PH.D. IN BIOMEDICAL ENGINEERING

Program Objectives

The goal of the PhD program in Biomedical Engineering at the University of Miami is to train students for independent research and innovation in biomedical engineering. The program is designed to prepare graduates for careers in academia, industrial research and development, or government (FDA, US Patent Office).

PhD students conduct research at the Department of Biomedical Engineering and at clinical departments and research centers at the School of Medicine, including the Bascom Palmer Eye Institute, the Miami Project to Cure Paralysis, the Diabetes Research Institute, the University of Miami Ear Institute, Biomedical Nanotechnology Institute, the Departments of Pathology, Radiology, Radiation Oncology, Otolaryngology, and Surgery, and the Miami Veterans Administration Research Service. Many of our doctoral students work closely with physicians to develop and investigate new therapies, devices, and technologies that address real-world clinical problems.

Admission Requirements

The qualifications and documentation required for admission to the PhD program in Biomedical Engineering are the same as for the College of Engineering.

In general, the Department admits three types of students to its PhD program:

- Students with MS degrees in Biomedical Engineering or related science and engineering fields.
- Students with MD degrees with undergraduate degrees in sciences or engineering.
- Highly qualified students with BS degrees in engineering or sciences.

Students admitted with non-engineering degrees are generally given conditional admission and required to take additional undergraduate courses in engineering, physics, and/or mathematics depending on their previous course work, as specified in the admission letter. The requisite courses will be prescribed by the Department Chair or Graduate Program Director during the first advising session.

The PhD program in biomedical engineering is also a degree-granting program of the University of Miami’s MD-PhD program.

Required Core Courses

There are four core graduate courses: Unified Medical Sciences I/II/III (BME 601/BME 602/BME 603, 3 credits each) and a Graduate Scholarship course (BME 780, 3 credits). The three courses of the Unified Medical Sciences sequence are designed to provide a basic understanding of human physiology and anatomy and cellular and molecular biology. The Graduate Scholarship course provides training in grant proposal writing, manuscript preparation and other doctoral-level research and professional skills.

All BME PhD students are required to take at least two of the three Unified Medical Sciences courses, with the following exceptions:

- Students enrolled in the MD-PhD program and students with an MD from a medical school accredited by the World Health Organization are exempted from taking these 3 courses.
- Students admitted in the direct BS to PhD are required to complete all 3 courses.
- With the permission of the graduate advisor, students who have completed these courses or similar coursework in a previous graduate course of study may substitute technical electives for this requirement.

Graduation requirements

The general requirements for award of the Doctor of Philosophy include:

- Completion of a minimum of 60 course credits beyond the BS degree.
- Satisfactory completion of a written qualifying examination.
- The submission, oral defense, and approval of a dissertation proposal.
- The submission, oral defense and approval of a dissertation.
- Completion of the publication requirements.

All work, including credit transferred from other institutions, must be completed within 8 years of the time of admission to graduate work, and/or within four years of approval of the dissertation proposal. An average of B (3.0) is required for a graduate degree, and no “D” credit may be counted toward the degree. A C- is the lowest passing grade for graduate students.

Curriculum

The PhD curriculum was designed to provide the technical and intellectual skills required to identify and solve complex scientific or technical problems at the interface of engineering and medicine or biology. The curriculum combines advanced coursework which provides depth in a specific area of concentration, with independent original research in one of the laboratories of the faculty from the Department of Biomedical Engineering or the School of Medicine.

Except for the Medical Physics program there are no formalized graduate curricular tracks in the PhD program. The student’s mentor and supervisory committee work with the student to develop a personalized course plan, based on the student’s own needs and interests. The personalized course plan is designed to ensure that the student is prepared for advanced independent research and technical innovation in biomedical engineering. The course plan can include any of the graduate course offerings, as long as the student satisfies the course pre-requisites.

The proposed individualized course curriculum must be submitted to the Graduate Program Director for final approval or to the Department Chairperson when the Graduate Program Director is the student’s mentor.

