



**IUPUI**

DEPARTMENT OF BIOMEDICAL ENGINEERING

**GRADUATE HANDBOOK**

Doctor of Philosophy Degree in Biomedical Engineering

(Ph.D. BME)

**Fall, 2023**

## AMENDMENTS

1. First version was submitted for approval to the BME faculty on December 7, 2020
2. Amended by the BME faculty on August 16, 2021.
3. Amended by the BME faculty on August 17, 2022
  - a. Added significant updates and detailed descriptions in Sections 6 through 11, to specify program requirements on Curriculum Requirements, Advisory Committees, Plan of Study, and Guidelines for selections courses for Plan of Study
  - b. Add details about Examination Requirements (Section 13), especially the PhD Qualifying Portfolio Process, and the Quantitative Literature Analysis
  - c. Updated Section 20 Milestone Checklist & Timeline
  - d. Added Appendices C and D: Sample Plans of Study for Direct-Admit and Traditional-Admit students.

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## 1. INTRODUCTION

This handbook addresses common questions from applicants and current graduate students concerning the Ph.D. program in Biomedical Engineering at IUPUI. Information is provided concerning the application process, establishing a program of study, required scholastic performance and general administrative expectations of the IUPUI Graduate School and the Department of Biomedical Engineering.

## 2. BIOMEDICAL ENGINEERING FACULTY

As of Fall 2022, the core biomedical engineering faculty at IUPUI are:

<b>Karen Alfrey, Ph.D.</b>	Rice University, 2000. Computational biology, neuronal modeling; biological control systems
<b>Edward Berbari, Ph.D.</b>	University of Iowa, 1980. Computer-based medical instrumentation, biomedical signal processing, cardiac electrophysiology and biophysical modeling
<b>Jennifer Hatch, M.S.</b>	Indiana University Purdue University Indianapolis, 2021
<b>Steven Higbee, Ph.D.</b>	Rice University, 2013. Biomaterials and tissue engineering, undergraduate research
<b>Julie Ji, Ph.D.</b>	University of Pennsylvania, 2004. Endothelial mechanobiology, cell and nuclear mechanics, signal transduction in human diseases
<b>Chien-Chi Lin, Ph.D.</b>	Clemson University, 2007. Development of functional hydrogels for tissue regeneration and controlled release applications
<b>Sharon Miller, Ph.D.</b>	University of Michigan, 2008. Biomaterials and tissue engineering
<b>Sungsoo Na, Ph.D.</b>	Texas A&M University, 2006. Cellular/molecular mechanics and mechanotransduction of skeletal and vascular systems
<b>John Schild, Ph.D.</b>	Rice University, 1995. Electrophysiological and computational study of neurocirculatory control
<b>Rachel Surowiec, Ph.D.</b>	University of Michigan, 2019. Biomedical imaging, quantitative MRI
<b>Joseph Wallace, Ph.D.</b>	University of Michigan, 2007. Biological and environmental factors influencing the organization and assembly of bone
<b>Dong Xie, Ph.D.</b>	Ohio State University, 1998. Polymer biomaterials
<b>Hiroki Yokota, Ph.D.</b>	University of Tokyo, 1983. Indiana University, 1993. Biomechanics and systems biology of bone and cartilage
<b>Ken Yoshida, Ph.D.</b>	University of Utah, 1994. Neural engineering, bioinstrumentation

Current research topics as well as course subjects offered by the BME faculty include:

- Biomaterials / Tissue Engineering
- Biomechanics / Mechanobiology
- Bioinstrumentation/Neural Engineering / Biosignal Processing

## 3. GRADUATE SCHOOL ADMISSION REQUIREMENTS

The BME Graduate Committee will review all applications following the Purdue Graduate School requirements and standards. Applicants ordinarily will be expected to hold baccalaureate degrees from colleges or universities of recognized standing prior to registration

as graduate students. Three-year Bologna bachelor's degree recipients are eligible for admission. Applications for admission will be considered for those with an MS degree (Traditional Admit) or highly qualified students with a BS degree (Direct Admit). All applicants to the BME Ph.D. program must submit the following:

- Official transcripts from all undergraduate and graduate institutions they have previously attended. The minimum Program cGPA of the highest applicable degree is 3.2/4.0
- Graduate Record Exam (GRE) scores for the general exam. Students are required to take the Quantitative, Analytical Writing and Verbal GRE exams.
- Three letters of recommendations from professionals familiar with the applicant's academic or professional background.
- A Statement of Purpose
- BME Graduate Interests Form
- Non-native English speakers are required to demonstrate English proficiency. The minimum scores as required by the Purdue Graduate School will be enforced.

