**Departmental Assessment Plan:**

At the end of the Biomedical Engineering PhD program, students will be able to:

<table>
<thead>
<tr>
<th>Learning Goals</th>
<th>Measures</th>
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</table>
| Demonstrate mastery of the subject matter. | Graduate course grades  
Qualifying Exam  
Research Proposal  
Dissertation and Defense  
PhD Self-assessment |
| Demonstrate advanced research skills; design and execute a research project and conduct original and publishable research in the field.  
- Master application of existing methodologies and techniques.  
- Critically analyze and evaluate one's own findings and those of others. | Research Proposal  
Dissertation and Defense  
PhD Self-assessment |
| Make an original and substantial contribution to the discipline.  
- Think originally and independently to develop concepts and methodologies.  
- Identify new research opportunities within one's field. | Research Proposal  
Dissertation and Defense  
PhD Self-assessment  
Publications  
Conference presentations  
Doctoral Candidate Seminar |
| Demonstrate professional skills.  
- Effective oral communication skills.  
- Effective written communication skills.  
- Graduate Teaching | Qualifying Exams  
Research Proposal  
Dissertation and Defense  
PhD Self-assessment  
Publications  
Doctoral Candidate Seminars  
Conference presentations  
GTA evaluations |
| Practice responsible conduct of research. | Research Proposal  
Dissertation and Defense  
PhD Self-assessment  
Publications  
Doctoral Candidate Seminars  
Conference presentations  
RCR Training  
GTA evaluations |
DOCTORAL ADMISSION PROCESS:

Applications must be received by the admissions deadline to receive support from the Department of Biomedical Engineering (BME) PhD program:

- Fall semester admission: PhD application deadline is January 15.
- Spring semester admission: PhD application deadline is July 1. However, most applicants are awarded support for the fall semester, very few applicants are awarded support for the spring semester.

Applications submitted after the deadline will be considered on a rolling basis. For full consideration of support, applications should be submitted by the deadline.

Support letters will be sent to applicants by April 1 for the fall semester and October 1 for the spring semester. Applicants will have until April 15 to accept or decline the offer of support.

Admission Requirements:

Applicants that meet the required criteria are not guaranteed an acceptance into the program.

- GPA of 3.25 on a 4.0 scale
- To convert your GPA to the 4.0 scale, please use this link: http://www.foreigncredits.com/Resources/GPA-Calculator/
- GRE: Recommended scores of 85% (Michigan Tech students are exempt)
  o 165 Quantitative
  o 153 Verbal
  o 3.0 Analytical
- TOEFL: Recommended Score of 110 iBT (International Students)
- IELTS: Recommended Overall Band Score of 8.0 (International Students)

The graduate committee will review applications approximately biweekly and reject any applications that do not meet the basic requirements.

The applications that were not rejected will be saved to the departmental Google drive for BME faculty to review. Faculty will review applications and identify applicants with mutual research interests. Applicants whose statement of purpose poses a mutual research interest will be approved for acceptance into the program (this final approval does not indicate funding will be received). The applicant will be temporarily paired with the faculty member for advising.

A Faculty Meeting will be held mid to late March to discuss which students will be accepted by faculty.

Support letters will be sent out by April 1.

Applicants must respond to the offer letter by April 15 so that an alternative offer letter can be sent to someone else. Offer letters are to be signed by the department chair and must be in the Graduate School format. Stacey & Cory will monitor acceptances.
Requirements and Deadlines

Each PhD student enrolled in the Department of Biomedical Engineering (BME) PhD program is required to adhere to the following requirements and deadlines. Students requiring additional coursework will be notified of any required prerequisites as determined by the student’s advisor and/or BME graduate program director.

REMEMBER THAT FORMS ARE AVAILABLE ON THE GRADUATE SCHOOL WEBSITE, MyMichiganTech AND THE BIOMEDICAL ENGINEERING’S GRADUATE WEBSITE.

STUDENTS ARE REQUIRED TO MONITOR THEIR ACCOUNTS AND SUBMIT FORMS BY THE REQUIRED DEADLINES.