The proposed individualized course curriculum must be submitted to the Graduate Program Director for final approval or to the Department Chairperson when the Graduate Program Director is the student’s mentor.
MD-PhD program

Students enrolled in the MD-PhD program start the PhD program after completion of the first two years of medical school.

MD-PhD students who choose BME as their degree-granting program can count up to 15 credits of work completed during the first two years of medical school towards their PhD degree requirements (See: Credit Requirements). To receive credit, students enroll in the following courses:

- BME 711 - Accelerated Basic Science Medical Curriculum (9 credits). BME 711 satisfies the Unified Medical Sciences (9 credits) requirement.
- PIB 731 - Laboratory Research (1-6 credits). Students receive up to 3 credits for each research rotation that they complete during their first two years of medical school, up to a maximum total of 6 credits.

To receive credit, students must submit a report for each rotation, following the guidelines for BME Independent Study reports.

All MD PhD students must complete a 3-credit biostatistics course. Students who have successfully completed equivalent coursework in a previous course of study can be exempted from this requirement.

Medical Physics Program

The Department of Biomedical Engineering at the University of Miami offers a special PhD program in Medical Physics accredited by CAMPEP. The objective of the Medical Physics program is to provide advanced knowledge in the field of therapeutic medical physics, and to provide the training required for students to become licensed medical physicists. This program is coordinated by the Department of Biomedical Engineering and the Department of Radiation Oncology at the School of Medicine.

Candidates are required to have completed a 3 credit course in Modern Physics (PHY 360 or equivalent) and a 3 credit course covering the physical foundations of medical imaging (BME 330 or equivalent) before they start their course work in the Medical Physics program.

Students enrolled in the Medical Physics program must complete the following courses:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credit Hours</th>
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</thead>
<tbody>
<tr>
<td>BME 602</td>
<td>Unified Medical Sciences II</td>
<td>3</td>
</tr>
<tr>
<td>BME 620</td>
<td>Medical Imaging System</td>
<td>3</td>
</tr>
<tr>
<td>BME 681</td>
<td>Radiation Biology and Physics</td>
<td>3</td>
</tr>
<tr>
<td>BME 682</td>
<td>Radiation Therapy Physics</td>
<td>3</td>
</tr>
<tr>
<td>BME 683</td>
<td>Radiation Protection</td>
<td>3</td>
</tr>
<tr>
<td>BME 729</td>
<td>Advanced Medical Imaging</td>
<td>3</td>
</tr>
<tr>
<td>BME 781</td>
<td>Radiation Dosimetry And Physics</td>
<td>3</td>
</tr>
<tr>
<td>BME 783</td>
<td>Radiation Therapy Physics</td>
<td>3</td>
</tr>
<tr>
<td>BME 784</td>
<td>Medical Physics Journal Club</td>
<td>1</td>
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</tbody>
</table>

Students enrolled in the Medical Physics program must also complete an additional separate qualifying examination focused on the medical physics curriculum (see below section on qualifying examination).

Additional information on the Medical Physics program can be found on the Department website. (http://www.coe.miami.edu/dept-bio/graduate/ms-programs/medical-physics)

Credit Requirements

The credit requirements are summarized below. Students admitted with non-engineering degrees are generally accepted conditionally, with the requirement to complete a set of undergraduate courses in engineering and/or mathematics before gaining full admission into the PhD program. The list of pre-requisite courses is defined before the start of the first semester of study by the Graduate Program Director and Department Chairperson, in consultation with the student mentor. Course pre-requisites are not counted towards the degree requirements.

