GRADUATE PROGRAM IN BIOMEDICAL ENGINEERING

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The Graduate Program in Biomedical Engineering offers advanced training appropriate for careers in academia or industry in the field of Biomedical Engineering. Admission is open to both Masters-level and Ph.D.-level students.

I. Governance

To fulfill Ph.D. requirements, students must complete a prescribed course of study, pass a Qualifying Examination, complete and publicly defend a doctoral dissertation, and participate in the undergraduate and graduate teaching programs in Biomedical Engineering, which include course offerings in both the Division of Engineering and the Division of Biology and Medicine. Attainment of the Ph.D. degree normally requires four to five years for Ph.D. candidates and three to four years of graduate work for M.D./Ph.D. candidates. A Masters 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 Program Director and a series of standing and ad hoc committees, as a component of the Division of Biology and Medicine and the Division of Engineering. 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 graduate 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 Division of Engineering, one senior faculty member of the Division of Biology and Medicine, and the Director 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. Senior faculty member, in this context, means tenured faculty member.

The Program Director is a senior faculty member jointly appointed by the Dean of Medicine and Biological Sciences and the Dean of Engineering upon recommendation by the Steering Committee for a term of three years, renewable. The same individual may serve as both Director of the Center for Biomedical Engineering and as Graduate Program Director, or different individuals may hold each post.

The Graduate Program Committee is composed of the Program Director and at least two other faculty members. The faculty members are appointed by the Program Director 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 and curriculum recommendations to the Steering Committee.

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 areas encompassed by the Program. They will participate in the activities of the Program by involvement in an upper level course, by attending program seminars or journal clubs, and by serving on ad hoc committees. They may serve as thesis advisors for Master of Science or Master of Medical Science 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. They are also expected to have the financial resources to support research projects by graduate students not having their own support, to provide stipends to them during the summer months and to provide year-round support once they have fulfilled their tuition requirements. Ph.D. training is most appropriate in an environment where the student can interact with other active investigators and graduate students. Trainers are expected to offer at least one upper level course every other year, either alone or as a leading instructor in a group.

Potential members and trainers are proposed to the Steering Committee by one of its members, who will provide the committee 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.

II. Admission

Entering students are expected to have an undergraduate bachelor's degree in either engineering or science. The Graduate Program will make recommendations to the full faculty for interviews and acceptance after the applications have been made available for review by the faculty. Students participating in the Ph.D.-level Program in Biomedical Engineering are admitted by the Graduate School and must primarily affiliate with the MPPB or Neuroscience departments in the Division of Biology and Medicine, the Division of Engineering, or other department as deemed appropriate by the Program Director.

III. Counseling

Until the Thesis Advisory Committee is selected, counseling on academic matters and review of student progress will be carried out by the Graduate Program Committee. This committee will put students in touch with other faculty members with related interests who may also provide useful advice.

IV. 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 basis. A maximum of 8 tuition units can be transferred from post baccalaureate work. Additionally, 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 complete an approved sequence of six structured upper level courses, at least two of which must be in engineering, two of which must be in biology, and two of which must be 200-level courses.

V. Student Seminar

Graduate students are expected to attend and participate in regularly scheduled biomedical engineering seminars. Each student will give at least one departmental seminar each year. This may be based on the student's original research or may consist of a critical analysis of the literature.

VI. Teaching

Graduate students are expected to gain experience in teaching. Students may serve as a teaching assistant, preferably in a course in which graduate students conduct a discussion or laboratory section or present a small number of lectures. Prior teaching experience, comparable to that which would be obtained at Brown, is applicable toward fulfillment of the teaching requirement. Participation in seminars and certificate programs offered through the Sheridan Center is another way to enhance teaching skills.

VII. Research

The choice of a Ph.D. 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 Program Director. 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 entering students will be reviewed by the Graduate Program Committee at the end of the first year. The students will submit a one page report describing their academic and research progress for the first year.

VIII. Qualifying Examination

Before semester 5, each student is required to take a Qualifying Examination. The examining committee, designated the Qualifying Examination Committee, shall consist of the thesis advisor, three other members of the Brown Faculty (one from the Division of Engineering and one from the Division of Biology and Medicine), and, where possible, an authority in the area of the thesis research from another institution. At least one member of the committee must also be a member of the Graduate Program Committee (who will give continuity from exam to exam). Members of the committee will be asked to serve by the thesis advisor after being selected jointly by the advisor and the student. The thesis advisor will send a memo to the Graduate Program Director listing the membership of the committee for inclusion in the student's file. The thesis advisor will also schedule the meeting time of this committee, but should not chair the committee. The Program Director will designate the chair of

the committee. Requests for delays in achieving the stated deadline will be reviewed by the Steering Committee of the Graduate Program before approval of the request by that committee.

The Qualifying Examination will consist of written and oral parts. The student will submit a detailed written document describing both his/her research progress and a proposal for thesis research. The thesis proposal will be no more than 25 pages (single-spaced) in length excluding references. This document will be written in the style of a research grant proposal with the following sections; specific aims, background/significance, preliminary studies/progress report, research design and methods, literature cited. A final draft 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 45 minute oral presentation of research progress and the proposal by the student, followed by a question and answer session with the committee covering the research progress and thesis proposal. The Qualifying Examination Committee will assess the student's written and oral communications skills, progress in research, ability to devise a research plan and their depth and breadth of knowledge of the chosen topic and 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 with stipulations" is made, the committee will devise a plan and a time line for the student to correct all deficiencies and a means to assess that the deficiencies have been corrected. If a recommendation of "fail" is made, the student will be allowed to retake the Qualifying Examination, but it must occur before the end of the 5th semester. If a student fails for a second time, the committee chairperson will recommend to the Program Director and the full faculty that the student be dismissed. The chairperson will communicate the final decision and summarize the committee's response to the candidate. Written notification of the outcome of the examination and a copy of the student's written proposal will be sent by the chair of the Qualifying Examination Committee to the Program Director for inclusion in the student's record. Qualifying Examination results will be reported to the Registrar. Each student who passes and satisfies the requirements of the Qualifying Examination will become a candidate for a Ph.D. in Biomedical Engineering.