Newly accepted student responsibilities upon arrival on campus and prior to 1st day of class:

Obtain Husky Card

International students report to International Programs and Services (IPS)

Attend Graduate School Orientation

- Complete Basic Responsible Conduct of Research Training:
  - Provided during Graduate School Orientation
  - [Link](www.mtu.edu/gradschool/administration/academics/resources/rcr/online-basic/)
- Complete on MyMichiganTech the Patent, Research, & Proprietary Rights Agreement Form
- Submit official proof of previous degrees earned to the Graduate School

Attend BME Department Graduate Student Orientation Meeting.

Beginning of 1st semester:

- Complete Campus Clarity Training
  - [Link](www.mtu.edu/gradschool/administration/academics/resources/rcr/online-basic/)
- Complete Advisor & Committee Recommendation Form (D2) and submit to the Graduate School. A copy of the document is also required for department files. This process is to confirm who the advisor will be.

2nd semester:

- Complete Advisor & Committee Recommendation Form (D2) and submit to the Graduate School prior to the end of the semester. (Post Master’s students only.) A copy of the document is also required for department files. This process is to choose an advisory committee. The committee will consist of the student’s advisor, and at least 3 additional full-time faculty members. Two members must have a primary appointment in the BME department. There must be at least one member who does not have a primary appointment in the BME department.

- Proposed coursework: Biomedical Engineering Plan of Study Form. The proposed coursework will include the classes taken during the first semester. This must be signed by the advisor. This form is for department files only.

2nd – 3rd semester:

- Complete Advanced Responsible Conduct of Research Training:
  - [Link](www.mtu.edu/research/administration/integrity-compliance/responsible-conduct/training/courses/)
  - Students are recommended to take these courses fall or spring semester
3rd - 6th semester: (completion of coursework)

- **One semester of GTA**
- **Proposal Defense**
  - Provide date, time, building/room number and proposal title to departmental coordinator.
- Submit Qualifying Exam and Research Proposal Exam (D4/D6) to the department. Staff enters into BANNER.
- Submit Petition to Enter Research Mode to the Graduate School
- Submit Degree Schedule to the Graduate School (D5)
- **All PhD students will be required sometime during their study (prior to their defense) to present a seminar to BME faculty and other BME graduate students. Two students will be selected per semester. Discussions with selected students will occur early in the semester to allow presenting students time to prepare their seminar.**

4th semester:

- Complete Advisor & Committee Recommendation Form (D2) and submit to the Graduate School prior to the end of the semester. (Post Bachelors students only.) A copy of the document is also required for department files. This process is to choose an advisory committee. The committee will consist of the student's advisor, and at least 3 additional full-time faculty members. Two members must have a primary appointment in the BME department. There must be at least one member who does not have a primary appointment in the BME department.

Every semester:

- **Must attend a minimum of 6 BME graduate seminars each semester. Attendance of other department seminars is required if there are not enough BME seminars offered.**

At the end of every semester:

- Submit Graduate Student Self-assessment Form to advisor at the end of each semester/prior to the beginning of the next semester
- Arrange meeting with advisor to review the self-assessment
- The purpose of the self-assessment is to keep the advisor abreast of progress and garner their feedback. The advisor may determine if more frequent meetings are required. This also provides graduate students with a review of their performance and expectations for the coming semester. Negative reviews will reflect in the graduate student's grade.

SEMESTER OF PLANNED DEGREE COMPLETION:

Students need to monitor their MyMichiganTech account for required Graduate School forms and deadlines.

6th - 10th Semester:

- Submit Degree Completion Form to the Graduate School

Defense of research proposal presentation (dissertation defense):

2 weeks prior to defense:

- Provide date, time, building/room number and defense title to departmental coordinator. M&M 309 staff can reserve a room for the defense.
- Submit Pre-defense Form & Defense Draft (D7) to the Graduate School and advisory committee. Committee members may request to have the defense draft turned in sooner.
On the day of the defense:

- Bring a copy of the Report on Final Oral Examination Form (D8) to the defense.
- The dissertation defense is open to the public. The student will give a presentation to the audience. The general audience will first question the student on the proposal. Upon dismissal of the general audience, the committee members will continue to question the student. The committee will evaluate the student's ability to present and defend the dissertation. If the student does not pass the defense, he/she can retake the defense a second time. Failure in the second defense will result in the student’s dismissal from the PhD program.

