Tufts University | School of Engineering

Department of Biomedical Engineering

Handbook of Academic Requirements and Procedures for the Graduate Degrees in Biomedical Engineering

- Master of Science (M.S.)
- Master of Science with thesis (M.S.)
- Doctor of Philosophy (Ph.D.)

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1. INTRODUCTION

1.1. Graduate Programs in the Department of Biomedical Engineering.

The Department of Biomedical Engineering offers programs leading to the degrees of Master of Science (M. S.) for students seeking an education at an advanced level in biomedical engineering, and Master of Science with thesis (M.S.) and Doctor of Philosophy (Ph.D.) for students preparing for careers in which research is a central activity.

1.2. Purpose and Content of the Handbook.

This handbook provides a detailed account of the academic requirements and procedures for graduate students in the Department of Biomedical Engineering. The intent is to describe the programs and explain the rationale behind them; to delineate the responsibilities of students, faculty committees, faculty members and the administration of the Department; to promote consistency in procedures and standards; and to provide a basis for communication between the faculty and students regarding expectations for performance and achievement. **Although the information in this Handbook is updated on a regular basis, if any conflict exists the decision of the Biomedical Engineering Graduate Committee is final.**

1.3. General Information.

A general summary of the academic structure is found in the Bulletin of Tufts University for the School of Arts and Sciences and the School of Engineering. Graduate School regulations are found in the "Guide for Graduate Students" available in the Graduate School office or at http://asegrad.tufts.edu/sites/default/files/GraduateStudentHandbook.pdf. **It is the responsibility of each graduate student to become aware of the academic requirements, procedures and deadlines of the School of Engineering, Graduate School Office of Graduate and Professional Studies, and the Department of Biomedical Engineering.**

2. THE GRADUATE COMMITTEE

2.1. Channels of Communication.

All communications from students concerning clarification of and petitions for exceptions from the rules described in this handbook should be addressed to the Chair of the Biomedical Engineering Graduate Committee. The Graduate Committee may waive specific requirements if there are conditions that justify such action. This committee comprises faculty members charged with the responsibility of monitoring a student's progress through the rules and requirements delineated in this handbook. The Committee will consist of at least three faculty members of the Department of Biomedical Engineering.

2.2. Graduate Committee Functions.

(a) The Chair of the Graduate Committee (GC) serves as the interim academic advisor for all newly admitted students. Depending on their academic or research interests, students will choose their own academic advisors preferably by the end of the first semester (for M.S. students) or the first year (for Ph.D. students). The academic advisor of an M.S or Ph.D. student will act as the Chair of the Research Committee (RC) for this student. The student's academic advisor will advise in planning a program that will provide the foundation and

background needed in the student's area of intended concentration. The student's academic advisor will approve the student's University registration. In some cases, the roles of research advisor and academic advisor will be held by different people. While the academic advisor must be a full time regular member of the Biomedical Engineering Department, the research advisor may be an adjunct member of the faculty. The GC Chair maintains a record of all committee actions and student programs.

(b) The GC operates according to general policies determined by faculty vote.

(c) The GC is charged with the evaluation of transfer credits for entering students with previous graduate course work according to the policies described in Section 3.7. Requests should be made using the Graduate School form *Petition for Transfer of Credit*.

2.3 Academic Review.

At the end of each semester, the student's record is reviewed by the GC. Candidates with unsatisfactory progress may be placed on academic probation (see Section 9).

3. REQUIREMENTS AND QUALIFICATIONS FOR THE M.S. AND Ph.D. DEGREES

3.1. Introduction.

Applicants to the graduate program are expected to have a degree at the level of Bachelor or Master in engineering or basic/applied/health sciences. GRE and TOEFL (if applicable) are required for admission into the programs.

A student can be accepted either into the M. S. program, the M.S. with thesis program or directly into the Ph.D. program. An M. Eng. or M.S. degree is not required for a student to apply to the Ph.D program. A Ph.D. candidate may obtain an M.S. degree during his/her study if the requirements for this degree are fulfilled. A student in either of the M.S. programs who wishes to continue his/her studies toward the Ph.D. must submit a letter of application to the Department (in which he/she describes the reasons for switching to the Ph.D. program), an updated resume once he/she has completed at least one semester of study in the Master's program, and a letter from the intended PhD advisor to confirm research support. The faculty will then vote on the application and if the vote is positive, the student will be allowed to take the PhD qualifying examination (Section 6). After passing this examination he/or she should make a formal application to the School of Engineering using the regular application forms and procedures. The application fee is waived and in place of the letters of recommendation, the student must submit their personal and advisor supporting statements. A student in the M. S program who wishes to switch his/her program of study to the M.S. with thesis degree must submit a letter of application to the Department (in which he/she describes the reasons for switching to the MS with thesis program), a copy of his/her transcript and a letter from the intended MS research advisor confirming supervision of the student for an MS thesis.

The M.S. with thesis and Ph.D. programs in the department of Biomedical Engineering are strongly research-oriented, with emphasis on the candidate's independent research work reflected in his/her thesis or dissertation. Because Biomedical Engineering is a multidisciplinary field, students are expected to work in collaboration with scientists in diverse fields including engineering, health and life sciences. The required courses consist of foundation courses and

elective courses. The purpose of the foundation courses is to provide a broad background in Biomedical Engineering, and to introduce the research activities in the Department. The purpose of the elective courses is to provide in-depth knowledge in specific areas of Biomedical Engineering and to pose a solid basis for students to excel in his/her research work. It is advisable that M.S. with thesis and Ph.D. students first identify a field of interest and a research advisor, and then select elective courses around the research topic of choice.

