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University of Rochester – PhD in Biomedical Engineering- Assessment Plan

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A. Program Title

Biomedical Engineering

B. Program degree

PhD

C. Program objectives and learning outcomes

Program objective 1*: Scholarship.* Program will prepare students to carry out independent and original research that addresses problems in the multi-disciplinary field of biomedical engineering.

1a. Core knowledge: Students will demonstrate in-depth knowledge of the core theories and methods in the field of biomedical engineering. The demonstration will include the application of physics, advanced mathematics, and/or engineering principles to problems in medicine, biology, or biotechnology.

1b. Specialized knowledge: Students will demonstrate in-depth knowledge of the theories and methods within one or more sub-specialties of biomedical engineering.

1c. Creative synthesis: Students will creatively synthesize theory, literature, and personal experience to: 1) generate new ideas or hypotheses in biomedical engineering, and 2) devise critical tests of hypotheses and/or develop unique solutions to biomedical problems.

1d. Critical thinking: Students will be able to critically analyze work by others in their field of specialty.

1e. Research Design and Methods: Students will demonstrate the ability to plan and conduct research that meets or exceeds modern standards for scientific excellence in their specialty.

1f. Scholarship: Students will produce original, scholarly contributions in their field.

1g. Independence in learning: Students will demonstrate an ability to independently gain knowledge of new areas.

Program objective 2: *Professionalism.* Program will prepare students to be successful professionals in the field of biomedical engineering or related fields.

2a. Written communication: Students will convey ideas or arguments in clear, concise, well-organized papers and proposals.

2b. Oral communication: Students will convey ideas in cogent, persuasive, and organized presentations.

2c. Teaching: Students will present well-organized lectures, classroom activities and/or assignments that support student learning.

2d. Professional ethics: Students will demonstrate an appreciation for ethical decision making in professional work.

2e. Collaboration: Students will demonstrate the ability to work with other professionals inside their own laboratory and to collaborate with colleagues of diverse scientific backgrounds.

Program objective 3. *Leadership.* Program will prepare students as responsible global citizens, and as leaders and scholars in the field of biomedical engineering.

3a. Leadership as professional: Students will demonstrate leadership through positions held in scholarly and other professional organizations, by mentoring fellow students in the laboratory and classroom, and/or by contributing voluntary service to the department, university, or community.

3b. Leadership as scholar: Graduates will demonstrate leadership through development of original, scholarly publications in the field.

3c. Awareness of broader impact: Students will demonstrate an awareness of the social, economic, technical, or ethical impact of their work.

D. Program Components

The following are the key curricular, extracurricular, and scholarly components of the BME PhD program that achieve the program objectives.

1. **Rotations course:** Each student completes three laboratory rotations in the first year of the program. The rotations are roughly six-week research experiences during which a student completes a small supervised research project and participates in other activities of the lab such as group meeting and journal clubs.
2. **IND 501 Ethics & Professional Integrity:** This 1-credit ethics course is a requirement of the PhD curriculum and is typically taken in the first semester. The course covers the many facets of ethical practices in biomedical research. Among the topics covered each year are: 1) plagiarism/scientific misconduct, 2) human subjects, 3) conflicts-of-interest, 4) animal experimentation, 5) data ownership and authorship, and 6) copyright/publications.
3. **BME Intensives:** The BME core curriculum includes elective courses called **BME Intensives**. BME Intensives provide instruction at the interface of engineering and medicine and/or biology in specialized topics such as medical imaging, biomechanics, etc.
4. **Graduate engineering and biology course requirements:** The PhD curriculum requires the equivalent of three graduate courses in engineering beyond the requirement for BME Intensives, and 2 courses in graduate-level biology.
5. **BME 509 Proposal Writing:** This course provides instruction in scientific proposal writing. Typically taken in the second year of the PhD program, the document created in this course provides a student with an excellent basis for the qualifying examination taken in the third year of the program.
6. **Preliminary exam:** The preliminary exam is taken at the end of the second semester and prior to a student formally joining a research laboratory. The basis of the exam is a recent article from the literature. Each student is required to write and orally present both an original critique of the article and an engineering analysis based on the subject of the article. Students are then given an oral exam by three graduate faculty members in which the student must defend their critique and engineering analysis and answer relevant questions from their graduate coursework.
7. **Qualifying exam:** As the formal doctoral qualifying exam in BME, each student must prepare a research proposal in the style of an NIH grant application, present the proposal in a public seminar, and defend the proposal in closed session with the thesis committee and an external chair appointed by the Graduate Committee. The examination is typically completed by the third year in the program.

