

DOCTOR OF PHILOSOPHY DEGREE IN BIOMEDICAL ENGINEERING

I. Introduction:

Biomedical Engineering (BME) is an interdisciplinary field that is based on the application of engineering principles and experimental and analytical techniques to the development of biologics, materials, devices, implants, processes, and systems that advance biology and medicine and improve medical practice and health care.

The Doctor of Philosophy (PhD) degree in BME is a research degree that is intended to provide the graduate with the breadth and depth of knowledge in one area of specialization within BME, as well as the scientific research training needed for successful careers in academia, biomedical industry, or government. The research training process begins with the student working closely with their Dissertation Director and participating in the Dissertation Director's research program. Building on these experiences, the student begins to conduct independent research that eventually leads to an original contribution to the field of BME. The strength and efficacy of the training process depend to a large extent on the direct interactions of the student with their Dissertation Director and on the time the student spends in the laboratory working on their research. The importance of this research training to a PhD degree in BME is underscored in the following learning objectives that were developed to evaluate the efficacy of the PhD program in BME.

- *Conduct independent research that reflects an original contribution to BME.*
- *Demonstrate technical proficiency in at least one area of BME.*

- *Recognize the need to apply ethical principles in conducting research.*
- *Demonstrate a commitment to life-long learning by participating in local and national professional development activities on a continuing basis.*

Students in the Medical Scientist Training Program (**MSTP**; a combined **MD/PhD** degree program) at Medical College of Wisconsin (MCW) are eligible to choose the PhD program of the Joint Department of BME for the PhD requirements of the MD/PhD degree program.

MSTP students begin their curriculum at MCW with two full years of medical school (M1 and M2 years), during which they complete a large array of clinical, translational, and basic science coursework, equivalent to an MS degree. During their M1 and M2 years, they also complete four one-month-long laboratory rotations during which they gain valuable research experience. These lab rotations are intended to help MSTP students to choose a lab and a research area (by the end of their M2 year) for conducting their PhD dissertation research. Following their M1 and M2 years, MSTP students typically spend three to four years in graduate school, working toward their PhD dissertation before returning to medical school to complete their medical training.

II. Specializations/Tracks:

Upon enrolling in the Joint Department of BME PhD program, a student should select one of the following specializations/tracks. The student's Academic Advisor and Dissertation Director then work with the student to design the appropriate curriculum and research program. This will include courses in engineering, biology, mathematics, and medicine, all of which are integrated with research laboratory experience.

1. Bioinstrumentation

Medical devices are at the heart of biomedical engineering, and faculty in the MU-MCW Department of Biomedical Engineering have proficiency in instrumentation, biomaterials, medical device testing and design, and clinical and regulatory expertise. This broad base of skills and expertise positions our department at the forefront of medical device innovation.

Research theme: [Medical Devices & Bioinstrumentation](#)

2. Biomechanics

Simply put, Biomechanics is the study of the structure, function, and motion of the mechanical aspects of biological systems. When applied to the human body, biomechanics describes how muscles, bones, tendons, and ligaments work together to produce movement under neuromuscular control.

Research theme: [Biomechanics & Rehabilitation Bioengineering](#)

3. Biomedical Imaging

The Biomedical Imaging Engineering research groups in the Joint Department of Biomedical Engineering focus on developing new techniques to noninvasively visualize the structure and function of living objects for clinical analysis and medical intervention.

Research theme: [Biomedical Imaging](#)

4. Cellular and Molecular Engineering

Tissues may become damaged due to injury or disease. Molecular, Cellular, and Tissue Engineering is a research specialization in Biomedical Engineering which seeks to repair or replace damaged tissues, such as heart valves, blood vessels, skin, cartilage, or bone by gaining understanding of the molecular and cellular mechanisms involved in the damage and regeneration.

Research theme: [Molecular, Cellular & Tissue Engineering](#)

5. Computational Biology and Bioinformatics

Computational Modeling is the practice of using computer models and systems to simulate complex biological processes. Computational modeling has many applications in medicine, which include improving our understanding of human physiology, visualizing and interpreting experimental data, and designing novel therapies.

Research theme: [Computational Systems Biology & Medicine](#)

6. Rehabilitation Bioengineering

The Neural Engineering and Neurorehabilitation research groups in the MU-MCW Department of Biomedical Engineering focus on the brain, the nervous system, and motor control. Researchers use a variety of engineering tools to analyze neurological function and engineering solutions for problems associated with neurological pathologies, disabilities, limitations, and dysfunction.

Research theme: [Neural Engineering & Neurorehabilitation](#)

These tracks correspond to the BME Department's research themes, as indicated above.

To learn more about the research themes, please visit the [BME Department research website](#).

III. Admission Requirements:

1. Educational Background

Graduates of accredited colleges or universities with a Bachelor's (BS) or Master's (MS) degree in various engineering, physical science, or life science disciplines or equivalent are eligible for admission to the Joint Department of BME PhD program.