Typically, full time students will take two years to complete the M.S. with thesis program and four-five years for the Ph.D program. The MS degree can be completed by exceptionally strong students in two semesters, but in most cases it is expected that requirements will be completed in three semesters. Tufts undergraduate students can enroll in a combined B.S./M.S. program.

Prospective students can obtain more admission information, financial-aid information and application forms at http://gradstudy.tufts.edu.

3.2. Responsibility.

A graduate student accepted into one of the graduate programs must satisfy all requirements for that program. To obtain the degree, students must complete the requirements according to the timetable delineated below, unless a written exemption is obtained from the Graduate Committee. Even though a periodic review is made by the Graduate Committee, **each student is personally responsible for ensuring that all requirements are fulfilled.** At the beginning of each semester, each student is required to submit an updated progress form corresponding to their degree program. Copies of these forms are reproduced at the end of this handbook.

3.3. The Foundation Requirement for Graduate Degree Candidates.

(a) In order to fulfill this requirement, the student must demonstrate proficiency in the core areas defined by departmental tracks. Proficiency is demonstrated by passing with a minimum grade of B- the foundation courses (BME 162: *Molecular Biotechnology*; BME 141: *Analytical Tools for Biomedical Engineering*; BME 250: *Principles of Biomedical Engineering*) that are designed to expose the student to the breadth of the field of biomedical engineering

(b) The foundation requirement must be fulfilled by the end of the student's second semester in residence or the student may be placed on probation.

(c) Students who do not fulfill the foundation requirement by the end of the third academic semester will not be allowed to continue in the program.

(d) Students may place out of one (or more) course needed to satisfy the foundation requirement if they demonstrate graduate proficiency in the areas covered in this foundation course by some other means. The particular way in which proficiency is demonstrated is at the discretion of the faculty member who is responsible for that foundation topic. Students requesting a waiver of foundation course requirements should fill out Form D (see Appendix), get it signed by the foundation course instructor and by the student's adviser, and return it to the Biomedical Engineering Department main office. Any foundation course for which the student receives the foundation requirement waiver must be replaced by an elective course.

3.4. Requirements for M. S non-thesis Candidates.

The M. S. non-thesis program is aimed at students who desire to acquire broad knowledge in Biomedical Engineering. The emphasis will be on multi-disciplinary interfaces in the areas covered by the two tracks of Biomedical Imaging and Sensors and Regenerative Medicine.

a) *Courses*: M. S. non-thesis candidates are required to fulfill nine course credits at the graduate level; two must be foundation courses, five must be BME electives, one of the remaining two courses must be a course with professional development focus (see list of accepted courses in Appendix B), and one may be an elective with a non-BME designation (requiring advisor's approval). All courses must be completed with a grade of B- or better. At least eight of the nine course credits must be fulfilled by the end of the third academic semester or the student may be placed on probation. See section 9 for details. Students who do not fulfill the complete course requirements by the end of the fourth academic semester may not be allowed to continue in the program. Graduate courses offered in related fields outside the Biomedical Engineering Department must be approved by the GC or the academic advisor.

b) *Project*: The project is worth one credit. The project can be a comprehensive literature study, or a contribution to on-going research activities; theory or design. The project results must be documented in the form of a written report.

c) *Admission and Continuation*: The program accepts students who have a B.S. or B.A. degree. Students enrolled in the M.S. with thesis or Ph.D programs in Biomedical Engineering may switch to the M.S. program with approval of the graduate committee.

d) *Summary of credit requirements:* A total of 10 credits is required for an M. S. degree. The credit requirements are outlined as follows:

1. Two foundation courses (2 credits)
2. Seven graduate courses, including 1 professional development-focused course (7 credits)
3. Project (1 credit)

   Total = 10 credits for M. S.

3.5. Requirements for M.S. with thesis Candidates.

(a) *Courses*: M.S. with thesis candidates are required to fulfill six course credits at the graduate level; two must be foundation courses, three must be BME electives, and the remaining course may be an elective with a non-BME designation (requiring advisor's approval). All courses must be completed with a minimum grade of B-. The course requirements must be fulfilled by the end of the third academic semester or the student may be placed on probation. See section 9 for details. Students who do not fulfill the course requirements by the end of the fourth academic semester may not be allowed to continue in the program. Graduate courses offered in related fields outside the Biomedical Engineering Department must be approved by the GC or the research advisor.

(b) *Graduate Seminars*: M.S. with thesis candidates are required to register for the Graduate Seminar course (BME 291/292) every semester. Students who miss more than three seminars in a given semester will receive a grade of unsatisfactory. A student receiving two unsatisfactory BME seminar grades will be placed on probation. If taken for credit, students will present a seminar and earn a half credit per semester taken. During the course of study, at least two half-credit seminar presentations are required.

(c) *Thesis*: M.S. with thesis candidates must prepare a thesis, which they defend before their

research committee. See Section 8 for details.

(d) *Scientific publications*: M.S with thesis candidates should demonstrate the quality of their work and their capability of reporting the results of their research by publishing (or submitting for publication) a minimum of one abstract for a scientific conference or journal publication.

