



# **Biomedical Engineering Graduate Program**

## **Guidelines**

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## **GRADUATE PROGRAM IN BIOMEDICAL ENGINEERING**

The Graduate Program in Biomedical Engineering, as part of the School of Engineering (SOE) and Division of Biology and Medicine (BioMed), provides advanced research training appropriate for careers in academia, government, industry and beyond in the field of Biomedical Engineering (BME). Admission is open to both Master's-level and Ph.D.-level students. Faculty advisers are members of the Center for Biomedical Engineering.

### **I. Governance**

To fulfill Ph.D. requirements, students must complete a prescribed course of study, pass a Qualifying Examination, and complete and publicly defend a doctoral dissertation. Students admitted and pursuing research in a laboratory within the Division of Biology and Medicine must participate in the undergraduate and graduate teaching programs in BioMed. Attainment of the Ph.D. degree normally requires four to six years for Ph.D. candidates and three to four years of graduate work for M.D./Ph.D. candidates. A master's degree will require one to two full years depending upon the student's undergraduate preparation.

The Graduate Program in Biomedical Engineering is administered by the Director of Graduate Studies (DGS) and a series of standing and ad hoc committees. Standing committees are the Steering Committee and the Graduate Program Committee, described below. Ad hoc committees include a Qualifying Examination Committee, Thesis Advisory Committee, and Thesis Committee for each Ph.D. student, or a Thesis Advisor and Reader for each master's student. These committees, chosen at appropriate stages in the student's career, are described below.

The Steering Committee is composed of one senior faculty member of the School of Engineering, one senior faculty member of the Division of Biology and Medicine, and the Director(s) of the Center for Biomedical Engineering. The Steering Committee is responsible for establishing policy, allocating resources and designating faculty as trainers or members within the Graduate Program, as outlined below. The term for faculty members of the Steering Committee is five years, renewable. In this context, 'senior faculty member' means a tenured, [core BME faculty](#) member as listed on the Center for BME website. The External Advisory Board for BME will provide input to the Steering Committee on the BME graduate programs.

The Director of Graduate Studies (DGS) is a core BME faculty member jointly appointed by the Dean of Engineering and the Dean of Medicine and Biological Sciences upon recommendation by the Steering Committee for a term of three years, renewable.

The Master's Program Director is a faculty member jointly appointed by the Dean of Engineering and the Dean of Medicine and Biological Sciences upon recommendation by the Steering Committee for a term of three years, renewable.

The Graduate Program Committee is composed of the DGS and at least two other faculty members. The faculty members are appointed by the DGS in consultation with the Steering Committee. The term for faculty members of the Graduate Program Committee is three years, renewable. The responsibilities of

the Graduate Program Committee include admissions recommendations to the Graduate School via SOE and BioMed, curriculum updates, review of first-year Ph.D. students, and review of all cases of Satisfactory and Warning academic standing.

The faculty of the Graduate Program will be divided, with respect to graduate training, into two categories, Members and Trainers. Members will have an active research interest in the area of Biomedical Engineering. They will participate in one or more of the following activities associated with the Program: serve as an instructor in an upper level course; attend program seminars or journal clubs; or serve on ad hoc committees focused on maintaining the excellence of the Program. Members may serve as thesis advisors for master's students. Trainers are those faculty who may serve as thesis advisors for Ph.D. students. Trainers must conduct an active research program and must be prepared to commit the time and effort required to supervise the student's research, such as meeting individually with the student and/or in groups (e.g., laboratory group meetings). Trainers are expected to engage in annual mentoring training education, including in diversity, equity, and inclusion. Trainers are expected to report their participation to the DGS at the end of the spring semester. Trainers can self-select opportunities, and the DGS will also inform faculty of training opportunities. Trainers are expected to have the financial resources to support research projects by graduate students. When accepting a graduate student into the lab, Trainers must make a commitment to provide funding for stipend, tuition, health insurance, and fees until the student's thesis is completed. Any potential complications to fulfilling this obligation must be communicated to the Director of Graduate Studies in a timely manner before the semester in which funding is not available. In cases where student progress is not good and warrants moving a student to Satisfactory or Warning status, this feedback must be documented in writing and shared with the student and Director of Graduate Studies. Doctoral training is most appropriate in an environment where the student can interact with other active investigators and graduate students.

Potential Members and Trainers are proposed to the Steering Committee and Director of Graduate Studies by one of its members or express interest themselves to a Steering Committee member or the Director of Graduate Studies. The proposed Member or Trainer will provide the Steering Committee and Director of Graduate Study with documentation of the candidate's credentials. Designation of faculty status, as a Member or Trainer, is made on the basis of the credentials, subject to review every three years or as needed. New Trainers must provide a summary of the academic and research guidance they provided to their student following the first-year annual review for assessment of the training environment by the Steering Committee.