The time constraints to which **MSTP students** adhere (i.e., three to four years of graduate school) preclude them from completing any pre-requisite/leveling courses that may not have been completed as part of their undergraduate education. **Therefore, MSTP students interested in the Joint Department of BME PhD program must have an undergraduate degree in a field of engineering.**

2. Pre-requisite Coursework for Students Enrolling Without an Engineering Degree

Students who do not have an engineering degree are admitted into the PhD program on a conditional status based on successful completion (grade of B or better) of a sequence of leveling courses. These courses will provide them with fundamental engineering principles and analytical skills needed for successful

completion of the PhD degree in BME and prepare them for careers in BME. The following is a list of pre-requisite leveling courses:

- **Mathematics:** Calculus through Differential Equations
- **Programming:** Knowledge of a high-level computer programming language (e.g., C, C++, Java, Python, R, MATLAB)
- **Basic Sciences:** A minimum of 3 courses from: Calculus-based Physics, Biology (for scientists/engineers), Physiology, or Biochemistry subject to at least one in Physics and one in Biology.
- **Engineering Sciences:** 4 technical engineering courses relating to one of the specializations/tracks ([research themes](#)) within the BME Department. The selection of these engineering courses should fill gaps in the student's knowledge related to their intended research focus. The selection must be submitted to and approved by the student's Dissertation Director and by the BME Director/Co-Director of Graduate Studies (DGS/Co-DGS). See "[PhD Plan of Leveling form](#)" to be completed by the student and their Dissertation Director.

Equivalent courses completed prior to application to the PhD program can be used to satisfy these pre-requisite courses.

To gain regular status, a student must complete these pre-requisite courses with a grade of B or better. Cost-effective online courses could be used to satisfy these pre-requisite courses. Approval from the DGS/Co-DGS is needed prior to enrolling in online courses.

Graduate tuition waiver does not cover these pre-requisite courses.

3. Application for Admission

All applicants for the Joint BME PhD must file the following documents with the MCW Graduate School. Normally, files are not considered for admission until they are complete. Priority deadline for completed applications for fall admission is December 15th. The requisite materials are:

- Application for Admission.
- Official transcripts of undergraduate and graduate records, sent directly to the MCW Graduate School by the institution concerned. **A GPA of 3.0 or higher is required for admission.** Foreign transcripts submitted may include an evaluation/translation to determine equivalencies. If a transcript or mark sheet is not in English, the applicant must supply a translation.
- Optional: results of the Graduate Record Examination (GRE) General Test, sent directly to the MCW Graduate School by the [Educational Testing Service](#).
- Three letters of recommendation and recommendation form, including from recent teachers and/or supervisors.
- A "*Statement of Purpose*" in which the student indicates their reasons for seeking the doctoral degree in BME, declares their areas of interest (from the above six Specifications/Tracks), and identifies BME faculty (up to three in the order of preference) that they would be interested in working with for dissertation research.

- Evidence of research ability, if available (e.g., copy of independent study research reports, undergraduate Honor's thesis, MS thesis, reprints of manuscripts, conference abstracts).
- Application fee (non-refundable).
- International students must submit results of their TOEFL examination, sent directly to the MCW Graduate School by the [Educational Testing Service](#). International students who are in the process of completing or have completed their undergraduate degree in the United States, United Kingdom, Australia, New Zealand, or Canada (excluding Quebec) are not required to take the TOEFL examination.

Admission is not official until the student is notified in writing of acceptance by the MCW Graduate School. **Students who cannot matriculate following admission to the PhD program can request deferment for up to one year.** Acceptance will be withdrawn for students who do not enroll and fail to request deferment of admission.

Students with an MS degree from Marquette University (MU) or MCW interested in pursuing a PhD degree in the Joint Department of BME must submit a new application to the MCW Graduate School.

MSTP students at MCW wishing to pursue a PhD degree in BME need not formally apply to the Joint Department of BME PhD program. Instead, they must satisfy the following requirements prior to pursuing of the BME PhD degree:

- The student must identify an Academic Advisor with a primary or secondary/adjunct appointment in the Joint Department of BME prior to the start of their BME PhD degree (typically, by the end of their M2 year). MSTP students typically begin their PhD degree program in the summer or fall semester following their M2 year. The Academic Advisor must express their consent for accepting the student into their lab in writing to the student, the MSTP Program Director, the Director/Co-Director of Graduate Studies (DGS/Co-DGS) in BME, and the Chair of the Joint Department of BME. The writing could be through an email to the student, cc'ing other officials involved.
- The student must meet with and obtain approval from the BME DGS/Co-DGS prior to entry into the Joint BME PhD program.
- The Academic Advisor and the BME DGS/Co-DGS will need to ensure that the student satisfies all the eligibility criteria, including undergraduate academic background, for pursuing a PhD degree in BME.

4. Transfer of Credits

The transfer of credits completed at the graduate level at another institution is handled on an individual basis. **No more than 18 graduate-level credit hours will be accepted for transfer into the Joint BME PhD program.** The 18 credit hours include coursework taken at MU and/or MCW prior to admission and credits earned at other institutions before or during enrollment in the Joint BME PhD program.

Credits are eligible for transfer only if **a)** the grade earned is a B or better (3.0 on a 4.0 scale), **b)** earned no more than five years before the start of the MU-MCW BME PhD program, and **c)** are not used as a part of the requirements for another degree (e.g., MS degree). Pass/Fail courses are not eligible for transfer. Students need to complete the [MCW Transfer of Credits Request form](#).

Graduate credits used as a part of the requirements for another degree (e.g., MS degree) and earned no **more than five years** before the start of the Joint BME PhD program could be used to **waive** the pertinent didactic coursework requirements. The students still need to satisfy the 60 graduate credits requirement of the MCW Graduate School by taking additional reading and research courses.