(e) *Summary of credit requirements:* A total of 10 credits is required for an M.S. with thesis degree. The credit requirements are outlined as follows:

1. Two foundation courses (2 credits)
2. Four graduate courses (4 credits, can include special topics courses)
3. Attend Graduate Seminars and participate as presenter for two semesters (1 credit)
4. Thesis credit (3 credits)

Total = 10 credits for M.S. with thesis

3.6. Requirements for Ph.D. Candidates.

(a) *Courses*: Ph.D. candidates must complete three foundation courses, one BME project course for which they register when the PhD thesis proposal is defended, and a minimum of five (if with prior B.S. degree) or one (if with prior graduate degree in a related discipline) additional graduate level courses with a minimum grade of B-. The course requirements must be fulfilled by the end of the third academic semester or the student may be placed on probation. See section 9 for details. Students who do not fulfill the course requirements by the end of the fourth academic semester may not be allowed to continue in the Ph.D. program. Graduate courses offered in related fields outside the Biomedical Engineering Department must be approved by the GC or the academic advisor.

(b) *Teaching and Research Assistantships*: Full-time graduate students may be offered teaching or research assistantships as part of their graduate program. These are important educational and pre-professional experiences that also provide some financial support during a student's graduate education. Teaching assistants (TA's) work with faculty in the delivery of the curriculum in a variety of ways including conducting review sessions, assisting in preparation of course materials, proctoring laboratories, grading and holding office hours to assist students. Research assistants (RA's) work with individual faculty on projects usually funded by outside agencies. These appointments may be held any time during the calendar year. Graduate students may hold concurrent, hybrid RA/TA appointments as long as their assistantship duties and stipend levels conform to the general guidelines. Because of the educational value of a teaching experience, Ph.D. candidates are required to serve in a teaching capacity (such as TA or an equivalent alternative) for at least two semesters.

(c) *Graduate Seminars*: Ph.D. candidates are required to register for the Graduate Seminar course (BME 291/292) every semester. Students who miss more than three seminars in a given semester will receive a grade of unsatisfactory. A student receiving two unsatisfactory BME seminar grades may be placed on probation. If taken for credit, students will present a seminar and earn a half credit per semester taken. During the course of study, at least four half-credit seminar presentations are required.

(d) *Critical paper review, research proposal, and dissertation*: Ph.D. candidates must prepare a critical analysis of a scientific article, an original research proposal and a dissertation to be presented before their Research Committee. See Sections 6, 7 and 8 for details.

(e) *Scientific Publications*: Ph.D. candidates must demonstrate the quality of their work and their capability of reporting the results of their research by publishing a minimum of three scientific articles as first author. At least two of these articles must be published in peer-reviewed scientific journals, while a third publication may be a full-length conference proceedings paper.

(f) *Summary of credit requirements:* A total of 31 credits is required for a Ph.D. with prior B.S. degree, and a total of 21 credits is required for a Ph.D. with prior M. Eng. or M.S. degree. The credit requirements are outlined as follows:

With Prior B.S. Degree:

1. Three foundation courses (3 credits)
2. One BME project course taken when thesis proposal is prepared and defended (1 credit)
3. Graduate elective courses (at least 5 credits)
4. Attend Graduate Seminars and participate as presenter for four semesters (2 credits)
5. Thesis credit (up to 19 credits)

Total = 30 credits for Ph.D. without prior M.S.

With Prior Relevant Graduate Degree:

1. Three foundation courses (3 credits)
2. One BME project course taken when thesis proposal is prepared and defended (1 credit)
3. Graduate elective courses (at least 1 credit)
4. Attend Graduate Seminars and participate as presenter for four semesters (2 credits)
5. Thesis credit (up to 18 credits)

Total = 25 credits for Ph.D. with prior relevant graduate degree

3.7. Graduate Committee Policies for Transfer of Graduate Course Credit.

(a) Graduate courses taken prior to enrollment in the Biomedical Engineering graduate program (taken at Tufts or elsewhere) may, under certain circumstances, be transferred and counted towards a Biomedical graduate degree. Students wishing to transfer a course should file a written petition (attached Form D) with the GC. For a course to be eligible for transfer, the student must have earned a minimum grade of B- in that course.

(b) No more than two of the total required courses may be transferred from another institution for M.S. or Ph.D. candidates. An additional two graduate courses may be transferred if taken at Tufts. Four courses, if taken as part of a Tufts Certificate program, may be transferred if relevant to the program of study.

(c) Courses transferred must not have been counted toward a previously conferred baccalaureate degree. However, courses used towards advanced degrees earned at other institutions may be transferred, subject to the two course maximum.

(d) Students should consult the Student Services Center's "Graduate Student Handbook" prior to submitting Form D to the GC.

3.8. Petition to receive an M.S. degree when enrolled in the PhD program

Students accepted and enrolled in the PhD program are eligible to request receiving an M.S. non-thesis degree upon completion of the following requirements:

1. Three foundation courses (3 credits)
2. One BME project course taken when thesis proposal is prepared and defended (1 credit)

3. Graduate elective courses (at least 5 credits)
4. Attend Graduate Seminars and participate as presenter for two semesters (1 credits)

Total = 10 credits for M.S. degree for students in the PhD program

Students are responsible for filing the appropriate documentation with the School of Engineering Graduate Studies Office so that they can receive this M.S. degree upon completion of these requirements.

4. RESEARCH ADVISOR (M.S. with thesis and Ph.D. Candidates)

4.1. Selection of the Research Advisor.

(a) The research advisor is the faculty member with whom the student chooses to collaborate on his/her thesis or dissertation research project. Most often, the student selects a subject from among several that the professor may suggest as appropriate for the M.S. thesis or the Ph.D. dissertation. The student is expected to contribute to the direction of the work as the research progresses.