Please refer to the Graduate School guidelines for remaining procedures at:

www.gradschool.mtu.edu/td/submission/#final or MyMichiganTech
BME PhD Coursework Requirements

Coursework Requirements:

A total of 60 credit hours of coursework, research credits, and at least 1 semester of teaching are required prior to graduation. A minimum of 24 credits of coursework, with a minimum cumulative GPA of 3.25, must be completed while enrolled in the BME PhD program at MTU to be eligible for the qualifying examination and research proposal examination. A minimum of 12 credits of coursework must be from the BME department.

The following courses are required core courses, all students must take and pass with a minimum of a “B” grade. Students will be required to re-take the course with grades less than “B”:

- MA5701 Statistical Methods I offered Fall
- BE5200 Cellular & Molecular Biology II offered Spring

All graduate students must attend the BME graduate seminars. See the separate section Graduate Seminar Series for further information.

There is potential for a waiver of the core courses if students from universities other than MTU have taken graduate level courses and received a satisfactory GPA. Waivers will be granted at the discretion of the advisor.

Student’s coursework must be approved by their advisor, BME graduate program director, and/or BME department chair. Coursework requirements will vary by individual student based on his or her background.

Graduate students who wish to take 3000 or 4000 level courses must get special approval from their advisor.

Requirements for Students with Non-Engineering Degrees:

In addition to students with BS or MS engineering degrees, the BME department also accepts qualified students from non-engineering programs. To ensure success of these students in the program, students with non-engineering degrees will need to demonstrate proficiencies in mathematics and engineering knowledge. Deficiencies in engineering topics will be determined by their advisor and BME graduate program director. The requirement to fulfill these deficiencies can be accomplished with the following options.

- **Courses:** Students need to take specific courses to fulfill the engineering requirement. The exact courses will depend on the student’s deficiencies. The number of credits and courses will be determined by the student’s advisor (and advisory committee, if applicable), and approved by the BME graduate program director. These extra credits can be counted towards the credit requirement for the degree up to 9 credit hours if the courses are 3000 levels or higher.

- **Independent Projects:** If a student does not have the proper engineering background in a certain area, he/she can enroll in an independent study/project advised by a faculty with the appropriate expertise, and approved by the BME graduate program director. The independent project can be counted towards the credit requirement for the degree.
Biomedical Engineering Graduate Courses

BE 5000 - Biomedical Masters Research Includes the study of an acceptable biomedical engineering problem and the preparation of a report or thesis.  
Credits: variable to 12.0; May be repeated; Graded Pass/Fail Only  
Seminars Offered: Fall, Spring, Summer

BE 5115 - Finite Element Modeling The course teaches both fundamentals of finite element theory and hands-on experience for bio-engineers.  
Credits: 3.0 Lec-Rec-Lab: (3-0-0)  
Seminars Offered: Spring

****BE 5200 - Cellular and Molecular Biology II Covers, at an advanced level, the general principles and engineering applications of science and biology, including cell biology, physiology, molecular biology, genetics, and biotechnology.  
Credits: 3.0 Lec-Rec-Lab: (3-0-0)  
Seminars Offered: Spring

BE 5230 - Stem Cell and Tissue Engineering This course will introduce (1) basic concepts of tissue engineering, (2) scaffold materials and biotechnologies for tissue engineering, (3) basic concept of stem cells, (4) review of stem cell sources and related policies, (5) current progress in stem cell research, (6) application of stem cells in tissue engineering and regenerative medicine.  
Credits: 3.0 Lec-Rec-Lab: (3-0-0)  
Seminars Offered: Spring

BE 5250 - Biomedical Optics Light plays a significant role in modern clinical diagnostics and in the clinical treatment of disease. Examples include non-invasive surgery, optical biopsy, and cancer therapy. This course will focus on the study of how light propagates through biological tissue.  
Credits: 3.0 Lec-Rec-Lab: (3-0-0)  
Seminars Offered: Spring - Offered alternate years beginning with the 2014-2015 academic year.