Direct BS to PhD Track

Total of 60 Course & Dissertation Credits

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BME 601</td>
<td>Unified Medical Sciences I (Cellular/Molecular)</td>
<td>9</td>
</tr>
<tr>
<td>BME 602</td>
<td>Unified Medical Sciences II (Human physiology)</td>
<td>3</td>
</tr>
<tr>
<td>BME 603</td>
<td>Unified Medical Science III (Neuroscience)</td>
<td>3</td>
</tr>
<tr>
<td>Graduate Scholarship Course</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>A minimum of 15 credits of additional courses^2</td>
<td></td>
<td>15+</td>
</tr>
<tr>
<td>Responsible Conduct of Research Training^3</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>RST 611</td>
<td>Responsible Conduct of Research</td>
<td>3</td>
</tr>
<tr>
<td>RST 612</td>
<td>Responsible Conduct Of Research</td>
<td>6</td>
</tr>
<tr>
<td>Dissertation Work^4</td>
<td></td>
<td>12+</td>
</tr>
<tr>
<td>BME 830</td>
<td>Pre-candidacy Doctoral Dissertation</td>
<td>3</td>
</tr>
<tr>
<td>BME 840</td>
<td>Post-Candidacy Doctoral Dissertation</td>
<td>9</td>
</tr>
</tbody>
</table>

Total Credits 60

^1 If the student has completed equivalent coursework, this requirement can be waived. However, these courses must be substituted with another 9 credits of coursework.

^2 A minimum of 15 credits of additional courses to be selected by the student in consultation with his/her mentor and the supervisory committee. Beyond the minimum requirement of 24 course credits, the supervisory committee shall decide which additional courses, if any, will be required to ensure that the student is prepared for advanced independent research and technical innovation in biomedical engineering. A three credit advanced biostatistics course is strongly recommended.

^3 More information about these courses can be found on the CoE website (http://www.coe.miami.edu) and the UM RCR website (http://www.miami.edu/index.php/ethics/projects/rcr).
A minimum of 12 credits of dissertation work must be completed. Students should enroll into BME 830 before admission to candidacy and BME 840 after admission to candidacy.

### MS to PhD Track

**Total of 30 Course & Dissertation Credits**

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credit Hours</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Course Credits:</td>
<td>9-18</td>
</tr>
<tr>
<td></td>
<td>At least two of the following three courses:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>BME 601 Unified Medical Sciences I (Cellular/Molecular)</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>BME 602 Unified Medical Sciences II (Human physiology)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>BME 603 Unified Medical Science III (Neuroscience)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Graduate Scholarship Course</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Additional Courses</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Responsible Conduct of Research Training</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>RST 611 Responsible Conduct of Research</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>RST 612 Responsible Conduct Of Research</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dissertation Work</td>
<td>12+</td>
</tr>
<tr>
<td></td>
<td>BME 830 Pre-candidacy Doctoral Dissertation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>BME 840 Post-Candidacy Doctoral Dissertation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total Credits</td>
<td>30</td>
</tr>
</tbody>
</table>

1. A minimum of 15 credits of additional courses to be selected by the student in consultation with his/her mentor and the supervisory committee. Of these credits, up to 6 credits can be satisfied by PIB 731. Beyond the minimum requirement of 24 course credits, the supervisory committee shall decide which additional courses, if any, will be required to ensure that the student is prepared for advanced independent research and technical innovation in biomedical engineering.

2. This course is not counted towards the minimum of 21 course credit requirement.

3. More information about these courses can be found on the CoE website (http://www.coe.miami.edu) and the UM RCR website (http://www.miami.edu/index.php/ethics/projects/rcr).

4. A minimum of 12 credits of dissertation work must be completed. Students should enroll into BME 830 before admission to candidacy and BME 840 after admission to candidacy.

### Medical Physics Program

Students enrolled in the Medical Physics Program must follow the general requirements of the PhD program and must complete the following classes as part of their course curriculum:

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<tr>
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<tr>
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<td>BME 682</td>
<td>Radiation Therapy Physics</td>
<td>3</td>
</tr>
<tr>
<td>BME 683</td>
<td>Radiation Protection</td>
<td>3</td>
</tr>
<tr>
<td>BME 729</td>
<td>Advanced Medical Imaging</td>
<td>3</td>
</tr>
<tr>
<td>BME 781</td>
<td>Radiation Dosimetry And Physics</td>
<td>3</td>
</tr>
<tr>
<td>BME 783</td>
<td>Radiation Therapy Physics Clinical Rotation</td>
<td>3</td>
</tr>
<tr>
<td>BME 784</td>
<td>Medical Physics Journal Club</td>
<td>1</td>
</tr>
</tbody>
</table>