## **II. Admission**

Entering students are expected to have an undergraduate bachelor's degree in either engineering, physics, applied math, or computer science. If a student has a life sciences degree, documentation must show completion of coursework in quantitative courses to be considered for admission to the program. Past coursework should generally cover topics in math (e.g., multivariable calculus, differential equations, linear algebra) as well as physics (e.g., statics, electromagnetism, circuits), chemistry (e.g., materials), and biology (e.g., cell biology, biochemistry, anatomy/physiology), with flexibility related to the exact courses taken. Students requesting transfer into the BME graduate program are held to the

same admission standards as applicants directly applying to the program. Minimum coursework includes Intermediate Calculus (Differential Equations; MATH 0180 or 0200 at Brown), Applied Ordinary Differential Equations (APMA 0350), one of the following core engineering courses: Thermodynamics (ENGN 0720), Electricity and Magnetism (ENGN 0510), Electrical Circuits and Signals (ENGN 0520), or Fluid Mechanics (ENGN 0810), and at least one advanced undergraduate BME class such as: Transport and Bitransport Processes (ENGN 1110), Biomechanics (ENGN 1210), or Biomaterials (ENGN 1490).

Doctoral and master's applications will be made available for review to the faculty, which will submit their admission recommendations to the Graduate Program Committee. The BME PhD Program is a "direct match" program, where applicants are made offers of admission with the understanding of joining a specific faculty's research program. The Program's processes for reviewing and interviewing applicants is intended to assess readiness for graduate study in the Program and with the recruiting Trainer. The Graduate Program Committee shall review all requests for admission by Trainers and approve these requests prior to making recommendations to the Graduate School. Master's students are offered admission to the Program, and those that wish to pursue a research thesis will be able to join a specific faculty's research program upon matriculation.

Students can be admitted to the Biomedical Engineering Graduate Program as Ph.D. candidates or as candidates for a terminal master's degree. Non-Brown students must apply by completing the standard Graduate School application and indicate their interest in the Biomedical Engineering Ph.D. or master's degree programs. TOEFL scores are required for international applicants unless they obtained an undergraduate degree from a US institution or a non-US institution where primary instruction was in English. The Ph.D. and master's applications require a personal statement, a CV/resume, and three letters of recommendation. GRE scores are optional. The election to pursue the Sc.M. or Sc.M.-thesis degree requirements is made upon matriculation. Students in the master's programs are normally not eligible for financial aid.

Brown undergraduate students may enter the graduate program through the 5<sup>th</sup> Year Master's Program. For the 5<sup>th</sup> Year Master's Program, a student must apply prior to the end of the last semester of undergraduate study at Brown. The application requires a personal statement, CV/resume, and two letters of recommendation. 5<sup>th</sup> Year students can pursue the Sc.M. or Sc.M.-thesis degrees. When applying to the Sc.M.-thesis program, one of the letters of recommendation must be obtained from a Brown faculty member willing to host the student in the lab or mentor their design project. To be eligible for the 5<sup>th</sup> Year Master's Program, students must have successfully completed and fulfilled all requirements of an undergraduate concentration at Brown. The Biomedical Engineering Graduate Program does not accept students into Brown's concurrent baccalaureate and master's program.

Upon review, final admission recommendations will be sent to the Graduate School by the Director of Graduate Studies on behalf of the Graduate Program Committee. Any requests for transfer into the Program will be evaluated by the Graduate Program Director in consultation with the Graduate Program Committee. All students admitted to the Graduate Program must submit their official final transcript demonstrating conferral of all degrees listed on their application before matriculating into the Program. Failure to provide the official transcript according to the Graduate School's deadline will result in a student being withdrawn from the Program. Students participating in the Graduate Program in Biomedical Engineering are admitted by the Graduate School and must primarily affiliate with the

School of Engineering, departments in the Division of Biology and Medicine, or other affiliated departments in accordance with the appointment for the Trainer recommending admission as deemed appropriate by the Director of Graduate Studies.

### III. Ph.D. Student Appointments

PhD students admitted to the BME program receive a stipend as well as coverage of tuition, health fee and health insurance. Each graduate student receives an “Appointment” at Brown that stipulates the terms of your stipend and support. Graduate students are paid once monthly, on the last day of the month. There are four possible appointment types: Fellow, Teaching Assistant (TA), Trainee and Research Assistant (RA). Students may also work as a Supplemental Teaching Assistant (STA) with approval from their thesis adviser.

A student is appointed as a **Fellow** when they are being supported by their own external fellowship OR when they are being supported by the School of Engineering or Division of Biology & Medicine (BioMed) during their first year in the Program. Each granting agency has specific rules and we will work with you and Grants Administration to be sure that your appointment reflects the terms of the grant. Even students who receive grants that pay them directly should receive an appointment at the Grad School. Payroll taxes and income taxes are not withheld from students appointed as Fellows. If your fellowship award is less than the published Brown stipend, your award will be supplemented so that your stipend level is the same as other BME Ph.D. students, as long as the terms of your award do not prohibit supplementation.

