Examination Report – Doctor of Philosophy (Form signed by committee)</strong></td>
<td>June 30</td>
<td>Doctoral Student Administrator</td>
</tr>
<tr>
<td>_________</td>
<td>Proposed Thesis Committee</td>
<td>End of 2nd year</td>
<td>Director of Doctoral Studies &amp; Doctoral Student Administrator</td>
</tr>
<tr>
<td>_________</td>
<td>Attended MTE Orientation and completed LGS GSAS 600</td>
<td>End of 2nd year</td>
<td>Doctoral Student Administrator</td>
</tr>
<tr>
<td>_________</td>
<td>Attended two MTE Workshops</td>
<td>End of 3rd year</td>
<td>Doctoral Student Administrator</td>
</tr>
</tbody>
</table>

Checklist continued on page 30
<table>
<thead>
<tr>
<th>Requirement</th>
<th>Target Date</th>
<th>Responsible Party</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teaching Requirement (oral presentations)</td>
<td>Immediately upon completion of requirement</td>
<td>Doctoral Student Administrator</td>
</tr>
<tr>
<td><strong>Submit Teaching Requirement Fulfillment form (signed by the thesis research mentor)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thesis Proposal Scheduled</td>
<td>June 1 (of 3rd year)</td>
<td>Director of Doctoral Studies &amp; Doctoral Student Administrator</td>
</tr>
<tr>
<td>Thesis Proposal (Written) Completed</td>
<td>2 weeks prior to proposal date of June 30th of 3rd year (whichever is earlier)</td>
<td>Thesis Proposal Committee</td>
</tr>
<tr>
<td>Thesis Proposal (Oral) Completed</td>
<td>August 31 (of 3rd year) or 12 months prior to defense (whichever is earlier)</td>
<td>Doctoral Student Administrator</td>
</tr>
<tr>
<td><strong>Title, Scope and Procedure</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Submit Title, Scope &amp; Procedure form signed by committee</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual update with Thesis Committee</td>
<td>Meet at least once every 12 months with committee members</td>
<td></td>
</tr>
<tr>
<td>Denote peer-reviewed paper acceptances</td>
<td></td>
<td>PI and Doctoral Student Administrator</td>
</tr>
<tr>
<td>Schedule thesis defense</td>
<td>2-3 months prior to date</td>
<td>Director of Doctoral Studies &amp; Doctoral Student Administrator</td>
</tr>
<tr>
<td>Submit Thesis</td>
<td>2-4 weeks prior to date</td>
<td>Thesis Committee</td>
</tr>
<tr>
<td><strong>Thesis Defense</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Submit Examination Approval form to be signed by committee</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Please see Graduate School website for procedures on Intent to Graduate and Dissertation submission. ([http://graduateschool.wustl.edu/current_students](http://graduateschool.wustl.edu/current_students))