

# Graduate Studies Handbook

Department of Biomedical Engineering  
School of Engineering & Applied Sciences  
University of Rochester

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## *PREFACE*

This handbook is intended to summarize the major features and policies of the graduate program in Biomedical Engineering. The general features of the graduate experience at the University of Rochester are summarized in the Graduate Bulletin, which can be accessed at [www.rochester.edu/GradBulletin/](http://www.rochester.edu/GradBulletin/) and is updated every two years. Both students and advisors will need to consult both sources, though it is our intent to provide the salient features here. Policy, of course, continues to evolve in response to the changing needs of the graduate program and the students in it. Thus, it is wise to verify any crucial decisions with the Biomedical Engineering Graduate Committee.

Students in the BME Program can engage in laboratory rotations with and conduct their research with any member of the graduate faculty in Biomedical Engineering.

Although the Ph.D. in Biomedical Engineering is primarily a research degree, it also represents a certain breadth of training in areas that are not directly related to the thesis research project. This breadth is best attained by taking formal courses, attendance at and participation in various seminar programs, teaching, and research activities including publication.

## I. BME PROGRAM REQUIREMENTS

### Doctoral Degree Requirements

Biomedical Engineering is a diverse field requiring flexibility in training requirements for different research interests. The backgrounds of incoming students are also diverse, requiring differences in the balance between training in engineering and biological sciences, as well as in the type of in-depth training in engineering required for the particular research that the student chooses. Nevertheless, there are needs common to all biomedical engineering students, regardless of specialty. These include training in oral and written presentation, professional ethics, laboratory etiquette and lab safety, as well as exposure to the diverse opportunities available in the field of biomedical engineering. Most importantly, all students should receive advanced, state-of-the-art training in both engineering and biological sciences related to their doctoral research.

For the doctoral degree the University requires a total of 90 credit hours. In practice, most of these are research credits, that is, credits received for activities directly related to the doctoral research project. In addition to research, all students are required to take: Biomedical Engineering Laboratory (4 credits), Laboratory Rotations (4), Graduate Seminar in Biomedical Engineering (3 credits), Ethics in Research (no credit), Proposals in Biomedical Engineering (1 credit), and Physiology (4 credits). Exceptions to these requirements must be petitioned and approved by the Graduate Committee. In addition to these requirements, students are required to take a minimum of 24 credits in elective coursework, at least 12 of which must come from the approved list of BME courses (see page 5). The electives must include at least one graduate level course in the biological sciences and one graduate level course in an engineering department outside of biomedical engineering. Among the 24 elective credits a course in Applied Mathematics is strongly recommended. The choice of courses used to satisfy these requirements depends on the student's background and research direction.

Recommended progress toward the doctoral degree:

#### **Coursework**

##### **First Year**

###### *Fall Semester*

###### Course (credits)

Applied Mathematics or  
Engineering Elective or Biol. Sciences (7-8)  
BME Laboratory (4)  
Ethics in Research (0)  
Laboratory Rotations (2)  
Graduate Seminar I (1)

###### *Spring Semester*

###### Course (credits)

Engineering or Biological Sciences Electives (8)  
Physiology (4)  
Laboratory Rotations (2)  
Graduate Seminar II (2)

## Second Year

### *Fall Semester*

#### Course (credits)

Electives (8-12)

Ph.D. Research (4 or 8)

### *Spring Semester*

#### Course (credits)

Proposals in BME (1)

Ph.D. Research/ Electives (15)

In addition to course work requirements, each doctoral student will be required to give at least four formal seminars during the course of study.

## Other Requirements

### *At the end of the first academic year*

Choose a research advisor.

Take First Year Preliminary Examination.

Begin Ph.D. thesis research.

### *Second Year, Fall Semester*

No later than December, submit a list of possible members of your Research Advisory Committee to the Program Office for approval.

Meet with Advisory Committee to discuss scope of doctoral project.

### *Second Year, Spring Semester*

Complete course work.

Be sure to have met with Research Advisory Committee by June 1 (can be done the previous Fall).

Prepare for Qualifying Examination by writing thesis proposal.

### *Third Year, Fall Semester*

Submit final copy of research proposal to Program Office.