8. **Public presentation requirement:** Students are required to make four public presentation of their scientific progress before graduation. Students can meet this requirement with presentations at departmental seminars and at local or national meetings.
9. **Teaching assistantship:** The program requires students to complete two teaching assistantships. These assistantships are typically completed during the first two years in the program while the student is still taking courses.
10. **Annual advisory committee meetings:** After the preliminary exam each student is required to hold at least 1 meeting with their advisory committee each year until the completion of the thesis.
11. **PhD research project and thesis:** As the capstone of the PhD experience, each student completes an original, significant, and scholarly contribution to science in their field of specialty. The student presents his/her results in the form of a thesis document and public presentation and successfully defends his/her results in front of an expert faculty exam committee.
12. **Departmental Seminar Series:** The department runs a seminar series throughout the academic year. The seminar series features both invited external speakers and talks by program faculty who use the forum to introduce themselves and their research areas to the graduate student body. All graduate students are required to attend the seminars throughout their tenure in the program.
13. **Graduate Student Council:** The department provides an annual budget supporting the operation of a Graduate Student Council. This student-run group organizes many service and social events throughout the year. Service efforts include hosting and entertaining visiting students during recruitment visits, organizing panels to prepare 1st year graduate students on preliminary exam preparation, and community outreach through Habitat for Humanity.
14. **Student Summer Seminar Series:** The GSC organizes and runs a student-only summer seminar series in which students present their research progress to fellow students. The faculty-free environment provides a unique setting where students can hone their presentation skills without the pressure of faculty opinion. It also provides an opportunity for peer mentorship as students provide each other with both written and oral feedback on the presentations.

E. Process Tables

The following tables align the content of program components with the program objectives and learning outcomes. The purpose of these tables is to ensure that each learning objective is delivered through at least two program components.

	Objective 1: *Scholarship.* Program will prepare students to carry out independent and original research that addresses problems in the multi-disciplinary field of biomedical engineering.						
	1a. Core knowledge	**1b. Specialized knowledge**	**1c. Creative Synthesis**	**1d. Critical Thinking**	**1e. Research Design and Methods**	**1f. Scholarship**	**1g. Independence in Learning**
1. Rotations course	X	X		X	X		X
2. Ethics course			X	X	X	X	
3. BME Intensives	X	X		X			X
4. Engineering and Biology Course Requirements	X	X		X			X
5. Proposal Writings Course		X	X	X	X	X	
6. Preliminary exam	X	X	X	X	X	X	
7. Qualifying Exam	X	X	X	X	X	X	X
8. Public presentation requirement						X	
9. Teaching assistantship	X	X					X
10. Annual Advisory Committee Meeting	X	X	X	X	X	X	X
11. PhD Research and Thesis	X	X	X	X	X	X	X
12. Departmental Seminar Series		X			X	X	
13. Graduate Student Council							X
14. Student Summer Seminar Series		X					X
Total	***8***	***11***	***6***	***9***	***8***	***8***	***9***

	Objective 2: *Professionalism.* Program will prepare students to be successful professionals in the field of biomedical engineering or related fields.				
	2a. Written Communication	**2b. Oral Communication**	**2c. Teaching**	**2d. Professional Ethics**	**2e. Collaboration**
1. Rotations course	X	X			X
2. Ethics course				X	
3. BME Intensives					
4. Engineering and Biology Course Requirements					
5. Proposal Writings Course	X	X			
6. Preliminary exam	X	X			
7. Qualifying Exam	X	X			
8. Public presentation requirement		X	X		
9. Teaching assistantship			X		
10. Annual Advisory Committee Meeting		X	X	X	X
11. PhD Research and Thesis	X	X		X	X
12. Departmental Seminar Series		X			
13. Graduate Student Council			X	X	X
14. Student Summer Seminar Series		X	X		X
Total	***5***	***9***	***5***	***4***	***5***

	Objective 3: *Leadership.* Program will prepare students as responsible global citizens, and as leaders and scholars in the field of biomedical engineering.		
	3a. Leadership as Professional	**3b. Leadership as Scholar**	**3c. Awareness of Broader Impact**
1. Rotations course			X
2. Ethics course			X
3. BME Intensives			
4. Engineering and Biology Course Requirements			
5. Proposal Writings Course	X	X	X
6. Preliminary exam			
7. Qualifying Exam			
8. Public presentation requirement	X	X	
9. Teaching assistantship	X	X	X
10. Annual Advisory Committee Meeting			
11. PhD Research and Thesis	X	X	X
12. Departmental Seminar Series			X
13. Graduate Student Council	X	X	
14. Student Summer Seminar Series	X	X	
Total	***6***	***6***	***6***

F. Assessment of Student Performance

The following assessments of student performance are made for each doctoral candidate as they the progress through the program. Transcripts, review forms, and other supporting data are kept in each student's file.