(b) New students are strongly encouraged to inform themselves about the research interests of the faculty by reading background material, requesting reprints for in-depth study, and especially by visiting those professors and their graduate students whose work appears to be of greatest interest. These visits are the occasion for detailed discussions of the research the student might undertake for the degree.

(c) When the student is ready to select a research advisor, an appointment should be made with the professor to discuss arrangements. The professor and the student should discuss the initial research topic on which the student will begin, the sources of financial support during the academic year and summer, and course work or other requirements the professor feels are essential to the proposed research.

(d) Students usually select a research advisor by the end of their first semester. The selection should be done thoughtfully, as student and research advisor normally work together very closely, and each has a vital interest in the progress of their collaboration.

(e) In most cases the research advisor also acts as the student's academic advisor. If the research advisor is not a full-time BME faculty member, then the student must also have an academic advisor who is a full-time BME faculty member.

5. RESEARCH COMMITTEE (M.S. with thesis and Ph.D. Candidates)

5.1. Selection and Purpose.

(a) When the student is ready to begin reporting the results of the research, or after passing the Critical Review examination (Section 6 below) the student and research advisor meet to choose a formal research committee. The Ph.D. committee is composed of at least four members: the research advisor and at least one other biomedical engineering faculty, one additional member outside the department and one member from outside the university. The M.S. committee is composed of at least three members: the research advisor and at least one other biomedical engineering faculty, and one additional member outside the department.

(b) The research committee is charged with the following duties:

(i) Continue the academic advising function;
(ii) Evaluate the written & oral defense of the original research proposal (Ph.D. candidates);
(iii) Evaluate the candidate's scientific publications;
(iv) Evaluate the written & oral defense of the student's thesis/dissertation research.

5.2. Periodic Evaluation.
The research committee meets periodically to evaluate the student's progress. These evaluations may result in one of the following actions:
(a) Continuation in the program, which may be conditional upon satisfaction of a prescribed set of requirements;
(b) Academic probation.

6. CRITICAL ANALYSIS OF A SCIENTIFIC ARTICLE (Ph.D. Candidates)

6.1. Purpose.
Critical thinking, quantitative analysis capabilities, and depth of technical knowledge shall be demonstrated by successfully completing a written and oral review of a published scientific article. Research scientists and engineers are often called upon to give an oral presentation of research work or technical achievements, and are required to critically evaluate the state of the art. Hence, it is necessary to learn how to read the scientific literature, perform quantitative and critical analyses, and present effective summaries both orally and in writing.

6.2. Content.
The exam consists of a *critical review and analysis* of a technical paper taken from the literature to be presented to the department faculty. The exam outcome will be based on three parts:
(a) A written review of the technical paper 5 to 10 single spaced pages in length excluding references, 12pt font with one inch margins;
(b) An oral report;
(c) A question/answer session.
The student will have the choice of one of a set of papers which will be made available in the department office *three weeks* before the examination. The written review must be delivered to the department faculty *no later than two business days* before the time of the examination.

Students should be prepared to give a 15 minute presentation of their analysis of the assigned paper and to allow 60 minutes to answer questions on the paper analysis and on any basic concepts, experimental techniques, instrumentation technology, theoretical models, and methods of data analysis that are relevant to the paper.

6.3. Guidelines for Preparing and Presenting the Written Review.
A. Written Report
The following are suggested guidelines for the critique of the assigned paper. Note that these guidelines are not intended as detailed or specific instructions on how to prepare your presentation. Instead, they suggest the scope of your analysis. At a minimum, your critique should contain the following two elements:

1. *Technical analysis:* Determine whether the contents of the paper are technically sound. For example, are there any logical flaws? Are the assumptions correctly stated and justified? How

crude or sophisticated is the analysis and is the approach appropriate? Are the conclusions supported by the data presented?

2. *Context:* Without reiterating the contents of the paper, identify the key contribution(s) of the paper and evaluate whether these are significant. You should identify and state the nature of the contribution. For example, does the paper present a new method of analysis? Does it present new data? Resolve a conflict in the literature? Do the results of the paper lead to new research questions? If so, what are they? Most importantly, be ready to defend your judgment based on your knowledge and scientific reasoning. Please note that your presentation should not be just a summary of the article, but should take the article as a starting point for a critical assessment of the article.

The written review should contain just enough technical background to inform a scientist or engineer who is not an expert in the topic of the paper of the theoretical and experimental basis of the methods and analytical tools by the paper. The review should be scientifically accurate and fully referenced. The written report should be aimed at a specialist readership and should be similar in style to a review article. The written report should represent the best effort of the student to present his/her own ideas in a clearly written, error-free document.

Since the exam is based on a common set of papers, **every student must work independently**.

B. Oral Report and Examination

The oral presentation must reflect a graduate-level understanding of the paper and be appropriately detailed. The presentation should be aimed at a biomedical-engineering-educated general audience, not a lay audience. The student must demonstrate a thorough knowledge of the subject material in response to questions from the examination committee.

Responses to questions must be lucid. Questions may cover any aspect of the paper, including general principles, basic technology, and scientific methods related to the paper selected and the written report. Related questions will also address topics covered in any courses taken by the student during his/her academic tenure in the Department.