A student who is working in a lab or on a project with a faculty member and is being funded by their advisor’s grant or program is appointed as a **Research Assistant (RA)**. Most students in their second or third year and above are appointed as RAs. Typically, income and payroll taxes are withheld from RA paychecks.

A student is appointed as a **Teaching Assistant (TA)** when they are assigned to be a Teaching Assistant. Ph.D. students with thesis advisers in BioMed are required to be a TA and in general, they are appointed as a TA in their second year. In many cases, payroll / income taxes will be withheld while a student is a TA. The Associate Dean of BioMed will work with the DGS to determine the best matches for TA assignments. Every effort will be made to pair your skills and training objectives with the teaching needs of BioMed, but students do not select their own assignments.

A student who is funded through a training grant will be appointed as a **Trainee**. These are grants awarded to Brown and administered by a faculty member. The grant is devoted to the training of students. Each training grant is different and has different objectives – the terms of the grant will dictate the selection of students who are appointed. Students who are appointed as Trainees will not have income or payroll taxes withheld.

A student who elects for a part-time (5 hrs/week) **Supplemental Teaching Assistant (STA)** position in the School of Engineering must obtain approval from their thesis adviser. This position pays an

additional stipend to the student. It is generally expected that research progress continues in order for the student to maintain Good academic standing.

Appointment types are linked to funding sources. Be aware that the source of your funding can change from semester to semester and year to year. This affects your taxes, net pay, and membership in the graduate union. You may find more information in the [Graduate School Handbook](#) and [Graduate Unionization website](#).

Your advisor will decide upon your appointment prior to the start of each semester and summer in consultation as necessary with you, the DGS, and/or your advisor's Dean in the School of Engineering or Division of Biology and Medicine. It is important to keep in mind that any money you receive from Brown may be considered taxable income and it is your responsibility to file appropriate tax returns. The impact of the appointment type dictates only whether taxes will be withheld from your check – NOT whether you owe taxes. You may contact the Program Coordinator if you have any questions about your appointment. Your membership in the Graduate Student Union may change with your appointment type, which will impact your dues to the union. See the [Graduate School's website about unionization](#).

#### **IV. Leaves of Absence**

Students seeking more information about Professional, Medical, Family, Personal or other leaves of absence should contact the BME DGS and/or Student Support Services (Graduate Center, 4th floor). Further information can be found in the Brown [Graduate School Handbook](#). Return from leave requires permission of the BME Program, as stated in the [Graduate School Handbook](#).

#### **V. Advising and Evaluation**

Until the Thesis Advisory Committee is selected, counseling on academic matters and review of student progress will be carried out by the Director of Graduate Studies or the Director of the Master's Program in consultation with the Graduate Program Committee. This committee will put students in touch with other faculty members with related interests who may also provide useful advice. In subsequent years, counseling will be provided by the advisor and the student's qualification exam/thesis committees. In the case where the student and project or advisor is not a good match, the Director of Graduate Studies should be notified by either the student or advisor. In consultation with the Graduate Program Committee and Director of Master's Program (as appropriate), an attempt to identify a new research advisor and/or project will be made. In the case that a new advisor and/or project is not identified in a timely manner, master's students may opt for pursuing a non-thesis degree. PhD students must identify a new research advisor and/or project that is funded in order to remain in good academic standing (See Section VI on Academic Standing Status).

Ph.D. students will complete the Annual Progress Review by completing the Annual Progress Review Form (found on the Center for BME website under Academic/Resources/Forms) describing their academic and research progress. First year Ph.D. students submit the form to their advisor for review and addition of a full evaluation of the student's performance in the first year. The advisor will send it to the DGS and Coordinator for review by the Graduate Program Committee. Ph.D. Students in their second year and higher will complete the form and send it to the chair of their Thesis Committee for

review and comment by all committee members each year. The chair will send the completed review to the DGS and Coordinator for review and addition to the student record. Graduate students are expected to use the Graduate School Digital Curriculum Vitae (GSDCV) to maintain up-to-date records of accomplishments for the required Annual Reviews. It is recommended that periodic updates are completed, and an updated GSDCV is required annually before the end of April for timely annual reviews. Student academic status is reported to the Graduate School every semester, upon completion of the Annual Review, and any additional reviews during the year. (See Academic Status, below.)

Sc.M. student status is evaluated after completion of each semester. The Master's Program Director reviews each student's academic transcript in addition to the research or design progress of Sc.M.-thesis students. Each advisor completes a survey regarding the progress of their students that is reviewed by the Master's Program Director. The Director will then report the academic status of the students to the Graduate School.

## VI. Academic Standing Status

The Program follows policies defined by the [Graduate School Handbook](#), as follows: Students' academic standing can be classified in four ways: good, satisfactory, warning, or termination.

Students who are in **Good** standing are making both good and timely academic progress. No more than one incomplete can be carried on a student record in Good standing.