Complete oral examination of thesis research proposal by December 1.

**Note:** Students entering this program with an MS degree are encouraged to accelerate their examination program.

**Approved list of Biomedical Engineering courses: At least 12 core credits must be taken from this list (18 for the M.S. degree)**

BCH 402	Advanced Biochemistry
BCS 504	Sensory Systems
BCS 505	Perception and Motor Systems
BCS 512	Computational Methods in Cognitive Science
BCS 519	Instrumentation and Methods for Vision Research
BCS 532	Advanced Computational Methods in Cognitive Science
BCS 536	Sensory Motor Systems
BCS 538	Computational Problems in Vision

BCS 547	Introduction to Computational Neuroscience
BIO 402	Molecular Biology
BME 442	Cellular Motility and Molecular Machines
BME 451	Biomedical Ultrasound
BME 452	Medical Imaging – Theory and Implementation
BME 453	Advanced Ultrasound Imaging
BME 462	Cell and Tissue Engineering
BME 466	Microhydrodynamics
BME 483	Biosolid Mechanics
BME 484	Vascular Biology
BME 485	Cellular Mechanics & Adhesion
BME 486	Finite Elements
BME 487	Nonlinear Finite Element Analysis
BME 502	Graduate Laboratory
BME 503	Graduate Seminar I
BME 504	Graduate Seminar II
BME 513	MR Imaging: From Spins to Brains
BME 515	Neural Cortical Movement
CHE 421	Thermodynamics
CHE 441	Momentum and Energy Transport
CHE 460	Bio System Fundamentals & Analysis
CHE 469	Biotechnology and Bioengineering
CHE 487	Polymer Rheology & Processing
ECE 420	Physics of Solid-State Devices
ECE 423	Semiconductor Devices
ECE 432	Fundamentals of Acoustic Waves
ECE 434	Transducers and Actuators
ECE 435	Intro to Optoelectronics
ECE 440	Introduction to Random Processes
ECE 441	Detection and Estimation Theory
ECE 446	Digital Signal Processing
ECE 447	Image Processing
ECE 448	Pattern Recognition
ECE 450	Bioelectric Phenomena
IND 408	Biochemistry
IND 409	Cell Biology
IND 447	Signal Transduction
MBI 445	Industrial Microbiology
MBI 473	Immunology
ME 201	Applied Boundary Value Problems
ME 401	Methods of Applied Math
ME 405	Diffusion
ME 406	Dynamical Systems
ME 437	Incompressible Flow
ME 440	Mechanics of Structures
ME 441	Finite Elements
ME 443	Mechanical Vibrations
ME 444	Continuum Mechanics
ME 449	Elasticity

ME 458	Nonlinear Finite Element Analysis
ME 462	Experimental Materials Science (crosslisted MSC 407)
MSC 410	Mechanical Properties of Polymers
NSC 512	Cellular Neuroscience (crosslisted with ANA 512)
OPT 411	Complex Analysis & Differential Equations
OPT 425	Radiation & Detectors
OPT 441	Geometrical Optics
OPT 448	Principles of Eye Design
OPT 492	Biomedical Optics
PHP 403	A Disease-Based Approach I
PHP 404	A Disease-Based Approach II
RAD 501	Physics of Medical Imaging

## II. ADDITIONAL REQUIREMENTS

### A. Student Laboratory Rotations

All first year students are required to complete a minimum of three laboratory rotations during the first year. At the beginning of the academic year, faculty members will present short (20-30 minute) informal lectures to the incoming students describing their research activities. The goals of this series are to acquaint students with ongoing research in the Program and to alert them to opportunities for their laboratory rotations and future Ph.D. research. Attendance at these lectures is mandatory. At the end of this series of presentations, students are expected to sign up for laboratory rotations by submitting a list of their choices to the Graduate Studies Committee. Every effort will be made to accommodate the students' wishes. Students are expected to complete 3 rotations in laboratories representing more than one area of interest before requesting assignment to a laboratory in which their Ph.D. research project will be completed. Each rotation will be four to six weeks in duration during which time students are expected to spend 6-10 hours/week in laboratory activities. If advisable, a student will complete an additional rotation before requesting assignment. Choices are subject to the approval of the Graduate Studies Committee.