The student must display a familiarity with the relevant theoretical, experimental, or computational methods reported in the paper. Well-established and latest models/mechanisms related to the subject of the paper should be reviewed and described at a sound technical/scientific level in both the written and oral communications. In particular, the oral component of the examination will be aimed at understanding the depth of the student's knowledge of the experimental methods and theoretical principles that form the basis of the paper presented, and his/her critical thinking skills.

6.4. Evaluation.

Once all students have completed their qualifying exam, the faculty will convene and discuss the results of the examination. The students will be formally notified of the outcome of the examination by the next business day after the exam. The committee will evaluate the student’s performance using the criteria detailed above.

6.5. Completion Date

These examinations are generally given in Spring (late May or early June) and in Fall (mid September). Students must attempt the Spring examination immediately following their first academic year.

If the student fails, he/she can retake the exam in the Fall of the same year. If the student fails the second examination, he or she will be dismissed from the Ph.D. program and may be allowed to complete the M.S or M.S. with thesis program. In extraordinary cases, additional assignments can be considered to allay the concerns of the examination committee.

7. ORIGINAL RESEARCH PROPOSAL (Ph.D. Candidates)

7.1. Definition and Purpose.

The research proposal is, in part, an assessment of the student's ability to frame hypotheses and identify questions of scientific importance. The research proposal should be based on the student's own research. It provides the opportunity to demonstrate both understanding and originality. The original proposal consists of a written document, an oral presentation, and defense before the research committee.

7.2. Role of Research Committee.

As described in Section 5, the student's research committee will advise on the preparation of the proposal, and is charged with evaluating it as sufficient to satisfy this portion of the degree requirement.

7.3. Guidelines for Preparing the Original Proposal.

The student must meet these guidelines in order to complete successfully the research proposal requirement.

A. Written Proposal

A modified NIH format as described below should be used, but the specific aims should be limited to one. The complete proposal should be 8-10 pages maximum (single-spaced, not including references). The student must be certain to document evidence and statements fully in the references. Citations should include all authors and full title of the article in each reference, following a consistent set of bibliographic conventions, preferably those used by a leading journal in the area of the proposal. Reviewers often consider brevity and clarity in the presentation to be indicative of a focused approach to a research objective and the ability to achieve the specific aim of the project. Therefore, proposals should include sufficient, but concise, information to facilitate an effective evaluation without having to review other material.

Organize items 1-4 below in the NIH format, to answer these questions: (a) Why is the work important? (b) What has already been done? (c) What do you intend to do and how would this extend current knowledge in the field? (d) How are you going to do the work? Do not exceed 10 pages for items 1-4. All tables and graphs must be included within the 10-page limit of items 1-4.

1. Specific Aim (1/2 page)

List the broad, long-term objectives and describe concisely and realistically what the specific aim described in this proposal is intended to accomplish and the hypothesis to be tested.

Briefly summarize experiments which will be proposed to investigate the specific aim. The statement of the problem must be precise and unambiguous. There should be no room for doubt as to what is meant.

2. Introduction (Background and Significance) (2-3 pages)
Emphasize the importance and context of the proposal. Briefly sketch the background to the proposal, critically evaluate existing knowledge, and specifically identify the gaps which the project is intended to fill. State concisely the importance of the research by relating the specific aim to the broad long-term objectives.

3. Research Design (5-6 pages)
Describe the research design and the procedures to be used to accomplish the specific aim of the project. The approach to the research should be described fully, including the feasibility of each step in the process proposed for solving the problem. Include the means by which the data will be collected, analyzed, and interpreted. Do not emphasize details such as recipes for buffered solutions. Describe any new methodology and its advantage over existing methodologies. The probable results of the proposed research and the conclusions which would follow from each, should be fully described. Discuss the assumptions, potential difficulties, and limitations of the proposed procedures and alternatives approaches to achieve the aims. Provide a tentative timetable for the investigation. Substantial costs for equipment, computer time, and materials, should also be estimated.

4. Discussion and Future Directions (1/2 page)
Describe how the results obtained from this proposal can be interpreted and how they will contribute to the overall knowledge in the area and influence future investigations.

B. Oral Presentation and examination

The student should be prepared to give a 20-25 minute oral presentation of the research proposal. The student should feel free to prepare additional explanatory materials about the proposal which may be used during the exam. The examination itself will be directed at the exploration of the theoretical and practical basis of the research proposal, as well as its rationale.

C. General

1. The student is encouraged to consult with his or her research advisor in formulating the basis of the proposal since it will likely lay the groundwork for subsequent dissertation research. However the proposal as a whole is to be developed mainly by the student, and all writing should be done by the student. Faculty or other students may provide assistance with specific technical problems, and will be accessible to the student to address specific questions. Review of the written material by other students and postdoctoral fellows is permitted and encouraged to facilitate the production of a clear, concise and grammatically correct document.
2. If advice is needed as to whether a problem is suitable as a basis for a proposal, a meeting should be scheduled with the research committee to discuss these matters.
3. A copy of the written proposal should be given to each member of the research committee at least one week before its presentation/defense.

7.4. Completion Date.
Students must complete the research proposal before the end of the fifth semester. Students failing to complete this requirement may be placed on academic probation for one semester. At the end of the probationary semester the student may be dismissed from the Ph.D. program if the requirement remains unsatisfied.