Graduate credits earned more than five years prior to the start of the Joint BME PhD program could be used to satisfy equivalent pre-requisite leveling courses. Any graduate student contemplating coursework at another institution with the intent of transferring credits into the Joint BME PhD program should seek prior approval from the Director/Co-Director of BME Graduate Studies and the MCW Graduate School.

IV. Program Requirements:

The PhD degree in BME is conferred in recognition of marked ability and high attainment in the advancement of knowledge and pursuit of truth in the field. It is never awarded solely as a result of coursework completed, no matter how faithfully extended over any prescribed period of time. In defining the requirement for this degree, it is convenient to use semester

credits, but it should be clearly understood that no number of credits alone entitles a student to this degree. The comprehensive knowledge expected of the student in their major field is such that the requirements for the degree usually demand no less than four years of full-time work or the equivalent beyond the BS degree.

1. Academic Status

The Joint BME PhD program is administered through the MCW Graduate School of Biomedical Sciences, and hence, doctoral students need to abide by the policies as laid out in the [MCW Graduate School Handbook](#).

A doctoral student can only receive a **tuition waiver and stipend** if they maintain a **full-time status** throughout the PhD program and satisfactory academic progress. Traditionally, this means that 100% of the student's activity is devoted to the PhD program. **Thus, full-time students are not allowed to hold part-time work outside of the academic environment that would interfere with their doctoral work. Full-time also means 24 credits a year, which is split into 9, 9, and 6 credits for fall, spring, and summer, respectively.** This could be a combination of coursework and reading and research credits (see *Graduate Credits* below). If a student does not take a full credit load, they are not eligible for stipend or tuition waiver. Doctoral students need to be continuously enrolled for the duration of their study at a full-time level, but a student may take a Temporary Withdrawal (a.k.a. Leave of Absence) if they need to temporarily drop out of the PhD program for an extended time for personal reasons.

2. Graduate Credits

A minimum of **60 graduate credits** is required to complete the PhD degree in BME. For someone entering with a BS degree, this constitutes 36 credits in didactic coursework, 9 credits in dissertation, and a minimum of 15 credits in reading and research. For those entering with an MS degree or with Graduate credits (see Transfer of Credits Policy), they are required to complete a minimum of 18 credits in didactic coursework, 9 credits in dissertation, and a minimum of 33 credits in reading and research. The 18 credits of required didactic coursework could be a combination of BME core and specialization-specific courses. Additional didactic coursework beyond the required 18 credits may be taken if deemed beneficial to the student's research and training. Pre-requisite courses for applicants who do not have a BME degree are not counted as graduate credits. Reading and research credits can be earned by registering and attending a seminar series, workshop, conference, journal club, or simply carrying out dissertation-related activities. A student can register for up to 9 credits of reading and research per semester during fall and spring semesters and up to 6 credits during the summer. **Students should register for dissertation credits in the semester they intend to defend their dissertation.**

The graduate credits didactic coursework should include formal courses as defined at the end of this Handbook, and consist of:

- ***Core course requirements (18 credits):*** All doctoral students must complete

courses that satisfy the following competencies. Those entering with an MS degree or with Graduate credits and MSTP students can satisfy core course requirements by showing they have already completed an equivalent course.

- **Biomedical Science** (3 credits) (e.g., cellular and systems physiology, neurophysiology, intra- and inter-cellular signaling, genetics and developmental biology, pharmacology, cellular pathology, microbiology and immunology, molecular biology, biochemistry, etc.) (e.g., *MU BIEN 5700, MU BIEN 5720, MU BIOL 5102, MU BIOL 5703, MCW IDP 16215, 16216, 16217 and 16218, MCW IDP 16271, MCW NDP 12221, and 12237, MCW Physiol 08204*)
- **Biostatistical methods** (3 credits) (e.g., *MU MSSC 5720, MU MSSC 5740, MCW courses: BioStat 04224, BioStat 04231, BioStat 04232, BioStat 04233, BioStat 04363, BioStat 04365*)
- **Bioethics** (2 credits) (*MCW BIOETHICS 10222, MCW BIOETHICS 10444*). Both courses (1 credit each) are required for all doctoral students.
- **Scientific and technical writing** (2 credits) (e.g., *MCW IDP 16292 and 16293*).
- **Leadership, scientific communication, and teaching skills** (2 credits) (e.g., *MCW IDP 16290 and 16291, and MU GRAD 8961*)
- **Applied mathematics** (3 credits) (e.g., applied mathematical methods, fluid mechanics, finite element methods, biomedical signal processing, signals and systems, etc.) (e.g., *MU BIEN 5400, MU BIEN 5410, MU BIEN 5510, MU BIEN 6120, MU BIEN 6121, MU BIEN 6200, MU BIEN 6210, MU BIEN 6220,*

MU BIEN 6400, MU BIEN 6410, MU BIEN 6420, MU BIEN 6500, MU EECE 6010, MU MEEN 5265, MU MEEN 6101, MU MEEN 6102, MU MEEN 6360, MU MEEN 6365, MCW Biophys 03240)

- **Computational and modeling methods (3 credits)** (e.g., numerical methods for solving mathematical models of physical and biological phenomena, regression analysis, data science and machine learning, biological network analysis, computer simulations of physiological systems, etc.) (*e.g., MU BIEN 5410, BIEN 5710, MU BIEN 6120, MU BIEN 6121, MU BIEN 6620, MU COSC 5610, MU COSC 5610, MU EECE 6820, MU EECE 6822, MU EECE 6840, MU MEEN 5270, MCW BIOM 35284, MCW BIOM 35285*)
- ***Specialization-specific courses (18 credits):*** Courses intended to satisfy this requirement should be selected in consultation with the student's Dissertation Director. A minimum of three unique courses relevant to each specialization are offered within a three-year time span. Additional specialization-specific courses may be chosen from special topics offerings, overlapping courses with other specializations, and graduate courses offered through other departments at MU and MCW.
- PhD students and MSTP students in the Joint Department of BME are also required to register for the BME Department seminar series for the duration of their study (BIEN 6953, which counts for 0 credit/semester of reading and research). For a given semester, students are expected to attend at least two-thirds of the seminars.