BE 5300 - Polymeric Biomaterials A specialized study of polymers used in biomedical engineering. Topics include: processing-structure-properties relationships for polymers, polymer fibers and composites, degradation of polymers, and medical applications for composite biomaterials.  
Credits: 3.0 Lec-Rec-Lab: (3-0-0)  
Seminars Offered: Spring - Offered alternate years beginning with the 2009-2010 academic year.

BE 5330 - Biomimetic Materials This course introduces students to biologically inspired approaches to design functional biomaterials. Topics include the discovery and incorporation of biological designs into novel materials and their application in the biomedical field.  
Credits: 3.0 Lec-Rec-Lab: (3-0-0)  
Seminars Offered: Fall - Offered alternate years beginning with the 2014-2015 academic year.

BE 5335 - Smart Polymers This course introduces students to smart polymers that change their physical properties in response to various environmental stimuli. Topics include the molecular origin of the stimuli responsiveness of these materials and their application in the biomedical field.  
Credits: 3.0 Lec-Rec-Lab: (3-0-0)  
Seminars Offered: Fall - Offered alternate years beginning with the 2015-2016 academic year.

BE 5350 - Cell Biomechanics and Mechanical Transduction This course is designed to introduce the mechanical analysis and characterization of mammalian cells. Mechanotransduction, whereby cells detect loading and respond to the morphology and mechanical properties of the surrounding extracellular matrix, will be emphasized.  
Credits: 3.0 Lec-Rec-Lab: (3-0-0)  
Seminars Offered: Fall

BE 5390 - Scientific Computing Offers insight into advanced scripting, parallel computing with traditional CPUs and hardware accelerators, data analysis, and visualization. Students will get hands-on experience in designing, building, securing, managing, and using a HPC cluster in compliance with federal regulations.  
Credits: 3.0 Lec-Rec-Lab: (3-0-0)  
Seminars Offered: Fall, Spring
BE5410 – Medical Imaging This course covers the physical nature of the interactions between the waves and matter, especially the biological tissues, principle imaging modalities used in modern medicine and the common techniques used for the processing of the resulting images.

Credits: 3.0
Semesters Offered: Spring – Offered alternate years beginning with the 2018-2019 academic year.

BE 5510 - Cardiovascular Engineering Fundamental cardiovascular pathology and the biomedical engineering approaches being developed and used toward problems resulting in significant cardiovascular deficiency such as myocardial infarction, chronic kidney disease, atherosclerosis, and heart valve disease.

Credits: 3.0 Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall

BE5670 – Micro & Nano Technologies This course introduces students to micro- & nano- technologies and the processes involved in their manufacturing. Particular emphasis will be on the use in biomedical applications. Goal is to provide beneficial research and development to the industry.

Credits: 3.0
Semesters Offered: Fall

BE 5700 - Biosensors This course introduces the student to the fundamentals of biosensor development and applications. It provides an understanding of biological components, immobilization methods, transducers, and fabrication techniques.

Credits: 3.0 Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall - Offered alternate years beginning with the 2009-2010 academic year

BE 5755 - Medical Devices An introduction to medical devices used for diagnosis, monitoring, and treatment in clinical medicine. Topics covered include product planning, reliability, clinical trial design, regulatory as well as technical aspects of common medical devices.

Credits: 3.0 Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall

BE 5770 - Biomedical Microcontrollers The focus of this course is to provide biomedical engineering students the necessary skills to develop microcontroller-based devices. Provides basic knowledge on computer programming languages, microcontrollers, digital circuits, and microcontroller development kits. Students will design and fabricate a microcontroller-based device using a microcontroller development kit for a specific biomedical application.

Credits: 3.0 Lec-Rec-Lab: (1-0-2)
Semesters Offered: Fall - Offered alternate years beginning with the 2016-2017 academic year.