7.5. Evaluation.
(a) At the proposal defense, the research committee will discuss the proposal by probing the areas emphasized above. If appropriate, related aspects of the proposal may also be discussed. The proposal will be judged on the basis of novelty of the research idea and the suitability of the proposed approach. The objective is to assess the independent research ability of the student at this stage of the Ph.D. degree work.
(b) The research committee will deliberate in private at the conclusion of the defense and immediately inform the student of their decision. If the student fails, he/she will be placed on probation and must reschedule a new examination no later than the following semester. If the student fails the second examination, he or she will be dismissed from the Ph.D. program. Upon approval of the research proposal by the research committee, the student must file Form B (Appendix) with the GC Chair.

8. THESIS AND FINAL ORAL DEFENSE (M.S. with thesis and Ph.D. Candidates)
8.1. Requirements.
The "Graduate Student Handbook" specifies the thesis regulations, which have been set forth by the Graduate School of Arts and Sciences and the School of Engineering. Additional requirements for the thesis are the responsibility of the research advisor. The Biomedical Engineering Department requires, as part of the procedure by which a thesis is approved, a formal oral defense by the candidate before an examination committee. This committee recommends action to the university regarding the thesis. The Chair of the Biomedical Engineering Department certifies completion of the degree requirements and recommends to the Dean of the School of Engineering that the degree be awarded.

8.2. Selection and Composition of the Examination Committee.
(a) The M.S. examination committee consists of at least two members of the Biomedical Engineering Department. One additional member from outside the Department will be part of the M.S. examination committee. The Ph.D. examination committee consists of at least two members of the Biomedical Engineering Department, one additional member from outside the Department and one member from outside the university. Ordinarily, the members of the student's research committee serve as the Examination Committee. For the sake of maintaining the continuity of the committee, faculty members who have left the department during the year preceding the thesis defense may be considered as either Department or outside committee members.
(b) Copies of the thesis must be delivered to the examination committee at least TWO weeks prior to the examination.
(c) The student, in consultation with the Chair of the Examination Committee, arranges the time and place and notifies the Department Chair at least TEN days in advance. M.S.

examinations must be announced to the faculty of the Department, and Ph.D. examinations to the faculty of the University in the form of written announcements including the information listed below. A copy of the notice is also put into the student's file.

(i) Name of Student;
(ii) Name of Department (Biomedical Engineering);
(iii) Degree;
(iv) Title of Thesis/Dissertation;
(v) Names of Examining Committee Members, Chair, and Research Advisor;
(vi) Time and Place of Examination.

8.3. Presentation and Defense.

As part of the M.S. and Ph.D. requirements, the student is required to make a public presentation of the thesis/dissertation work, which is to be followed by a private oral defense in front of the Examination Committee.

8.4. Possible actions of the Examination Committee.

(a) *Acceptance of dissertation/thesis*.
(b) *Acceptance with minor changes*. This action requires the candidate to incorporate the minor changes, but allows for the signatures of all committee members at the conclusion of the defense with no further re-examination necessary.
(c) *Acceptance with major changes*. This action requires a re-examination of the corrected thesis by the committee, but no repetition of the oral examination.
(d) *Rejection*. This action requires the student to prepare a new thesis, and generally involves additional research work. The Examination Committee will address a brief memorandum apprising the Department and GC Chairs of the situation.

9. ACADEMIC PROBATION

9.1. Conditions Leading to Probation.

Academic probation is a formal status a graduate student assumes when he or she has not met the requirements to remain in the program. Some reasons for a student being subject to probation include:

(a) Significant number of courses below a B-;
(b) Failure to meet deadlines or fulfill requirements stipulated by the student's research advisor or research committee;
(c) Unsatisfied Foundation Requirement at the beginning of the second semester in residence;
(d) Course requirement not met after three semesters;
(e) Critical analysis of scientific article not completed after three semesters. (Ph.D. only);
(f) Original proposal not completed after 5 semesters. (Ph.D. only).

9.2. Rectification.

A student on probation has one semester to rectify the deficiency. Academic probation can only be removed by the Graduate Committee.

9.3. Consequences.

If not rectified by the end of the probationary semester the student may face dismissal from the graduate program. Such Ph.D. candidates may receive an M.S. degree if they have completed the

requirements for that degree at the end of their probationary semester. Students on probation may become ineligible to receive a teaching or research assistantship or other financial assistance including federal aid.

10. TEACHING ASSISTANT GUIDELINES

10.1. Assignment.

A teaching assistant (TA) is assigned to a course by the Department in consultation with the Graduate Committee and Department Chair. Individual requests may be made well in advance of each semester; however, the final decision rests with the Department Chair.

10.2. Responsibilities.

Teaching assistants (TA's) work with faculty in the delivery of the curriculum in a variety of ways including conducting review sessions, assisting in preparation of course materials, proctoring laboratories, grading and holding office hours to assist students.

The course supervisor assigns all course-related work to the TA. Failure to fulfill the teaching responsibilities as delineated by the course supervisor may be cause for dismissal as a teaching assistant. This may include not only loss of stipend but also loss of guaranteed support and tuition waiver.

10.3. Conflict of Interest.

(a) Since the TA is in a position of authority, any romantic involvement while the student/teacher relationship exists (even if consensual) must be avoided. In addition to being in violation of University policy, such relationships may lead to defacto sexual harassment and prompt disciplinary action.

(b) In a situation where a student and a TA are more than casual acquaintances, the TA should request that the student be switched to another section in order to avoid any real or apparent conflict of interest.

(c) Since the TA is being paid by the Department to teach his/her students, it is improper for a TA to tutor for profit any student for whom the TA has official grading or tutoring responsibility.