**Satisfactory** standing indicates that a student has encountered difficulties of some kind, such as inadequate performance or slow progress in coursework, research, writing, etc. Two or more incompletes will, at minimum, result in a shift from Good to Satisfactory standing. This status level has no immediate impact on funding. If the concerns impacting a student's status are not resolved, the student may be moved to Warning status.

**Warning** status signals chronic or severe problems, or lack of funding for the student's research project in SOE. Students on Warning are given a written notice of their deficiencies and the consequences of those deficiencies. Students also receive clear, written instructions of the steps to be taken (if possible) to regain Good or Satisfactory standing, and date-specific deadlines (typically one semester) for recovery. Such notice is provided every semester that a student is on Warning status. If the deficiencies are not resolved by the specified deadline(s), the student on Warning may be moved to Termination. Students will typically continue to receive funding in a probationary state during the specified time period, typically one semester. Warning can lead to an immediate removal of funding depending on the severity of the problem, but this occurs only in rare circumstances and only with the express approval of the Dean of the Graduate School.

**Termination** status signals severe and irrevocable problems. Termination indicates an immediate removal of matriculation/enrollment status, as well as all forms of financial support. A student may be dismissed from the Graduate Program for academic or non-academic reasons. The Graduate Program Committee will review each case. Two thirds of the Graduate Program Committee will constitute a quorum, and final decisions will require a majority vote. Appeal of such decision is to the Dean of the Graduate School.



## VII. Ph.D. Course of Study

The University requires three years of full-time study (i.e., 24 tuition units) for graduation at the Ph.D. level. Students must receive a grade of B or better on courses used in fulfillment of the Ph.D. requirement, and these courses must be taken for a grade rather than on a credit/no credit (S/NC) basis, with the exception of Graduate Independent Study. A mandatory S/NC course requires DGS approval and the agreement of the Instructor to write a course evaluation on the student's course performance for the Program. A maximum of 8 tuition units can be transferred from post baccalaureate work. Likewise, students in the M.D./Ph.D. program can receive 8 credits for satisfactory completion of the first two years of the Program in Medicine. Students must register for 4 credits per semester to be considered full-time students and receive Program benefits, including stipend.

Students must complete an approved sequence of six structured, non-seminar upper-level courses, at least two of which must be in engineering (with ENGN course listing), two of which must be in biology (with BIOL course listing), and two of which must be 2000-level courses. These courses should be selected in consultation with the student's research advisor and must be taken for a grade. The Program Director has discretion to approve courses outside of biology and engineering in cases where they appropriately supplement or support a student's thesis research, such as NEUR courses. Entrepreneurship courses in ENGN do not count towards the ENGN course requirements.

In addition to the structured course requirements, all students must fulfill training in Responsible Conduct of Research (RCR), taken during the first fall semester through the Office of Graduate and Postdoctoral Studies (<https://www.brown.edu/academics/biomed/graduate-postdoctoral-studies/>), and statistics. A statistics short course is offered for first-year PhD students during January. Students with demonstrated experience in statistical design and analysis may be excused from the statistics training requirement at the discretion of the DGS upon review of prior course content (syllabus). A typical progression through the Ph.D. program is outlined in Table 1.

**Table 1.** Typical progress through the Ph.D. Program

| <i>Year</i> | <i>Semester</i> | <i>Milestone</i>  | <i>Goals</i>              |
|-------------|-----------------|---|---------------------------|
| <b>1</b>    | Fall            | RCR, 2 courses, 2 research credits                        |                           |
|             | January         | Statistics short course                                   |                           |
|             | Spring          | BME seminar course (1), 2 courses, 1 research credit      | GSDCV update              |
|             | Summer          | 1 <sup>st</sup> Annual Review by GPC                      | Conference                |
| <b>2</b>    | Fall            | BME seminar course (2), 1-2 courses, 1-2 research credits |                           |
|             | Spring          | BME seminar course (3), 1-2 courses, 1-2 research credits | GSDCV update              |
|             | Summer          | Qualifying Examination (Annual Review)                    | Conference                |
| <b>3</b>    | Fall            | BME seminar course (4), 3 research credits                | Publication               |
|             | Spring          | BME seminar course (5), 3 research credits                | GSDCV update              |
|             | Summer          | Year 3 Annual Review                                      | Conference                |
| <b>4</b>    | Fall            | BME seminar course (6), 3 research credits                |                           |
|             | Spring          | 4 research credits  | Publication, GSDCV update |
|             | Summer          | Year 4 Annual Review                                      | Conference                |
| <b>5</b>    | Fall            | 4 research credits, Pre-defense                           |                           |

|        |   |                           |
|--------|---|---------------------------|
| Spring | 4 research credits, Pre-defense and/or Defense (by May 1) | Publication, GSDCV update |
| Beyond | Defense   |                           |

### VIII. Program Seminars and Retreat

Graduate students **must attend** and participate in regularly scheduled biomedical engineering seminars. Each student will give at least one departmental seminar each year in the BME/Biotechnology Seminar Course (BIOL 2230/40) during six semesters (starting in the second semester). This presentation may be based on the student's original research or may consist of a critical analysis of the literature. Students must also attend the Center for BME Seminar Series that hosts external speakers in the field of biomedical engineering. Students are encouraged to attend seminar series of individual interest hosted by other programs/departments.