#### 4. ENGLISH LANGUAGE REQUIREMENTS FOR NON-NATIVE ENGLISH SPEAKERS

All major aspects of the BME Ph.D. program are conducted in English. Thus, all BME graduate students are expected to have proficiency in oral and written English. All non-native English speakers must demonstrate English proficiency for admission into the BME Ph.D. program. Proficiency can be demonstrated through standardized examinations (TOEFL, IELTS) or completion of Bachelor's or higher degree from a University in an English Speaking Country.

The minimum TOEFL scores required before an application will be considered are as follows:

- **Internet-based test (iBT):** The following five (5) minimum scores must be met: **Writing: 20, Speaking: 20, Listening: 20 and Reading: 20; and Total score: 80.**
- **Paper-based test:** the minimum acceptable score is: **550.**

The British Council's International English Language Testing System (IELTS) is acceptable in lieu of the TOEFL. Both the minimum overall and sub-section scores must be met for admission.

- The minimum **Overall IELTS band score of 6.5**
- The minimum sub-section scores are as follows: **Reading: 6.5, Listening: 6.0, Speaking: 6.0, Writing: 5.5**

All BME graduate students must demonstrate acceptable proficiency in oral and written English. Per IUPUI policy, international students from countries where English is not the predominant native language must successfully pass the English for Academic Purposes (EAP) Placement Test even if the TOEFL test has been taken for admissions purposes.

Those applicants who obtain a TOEFL Internet-based test (iBT) score of 100 or higher, and those who obtain an IELTS score of 7.5 or higher are exempt from EAP test. The student's letter of admission from the Office of International Affairs will indicate if they are required to take this test. EAP tests are offered during new international student orientation, during the week prior to either the fall or spring semesters.

The EAP Exam is not an admission requirement but a placement exam that is used to determine whether students are required to take any English courses. In case EAP courses are required, students will take them alongside courses for their academic program within the first semesters. There is an additional cost for these courses. Language related courses cannot count towards the credit requirements for the Ph.D. program in Biomedical Engineering.

Students who fail to take the EAP exam or those who fail to enroll in an EAP course as required by their test results will have a hold placed on their enrollment for the next semester. Holds are not placed until after students complete their first semester. So, students have the first semester to take care of required EAP tests of courses. The IUPUI Graduate Office administers all Graduate EAP policy requirements and holds.

## **5. APPLICATIONS FROM NON-BIOMEDICAL ENGINEERING MAJORS**

Applicants with an undergraduate engineering degree in a discipline other than Biomedical Engineering or Bioengineering who can show evidence of proficiency Mathematics, Physics, Engineering and Life Science prerequisite requirements will be given full consideration for admission by the BME Graduate Admissions Committee. Applicants with a non-engineering undergraduate degree must show quantitative evidence of proficiency in the areas listed below. Additionally, proficiency with methods of analyses, and interpretation of quantitative data using numerical and/or computerized methods whilst understanding the impact of the method is highly valued and recommended.

Graduates from a discipline other than Biomedical Engineering will need to demonstrate some depth of academic proficiency consistent with the anticipated area of study (e.g. biomaterial, biomechanics, biosignals). The proficiency areas most often assessed by the Admissions Committee in terms of IUPUI course equivalents, include:

### **Engineering and Life Science Requirements**

BME 32200	Probability and Application in BME
BME 33100	Biosignals and Systems
BIOL K324	Cell Biology

The extent to which additional study is required to prepare the applicant for Ph.D. in BME is greatly dependent upon the nature of the undergraduate degree (e.g., B.S. vs. B.A., engineering vs. non-engineering, biology vs. chemistry, etc.) The proficiency areas most often evaluated by the Admissions Committee, in terms of IUPUI course equivalents, include:

BME 22200	Biomeasurements
BME 24100	Introduction to Biomechanics
BME 33400	Biomedical Computing
BME 38100	Implantable Materials
BME 35200	Cell and Tissue Behavior and Properties

If the Admissions Committee concludes that an applicant appears capable of graduate Ph.D. level work but would benefit from additional study in select academic areas, then

preliminary coursework may be recommended to prepare them for the BME Ph.D. program. Non-BME admitted students are required to meet with their advisor at the start of the program. The courses listed above serves as a guide for selection of preliminary coursework and obtaining at least a grade of "B" (3.0/4.0) in these courses would demonstrate proficiency in an area, for example. These classes would not count toward the credit requirements for the Ph.D. degree in Biomedical Engineering.