Students will be evaluated at the end of each rotation period by the faculty member in charge of the lab. The written evaluations (see Appendix) will be kept in the student's file in the Department Office. This will also be used to fulfill the progress report in the first year (see below).

### B. Teaching Assistantship

Each student will be required to be a teaching assistant for at least two semesters. Typically, this will be after the first semester of the first year. Students are welcome to request specific teaching assignments and every effort will be made to accommodate such requests. Assignments will be made by the Graduate Studies Director and approved by the Graduate Committee.

### C. Student Research Seminars

Experience in organizing research data, interpretation of data, synthesis of information from diverse sources, and presentation to an audience of scientific colleagues represents valuable preparation for a career in science whether in an academic or industrial setting. Therefore, students will be required to present a yearly seminar in the student series beginning in their third year of studies.

During the course of studies students will be required to make at least four seminar presentations (one in the Proposal course, annually in years 3 and 4, and one at the thesis defense). Presentation in another approved seminar course or at a national meeting can also fulfill this requirement. An abstract or outline of each presentation is required for the file in the Program Office.

#### **D. First Year Preliminary Examination and Evaluation**

On Monday following exam week in May, each student will be given copies of a dozen or more research articles for scrutiny. These articles will have been selected by Program faculty and screened by the Graduate Studies Committee for suitability for the purposes of the examination, and for variety of subject matter. The student will select one of the articles for the examination. Each article may be used by only one student.

By Friday the student must indicate in a letter to the Graduate Studies Committee which of the collection of articles has been chosen to serve as the basis of the examination. In the following week the Graduate Studies Director will meet formally with students to discuss the expectations for performance in the examination. Within 14 days following article selection (by noon), the student must submit to the Graduate Administrator of the Department a carefully written document, usually 15-20 double-spaced, typewritten pages, which contains three sections:

- (1) questions raised by the article,
- (2) critical appraisal of the article, and
- (3) proposal for additional research.

These sections are to be as specific and comprehensive as the length restriction allows, and the student should understand that there will be an opportunity to expand any aspect of the document during the oral part of the examination. The examination anticipates the application of all information and understanding gained in graduate course work and undergraduate background. In particular, the student must demonstrate the ability to apply quantitative, engineering approaches to address questions of medical or biological importance.

On the day that the document is submitted, it (and a copy of the selected article) will be distributed to the members of the examining committee. This committee will consist of three members chosen by the Graduate Studies Committee: the faculty member submitting the selected article and two members of the core faculty in Biomedical Engineering.

Within a week following submission of the document, the student will have an oral examination before this committee. The oral examination will start with a 15-20-minute presentation by the student, during which the student presents and explains the results of the study of the selected article, keeping in mind that the committee consists of experienced and knowledgeable scientists who are not necessarily expert in the research area of the selected article

but who have read and studied both the selected article and the student's submitted document. The balance of the examination will be mainly devoted to questions raised by the committee.

The examining committee assesses the student's performance with respect to four criteria:

- (1) the student's ability to evaluate published research critically and fairly,
- (2) the student's ability to draw upon formal graduate course work and to apply quantitative engineering methods to analyze the research,
- (3) the student's creativity in suggesting new and justified research, to improve and/or extend the study, and
- (4) the strength of the content and style of the written document, and the ability of the student to defend, modify or extend the document during oral debate.

At the end of this oral examination, the committee meets in closed session, to evaluate the student's performance and arrive at a consensus opinion of the student's performance. At the end of this session, the committee chairperson will discuss with the student the strengths and weaknesses found in the examination, and will inform the student what is their recommendation to the Graduate Studies Committee, but will not tell the student whether or not they are to proceed with their Ph.D. studies.

As soon as possible after all the first-year oral examinations have been completed, the Graduate Faculty will meet to hear the reports from the examining committees and to examine the records (course work, etc.) of the students. Based on these discussions, the Faculty will decide whether or not the student should proceed further with his/her graduate studies.

The decision of the Graduate Faculty will be reported to the students as quickly as feasible by the Director of Graduate Studies.