11. ETHICAL CONDUCT

All members of the Biomedical Engineering Department are required to maintain the highest of ethical standards in all of their research and teaching duties. Two documents which should be consulted are the Tufts University Handbook "*Academic Integrity*" published by the Dean of Students Office and "*On Being A Scientist - Responsible Conduct in Research*" published by the National Academy Press.

12. APPENDICES

Appendix A - Examples of degree programs
Appendix B - Professional Development Courses
The following forms are contained at the end of the handbook for your use:

- Progress Summary Sheet for Ph.D. Candidates
- Form B - Satisfactory Completion of Original Research Proposal
- Form C - Department Pre-Approval Form for Transfer of Credit Petition
- Form D - Form for waiver of foundation course requirement

NOTE: Upon completion of the requirement, the respective form must be completed by the student, signed by all the research committee members, and then submitted to the Chair of the Graduate Committee.

The following forms

- Approval of Thesis/Dissertation for Submission
- Certificate of Fitness

can be found at http://students.tufts.edu/registrar/what-we-assist/apply-graduation/graduate-students. In the same page, all graduate students can find directions for completing the Application for Graduation form along with relevant submission deadlines.

The form to Request a Leave of Absence can be found at:
http://students.tufts.edu/student-affairs/what-we-help/your-health-wellness-and-safety/leaves-absence

The form to Request Transfer of Credit can be found at:
http://students.tufts.edu/registrar/what-we-assist/transfer-credit/graduate-students

A full listing of similar forms can be found at:
http://students.tufts.edu/registrar/student-forms

The School of Engineering and the Graduate School of Arts and Sciences forms should be completed by the student and submitted to the Graduate Committee Chair. The forms will then be returned to the student who should forward them to the Graduate School.

APPENDIX A: Examples of degree programs

Example of M. S. Degree in Biomedical Engineering:

Two graduate foundation courses (2 credits)
- Principles of Biomedical Engineering (BME 250)
- Molecular Biotechnology (BME 162)

One professional development course from list in Appendix B (1 credit)
Graduate level elective courses (6 courses)
- BME 100 Design of Medical Instrumentation
- BME 215 Optics and Wave Motion
- BME 131 Principles of Medical Imaging
- BME 251 Graduate Introduction to Biophotonics
- BME 153 Biomaterials and Regenerative Medicine
- BME 154 Tissue Engineering and Regenerative Medicine

Project (1 credit)

Example of M.S. with thesis Program in Biomedical Engineering (focus on Biomedical Optics):

Two graduate foundation courses (2 credits)
- Principles of Biomedical Engineering (BME 250)
- Molecular Biotechnology (BME 162)

Graduate level elective courses
- BME 100 Design of Medical Instrumentation
- BME 215 Optics and Wave Motion
- BME 256 Graduate Quantitative Biomaterials Characterization Laboratory
- BME 251 Graduate Introduction to Biophotonics

BME 291,292 Graduate Seminar (1 credit)
Participation in research mentoring team
Thesis (3 credits)

Example of Ph.D. Program in Biomedical Engineering (with no prior M.S. degree) (focus on Biomedical Optics):

Three graduate foundation courses (3 credits)
- Principles of Biomedical Engineering (BME 250)
- Molecular Biotechnology (BME 162)
- Analytical Tools for Biomedical Engineering (BME 141)

Graduate level elective courses:
- BME 215 Optics and Wave Motion
- BME 131 Principles of Medical Imaging
- BME 251 Graduate Introduction to Biophotonics
- BME 153 Biomaterials and Regenerative Medicine
- BME 256 Graduate Quantitative Biomaterials Characterization Laboratory

BME Project (taken during the semester the thesis proposal is submitted and defended) (1 credit)
BME 291 (x2), 292 (x2) Graduate Seminar (2 credits)
Participation in research mentoring team
Thesis (19 credits)

Examples of M.S. with thesis Program (focus on Regenerative Medicine):

Two graduate foundation courses (2 credits)
- Principles of Biomedical Engineering (BME 250)
- Molecular Biotechnology (BME 162)

Graduate level elective courses
- BME 121 Quantitative Physiology I
- BME 163 or 168 Recombinant DNA Techniques or Biotech. Processing Projects Lab
- BME 153 Biomaterials and Regenerative Medicine
- BME 175 Tissue Engineering Research Laboratory

BME 291,292 Graduate Seminar (1 credit)
Participation in research mentoring team
Thesis (3 credits)

Examples of Ph.D. Program (with no prior graduate degree) (focus on Regenerative Medicine):

Three graduate foundation courses (3 credits)
- Principles of Biomedical Engineering (BME 250)
- Molecular Biotechnology (BME 162)
- Analytical Tools for Biomedical Engineering (BME 141)

Graduate level elective courses:
- BME 121 Quantitative Physiology I
- BME 163 Recombinant DNA Techniques
- BME 153 Biomaterials and Regenerative Medicine
- BME 168 Biotechnology Processing Projects Laboratory
- BME 169 Seminar in Biotechnology

BME Project (taken during the semester the thesis proposal is submitted and defended) (1 credit)
BME 291 (x2), 292 (x2) Graduate Seminar (2 credits)
Participation in research mentoring team
Thesis (19 credits)

APPENDIX B: Professional Development Courses

Professional Education classes available from the Tufts Gordon Institute that may satisfy professional development course requirement for students pursuing an MS non-thesis degree (Either a single 1.0 credit course or two 0.5 credit courses may be taken):