### Research in Residence

Once a student has completed all required course and dissertation credits, he or she must enroll in Research in Residence status (BME 850, 0 credit) until the degree has been granted. Research in Residence status is considered full time enrollment. Credit is not granted for research in residence, but a fee is charged for each enrollment.
Qualifying Examination

General Description
All students in the PhD program must pass a Comprehensive Qualifying Examination, which consists of two parts:

- A written examination which serves to assess proficiency in the core disciplines.
- The defense of a dissertation proposal

Upon completion of the examination process, the Supervisory Committee shall notify the Graduate School and the department that the student has passed or failed the examination.

Written Qualifying Examination

Format
The written examination is administered once a year (August) over a period of 1.5 days. The examination consists of three written tests on the topics of basic engineering, applied mathematics and computer science, and applied physiology and medical science. Each test lasts 2.5 hours and consists of a minimum of 12 independent questions or problems assigned by the primary faculty of the BME Department. In each test, students must select and satisfactorily answer 6 problems. Students enrolled in the MD-PhD program are exempt from taking the applied physiology and medical science section of the qualifying examination.

Schedule:
The examination must be taken the first time it is scheduled after completion of the first two semesters. The Graduate School will not, ordinarily, approve the taking of the qualifying examination until the student has had a minimum of one continuous academic year of graduate work in courses, seminars, and directed or tutorial study. In the Department of Biomedical Engineering, a student in good academic standing may take the examination after completing only one full semester of classes, with approval of his/her mentor, Graduate Program Director and Department Chairperson.

Repeat:
A student who fails the examination might be given the opportunity to repeat any or all parts of the examination once. Permission to retake the examination is not automatic. It requires approval of the program faculty. Under exceptional conditions, students may be allowed to repeat a single section a second time. Students who fail the qualifying examination are dropped from the program. Students admitted to the doctoral program with a BS degree that do not pass the qualifying examination may complete the MS degree.

Medical Physics Qualifying Examination

Students enrolled in the Medical Physics program must pass an additional written examination focused on topics covered in the Medical Physics curriculum. The examination is typically scheduled the semester following the regular BME screening examination, and consists of 6 separate written tests on the following topics, corresponding to courses in the curriculum: Anatomy/Radiobiology BME 602/BME 681; Medical Imaging (BME 620/BME 729); Radiation Therapy Physics (BME 682); Radiation Protection (BME 683); Radiation Dosimetry (BME 781); Medical Physics Clinical Rotation (BME 783). The entire examination is scheduled in a single day, with each test lasting 55 minutes. The minimum passing score for each test is 70%. Students who fail one or more of the tests must retake the test(s) before the end of the semester. Students who fail the same test twice are dropped from the Medical Physics program.

Supervisory Committee

In the Department of Biomedical Engineering, the PhD Supervisory Committee is appointed by the Chairperson during the first year of enrollment, in consultation with the student and his/her research mentor.

The role of the Supervisory Committee is to identify any additional courses required beyond the minimum course requirements, to oversee program milestones, and to administer any additional written or oral examination deemed necessary to complete the qualifying examination.

In the Department of Biomedical Engineering, the Supervisory Committee must be comprised of at least five members. The five members include the committee chair, who shall be a Primary Faculty member of the Department of Biomedical Engineering, as well as a regular member of the Graduate Faculty. Of the remaining members, it is also required that two shall be from Graduate Faculty and one from outside the department. It is an additional requirement of the Department of Biomedical Engineering that two of the remaining members shall be primary Faculty members from the Department. A research mentor who is not a Primary Faculty member of the Department of Biomedical Engineering, can serve as Co-Chair of the Supervisory Committee, together with a second Co-Chair who shall be a member of the primary faculty of the Department of Biomedical Engineering.