Ph.D. students are required to attend the annual BME Retreat that provides opportunities for research presentations, professional development, networking, and community engagement.

### IX. Teaching and Mentoring

Graduate students are encouraged to gain experience in teaching and mentoring. Students may serve as a teaching assistant, preferably in a course in which the graduate student has the opportunity to conduct a discussion or laboratory section or present a small number of lectures. Participation in seminars and certificate programs offered through the Sheridan Center is another way to enhance teaching skills. Mentoring other students in the laboratory may be formal (such as a summer undergraduate independent research project) or informal and is considered an important component of a graduate degree.

### X. Research Progress

The choice of a thesis advisor and research area will be made no later than by the end of the first semester unless an exception has been made by the Director of Graduate Studies. Entering students who have not identified a thesis advisor before coming to Brown are encouraged to attend seminars, talk with faculty, and participate in available opportunities for rotation through different research areas. Progress of all Ph.D. students will be reviewed annually as described in Evaluation (Section V) by the Graduate Program Committee at the end of the first year and by the student's Thesis Committee annual for each year thereafter. Failure to select a research mentor by the end of the first semester can result in a student being put on academic warning.

All Ph.D. students are expected to continually pursue research in a BME faculty Trainer's laboratory for the course of their graduate career. Failure to maintain residence in a lab or on a funded project can result in a student being put on academic Warning. Failure to produce satisfactory research progress or not maintaining continuous research progress can result in a student being put on academic Warning.

## **XI. Ph.D. Qualifying Examination**

By July 31 prior to the start of 5<sup>th</sup> semester, each student is required to have taken a Qualifying Examination. The examining committee, designated the Qualifying Examination Committee, shall consist of the thesis advisor and at least three other members of the Brown Faculty. These other members should include one with a primary appointment as faculty in the School of Engineering and one with a primary appointment as faculty in the Division of Biology and Medicine. At least one member of the committee must also be a member of the Graduate Program Committee in the Center for Biomedical Engineering to serve as committee Chair (and is not the thesis advisor) to give continuity from exam-to-exam. The Chair may also be selected from an approved list of BME Qualifying Exam Chairpersons, [found on the CBME website/PhD Program Overview](#), to satisfy the requirement of having a representative of the Graduate Program Committee. The student and thesis advisor will jointly select members of the committee, extending requests to serve in a timely manner. The student or thesis advisor will send a memo to the Director of Graduate Studies and Coordinator listing the membership of the committee for inclusion in the student's file. The Program Director will designate the chair of the committee, which typically will be the Graduate Program Committee representative. The thesis advisor cannot serve as chair of the committee. Requests for substantial delays in achieving the stated deadline will be reviewed by the DGS in consultation with the Graduate Program Committee.

The Qualifying Examination will consist of written and oral parts. The student will submit a detailed, written document describing both research progress and a proposal for thesis research. The thesis proposal document will be written in the style of an NIH R01 research grant proposal with the following sections: specific aims (1 page), motivation and significance, innovation, preliminary results, research strategy, and literature cited. The research strategy should include relevant subsections such as rationale/validation/evaluation and potential problems/alternative strategies, as well as a realistic timeline. A final version of the thesis proposal must be provided to all Qualifying Examination Committee members at least two weeks prior to the date of the oral examination. This document will be the primary focus of the oral examination. The exam will consist of a private oral presentation of the proposal by the student to the Committee. The Committee is free to ask questions at any time during the examination period. The Committee will assess the student's written and oral communications skills, progress in research, ability to devise a research plan, and depth and breadth of knowledge in the chosen topic and, more broadly, the discipline of Biomedical Engineering. Based on the student's overall performance, the Committee will make one of three recommendations; "pass, pass with stipulations, or fail."

- If a recommendation of "pass" is made, the student will advance to candidacy immediately.
- If a recommendation of "pass with stipulations" is made, the Committee will devise a plan and time line for the student to correct all deficiencies and a means to assess that the deficiencies have been corrected. If these deficiencies are minor, the student will remain in good academic standing. If the deficiencies are major, the student may be placed on academic warning. Failure to meet stipulations by the dates designated by the Committee is grounds for placing the student on academic warning with possible dismissal from the Program. Once stipulations have been met and approved by the Committee, the student will advance to candidacy.
- If a recommendation of "fail" is made, the Committee will decide whether to re-examine the student, require remedial action, or request the student's dismissal from the Program. The Chair will communicate the final decision to the candidate, summarizing the Committee's response. Written notification of the outcome of the examination, with notes detailing the student's

perceived strengths and weakness and specifics of any stipulations, will be sent by the Chair to the Director of Graduate Studies and Coordinator along with a copy of the student's written proposal for inclusion in the student's record. Qualifying Examination results will be reported to the Registrar.