1. **Annual assessment of progress by the Graduate Committee**: Each year, the graduate committee will conduct a review of all students in the doctoral program. To maintain progress toward graduation, students must maintain acceptable grades in course work and exams, and maintain acceptable progress toward degree completion. A student may be asked to leave the program before graduation if: 1) he/she does not pass preliminary, qualifying or exit exams, 2) earns grades of C for 8 credits or 2 or more classes, 3) if the student's advisory committee indicates a student is failing to make satisfactory progress toward a degree over a period of at least 1 year, or 4) if the graduate committee determines that the student has accumulated a significant record of poor performance in any number of evaluated areas such as class work, laboratory or program citizenship, research progress, exams, rotations, and teaching assistantships. ***Annual assessment of program components 1-12.***

2. **Rotation course and reviews**: Typically during the first year of doctoral study, students will complete 3 rotation projects as a course in the core curriculum. During the rotation, students are expected to: 1) participate in lab activities including group meetings and journal clubs; 2) complete experimental tasks agreed upon with the project mentor; and 3) document, analyze and present results. The mentor and the student complete a written evaluation form for each rotation. ***Assessment of program component 1.***

3. **Preliminary exam performance evaluation**: At the conclusion of the preliminary exam period, the faculty meet to discuss each student's exam performance as well as the student's record in courses, rotations and teaching assistantships during his/her first year in the program. If the student has satisfactory performance in each of these areas, the faculty will formally pass the student through the preliminary exam and allowing the student to join a laboratory and begin research. If the student has underperformed significantly during the exam or during the first year, the faculty may choose to separate the student from the program or prescribe remedial action such as an exam retake. ***1st year assessment of program components 1-4, 6, 9, 12.***

4. **Teaching assistantship evaluations**: Faculty instructors evaluate the student's participation as a teaching assistant at the completion of each assistantship. Evaluations are reviewed by the graduate committee at the end of each year. Exemplary performances can be nominated for departmental and university recognition. ***Assessment of program components 9.***

5. **Qualifying exam evaluation**: The thesis proposal document and oral exam will demonstrate a student's: 1) conceptual understanding of his/her field of specialty including pertinent literature, 2) his/her ability to develop an original and sound research strategy to address an unsolved problem of significance in biomedical engineering, and 3) his/her ability to articulate and defend scientific reasoning in front of a faculty panel. Faculty write a written assessment of the student performance and fail the student in whole or part if the performance is unsatisfactory. Re-examination is allowed at the recommendation of the exam committee. ***Assessment of program component 7.***

6. **Advisory committee reports**: Student must report progress to his/her thesis committee at least once a year. The update is given in the form of a presentation and summarized on a progress report form. Both the student and the advisory committee complete the faculty sections of this progress report form. Faculty record their advice and their assessment of both the research project and student progress. The student also document publications, conference attendance, presentations, service, teaching and career development. ***Annual assessment of program component 11.***

7. **Ph.D. thesis and final oral examination:** The capstone experience of the PhD thesis is a written dissertation and exam. The exam committee is composed of the PhD thesis advisory committee with the addition of a chairperson appointed by the University. The committee reviews the student's written dissertation and examines the student in a closed session in which the student must defend the thesis content. The examination follows a mandatory public presentation. ***Final assessment of program component 11.***

8. **Graduate Student Council report to Graduate Committee:** Each year the graduate student council will attend a meeting with the faculty Graduate Committee to report on the concerns of students and the activities of the GSC. The GSC will also submit an annual report documenting all prior year activities and budget expenditures. ***Assessment of program components 13, 14.***

G. Assessment Table

The following table cross-references program components with student assessments. The purpose of this table is to ensure that each program component is assessed at least once.