Dissertation Proposal

Format
Each student must submit an original written proposal describing the goals of the dissertation research project, the significance of the work, preliminary studies, and the research plan. The proposal must be submitted to the Supervisory Committee and orally defended before the end of the fourth semester for students admitted with an MS degree and before the end of the first semester of the third year for students admitted with a BS degree. The student’s knowledge of the proposed research topic will be tested during the oral defense. If any deficiencies are discovered during the defense of the proposal, an additional written or oral examination may be required by the Ph.D. Supervisory Committee.

Evaluation Forms
The candidate is responsible for distributing dissertation proposal evaluation forms (http://bulletin.miami.edu/graduate-academic-programs/engineering/biomedical-engineering/biomedical-engineering-phd/SACS_Graduate_Rating_Grid_Rubric_2016.pdf) to the members of the Supervisory Committee. The evaluation forms are used to assess the overall quality of the graduate program at the Department, College, and University level. The evaluation forms are available on the Graduate School and Department of Biomedical Engineering websites. The forms must be completed by the Committee members after the dissertation defense. The completed forms must be collected by the Dissertation mentor and forwarded to the Office Manager at the Department of Biomedical Engineering.

Admission to Candidacy

A student who has passed the written qualifying examination, and successfully defended the dissertation proposal must:

- submit a signed “Approval of the Dissertation Proposal” (http://bulletin.miami.edu/graduate-academic-programs/engineering/biomedical-engineering/biomedical-engineering-phd/Department_Dissertation_Proposal_Approval.pdf) form to the Graduate Program Director of the Department of Biomedical Engineering.
• form a Dissertation Committee (see below)
• submit an Application for Admission to Candidacy for the Ph.D./Ed.D./D.M.A. (https://umshare.miami.edu/web/wda/grad/forms_/web/admission_to_candidacy.pdf) to the Graduate School to be granted admission to candidacy.

Admission to candidacy recognizes the fact that a student enrolled in the Ph.D. program has completed all doctoral degree requirements except completion of an acceptable dissertation project and defense of the dissertation. Completion of the required course credits and dissertation credits (BME 830 and/or BME 840) is not a requirement for admission to candidacy in the Department of Biomedical Engineering.

No student may receive the degree in the same semester or summer session in which he or she is admitted to candidacy. The student must be admitted to candidacy before the dissertation defense is scheduled.

Dissertation Committee
In the Department of Biomedical Engineering, the Dissertation Committee is generally the same as the Supervisory Committee, but it may also be a committee formed anew to undertake the duties of advising and passing upon the dissertation. The Dissertation Committee is nominated by the Department, and is approved and appointed by the Dean of the Graduate School.

As with the Supervisory Committee, the Dissertation Committee must be comprised of at least five members, including the committee chair. The committee chair shall be a Primary Faculty member of the Department of Biomedical Engineering, as well as a regular member of the Graduate Faculty. Of the remaining members, it is also required that two shall be from Graduate Faculty and one from outside the department. It is an additional requirement of the Department of Biomedical Engineering that of the remaining members, at least two should be primary Faculty members from the Department. A research mentor who is not a member of the Primary Faculty of the Department of Biomedical Engineering, can serve as Co-Chair of the Dissertation Committee, together with a second Co-Chair who shall be a member of the primary faculty of the Department of Biomedical Engineering. One additional requirement is that the Dissertation Committee of students enrolled in the MD-PhD program must include one member of the MD-PhD program committee.

The duties of the Dissertation Committee are:
• to consult with and to advise students on their research;
• to meet, at least once per year, to review progress and expected results (see below);
• to read and comment upon the draft dissertation;
• to meet, when the dissertation is completed, to conduct the final oral examination and to satisfy itself that the dissertation is a contribution to knowledge and that it is written in lucid and correct English and submitted in approved format.

Yearly Progress Review
The student must schedule a yearly meeting with the dissertation committee. The purpose of the meeting is to give the student an opportunity to present his/her doctoral research progress to the committee and to receive the committee's feedback and recommendations. The student must submit a brief progress report to the dissertation committee at least seven days before the meeting. During the meeting, the student will present his/her doctoral research progress to the committee. The presentation will be followed by a discussion session. At the end of the discussion session, the committee will meet alone to discuss the student’s progress and provide recommendations to the mentor. The mentor will provide a written summary of the discussion and committee recommendations to the student and to the Graduate Program Director. Students who are not making adequate progress may be terminated from the program.