### **E. Qualifying Examination**

The purpose of the Qualifying Examination is to determine whether the student is qualified and competent to continue work toward a Ph.D. in Biomedical Engineering. It is not intended as a test of the proposed research problem or of the supporting experimental data, but rather as a means of determining the potential of the student for independent thought and his or her comprehension of the general field and perspective for exploiting a relevant problem in a scientifically sound manner.

The examining procedure involves preparation by the student of a written Ph.D. thesis research proposal. Because a career in science will undoubtedly involve submission and defense of research projects (whether in an academic or industrial setting) we recommend using a modified NIH proposal outline as described below. **The Qualifying Examination is typically taken before the end of the first semester of the third year.** The Qualifying Examination will be carried out by the thesis advisory committee which consists of the research advisor, at least two other members from the Graduate Faculty in BME and one faculty member who is not a member of the BME Graduate Faculty.

Students must have completed a minimum of 24 hours of course work credit, as outlined above, at the time of the Qualifying Exam. The completed Ph.D. thesis research

proposal must be submitted to each member of the thesis advisory committee and to the Program Office at least two weeks before the day of the examination.

### **Suggested Outline for Qualifying Examination Research Proposal**

Page lengths are based on standard double-spaced pages. Do not exceed a total of 15 pages for sections A-D.

- A. **Specific Aims:** State concisely and realistically what the research described in the proposal is intended to accomplish and/or what hypothesis is to be tested. Do not exceed two pages.
- B. **Significance:** Briefly sketch the background to the proposal and critically evaluate existing knowledge. State concisely the importance of the research described in the proposal by relating the specific aims to longer term objectives. Do not exceed five pages.
- C. **Preliminary Studies:** Students are not expected to have a large amount of data accumulated at the time of the Qualifying Examination. This section should summarize what work has been done by the student and by other laboratories to indicate that the proposal is realistic and significant in scope. Do not exceed four pages. Graphs, diagrams, tables, and charts relevant to this section can be included as "Appendix" material.
- D. **Proposed Experiments:** Discuss in detail the experimental design and the procedures to be used to accomplish the specific aims of the work described in the proposal. Describe the protocols to be used and a tentative timetable for the investigation. Include the means by which the data will be analyzed and interpreted. Describe new methodology and its advantage over existing methodology. Discuss the potential difficulties and limitations of the proposed procedures and alternative approaches to achieve the aims. Include information about species of animals to be used. There is no page limitation for this section but make every attempt to be concise.
- E. **References:** Use a standard journal format that includes names of authors and full title.
- F. **Appendix:** Graphs, diagrams, tables, and charts supporting the proposal should be included in this section.

### **Qualifying Examination Format**

The student is expected to present an overview of the thesis research proposal for the first 15-20 minutes using blackboard, slides, overhead or LCD projector. The committee will then examine the student orally. A typical examination will take between two and three hours. The candidate is judged on: the written and oral presentation, a grasp of the fundamental issues, the ability to apply the background from formal course work to problems related to the proposal, and a demonstration of critical assessment of results. It is

important to recognize that while the written proposal serves as a focus for the oral examination, questions about related areas can be raised.

#### **F. Exemptions from Requirements**

All entering students desiring exemptions from core courses may petition the Graduate Committee by a written memo justifying their request. The Graduate Committee may require an interview to determine whether an exemption is appropriate. The exemption interview will consist of a brief (30-60 min) discussion with a committee of three faculty appointed by the Director of Graduate Studies who will ask questions based on the content of the course to be exempted. The committee will then advise the student and the Director of Graduate Studies whether the course needs to be taken.

### **III. MD/PhD PROGRAM**

An MD-PhD in Biomedical Engineering is also offered. The usual requirements for the BME degree are adjusted because of the extensive training received as part of the MD degree. The schedule of training is two years of Medical School, 3-4 years of doctoral training and research followed by two years of medical training. The qualifier examination for the PhD should be completed in the second year of doctoral training. During the years of doctoral training, students will continue with clerkship activities for one afternoon each week so that they can remain involved in medical training. This time accumulates as medical school credit, enabling the student to have a free block in the last year of medical training to pursue either additional electives or further research activities. The curricular requirements for the Ph.D. in BME are modified as follows:

The requirements for Physiology and an upper level biological science course are waived.  
The Biomedical Engineering Laboratory course is not required.  
Laboratory rotations are required, but should be completed during the first two years of medical training.  
The TA requirement is waived.  
The first year preliminary examination is waived.