MSTP students in the BME PhD program must also earn a minimum of 60 graduate credits to obtain the PhD degree. This includes a minimum of 18 credits in didactic coursework, 9 credits in dissertation, and a minimum of 33 credits in reading and research. The number of didactic courses for MSTP students is reduced from 36 to 18 credits due to the wealth of didactic coursework that MSTP students take during their M1 and M2 years. The 18 credits of required didactic coursework could be a combination of BME core and specialization-specific courses. Additional didactic coursework beyond the required 18 credits may be taken if deemed beneficial to the student's research and training. **MSTP students** are required to demonstrate that they possess all core competencies by showing they have already completed equivalent courses.

Upon entry into the BME PhD program, an **MSTP student** is required to consult with their Academic Advisor to determine which didactic courses (BME core and specialization-specific courses) are most appropriate for their dissertation research and training and gaining BME core competencies.

3. Grades

Satisfactory academic work is not determined exclusively by the didactic coursework grades. However, grades are one important factor in the evaluation process. **The minimum standard for graduation is a cumulative GPA of 3.0 (out of 4.0) and a GPA of 3.2 in core competency courses.** Students with a cumulative GPA under 3.0 and/or a GPA under 3.2 in core competency courses are automatically placed on

probationary status. Probationary status may only occur once during a student's academic career in the MCW Graduate School. See the [MCW Graduate School Handbook](#) for more information about the MCW Graduate School probation policy. See Section XII of this document regarding MCW Graduate School's expectations for the students' performance in the reading and research credits and the associated grading policy.

4. Doctoral Dissertation Outline Form

Before deciding to take up the Doctoral Qualifying Examination (DQE), the student must meet with their Dissertation Director to identify a Doctoral Dissertation Committee. A document listing the requested committee members (*Dissertation Committee Approval Form*) must be forwarded to the Director/Co-Director of BME Graduate Studies, the BME Department Chairperson, and the Dean of MCW Graduate School for reviewing and approval. The *Dissertation Committee Approval Form* must be approved by the student's Dissertation Director, the BME DGS/Co-DGS, the BME Department Chairperson, and the Dean of MCW Graduate School before the student can take the DQE.

5. Doctoral Dissertation Committee

The Doctoral Dissertation Committee consists of a Dissertation Director, at least four additional voting committee members, and additional advisory committee members, as needed. The Committee must be designed to represent expertise in the research area(s) of the dissertation. At least three committee members must

hold regular (i.e. primary or secondary/adjunct) appointments in the Joint Department of BME, two of whom should hold primary appointments. **The Dissertation Director must be a regular faculty member in the Joint Department of BME. The Dissertation Director must also have an MCW Graduate School Faculty Member Appointment at the PhD level.** The Dissertation Director will ensure that the appropriate paperwork is filed for the dissertation and ensure that graduation requirements are met.

A voting Dissertation Committee member without a regular appointment in the Joint Department of BME must meet the following qualifications:

- Curriculum Vitae on file in the Department's Office.
- Approval of the Dissertation Director.
- A terminal degree in the Committee Member's chosen profession.
- Recognized expertise in the area(s) of the dissertation.

The Graduate Committee of the Joint Department of BME must approve any exceptions to these qualifications for voting members. If, at any point, for any reason, there is an addition to or removal from the Doctoral Dissertation Committee, a *Committee Change Approval Form* and accompanying documents must be completed, signed, and on file with the graduate school before the student defends their dissertation.

6. Doctoral Qualifying Examination

The Doctoral Qualifying Examination (DQE) is intended to be both diagnostic and

prognostic. The objectives are to evaluate the student's a) breadth and depth of knowledge in the chosen area of specialization, and b) ability to apply basic engineering principles and analytical tools to address integrative questions in BME topics related to the chosen area of specialization. **Students on probation are not eligible to take the DQE.**

The DQE consists of two parts. The first part involves writing a dissertation proposal in the form of an **NIH-style F30/F31 fellowship grant** proposal and submitting it to the student's Dissertation Committee. The second part is an oral examination, involving the student's presentation and defense of the dissertation proposal. For this portion of the DQE, the dissertation committee members examine the student not only on their dissertation proposal, but also on the BME core competency courses. As such, the student should email the committee members a list of completed didactic courses 2 weeks prior to the oral portion of the DQE. The student must submit a dissertation proposal and pass the oral examination to advance to *doctoral candidacy*.

Students entering the PhD program with a BS degree are encouraged to take the DQE at or before the completion of 30 graduate credits of didactic coursework. **MSTP students** and students entering the PhD program with an MS degree are encouraged to take the DQE at or before the completion of 15 graduate credits of didactic coursework. Given the time constraints to which **MSTP students** must adhere, they are strongly advised to take the DQE and advance to *doctoral*

candidacy by the end of their second year in the BME PhD program.