## **XII. Ph.D. Thesis Advisory Committee**

Each Ph.D. candidate will have a Thesis Advisory Committee, consisting of the thesis advisor and at least three other members of the Brown Faculty. These committee members should include one with a primary appointment as faculty in the School of Engineering and one with a primary appointment as faculty in the Division of Biology and Medicine. At least one member must be core faculty in the Center for Biomedical Engineering. The student and thesis advisor will jointly select members of the committee, extending requests to serve in a timely manner. Members of the Qualifying Examination Committee are encouraged to serve as members of the Thesis Advisory Committee. The student or thesis advisor will send a memo to the Director of Graduate Studies and Coordinator listing the membership of the Thesis Advisory Committee for inclusion in the student's file. A [core BME faculty](#) member on the committee, not the thesis advisor, will serve as chair of this advisory committee. Annual meetings of the Thesis Advisory Committee are required each year after completion of the Qualifying Examination. If the full committee is unable to meet in person, the student must complete one-on-one meetings with additional committee members. Feedback from these members should be directed to the student as well as compiled by the Committee Chair and sent to the DGS and Coordinator for inclusion in the student's file. The purpose of this committee is to follow the progress of the student, to help the student with difficulties encountered in the dissertation research, and to aid with the evolution of the project. The student will complete an Annual Progress Review form that contains a written report of progress and proposed work and distribute it to committee members prior to each annual meeting. Progress reports should include courses completed; manuscript(s) published, submitted, or in preparation; a narrative of completed work and difficulties from the past year; and a detailed description of experiments and professional development planned for the upcoming year. Students are encouraged to make a slide presentation to summarize their research progress and have a discussion about the contents of the annual progress document. The Annual Progress Review form must be signed by all committee members and sent to the DGS and Coordinator for inclusion in the student's file. Accompanying this file should be an assessment by the thesis committee on the acceptability of the student's progress and any concerns that might exist, which will be communicated in the academic status update letter to the student.

Prior to scheduling a thesis defense, the Ph.D. candidate must convene a meeting with the Thesis Advisory Committee (pre-defense meeting). The student will give a private oral presentation summarizing the work completed, list of authored manuscripts (accepted for publication, submitted, or in preparation), and proposed plan to finish. It is required for the PhD candidate to have at least one first-author, peer-reviewed, scientific journal article accepted for publication. Students cannot schedule a thesis defense without approval from their Thesis Advisory Committee. The pre-defense meeting must be held between 1-3 months prior to the anticipated defense date. A written memo will be sent by the Committee to the DGS and Coordinator confirming the status of the research to approve scheduling of the thesis defense (see below).

### **XIII. Ph.D. Thesis**

The Thesis Committee consists of the Thesis Advisory Committee and an authority in the area of the thesis research from another institution is also strongly recommended to be included. The Director of Graduate Studies will designate the Chair of the committee, typically the core BME faculty member other than the thesis advisor. The Chair will preside over the thesis examination proceedings. The doctoral thesis will represent a comprehensive summation of the student's total research effort. It must contribute significantly to the field of study and be of sufficient quality to merit publication in a refereed journal. The thesis can be presented in either of two formats. The first format, which may be used by any degree candidate, will contain the following elements:

- a) Abstract – less than 350 words summarizing the thesis problem, methods used to solve the problem, results, and conclusions.
- b) Introduction – a comprehensive review of the field and reasons for performing the research.
- c) Methods and Results – a description of the research performed.
- d) Discussion – an evaluation of the contribution of the thesis research to the field of study and consideration of future directions.

The second format may only be used by candidates whose thesis work forms the basis for two or more papers accepted for publication in refereed journals. In this case the published papers (or relevant portions of the manuscripts) may be substituted for the Methods and Results section of the thesis. Otherwise the format will be the same as that given above; i.e., it should contain a complete Abstract, Introduction, and Discussion. *All candidates must publish or show proof of acceptance of at least one first-author, original peer-reviewed research paper by the date of thesis defense.*

If portions of the student's work have been done in collaboration with other investigators, the candidate will explicitly state these contributions to the work. Detailed instructions on preparation and format of the Ph.D. dissertation should be obtained from the Graduate School.

Students must submit a copy of their thesis to the Thesis Committee at least two weeks prior to the date of the thesis defense. This defense copy of the thesis must be approved by the thesis advisor prior to submission to the Thesis Committee. After submission of the thesis, the student will present this work in a public seminar, following which there will be a private oral examination attended by members of the Thesis Committee and other program faculty members who choose to participate. The student, in consultation with the thesis advisor, will schedule the thesis defense and notify the DGS and Coordinator at least one week before the defense. Information about the defense (title, advisor, chair, date, time, location) must be emailed to the Coordinator, who sees that the presiding officer has the official Graduate School form at the appropriate time. The thesis defense will be announced broadly through appropriate Brown forums and postings. After the examination, the signed documents should be returned to the Coordinator, who will submit them to the Graduate School.