Doctoral Dissertation
General Description
The doctoral dissertation is a monograph which describes the significance of the research and summarizes the research activities completed as part of the doctoral degree requirements. The objective of the dissertation is to evaluate the candidate's competence in the area of the Ph.D. research. The dissertation must demonstrate that the research is original and that it makes a significant contribution to the field of study.

A final public oral defense of the dissertation is required. However, none but the members of the dissertation committee may interrogate the candidate. The defense must be held before the deadline published on the Graduate School website (http://www.miami.edu/gs/index.php/graduate_school/current_students/electronic_theses_dissertations), generally at least two weeks prior to the last day of class in the semester the student wishes to graduate. The student must submit the Defense Notice Form available on the Graduate School website and provide a copy to the Department of Biomedical Engineering.

The candidate is well advised to have a final, acceptable typescript of the dissertation in the hands of each member of his/her committee at a time reasonably in advance of the final defense of the work a minimum of two weeks prior to the defense.

Dissertation Format and Deadlines
It is the duty of the student to ensure that the dissertation defense is scheduled and that a final version of the dissertation approved by the Dissertation Editor is submitted to the Dissertation Editor by the required deadlines set by the Graduate School. All information pertaining to the formatting and electronic guidelines for electronic thesis and dissertation submission can be found on the Graduate School website (http://www.miami.edu/gs/index.php/graduate_school/current_students/electronic_theses_dissertations). The Graduate School also encourages students to contact the Dissertation Editor at the Graduate School when they start preparing their dissertation.

Students must inform the Department of Biomedical Engineering of their intent to defend at least 2 weeks in advance of the defense date, by email to the Department staff. The email must include the dissertation title and the date, time and location of the defense. The information will be posted in the Department’s physical and online bulletin boards.

Each dissertation must be accompanied by Certificate of Defense Approval for Doctoral Dissertation (https://umshare.miami.edu/web/wda/grad/etd/forms/phd_cert_defense.pdf) signed by all members of the Committee. Forms can be downloaded from the Graduate School website.

Evaluation Forms
The candidate is responsible for distributing dissertation evaluation forms (http://bulletin.miami.edu/graduate-academic-programs/engineering/biomedical-engineering/biomedical-engineering-phd/SACS_Graduate_Rating_Grid_Rubric_2016.pdf) to the members of the Dissertation Committee. The evaluation forms are used to assess the
overall quality of the graduate program at the Department, College, and University level. The evaluation forms are available on the Graduate School and Department of Biomedical Engineering websites. The forms must be completed by the Committee members after the dissertation defense. The completed forms must be collected by the Dissertation mentor and forwarded to the Office Manager at the Department of Biomedical Engineering.

**Publication Requirements**

As a requirement for graduation, all PhD Candidates at the University of Miami Department of Biomedical Engineering are expected to have published, or have in press (i.e., the manuscript must have received final acceptance), in high quality peer-reviewed journals, a minimum of 2 publications describing work related to the dissertation. The candidate must be the first author on at least one of these two publications. In addition, the candidate must have been the presenting author of at least 2 oral or poster presentations describing the dissertation work at major peer-reviewed international conferences.

**Teaching Requirements**

Students enrolled in the PhD program in Biomedical Engineering who passed their qualifying examination are required to participate in undergraduate teaching activities. The minimum requirement will be to teach one undergraduate classroom lecture per academic year, under the supervision of the primary or secondary mentor, and/or the faculty responsible for the course and to help supervise at least one undergraduate student research project per academic year. For each classroom lecture, the mentor will provide feedback to the student and complete and sign a teaching evaluation form (http://bulletin.miami.edu/graduate-academic-programs/engineering/biomedical-engineering/biomedical-engineering-phd/Grad_Teaching_Eval.pdf) which must be returned to the Graduate Program Director.