If the student fails the DQE, they will be given one additional chance to retake it, normally within 6 months of the first attempt. If the second attempt is unsatisfactory, no further oral examination is permitted. **Those students who fail the second attempt are permitted to complete a Joint Department of BME MS degree (thesis-based) in BME.** The student's dissertation proposal and the *DQE Evaluation Forms* completed by each member of the student's dissertation committee become a part of the student's permanent file in the Office of the Joint Department of BME.

A 1-page document summarizing the DQE is available on the [BME website](#).

A. Dissertation Proposal

Before taking the oral examination, the student must prepare a detailed dissertation proposal (NIH-style F30/F31 fellowship grant proposal covering specific aims and hypotheses, background and significance, innovation, preliminary data, and research methodology including scientific rigor and statistical analysis). The proposal should be appended to a completed *Dissertation or Thesis Proposal Approval Form*. The dissertation proposal should clearly state the research problem to be addressed; give a cogent perspective of the problem relative to the state of the art; discuss the methods proposed to solve the problem; and discuss the expected results, potential difficulties, and alternative approaches. As a guide, the dissertation proposal should be

approximately 7 pages in length (NIH-style font, size, margins, and spacing), including 1 page for specific aims and 6 pages for research strategy, which is the length of an NIH fellowship grant proposal (F30/F31). The student is required to send a copy of their dissertation proposal to each member of their Dissertation Committee at least two weeks prior to taking the oral examination.

See [IDP courses under the Core Courses](#) for a course on writing an individual fellowship proposal.

B. Oral Examination

The principal focus of the oral examination will be the dissertation proposal and BME core competency courses. Again, it is to be both diagnostic and prognostic, as detailed above. It is recommended that the oral examination not exceed three hours in duration.

The oral examination requires that the student present their dissertation proposal to the Dissertation Committee, followed by an extensive question-answer (QA) session not only on the dissertation proposal, but also on BME core competency courses.

Again, the objectives of the QA session are to evaluate the student's **a)** breadth and depth of knowledge in the chosen area of specialization, and **b)** ability to apply basic engineering principles and analytical tools to address integrative questions in BME topics related to the chosen area of specialization. At the end of the QA session, the student will be asked to leave the room. The Dissertation

Director and the Dissertation Committee members will then discuss the student's performance and determine if they have gained the requisite core knowledge and skills needed to complete the proposed work. At the end of this discussion, the Dissertation Director will take a vote of the Dissertation Committee members on whether to pass or fail the student. **A majority of "pass" votes is needed for the student to pass the oral examination and advance to *doctoral candidacy*.**

At the end of the oral examination, a *Qualifying Examination Report form* should also be completed by each member of the Dissertation Committee and submitted by the Dissertation Director to the BME DGS/Co-DGS and the MCW Graduate School. In the *Qualifying Examination Report form*, each Dissertation Committee member should identify the areas of weakness in the student's dissertation proposal and oral examination. Through this process, the Dissertation Committee members will also identify any additional didactic coursework necessary to fill potential knowledge gaps required to prepare the student for ongoing research and training. Prescriptions to address the perceived weaknesses should be included in the *Qualifying Examination Report form*.

If the student passes the oral examination, the *Dissertation or Thesis Proposal Approval form*, along with the approved dissertation proposal, must be completed by the Dissertation Director and submitted to the MCW Graduate

School.

After advancing to *doctoral candidacy*, students should register for the required 9 hours of dissertation credits in the semester they are expected to defend their PhD dissertation. **There must be at least 18 months of duration between the student's advancement to candidacy and defense of their PhD dissertation.**

7. Academic Progress and Evaluation of Performance

Doctoral students within the Joint Department of BME are recommended to present a summary of their research progress to their Dissertation Committee on an annual basis after passing the doctoral qualifying examination.

At the annual meeting (following the student presentation), the Dissertation Committee shall jointly complete a departmental assessment of the graduate student's progress. The Dissertation Committee shall make a determination as to whether student progress is satisfactory or unsatisfactory and whether or not they believe the student should be allowed to continue in the BME PhD program.

Following the meeting, the Dissertation Director shall draft a brief summary of student performance (20-100 words) to be submitted with the department assessment form to the Graduate Committee of the BME Department for review.

The summary should also be submitted to the MCW Graduate School.

In addition, the MCW Graduate School requires that the student meet with their Dissertation Director on an annual basis to complete an assessment rubric (MCW Graduate School form) to be submitted to the MCW Graduate School.

Based on the student's academic work (cumulative GPA of at least 3.0 and a GPA of 3.2 in core competency courses) and progress and performance (annual progress reports from student's dissertation committee), the BME Graduate Committee shall recommend to the BME Department Chairperson and the MCW Academic Standing Committee as to whether the student is performing satisfactory work. If the student is not performing satisfactory work, the Graduate Committee and the Academic Standing Committee will recommend one of the following:

- A probationary period of two terms per the MCW Graduate School's probationary policy.
- Transfer to the Joint Department of BME MS program.
- Withdraw from the Joint Department of BME PhD program.

If a student is not performing satisfactory work, the student, Dissertation Director (or Academic Advisor), MCW Academic Standing Committee, and the Dean of the MCW Graduate School will be notified in writing by the Department Chair.