BE 5800 - Advanced Biomaterials Interfaces This course introduces the students to the effects of topography and texture on the performance of biomaterials. Special emphasis is placed on tissue engineering scaffolds and microfabrication and nanofabrication techniques. Some of the topics include: self-organization of biomembranes and supramolecular systems, bioactive materials, and the molecular basis for surface recognition and masking.

Credits: 3.0 Lec-Rec-Lab: (3-0-0)
Semesters Offered: Spring - Offered alternate years beginning with the 2010-2011 academic year.

BE 5850 - Tissue Mechanics This course integrates continuum mechanics, experiments and computational methods to understand soft tissue mechanics. The first half of the course is dedicated to building continuum mechanics foundation, which will be used to formulate constitutive equations for arteries and the heart in the second half.

Credits: 3.0 Lec-Rec-Lab: (3-0-0)
Semesters Offered: Fall

BE5900 – Biomedical Engineering Master’s Topics Biomedical engineering courses will be offered as professional electives dependent upon the interest of the faculty.

Credits: variable to 6.0; May be repeated
Semesters Offered: Fall, Spring, Summer

BE6000 – Biomedical Engineering Doctoral Research Includes the study of an acceptable biomedical engineering problem and the preparation of a report or thesis.

Credits: variable to 12.0; May be repeated; Graded Pass/Fail Only
Semesters Offered: Fall, Spring, Summer
**BE 6900 - Biomedical Engineering Doctoral Topics** Biomedical engineering courses will be offered as professional electives dependent upon the interest of the faculty.

**Credits:** variable to 6.0; May be repeated

**Semesters Offered:** Fall, Spring, Summer

****MA 5701 - Statistical Methods**** Introduction to design, conduct, and analysis of statistical studies, with an introduction to statistical computing and preparation of statistical reports. Topics include design, descriptive, and graphical methods, probability models, parameter estimation and hypothesis testing.

**Credits:** 3.0 Lec-Rec-Lab: (0-3-0)

**Semesters Offered:** Fall

****REQUIRED CORE COURSE: BE 5200 - Cellular and Molecular Biology II
MA 5701 - Statistical Methods

**REQUIRED CORE COURSES MUST HAVE A GRADE OF "B" OR BETTER. STUDENTS WILL BE REQUIRED TO RE-TAKE THE COURSE WITH GRADES LESS THAN "B"."
Research Proposal Exam and Qualifying Exam

The student needs to pass the research proposal exam and the qualifying exam to become a PhD candidate and enter Research Mode. A minimum graduate cumulative GPA of 3.25 is required to be eligible.

- The exam must be scheduled before the beginning of the 3rd year (5th semester) of the PhD program.
- The exam should be scheduled 3 months prior to the exam date.
- Provide the date, time, building/room number and proposal title to the departmental coordinator. M&M 309 staff can reserve a room.
- The advisory committee needs to select a chairperson to oversee the exam. The chairperson must be a primary BME faculty member. The advisor shall only serve as an observer during the exam process.
- If a student fails a portion of the exam, he or she must retake the failed portion of the exam within a year. A student that fails either portion of the exam 2 times will be dismissed from the program.

Research Proposal Exam and Qualifying Exam: This is a public presentation of the student's research proposal to the advisory committee covering the background, hypotheses, aims, goals, preliminary data, and experimental methods of the proposed research for their defense dissertation (this constitutes the research proposal exam). After the presentation, the student's advisory committee meets with the student alone to ask the student questions (this constitutes as the qualifying exam section). Both exams will also serve to test the student's basic knowledge of the research topic. The research proposal exam and qualifying exam are typically performed on the same day, one immediately following the other.

- The student must provide each committee member the abstract and scope of the research proposal no later than 3 months prior to their Exam. The written research proposal must follow the full research proposal guidelines of a federal funding agency (NIH, NSF, DoD, etc.). The final proposal must be submitted to each committee member 2 weeks before the exams.
- The proposal presentation is open to the public. The student will give a presentation (45 minute maximum) to the audience covering the background, hypotheses, aims, goals, preliminary data, and experimental methods of the proposed research. The general audience and committee members will question the student on the proposal.
- Based on the feedback from the entire audience, the committee will evaluate the student’s ability to present and defend a reasonable and technically sound research plan using the Biomedical Engineering PhD Evaluation Rubric and record the results on the Biomedical Engineering Evaluation of PhD Graduate Student Outcomes – Research Proposal and Biomedical Engineering Evaluation of PhD Graduate Student Outcomes – Qualifying Exam.
- Approval of the research proposal exam and qualifying exam may come upon successful completion of the proposal presentation and question session or may require additional meetings with the committee and the approval of another separate oral qualifying exam covering basic research topics discussed with the advisory committee. Approval must be made within a year of the proposal presentation or the student will be dismissed from the program.
Petition to Enter Research Mode:

A student is eligible for Research Mode after successfully completing all required coursework and passing the qualifying exam and research proposal exam. The Research Mode Petition, with the Degree Schedule if not previously submitted, must be submitted to the Graduate School 1 week prior to the 1st day of the semester.
Dissertation and Dissertation Defense

A dissertation is the culmination of a research project. Students must prepare their document using the guide found on the Graduate School website.

The final oral dissertation defense may be scheduled using the Pre-defense Form found on the Graduate School website. This form requires a date, time and building/room number for the defense. Students must provide this information along with the title of the defense to the departmental coordinator before or at the same time the Pre-defense Form is submitted. Staff in M&M 309 can reserve a room for the defense.

To graduate in a given semester, a student must present their defense on or before Tuesday of week 12 of the semester. Defenses may be scheduled after week 12, however students will not be eligible to complete their degree in that semester. All defenses must be scheduled two weeks in advance of the desired date. Students must submit the complete defense draft of their dissertation to the Graduate School and also to their advisor and committee two weeks before their defense.

The dissertation defense is open to the public. The student will give a presentation to the audience. The general audience will first question the student on the proposal. Upon dismissal of the general audience, the dissertation committee members will continue to question the student. The committee will evaluate the student’s ability to present and defend the dissertation based on the Biomedical Engineering PhD Evaluation Rubric and record the results on the Biomedical Engineering Evaluation of PhD Graduate Student Outcomes – Dissertation & Defense. If the student does not pass the defense, he/she can retake the defense a second time. Failure in the second defense will result in the student’s dismissal from the PhD program.

Upon completion of the oral dissertation defense, students should make any technical corrections requested by their advisor and committee and also any formatting corrections from the Graduate School. Print the Approval of Dissertation, Thesis or Report Form from the Graduate School website and obtain signatures from advisor and all committee members. The completed form must be submitted to the Graduate School. Within one week and prior to the deadline, submit the final dissertation to the Graduate School (see the website for submission instructions). The deadline to submit a final dissertation is Monday of week 13 of the semester.
Graduate Seminar Series

Attendance of all Biomedical Engineering Graduate Seminars is required.

PhD students are required to present a seminar to BME faculty and BME graduate students.

Faculty attending the PhD student’s seminar will use the Biomedical Engineering PhD Evaluation Rubric and record the results on the Biomedical Engineering Evaluation of PhD Graduate Student Outcomes – Seminar.

The department coordinator will email notifications about the date, time, and location for seminars that will occur (a seminar will not be held every week so please watch your email closely).

Requirements:

- All graduate students MUST attend all Biomedical Engineering seminars.
  - There will be a sign in sheet at the seminar to ensure attendance.
- Graduate students must attend 6 seminars per semester (emails are sent from the department coordinator announcing other departmental seminars as well). If the BME department does not hold 6 seminars per semester, students must attend seminars from other departments.
  - BME PhD proposal defense, dissertation defense and MS Thesis/Report defense are considered to be part of the seminar series.
- Graduate students must write up a brief summary of each seminar attended. They must have their advisor approve and sign the summary and then turn it in to staff at the front desk.
- Failure to attend the appropriate number of seminars will result negatively on student's evaluations that occur each semester and will negatively impact their research grade.

Events that are not acceptable for seminar assessments:

- Seminars must be of a scientific or technical research topic
- Webinars
- Graduate School workshops or training sessions
- PhD proposal defense, dissertation defense and MS Thesis/Report defense outside of the BME department
- Conferences
- Tech Talk Series