The oral examination must follow the Graduate School's rules, provided to the thesis advisor prior to the defense:

- 1) A brief preliminary consultation is appropriate among the members of the committee, led by the committee chair. The thesis advisor may be invited to give a brief resume of the candidate's career to date. The chair will then ask committee members to comment on their reactions to the dissertation, as well as agreement on the general plan of the examination, the order in which questioners will be called upon, etc.
- 2) The candidate will then be admitted to the examination room and introduction of the candidate and any faculty or others attending who do not know each other. Formal proceedings are opened by the chair and will proceed until all questions, comments and discussion are complete to the satisfaction of the committee.
- 3) At the conclusion of the examination, the candidate is asked to withdraw to a nearby area to await the committee's decision. Under the committee chair's direction, the committee members discuss the candidate's performance. When this discussion is concluded, the committee votes, and the votes are recorded on the "Report of Final Examination". Members of the Brown faculty of professorial rank (Lecturer, Assistant Professor and above) are ordinarily asked to vote.
- 4) If the examination is satisfactory, the candidate is called back into the room to receive congratulations. If the examination is not satisfactory, the presiding officer, usually the committee chair, should communicate that conclusion to the candidate privately. In case of serious disagreement among committee members, the question might be held in abeyance for a day or two to allow time for reflection and further discussion, in which event the candidate should be informed that he or she will be notified shortly.
- 5) Satisfactory outcomes can still require minor, textual changes to the physical thesis document. Non-satisfactory outcomes are caused by significant problems with the thesis, such as a clear lack of understanding of the work or revisions that would require any laboratory research. In the case of a non-satisfactory outcome, the candidate will leave the program with a terminal master's degree. The thesis defense can only be taken once.

The official documents recording the vote of the committee and the thesis signature page must be signed by all committee members and returned to the Coordinator or included with the thesis submission, respectively. Students are responsible for providing the signature pages in the correct format and on the accepted thesis paper for signature.

#### **XIV. Financial Support**

Graduate students pursuing the Ph.D. degree are generally accepted into the Biomedical Engineering Program with a commitment of financial support while their research and academic studies progress satisfactorily and they are otherwise in good academic standing.

Any doctoral student in good standing and in compliance with all program requirements may request limited, annual travel funds from the Director of Graduate Studies, who administers the Graduate Program budget. These funds are available to students presenting an abstract at a scientific meeting or who can justify travel to a conference or workshop to the DGS with approval of their thesis adviser. The DGS will notify the student of the decision. Travel funds can only be requested once per fiscal year

(July-June). Additional travel funding is available through the Graduate School and Division of Biology and Medicine.

Ph.D. students accepted through the standard admissions process are guaranteed five years of support by Brown University's Graduate School, contingent on satisfactory academic and research progress. This support covers tuition, stipend, and health insurance and fees and is contingent on the student remaining in good standing. Financial support for degrees other than the Ph.D. are not provided by the University.

## **XV. Master's Degree**

### **Master's of Science Degree – research track (Sc.M.-thesis)**

To satisfy the requirements of the Sc.M.-thesis degree in the research track, students must complete an approved program of study consisting of a minimum of eight semester-long courses (eight tuition units). No more than three of the eight courses are to be for thesis research (Graduate Independent Study). Students must complete at least five, structured, advanced-level (1000/2000-level) biology and engineering courses, at least two of which must be in biology and two in engineering. These courses must be approved by the Master's Program Director. All students must attain a grade designation of B or better on courses/credits to count toward their degree requirements. One C grade during the full master's course of study may be counted toward the degree requirements at the discretion of the Master's Program Director. Master's students may be put on academic warning if they do not pass and obtain a B or better in their course work (even when a C is counted toward the degree). In general, courses/credits may not be taken on an S/NC basis, with the exception of Graduate Independent Study. A mandatory S/NC course requires Program Director approval and the agreement of the professor to write a course evaluation on the student's course performance for the Program. If a student does not pass their credits with a grade designation of B or better, they may be put on academic warning. Students must also complete the Responsible Conduct in Research (RCR) seminar. Students who cannot attend the seminar will be required to complete a replacement online RCR course. If the RCR requirement is not fulfilled by the end of their first semester, the student may be placed on academic warning.