8. Publications

PhD students are required to submit at least one first-authored manuscript to a refereed journal in the field based on their doctoral dissertation work prior to the public defense of dissertation.

See [IDP courses under the Core Courses](#) for a course on writing an individual fellowship proposal.

Also see the [MU Writing Center](#) for additional help with writing a dissertation or a scientific paper.

9. Public Defense of Dissertation

An acceptable doctoral dissertation must meet all the following 3 conditions:

- The dissertation must represent an original research contribution as determined by the student's Dissertation Director and Committee members.
- The dissertation must show a high degree of achievement and a clear ability to do independent research.
- The format of the dissertation must follow the "Dissertation Directives" issued by the MCW Graduate School.

When the student and their Dissertation Director consider the dissertation to be in appropriate form, the student should submit a copy to each member of the Dissertation Committee. This should be done a minimum of 2 weeks (14 days) before the scheduled dissertation defense. In addition, a dissertation defense announcement should be sent to the Graduate School at least 30 days prior to the defense. It is the obligation of the student to arrange a time and place on the MU or MCW campus for the dissertation defense. In addition, it is the obligation of the student to meet all appropriate deadlines as indicated in the MCW and MU Graduate School "[Academic Calendar](#)". Students must follow the MCW Graduate

School rules for dissertation defense and meet all the requirements.

There shall be a minimum of 18-month period between advancement to candidacy and dissertation defense.

A public defense of the dissertation (final oral examination) is conducted after the student has completed all other formal requirements for the PhD degree and has submitted the written dissertation to their Dissertation Committee. Although the examination is primarily a defense of the dissertation, it will also include material relevant to the general field in which the dissertation is written, with particular attention to the more recent and significant developments in the field. Because the examination is a public defense, it must be scheduled on the MU or MCW campus during weekday working hours, avoiding public or religious holidays. All dissertation defenses will be held in the format of a departmental seminar. The student will give a formal presentation of work, followed by questions invited from all present. Immediately following the seminar, the student will meet privately with the Dissertation Committee. In this private meeting, the Committee will address concerns with the oral presentation and written elements of the dissertation.

Please note that the BME Department is responsible for setting up the virtual link for any public dissertation defense.

The student's Dissertation Director will inform the Chairperson of the Joint Department of BME of the examination outcome. The Dissertation Director will also forward this information to the MCW Graduate School in a *Committee & Program*

Director Final Recommendations form, along with a list of any recommended modifications to the dissertation within two weeks after the dissertation defense. It is assumed that the dissertation will be reviewed and edited until it meets the approval of all the committee members. However, when complete consensus seems impossible to achieve, it will be accepted if the Dissertation Director and three other committee members approve. Three copies of the completed dissertation, along with a completed *PhD Dissertation Completion Checklist form*, are then submitted to the MCW Graduate School.

If the student does not pass the dissertation defense, see the MCW Graduate School policy regarding failed dissertation defenses.

10. Time Limitations

All work for doctoral degrees, including the dissertation defense, must be completed within 7 years from matriculation in the Joint Department of BME PhD program.

V. Learning Objectives

The Learning Objectives of the BME Doctor of Philosophy training program and their outcome assessments provide tools that ensure continuous quality improvement.

Graduates earning the PhD degree will be able to:

- **Conduct independent research that reflects an original contribution to BME:** This is measured via evaluation of doctoral dissertation and defense, submission of at

least one first-authored manuscript to a peer-reviewed journal, and a survey sheet that is completed by each of the Dissertation Committee members.

Specifically, the following parameters are evaluated: ability to execute an appropriate research plan; research methods appropriate to the topic; conclusions and main arguments supported by the conducted research; effective use of resources to investigate the state of current knowledge relative to the research project.

- **Demonstrate technical proficiency in at least one area of BME:** This is measured via evaluation of the doctoral dissertation and defense, and a survey sheet that is completed by each of the dissertation committee members. Specifically, the following parameters are evaluated: demonstration of factual knowledge of engineering and life science; professional quality public presentation of research findings.
- **Recognize the need to apply ethical principles in conducting research:** This is also measured via evaluation of doctoral dissertation and defense, and a survey sheet that is completed by each of the Dissertation Committee members. Specifically, the following parameters are evaluated: honest reporting of results and data; proper citing in the dissertation; understanding of plagiarism; understanding of and compliance with IRB/IACUC rules and regulations
- **Demonstrate a commitment to professional development by participating in local and national professional development activities on a continuing basis:** This is measured via surveys of the Department's faculty. Specifically, the percentage of

students who presented a conference abstract in the previous year is determined.

Furthermore, the number of doctoral students that are members of a technical or professional society is determined and the number of students that published first-authored, peer-reviewed manuscripts is documented.

VI. Academic Dishonesty and Research Misconduct

Upon detection of academic dishonesty, the student involved will automatically receive an “F” or “U” grade in the course. Beyond this, additional credit for graduation may be required, or expulsion from the school may result, depending on the nature of the offense and the decision of the Dean of the MCW Graduate School according to MCW policy. Refer to the [MCW Graduate School Handbook](#) for “Definitions of Academic Dishonesty” and its consequences, and to the statement regarding “Research Misconduct”.

VII. Registering for Courses at MU and MCW

Students should register at MCW **for all courses** they plan to take, and additionally at MU for the courses offered at MU.