## 6. CURRICULUM REQUIREMENTS

Ph.D. students will be required to complete ninety (90) credit hours to earn a Ph.D. degree Biomedical Engineering. Specific curriculum requirements are outlined in Table 1.

**Table 1: Biomedical Engineering Ph.D. Degree Course Credit Requirements**

	Credit Hours		Transfer Limit	
<b>Quantitative Reasoning/Mathematics</b>	Total 27	~ 6	No more than 21	6
<b>Biomedical Engineering</b>		≥ 6		6
<b>Life Science</b>		~ 6		6
<b>Other Courses (Engineering, Math, Life science)</b>		~ 9		3
<b>Ethics</b>	1		—	
<b>Critical Literature Analysis (CLA)</b>	2		—	
<b>Graduate Seminar</b>	> 4 semesters		—	
<b>Research Thesis Credit</b>	60		9	

A minimum of 30 graded graduate course credit hours are needed to fulfill the Ph.D. requirements in Biomedical Engineering. Students will work directly with their Doctoral Major Professor and Advisory Committee to design an appropriately themed course of study applied toward the student's Plan of Study. Ph.D. students may complete their core coursework on either the IUPUI campus or the Purdue West Lafayette campus.

Course requirements for these credit hours include:

- A minimum of six credit hours of 600-level or higher, with 3 of the 6 credits in BME
- Two BME core courses, one of which should be at or above the 600-level
- Two graduate-level Mathematics or approved Quantitative Reasoning courses
- Two graduate-level courses in the area of Life Science
- Three additional graduate-level courses that can be from Engineering, Mathematics, or Life Science
- Two 1-credit hour Critical Literature Analysis courses completed within the first two semesters of the student's academic program
- One 1-credit Ethics course

## **CLA Requirement**

To develop skills in critical reading and analysis of the literature, BME doctoral students are required to complete two successive semesters of CLA courses in their first year into the BME Ph.D. program. Each of the CLA courses is 1 cr. The two CLA courses are part of the Ph.D. Qualifying Process.

## **Seminar Requirement**

The BME Department sponsors many opportunities for academic, scientific research, and professional career enrichment. Graduate students are strongly encouraged to make the most of these opportunities to ensure their training is grounded in a broader understanding of the BME field and its role in advancing medical science. Consequently, all BME Ph.D. students are required to register for four (4) semesters of the BME Graduate Seminar (BME 50000) and pass with a Satisfactory grade. This course may include attending departmental seminars, invited speaker series plus other talks, as well as Graduate Student Association sponsored meetings. This is a zero-credit hour course but a grade of Satisfactory or Unsatisfactory is assigned at the end of the semester.

## **Ethics Requirement**

One 1-credit Ethics course is required for the Ph.D. program. The recommended course is GRDM G505: Research Ethics (1 credit), offered by the IU School of Medicine, Center for Bioethics. Students can also petition alternative Ethics courses to be used to satisfy this requirement on their Plan of Study.

## **600-Level Course**

Students will be required to complete at least two (2) 600-level courses with at least one of the two being a BME 600-level course.

Failure to satisfy the above Curriculum Requirements may result in loss of Good Academic Standing, and prevent or delay graduation. Each student is responsible for completing a Ph.D. Plan of Study (PoS) consisting of their coursework as outlined by the Purdue Graduate School. Example Plans of Study are outlined in Appendix.

## **7. STUDENTS ENTERING WITH MASTER'S DEGREE (TRADITIONAL ADMIT)**

Ph.D. students who already completed a master's degree in BME from IUPUI or an accredited institution may contribute up to 30 credit hours toward satisfying the Ph.D. course requirement. See Table 1. Students must petition for approval by the BME Graduate Committee at IUPUI to determine if any credits from their MS program qualify as applicable to their Ph.D. requirements. For more information, see Section 10 Plan of Study.

If the student completed a course-only master's degree (no thesis), up to twenty-one (21) credits of graded graduate coursework (equivalent to 500-level or higher) can be applied.

If the student completed a thesis-based master's degree, up to thirty (30) credits can also be transferred. In this case, up to twenty-one (21) credits of graded graduate coursework



(equivalent to 500- level or higher) can be applied and up to nine (9) credits of appropriate master's thesis-level research credit can be applied.