All students (5<sup>th</sup> year and non-Brown) pursuing an Sc.M.-thesis degree must select a thesis advisor by the end of their first month in the program with whom they will do research for the duration of their time in the Program. Students are encouraged to have open conversations with their thesis advisor about the amount of time that should be dedicated to their thesis research and general expectations before joining a lab. It is expected that students are performing thesis research even if they are not enrolled in a graduate independent study course. Thesis research progress will be evaluated each semester by the student's thesis advisor. If a student is not making satisfactory progress on their thesis, their advisor may recommend to the Master's Program Director that the student be put on academic warning. In their terminal semester, students, in consultation with their thesis advisor, must choose a thesis committee which will consist of the thesis advisor and at least two other members of the faculty. Of these committee members, one must have a primary faculty appointment in the School of Engineering, one with a primary faculty appointment in the Division of Biology and Medicine, and one listed as a primary faculty member in the Center for Biomedical Engineering. The list of faculty serving on the committee should be communicated to the Master's Program Director and Coordinator. Students must prepare a written thesis according to the Graduate School guidelines. The written thesis is due to the student's

committee two weeks before the scheduled thesis defense. The final written thesis must follow all the guidelines specified by the Graduate School and be submitted to the Graduate School by the first business day in May. The thesis defense will be an open presentation with the requirement that the entire thesis committee is present. The thesis defense does not require a closed examination session. After reviewing the written thesis and presentation, the thesis committee will make a decision on whether it is acceptable for the Sc.M.-thesis degree.

### **Master's of Science Degree – design track (Sc.M.-thesis)**

To satisfy the requirements of the Sc.M.-thesis in the design track, students must also complete an approved program of study consisting of a minimum of eight semester-long courses (eight tuition units). Two of these courses should be ENGN 1930L and 1931L Biomedical Engineering Design and Innovation I and II in order to define and engage in a translational design project with a design team. Students may enroll in one additional independent study course. Students must complete at least five, structured, advanced-level courses, at least two of which must be in biology and two in engineering. The fifth structured course can be an additional course in biology, an additional course in engineering, or an elective in design from an approved list. Students must attain a grade designation of B or better in all courses, which may not be taken on an S/NC basis. A mandatory S/NC course requires Program Director approval and the agreement of the professor to write a course evaluation on the student's course performance for the Program. One C grade during the full master's course of study may be counted toward the degree requirements at the discretion of the Master's Program Director. Master's students may be put on academic warning if they do not pass and obtain a B or better in their course work (even when a C is counted toward the degree). Design students or teams must submit and defend an acceptable design project addressing a clinical challenge, as determined by critique panel. In their terminal semester, teams, in consultation with their design mentor, must choose a critique panel. The critique panel should include the design mentor and at least two other expert members. Of these panel members, one must have a primary faculty appointment in the School of Engineering, one with a primary faculty appointment in the Division of Biology and Medicine, and one listed as a primary faculty member in the Center for Biomedical Engineering. It is also encouraged that one panel member have a design, industry, or clinical background. Review and approval of the written design report and presentation will be made by this panel. Teams must prepare a written thesis according to the Graduate School guidelines. The written thesis is due to the team's panel two weeks before the scheduled critique. The critique will be an open presentation with the requirement that the entire panel is present. The critique does not require a closed examination session. Each team member should submit their own, final thesis to the Graduate School by the first business day in May, detailing the full design project while providing focused descriptions of their personal contributions.

### **Master's of Science Degree – non-thesis (Sc.M.)**

Students who elect to fulfill the requirements of the non-thesis program receive the Sc.M. degree. The Sc.M. degree consists of a minimum of eight semester-long courses (eight tuition units). These courses must be 1000/2000-level, structured courses relevant to the field of biomedical engineering. At least three of these courses must be in the biological sciences and three in engineering. These courses must be approved by the Master's Program Director. All students must attain a grade designation of B or better on courses/credits to count toward their degree requirements. Courses/credits may not be taken on an S/NC basis. One C grade during the full master's course of study may be counted toward the degree



requirements at the discretion of the Master's Program Director. Master's students may be put on academic warning if they do not pass and obtain a B or better in their course work (even when a C is counted toward the degree). If a student does not pass their credits with a grade designation of B or better, they may be put on academic warning.

### **5<sup>th</sup> Year Master's of Science Degree (Sc.M or Sc.M.-thesis)**

Two graduate-level courses taken at Brown as part of the student's undergraduate coursework may be applied towards the requirements of the graduate degree. These courses may also be used towards the fulfillment of the student's undergraduate concentration, but courses that do not fulfill concentration requirements are encouraged. Courses applied to the graduate degree are approved by the Master's Program Director. The 5<sup>th</sup> Year Program can be pursued within any of the three programs described above (non-thesis, thesis research/design). For the 5<sup>th</sup> Year Sc.M.-thesis (design track), students that have already taken ENGN 1930L and 1931L as part of their concentration requirements can substitute structured or independent study courses for these courses.

### **XVI. M.D./Ph.D. Degree**

Applicants to the Brown University Program in Medicine may also apply to the M.D./Ph.D. program. M.D./Ph.D. students must complete all of the BME Program requirements specified for the Ph.D. degree. Prior to leaving for continued medical training, the student must successfully pass the thesis defense, have the final written thesis signed by committee members, and submit this document to the Graduate School. If these requirements are not completed by the time the M.D./Ph.D. student leaves, then the student will be removed from the Ph.D. graduate program and awarded a terminal master's degree, commensurate with the completed requirements.