IX. Thesis Advisory Committee

Each PhD candidate will have a Thesis Advisory Committee, consisting of the thesis advisor, three other members of the Brown Faculty (one from the Division of Engineering and one from the Division of Biology and Medicine), and, where possible, an authority in the area of the thesis research from another institution. Members of the committee will be asked to serve by the thesis advisor after being selected jointly by the advisor and the student. Members of the Qualifying Examination Committee may serve as members of the Thesis Advisory Committee. The thesis advisor will send a memo to the Graduate Program Director listing the membership of the Thesis Advisory Committee, for inclusion in the student's file. The thesis advisor will also schedule the meeting times of this committee and will chair the committee. The thesis advisor should arrange a meeting of the Brown affiliated members of the Thesis Advisory Committee with the student at least once a year after completion of the Qualifying Examination. 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. These meetings could be scheduled for the intersession between semesters in the academic year,

a time when both faculty and students are likely to be available and free of teaching responsibilities. The student will prepare a written report of progress and proposed work to be distributed to committee members prior to each annual meeting. Examples of an acceptable annual report include a manuscript published, submitted, or in preparation along with a detailed description of planned experiments. Following the annual meeting, the thesis advisor will prepare, and the committee will review, a written evaluation of the student's progress. A copy of the student's and advisor's annual progress report should be sent to the Program Director for inclusion in the student's file.

The Thesis Advisory Committee must approve that the research is sufficiently near completion between 1-3 months prior to the defense date. A written memo will be sent by the Committee to the Program Director confirming the status of the research, in order to schedule the thesis defense (see below).

X. Ph.D. Thesis

The Thesis Committee consists of the thesis advisor, three other members of the Brown faculty (one from the Division of Engineering and one from the Division of Biology and Medicine), and a reader external to Brown. 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 to 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, the 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.

If portions of the student's work have been done in collaboration with other investigators, the candidate will explicitly state his/her contribution 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

his/her work in a seminar, following which there will be an oral examination attended by members of the Thesis Committee and other faculty members who choose to participate. The thesis advisor will schedule the thesis defense and notify the Program Director and all program faculty at least one week before the defense. Program faculty members are encouraged to read each thesis submitted, attend the seminar and participate in the examination.

XI. Financial Support

Graduate students who are candidates for the Ph.D. are generally accepted into the Program of Biomedical Engineering with a commitment of financial support while their research and academic studies progress satisfactorily.

Any student who has passed the Qualifying Examination may request up to $400/year from the Program Director who administers the Graduate Program budget for travel funds to attend scientific meetings if the student is presenting an abstract in the meeting. Students may also request the Program Director to have the Program budget pay their final dissertation fee (approximately $50).

XII. Dismissal

A student may be dismissed from the Graduate Program for academic or non-academic reasons. The Graduate Program Committee will review each case and place its recommendation before the Program faculty convened by the Program Director. Two thirds of the program faculty will constitute a quorum and a decision to accept the recommendation of the Graduate Program Committee will require a favorable majority vote. Appeal of such decision is to the Dean of the Graduate School.

XIII. Sc.M. Degree

Students can be admitted to the Graduate Program in Biomedical Engineering as candidates for the Sc.M. degree only. Students may enter the 5 year Baccalaureate/Masters (Integrated Program) or the Masters only degree program (Masters Program) which may require 1-2 years of study depending on the student's background. Students in these programs are normally not eligible for financial aid.

For the Integrated Program, a student must apply no later than the end of the third week of his or her penultimate semester of undergraduate study at Brown. Admission for students in good standing to the Integrated Program for the fifth year will ordinarily be a matter of course, however, such admission must be applied for at the proper time and decided on in the regular way.

To satisfy the requirements of the Integrated Program, students must complete an approved program of study consisting of a minimum of eight semester-courses (eight tuition units), not more than three of which are for thesis research or seminar. Students must complete the core requirements in basic science, engineering, and biology for an undergraduate concentration in Biomedical Engineering at Brown, and also complete at least five structured advanced-level biology and engineering courses, at least two of which must be in biology and two in engineering. Students must attain a grade designation

of B or better on these five courses, which may not be taken on a S/NC basis. As many as two graduate-level courses taken at Brown as part of the student's undergraduate concentration may be applied towards the requirements of the graduate degree as long as they are not used towards fulfillment of the student's undergraduate concentration. Students must submit and defend an acceptable thesis.

For the Masters Program, a student must apply by completing the standard Graduate School application and indicate their interest in the Sc.M. degree program. To satisfy the requirements of the Masters Program, students must complete an approved program of study consisting of a minimum of eight semester-courses (eight tuition units), not more than three of which are for thesis research. Students must complete at least five structured advanced-level biology and engineering courses, at least two of which must be in biology and two in engineering. Students must attain a grade designation of B or better on these five courses, which may not be taken on a S/NC basis. Transfer of credit towards the Masters Program is not accepted. Students must submit and defend an acceptable thesis.

XIV. 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 Program requirements specified for the Ph.D. degree.