The following requirements remain:

18 credits of elective courses, at least 12 of which must be at the 400 level or higher and at least 12 of which must be selected from the approved list of Biomedical Engineering courses.  
The first year graduate seminar course  
The proposals writing course  
Research Ethics  
Three formal presentations in a public forum

With the exception of the formal presentations, these requirements can be completed in the first year of doctoral study.

#### **IV. THESIS ADVISORY COMMITTEE**

Following selection of the research advisor, early in the summer after the first year of course work, the student's thesis advisory committee is selected. The thesis advisory committee performs several functions. It may help the student choose specific elective courses in preparation for the chosen field of research and to ensure an appropriate balance between engineering science and biological science in the student's curriculum. It provides advisory input during the development of the thesis research project with respect to scientific merit, techniques and methodology, relevant literature, etc. It gives final approval of the specific program presented for the thesis topic to be developed. Finally, it, along with a representative appointed by the University Dean of Graduate Studies as Chair, is the examining committee for the thesis defense. Committee members may also provide more complete guidance in the selection of final courses in preparation for research and assist the thesis advisor. By December of the second year, the student and the research advisor submit a list of suggested committee members to the Graduate Studies Committee for approval.

The thesis advisory committee should consist of the research advisor, at least two other members from the core faculty in Biomedical Engineering and one faculty member who is not a member of the core faculty. At least one member of the advisory committee is expected to have trained a graduate student through completion of a doctoral degree. Additional committee members may be included from either within or outside the University if it is considered useful or necessary. Thus, the minimum size of the committee will be four members, but five (or more) is quite possible. In the case of joint co-advisors, a minimum of five members may be required. Any exceptions to this procedure will have to be approved by the Associate Dean for Graduate Studies of The College and the University Dean of Graduate Studies.

#### **V. YEARLY PROGRESS REPORT AND RESEARCH REVIEW**

A yearly progress report must be submitted to the Program Office no later than June of each academic year in order to have stipend funding approved for the following year. Students should plan to meet with their thesis advisory committee (if designated) and file a Graduate Student Research Review form (see appendix) in the Program office during each academic year. In the first year of studies, the laboratory rotations evaluations and the first year preliminary examination results will be used to fulfill this requirement (see above).

The annual meeting with the thesis advisory committee is usually set up immediately following the student's seminar, provided that the committee members are all present.

#### **VI. PROGRAM OF STUDY FORMS**

Each full-time Master's student must submit a proposed Program of Study to the Associate Dean for Graduate Studies before the end of the second term. Part-time Master's students must submit the proposed program of study upon completion of 9 or 12 hours of graduate study. The number of credit hours required for the Master's degree is 30. Students who have completed 60-non-overlapping credit hours of course work with a

sufficient number of credits in another engineering department may qualify for a second Master's degree in that discipline. All Masters degrees are subject to the requirements and approval of the awarding department.

For the PhD the Program of Study is filed at the time the Qualifying Examination proposal is submitted. It lists all formal courses (both specifically required and electives), seminars and research credit that the student must complete in order to obtain the Ph.D. The total number of hours should be at least 90.

## **VII. THESIS PREPARATION AND REGISTRATION**

A booklet entitled "The Preparation of Doctoral Theses" is available in the BME Program Office. It is the responsibility of the student to see that style, format, margins, paper, binding, etc. are in accordance with University regulations. The student should be aware that the Dean of Graduate Studies has a deadline each year by which time a thesis must be registered in order to allow graduation at the next Commencement. This date is typically the first week in April although students should notify the Graduate Studies Office by February 1 of their intent to register a thesis before the deadline. It will usually take at least three months to prepare the thesis after all experimental work is complete and the most common mistake lies in not allowing adequate time for preparation of illustrations, typing, review by the advisor and thesis advisory committee and for registration in the Graduate Dean's Office.