VIII. Independent Study Course BIEN 6995

The Graduate Committee of the Joint Department of BME reviews all BIEN 6995 course proposals. The proposal specifies the method for documenting successful completion of the course. Appropriate documentation is typically a summary report (with an appropriate list of references) but can also take the form of a completed project (with documentation), formal presentation, examination, or other suitable evidence of accomplishment.

Completion of each BIEN 6995 course must be documented by the student, approved by the course director, and submitted to the Graduate Committee of the Joint Department prior to the end of the semester in which the course is completed.

IX. Vacation and Leave Policy

Please refer to the [MCW Graduate School Handbook](#) for more information regarding vacation and leave policy for PhD students.

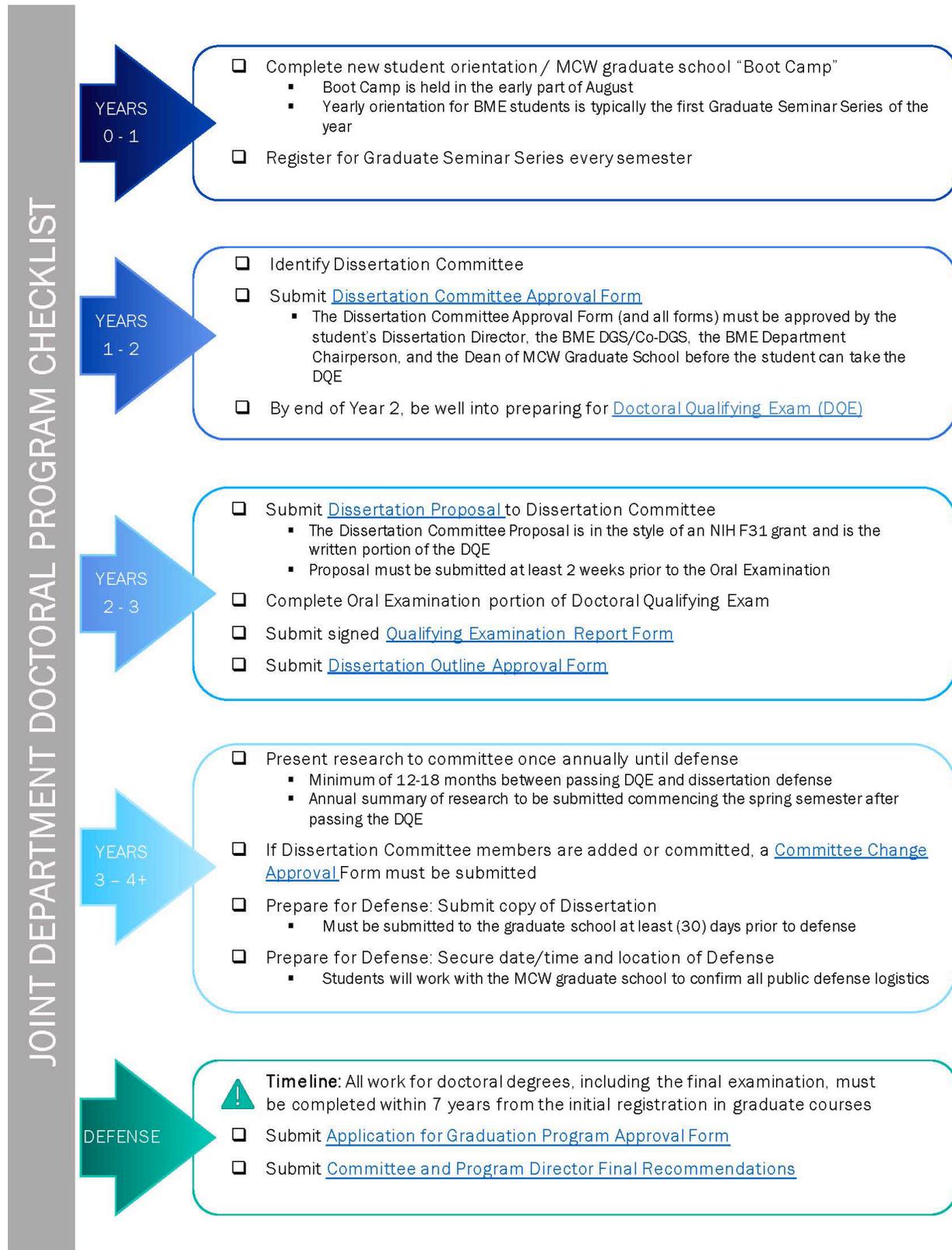
X. Financial Aid

- All **full-time** students admitted to the BME PhD program will receive continuing **tuition waiver, stipend, and health insurance** contingent on satisfactory progress.
- **Stipends:**
 - It is the policy of the MCW Graduate School that: (1) All full-time doctoral students in good academic standing receive a graduate stipend, and (2) the stipend level should be uniform among all eligible students at a comparable level of training (see [MCW Graduate School Handbook](#) for more information regarding this policy).
 - Three major sources of graduate stipends:
 - **Teaching Assistantships:** Teaching assistantships provide students with a stipend for the first three semesters in the doctoral program. In return the students are expected to satisfactorily perform 20 hours of teaching-related assignments per week. **MSTP students** are not eligible for Teaching

Assistantships due to the time constraints to which they must adhere (i.e. three to four years of graduate school).