	Program Component													
	Rotations course	**Ethics Course**	**BME Intensives**	**Eng & Bio Courses**	**Proposal writing course**	**Prelim Exam**	**Qual Exam**	**Student Presentations**	**TA**	**Advisory Committee Meetings**	**PhD Thesis**	**Depart Seminar**	**GSC**	**Summer Seminar Series**
1. Annual GC evaluation	x	x	x	x	x	x	x	x	x	x	x	x		
2. Rotation project reviews	x													
3. Preliminary exam evaluation	x	x	x	x		x			x			x		
4. TA review									x					
5. Qualifying exam							x							
6. Advisory committee report										x				
7. Thesis exam											x			
8. GSC report													x	x
Total	3	2	2	2	1	2	2	1	3	2	2	2	1	1

H. Assessment of Program Strength

The strength of our program is measured by the productivity of our students and affiliated laboratories. Student diversity and satisfaction are also assessed as these characteristics promote productivity. As a mechanism to evaluate the strength of the graduate program and provide feedback for continuous improvement, the graduate committee will collect the following data from the student population. Data will be presented to the faculty on an annual basis.

1. **Student Distinctions:** Student awards, fellowships, leadership positions, and other distinctions given by the program, the University, and external organizations will be recorded each year.
2. **Student Publications:** All scientific publications that include students as an author will be recorded in a database each year. Distinctions will be made between peer-reviewed and non-peer-reviewed articles, invited articles, conference proceedings and book chapters.
3. **Student Presentations:** Student presentations at national and local scientific meetings (non-UR) will be counted each year. Distinctions will be made between platform presentations, posters, and invited talks.
4. **Time-to-degree:** The average time for degree will be calculated each year. The % of students graduating in 6 years or less will be calculated using a 5-year running average.
5. **Diversity:** Year-by-year data on the diversity of our student population will be collected each year and compared to peer and higher-ranking programs in the NRC database. Diversity categories will include % minority, % female, and % international.
6. **Annual Graduate Student Survey**: A web-based survey will be distributed annually by the ASE Director of Assessment. The survey will ask students to comment on: 1) the overall quality of the graduate program, 2) the perceived importance and effectiveness of the curricula and other program components, 3) the quality of the facilities, 4) the support provided by the research and academic advisor(s), laboratory, department, and university, 5) the satisfaction of students with lab choices and lab selection, and 6) the Rochester community and living environment. The survey will also ask students to update a career plan following graduation.
7. **Exit Survey:** At the end of a graduate student's enrollment in the PhD program, the student will be asked to complete a departmental survey that will include the same questions as the annual survey but also students to comment on the program objectives, learning outcomes, and the effectiveness of the program components in delivering those outcomes and preparing the student for the next stage of his/her career.

8. **Lab-to-Student Ratio:** The number of active research laboratories available to graduate students will be counted each year and the ratio of PhD students to active laboratories monitored as a measure of program strength.

I. Assessment of Program Impact

The ultimate success of the graduate program is measured by achievements of our alumni and the national reputation of the program. As a mechanism to evaluate the impact of the graduate program, departmental administrators will collect the following data each year. The data will be included on the annual report to the faculty on the state of the graduate program.

1. **Alumni survey:** A web based survey will be distributed by the ASE Director of Assessment every 5 years beginning in 2011-2012. The survey will ask alumni to rate the importance of the program objectives and learning outcomes for current career tasks.
2. **Post-graduation career data**: Career data will be reported by students and alumni in each of the above surveys.
3. **Alumni leadership and achievement:** The Alumni Survey will collect data on the leadership positions and career achievements of our alumni.
4. **National rankings:** US News, NRC and any other national rankings will be documented in the annual report to the faculty.
5. **Faculty publications:** The total number of publications produced by the graduate faculty as well as the publications per faculty member will be calculated and reported each year.
6. **Impact of publications:** The average number of citations per publication affiliated with the program will be tallied for publications between 2 and 5 years old. The range and average impact factors for the journals in which our faculty publish will be surveyed each year.
7. **Intellectual property:** Each year we will update the total number of invention disclosures, provisional patent filings, and issued patents awarded to members of the graduate faculty.
8. **Graduate student staffing of research laboratories:** The program will survey the the faculty each year to assess the number of graduate research slots that have gone unfulfilled. The program will also ask the faculty to comment the their level of satisfaction with the quality of the graduate students working in their laboratory.
9. **Faculty research funding:** Total research funding awarded to all members of the BME graduate faculty will be tallied and reported each year. Subsets of this data showing awards to primary BME faculty and to those laboratories that have hosted BME doctoral students in the last 5 years will also be calculated.

10. **Faculty award and honors:** Faculty recognition such as teaching awards, distinction in scientific societies, and editorial positions, will be surveyed each year and included in the annual report.