Registration with the office of the Associate Dean of Graduate Studies must take place at least three weeks (15 full working days) before the final exam. (Registration deadlines vary. Please check in the Program Office for a schedule of dates for the academic year. Final exams may not be scheduled during specific periods, e.g., August through mid-September.) At least one week before that time, the student should bring to the Program Office:

1. A list of the members of the thesis advisory committee.
2. Date, time and place for the proposed final exam.
3. One copy of the thesis title page.
4. One copy of the thesis abstract.

The Graduate Coordinator in the Program office will provide the student with the additional required forms and will authorize payment of the microfilming fee from the appropriate account. The student will also be given termination forms at the time of the exam to complete before departure. The student then takes the completed forms to the Office of the Associate Dean for Graduate Studies. At registration, the student must bring to the office of the Dean of Graduate Studies a copy of the thesis to be given to the outside member appointed to the committee. All other committee members should also receive a copy of the thesis at this time.

Please see the "Regulations and University Policies concerning Graduate Studies" for details.

## VIII. FINAL EXAMINATION AND TERMINATION

Before the exam, the student's advisor will receive confirmation of the scheduling of the exam and name of the Chairperson of the Examining Committee appointed as the representative of the Vice-Provost of Research and Graduate Affairs.

The format of the Final Examination for the Ph.D. is as follows. The first hour of the exam is an open seminar to the public. The student's presentation should last 45 minutes and 10 minutes are allowed at the conclusion for questions from the audience. Notes, slides, charts, and the usual visual aids for a seminar are encouraged. The student and the Examining Committee will then adjourn to a private session where the second part of the exam will be conducted. Using oral interrogation, the committee will scrutinize the student's comprehension, execution, description and interpretation of the research described in the thesis.

After successful completion of the Final Examination and after making any required corrections in the thesis, the student must submit one corrected copy of the thesis to the office of the Associate Dean. This copy must be unbound in a manila envelope with the student's name and department marked plainly on the outside. In addition, one bound copy must be submitted to the Department Office.

A Termination Form should be completed and returned to the Department Office with a copy of the student's C.V. after the defense. The termination date will determine when the stipend payment will cease, usually two weeks after the defense date. The student should discuss this with his/her advisor.

## IX. GENERAL POLICY

A) Space: The Department Office will assign first-year students a desk from the general "pool" of office space. Once a research advisor has been chosen, the student will usually be given a desk in the advisor's area.

B) Copying, Supplies, etc. The advisor's account should pay for work-related supplies, copying, etc.

C) Travel: Students may apply for very limited travel funds toward the end of their program to attend national or international meetings. Advisors are usually responsible for travel support.

D) Vacations: Graduate students in the Department are supported by fellowships or research grants from a variety of sources, both internal and external, and each agency has slightly different regulations regarding vacations. In general, most state that fellows and trainees are expected to engage in full-time study and are entitled only to official University Holidays. We realize that many advanced students do not observe the semester breaks and take vacations at some other time during the year. However, the Department Office must submit monthly time reports on all graduate students and these are subject to close scrutiny by auditors from both the governmental accounting office and the University. Unjustified absences can jeopardize our already sparse funds. Thus, every student should inform his or her advisor of *any* absence and an

absence of more than two weeks must be cleared with the Department Office in advance. Students will not receive stipends if absent without authorization.

## X. M.S. DEGREE IN BIOMEDICAL ENGINEERING

Both the "Plan A" (thesis) and "Plan B" (coursework) Master's degrees are offered in Biomedical Engineering. For either degree, students must earn a minimum of 30 credits, at least 12 of which must be 400 level courses or higher, and 18 of which must come from the approved list of biomedical engineering courses. At least one year (two semesters) of full time enrollment or 2 years (four semesters) of part-time enrollment are required. Requests for part-time study should be submitted to and approved by the Graduate Committee. In most cases, course work requirements can be completed in one full-time academic year, but if a thesis masters is sought, additional time to conduct research and write the thesis is usually needed.

Each masters student is assigned a faculty advisor. When the masters involves research the advisor is typically the director of the laboratory in which the research is performed. In the case of a thesis masters (Plan A) the student is encouraged to assemble an advisory committee to help guide the direction of the research. All masters candidates are required to serve at least one semester as a teaching assistant.