- **EM 211** – Lean Six Sigma (with option to earn lean six sigma black belt certification) (1.0 credit)
- **EM 231** – Project Management Strategies & Methodologies (0.5 credit)
- **EM 241** – Strategic Management in the Era of Big Data Analytics (1.0 credit)
- **EM 262** – Negotiation & Conflict Resolution for Engineers & Technologists (0.5 credit)
- **EM 254** – Advancing Innovation: Breakthrough Methodologies for Technology Firms (1.0 credit)
- **EM 261** – Leadership for Technical Professionals (1.0 credit)

PROGRESS SUMMARY SHEET (M. S Candidates)

Name_____Semester Enrolled_____

Academic Advisor_____

REQUIREMENT	COMPLETION DATE	STATUS	
1) Foundation Courses (Two out of three)	End of 4th academic semester. (see requirement 2b below)	Molecular Biotech. (BME 162) Date Completed: Biomedical Eng. (BME 250) Date Completed: Analytical Tools (BME 141) Date Completed:	
2a) Graduate Course Work (Seven courses in addition to core requirement.)	End of 4th academic semester. (see requirement 2b below)	Course	Date Complete
		1 BME_____	
		2 BME_____	
		3 BME_____	
		4 BME_____	
		5 BME_____	
		6	
2b) Professional Development course		EM ____	
2c) Graduate Course Work	Eight of nine courses completed by end of 3rd academic semester.	Date completed:	
5) Project	Before the end of 4th semester.	Title: Date:	

PROGRESS SUMMARY SHEET (M.S. with thesis Candidates)

Name_____ Semester Enrolled_____

Research Advisor_____

REQUIREMENT	COMPLETION DATE	STATUS	
1) Foundation Courses (Two out of three)	End of 3rd academic semester.	Course	Date Completed
		Molecular Biotech. (BME 162)	
		Biomedical Eng. (BME 250)	
		Analytical Tools (BME 141)	
2) ResearchCommittee and Advisor	End of 1st academic semester.	1) Research advisor Name:_____ 2) Departmental member Name:_____ 3) Outside member Name:_____	
3) Graduate Course Work (Four in addition to foundation requirement)	End of 3rd academic semester.	Course	Date Completed
		1) BME_____	
		2) BME_____	
		3) BME_____	
		4)_____	
4) Graduate Seminar	Register each semester. Present two seminars	Date of 1st presentation_____ Date of 2nd presentation_____	
5) Scientific publication	Anytime before thesis defense	Title: Date:	
8) Written Thesis	No less than two weeks prior to oral defense.	Copy submitted to each examination committee member. Date:	
9) Thesis Defense		Date:	

PROGRESS SUMMARY SHEET (Ph.D. Candidates)

Name_____ Semester Enrolled_____

Research Advisor_____

REQUIREMENT	COMPLETION DATE	STATUS
1) Foundation Courses	End of 2nd academic semester.	☐ Molecular Biotechnology (BME 162) ☐ Biomedical Engineering (BME 250) ☐ Analytical Tools (BME 141) ☐ _____ ☐ _____
2) Research Committee (In addition to Advisor)	At completion of Critical Analysis of Article.	2)_____ 3)_____ 4)_____
3) Graduate Course Work (One minimum in addition to core requirement, five if no prior MS degree)	End of 3rd academic semester.	☐ ☐ ☐ ☐ ☐
4) Critical Analysis of Article	Immediately after 2nd semester.	☐
5) BME Project course---Original Research Proposal	Before the end of 5th semester .	☐
6) Teaching	Anytime	☐
7) Scientific publications	Anytime	☐
8) Written Thesis	No less than two weeks prior to oral defense.	☐ Copy submitted to each examination committee member.
9) Thesis Defense		☐ ☺

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Form A has been eliminated

FORM B

Satisfactory Completion of Original Research Proposal

_____has satisfactorily completed
Student Name and ID#

the written and orally presented original proposal on _____entitled
Date

_____

_____

Research Committee Signatures:

_____ _____
Research Advisor Committee Member

_____ _____
Committee Member Committee Member

After satisfactory completion of the original research proposal presentation and oral exam, this form must be completed by the student and returned to the Biomedical Engineering Department main office.

FORM C

Department Pre-Approval Form for Transfer of Credit Petition

Please fill out the top part of this form and then file it with any member of the GC. The course syllabus and description, as well as a completed Tufts Graduate School Transfer of Credit Form (available on p. 29 of the Graduate Student Handbook at: http://ase.tufts.edu/gradstudy/GSAShdbk.pdf) must accompany this form. Please use a separate Form D for each course.

To be filled out by student:

Today's date:

Student Name:

Student ID#:

Course number and title:

Date course taken (semester/year):

Where course was taken:

For Tufts GC use:

Tufts equivalent course (if any):

- ❑ This course satisfies the Core Requirement in: _____
- ❑ This course does not satisfy a Core Requirement but may be counted toward the Course Requirement.
- ❑ This course may not be used toward an advanced degree in Biomedical Engineering at Tufts.

Signature of Tufts Instructor (if applicable) _____

Signature of GC Representative _____

Signature of Department Chair _____

FORM D

Waiver of graduate foundation course requirement

_____
Date

The requirement of foundation course _____
Course #

has been waived for _____
Student's Name and ID#

because:

- ☐ This course or equivalent has been taken previously by the student
- ☐ Other (specify below)

_____

_____

_____

The replacement course is: _____
Course #

Required Signatures:

_____ _____
Course Instructor Student's Advisor

This form must be completed by the student and returned to the Biomedical Engineering Department main office.