- **Research Assistantships:** Research assistantships also provide students with a stipend. In return the students are expected to satisfactorily perform 20 hours of research-related assignments per week. Research assistantships are also available from individual faculty members with research grants.
- **Fellowships:** A limited number of fellowships are available through the [MU Graduate School](#). Doctoral students are also urged to seek fellowships available from various external government institutes (e.g., NIH, NSF, DoD), foundations (e.g., AHA), and other organizations.

XI. Timeline of Doctoral Student's Progress and Milestones



XII. Additional Resources and Information

Links to all forms and additional information can be found below and on the [Graduate Resources page](#) of the Joint Department website:

- PhD Plan of Leveling Form
- PhD Completion Checklist
- Dissertation Committee Approval Form
- Dissertation Committee Change Approval Form
- Qualifying Examination Report Form
- Dissertation or Thesis Proposal Approval Form
- Application for Graduation Program Approval Form
- Committee & Program Director Final Recommendations Form
- ProQuest Dissertation Publishing Info

Note: Please make sure to also apply for graduation on the MU side (via [CheckMarq](#)). Use the link “Apply for graduation” on the “My Academics” page in the “Student Center.”

1. Considerations for Evaluating Readings and Research

Criteria used to evaluate students in Readings and Research should reflect performance related to the student’s effort on their dissertation or thesis project. Specifically, it is recommended that faculty mentors evaluate student effort in terms of the Core Qualities and Competencies for Graduate Education. In brief, Core Qualities include: **Scholarship:** the pursuit of knowledge through study and

research; **Innovation:** creativity in the generation of new knowledge; and **Professionalism:** conforming to the behavioral norms of a profession. Similarly, Core Competencies that students are expected to achieve during their training experience include excellence in: **Knowledge and Skills, Communication, and Management, Teamwork, and Leadership.**

2. Criteria Used to Evaluate Readings and Research

Due to the varying nature of the research experience across different disciplines and mentors, fixed criteria for grading students are not easily established. Mentors should consider performance relative to the student's stage in the program on the following types of activities when evaluating Readings and Research:

- Written research summaries
- Presentations to the department and dissertation/thesis committee
- Motivation and commitment to research
- Data management and record keeping
- Familiarity with the literature
- Collegiality within the laboratory/group
- Ability to establish and meet pre-set deadlines and goals
- Laboratory/research skills and experimental design
- Oral and written communication skills
- Scientific honesty and integrity
- Research accomplishments and progress towards the dissertation/thesis

- Research problem solving and computing skills
- Creative thinking skills

3. Grading System for Readings and Research

Student performance in Readings and Research is graded according to the following scale: E (excellent), G (good), SD (substandard), and U (unsatisfactory).

Please note that the definition for S has been changed from satisfactory to substandard. Examples of student activities have been provided to help clarify these grading designations:

- **E (excellent)** – Student performance exceeds expectations. The student functions primarily independent from the mentor. For example, a student initiates and manages new collaborations related to their project, establishes a new technique for the laboratory or a new method for the research problem, submits his/her research proposal for outside funding consideration, and/or submits a manuscript for publication consideration. The student successfully troubleshoots a difficult experiment, research or computing problem independent of their mentor, or independently mentors and manages a student.
- **G (good)** – Student performance meets expectations. The student is beginning to function independently but still requires appreciable guidance from the mentor. For example, the student actively participates in a collaboration previously established by the mentor, masters an established

technique within the laboratory or problem-solving techniques, works toward initiation, preparation, or completion of their research proposal, and/or prepares a manuscript based on studies from their research project. The student successfully troubleshoots a difficult experiment/research problem with the help of the mentor or works with the mentor to successfully mentor and manage a student.

- **SD (substandard) – Student performance is below expectation.** The student meets the bare minimum requirements established and requires substantial guidance from the mentor beyond what is expected at this point in their training. For example, the student meets deadlines but requires frequent reminders or other input from the mentor or program director. The overall product produced in the laboratory or the progress made on the dissertation/thesis needs improvement in terms of quality, efficiency, and/or timeliness. The student remains unable to successfully troubleshoot an experiment/research problem even with input from the mentor.
- **U (unsatisfactory) – Student performance is below minimum standards and corrective actions are required.** There is a general lack of engagement by the student. The student fails to take ownership of his/her research project even after significant input from the mentor. The student fails to engage in timely communication, and overall student effort suffers from a lack of commitment to research.

4. Recommendation when Assigning an SD Grade for Readings and Research

Mentors who assign an “SD” in Readings and Research should plan to meet with their student to discuss the specific activities that have failed to meet expectations. Recommendations on how to improve student performance in these areas should be discussed and/or documented, and when warranted, specific milestones developed and periodically evaluated with the student to improve performance to one that meets expectations.

5. Policy for Assigning a U Grade for Readings and Research

Mentors should be aware that a “U” in Readings and Research automatically places a student on probation, and two “U” grades are grounds for dismissal from the Graduate School. Given the significance of this grade, prior to assigning a “U” the Mentor will consult with members of the Dissertation/Thesis Committee (for students that have formed a dissertation/thesis committee) and the Director of the Graduate Program for feedback on the appropriateness of the decision. If there is consensus that the student performance is evaluated as Unsatisfactory, a letter explaining the basis for this grade and detailed corrective measures and strategies shall be submitted to the Director of the Graduate Program and to the Dean of the Graduate School in Biomedical Sciences. A student who receives a second evaluation as Unsatisfactory during any subsequent semester of study will be considered for dismissal.