Applications for admission should be submitted by Feb. 1 for matriculation in the fall of the same year.

### *Specific requirements:*

**Plan A (Masters thesis):** The program of study for a Plan A masters typically includes a larger proportion "research credits," (that is, credits earned by conducting research) than for the plan B. For the Plan A masters, the program of study must include at least six and may include up to 12 credits of research. Specific course requirements include:

Physiology (4) \*  
Graduate Seminar I and II (3)  
Ethics (0 credit)

At least eleven additional coursework credits must be earned from the list of approved BME courses. Six of the remaining 12 hours must be research credits, and the remaining six may be any combination of formal coursework, research credits and directed readings.

For the Plan A degree, a research thesis must be developed from an independent research project accomplished under the supervision of a faculty member in the BME Program. Format and preparation of the thesis should follow guidelines set forth in the "The Preparation of Doctoral Theses" booklet available in the Program Office.

**Plan B (Coursework masters):** A total of 30 credits is required, 18 of which must be coursework credits from the approved list of biomedical engineering courses. Of the 30 credits, at

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\* For students with substantial background in Physiology, the Physiology course can be waived and another biological science course at the 400 level (or higher) should be taken that is appropriate for the student's area of interest.

least 12 must be courses at the 400 level or higher. For special cases, up to (but not more than) six research credits may count toward the Plan B masters. The following courses are required:

Physiology (4)\*  
Graduate Seminar I and II (3)  
Ethics (0 credit)

All masters degree candidates must pass a final comprehensive examination. For plan A candidates, this exam takes the form of a thesis defense, much like the thesis defense for a doctoral degree. If the student has formed an advisory committee, these faculty members would typically constitute the examining committee for the thesis defense. For plan B candidates, the examination follows the format of the first year preliminary examination for doctoral candidates (see above). Three members of the Graduate Faculty selected by the Director of Graduate Studies in consultation with the Graduate Committee review the critical analysis written by the student and question the student in the oral examination.

The department does not provide stipends for students in the M.S. Program. A limited number of partial tuition scholarships are available on a competitive basis. In cases where the student works as a research assistant on a funded research project the advisor may elect to provide stipend support to the student from extramural resources. Monetary compensation to M.S. candidates from the sponsoring advisor may not exceed the current stipend for doctoral candidates in the Department. All other financial obligations must be borne by the candidate.

### **3-2 Masters Program**

Early admission to the masters degree is possible for exceptionally well-qualified undergraduate majors at the University of Rochester. Students must apply by April 1 of their junior year for admission to the program. The standard application for graduate study should be used, and in addition, a proposed program of study and an essay describing the goals and rationale for advanced study should be provided as part of the application. The requirement for the GRE is waived. Partial tuition scholarships are available on a competitive basis for the fifth year of study only.

Admission to the 3-2 program provides the student with some flexibility in scheduling courses in the senior and fifth years of study. Up to two fall courses required for the undergraduate degree may be deferred until the fall of the fifth year. The University requires that all requirements for the bachelors degree must be completed before the start of the spring semester of the fifth year of study. Courses taken during the first four years of study that are not needed to fulfill the requirements for the bachelors degree may be applied toward the masters degree program of study with the approval of the Graduate Committee. All students in this program are expected to serve as teaching assistants for one semester.

University of Rochester Graduates who are not admitted to the 3-2 program may apply during their senior year for admission to the masters program. All applicants are considered for

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\* For students with substantial background in Physiology, the Physiology course can be waived and another biological science course at the 400 level (or higher) should be taken that is appropriate for the student's area of interest.

available tuition scholarships in any given year. Teaching experience as a teaching assistant for at least one semester is required.

## *APPENDIX*

Laboratory Rotation Evaluation

Proposed Advisory Committee Membership

Graduate Student Research Review

Approval of Graduate Reading/Independent Study Courses

Complete Program for the Master's Degree

Examination Appointment for MS Final and PhD Qualifying Exam

Complete Program for the Degree of Doctor of Philosophy

Examination Report Form for Masters Final Exam, Ph.D. Qualifying Exam

Appointment form for Ph.D. Final Oral Examination

Request for Enrollment/Degree Verification