## **8. DIRECT ADMIT PH.D. STUDENTS INTERESTED IN AN EN-PASSANT BME MASTER'S DEGREE**

Students directly entering the Ph.D. program following their BS degree (Direct Admit) may qualify for an MS BME through the completion of the requirements of the Ph.D. degree, an *en-passant* MS degree. Up to 30 credit hours of coursework applied towards your Ph.D. BME can be double counted towards an MS BME by satisfying the degree requirements for a non-thesis, course-only MS BME. Please consult the current MS BME Handbook for the degree requirements. In total 30 credit hours of coursework is required for the MS BME degree, thus additional coursework might be required in some cases. Paperwork and an application towards the MS BME must be approved by your Doctoral Advisory Committee and submitted for approval to the BME Graduate Committee no earlier than 1 year prior to your Ph.D. defense and no later than your Ph.D. defense. The MS BME must be completed and awarded prior to completion and awarding of the Ph.D. degree.

## **9. FACULTY ADVISOR AND ADVISORY COMMITTEE**

The Faculty Advisor or Major Professor is the chief mentor and academic advisor to the Ph.D. student and sponsor of the student's thesis project. The Academic Advisory Committee and Doctoral Advisory Committee provide guidance to the Ph.D. student as the student progresses through the Ph.D. program. Which committee advises the student depends on the student's progression in the Ph.D. program. Members of the committees can be the same, but are not required to be. They will be generally referred to as the Advisory Committee. If an action is required by a specific committee, their designated name will be used.

The Major Professor must be a BME or an Adjunct faculty. Other faculty who want to sponsor a BME Ph.D. student must first apply to become an Adjunct. When a student's Major Professor is an Adjunct and not one of the primary faculty, then a BME primary faculty must serve on the Advisory Committee as the co-Chair and the faculty of record.

### **Academic Advisory Committee (AAC)**

The Academic Advisory Committee provides advice on the student's choice of courses in the student's initial years in the Ph.D. program. This Committee consists of three BME faculty members (or BME Adjunct faculty) who advise the student's initial Plan of Study: the Major Professor who is assigned at admission plus two other faculty in related areas of research. An official Plan of Study must be approved and filed with the Graduate School by the 6<sup>th</sup> week of the second semester in the student's 1st year in the program. The three-person Academic Advisory Committee is a precursor to the Doctoral Advisory Committee, which is formed once the student completes the Ph.D. Qualifying Procedure (PQP) process. The membership of the two advisory committees can be, but is not required to be the same.

### **Doctoral Advisory Committee (DAC)**

The Major Professor and Ph.D. student must establish a Doctoral Advisory Committee once the Ph.D. student qualifies into the Ph.D. program. Although the Doctoral Advisory

Committee is not required to be formed until the Preliminary Exam, it is advisable to begin considering Committee members as soon as the student completes the QLA.

The primary duties of this committee are to assist in finalizing the student's Plan of Study for fulfillment of the Ph.D. degree requirements. This Committee advises through the course of their thesis research, and is responsible for conducting the Preliminary and Final Examinations.

The Doctoral Advisory Committee consists of at least four members. The Major Professor serves as chairperson of the Doctoral Advisory Committee. The Major Professor and Ph.D. student work together to choose other members of the committee. Membership of the committee must satisfy the following requirements:

- The chairperson and at least one other member must be an IUPUI BME faculty member
- The chairperson and at least one other member should have expertise in the Primary Area that the student has declared
- When a student's Major Professor is an Adjunct faculty, then one of the primary BME faculty must serve on the Advisory Committee as the co-Chair and the faculty of record, and should have expertise in the thesis research area.
- On committees with 2 co-Chairs, one other member must be BME faculty member
- 51% of the committee members must have regular graduate faculty certification.

## 10. PLAN OF STUDY

In the first semester of the program, Ph.D. students should consult with their Faculty Advisors to choose members of their Academic Advisory Committee. Students should contact members of the committee to confirm their participation. In consultation with the Academic Advisory Committee, student should identify courses to be put on the Plan of Study during the first year. An official preliminary PoS must be approved and filed with the Graduate School by the 6th week of the 2nd semester in the program.

The Plan of Study Form (GS-6) is filed online via the Purdue Graduate School Portal website. Near the end of the first semester, students will receive an email from the Purdue Graduate Recorder with instructions to set up a Purdue Career Account (PCA). Once complete, students can log in and follow directions online to complete the Plan of Study and submit Advisory Committee members. All relevant signatures will be obtained electronically. The completed form is then recorded in the student's academic file. Approval by the Director of the Graduate Program and the Graduate School officially establishes both the Plan of Study and the Advisory Committee.

The BME Graduate Program Coordinator can assist with the logistics of filing a Plan of Study. The Appendix at the end of this document includes helpful hints for filing Plan of Study (GS-6) as well as sample Plans of. **Each student is expected to file the Plan of Study Form (GS-6) by the 6th week of the 2nd semester in the degree program.** Students failing to meet this requirement may lose Good Academic Standing and may not be permitted to register for additional courses or thesis credits. It is possible to make changes to a Plan of Study that has been submitted and approved. See Section 17.

Plans of studies must satisfy the Purdue programs residency requirement. At least one-third of the total credit hours used to satisfy degree requirements must be earned while registered for doctoral study at IUPUI.

Ph.D. students may complete their coursework on either the IUPUI campus or the PUWL campus. PUWL offers online and hybrid versions of some pertinent graduate courses that our students will still be encouraged to consider, if appropriate for their Plan of Study. Credit for courses taken off campus including PUWL are considered transfer credits and subject to the 12 credit hour limit.

Doctoral students who fail to meet the requirements and deadlines for filing the PoS will not be permitted register for the following semester. The responsibility of paying late registration fees and/or the consequences for potential delay in completing academic course requirements for the BME Ph.D. program will rest entirely with the student and may result in loss of departmental fellowship support.

## 11. GUIDELINES OF SELECTION OF COURSES FOR PLAN OF STUDY

### BME Courses

The BME Department consistently offer on rotation the graduate level courses listed in Table 2. Select 500-level courses will be developed into 600-level offerings and additional 600-level courses will be added as needed. Offering frequency is shown for the last four academic years. Course descriptions and rotation schedule can be found on department website.

**Table 2: BME Graduate Course Titles and Recent Course Offerings**

Course Number	Course Title	Instructor	Frequency
<b>BME 500-level Graduate Course Offerings (Graded)</b>			
<b>BME 52700</b>	Implantable Systems	Schild	FA17
<b>BME 53700</b>	Experimental Methods in BME	Schild	FA18
<b>BME 54400</b>	Musculoskeletal Biology and Mechanics	Wallace	SP17, SP19
<b>BME 57100</b>	Drug Delivery	Ji	SP17, SP19
<b>BME 58200</b>	Advanced Biomedical Polymers	Xie	FA16, FA18
<b>BME 59500</b>	Biomolecular Engineering	Yokota	FA16, FA18
<b>BME 59500</b>	Tissue Engineering	Lin	FA15, SP17
<b>BME 59500</b>	Cardiac Electrophysiology	Berbari	FA15, FA17, FA18
<b>BME 59500</b>	Cellular Mechanotransduction	Na	FA15, FA17
<b>BME 59500</b>	Cellular Electrophysiology	Schild	FA16
<b>BME 59500</b>	Embedded Bioinstrumentation	Yoshida	SP16, SP18
<b>BME 59500</b>	Engineering Analysis of Tissues	Wallace	SP16, SP18
<b>BME 59500</b>	Engineering Principles of Biotechnology	Ji	SP16, SP18
<b>BME 59500</b>	Molecular and Cellular Mechanics	Yokota	FA15, FA17
<b>BME 59500</b>	Neural Engineering	Yoshida	SP17, SP19
<b>BME 59500</b>	Polymers for Biomedical Applications	Xie	FA15, FA17
<b>BME 59500</b>	Vascular Biomechanics	Na	FA16, FA18
<b>^BME 59500</b>	<i>Cancer Bioengineering</i>	<i>Lin</i>	-

### BME 600-level Graduate Course Offerings (Graded)

<b>BME 69500</b>	Advanced Biomolecular Engineering	Yokota	
<b>^BME 69500</b>	<i>Contemporary Polymers in Biomedical Applications</i>	Xie	
<b>*BME 69500</b>	<i>Engineering Principles for Biomolecular Interactions</i>	Lin	As 500-level SP16, SP18
<b>^BME 69500</b>	<i>Advanced Cell and Tissue Engineering</i>	Lin	-
<b>*BME 69500</b>	<i>Cellular Electrophysiology</i>	Schild	As 500-level FA16
<b>^BME 69500</b>	<i>Advanced Analysis of Cellular Mechanobiology</i>	Na	-
<b>*BME 69500</b>	<i>Advanced Neural Engineering</i>	Yoshida	As 500-level SP17, SP19
<b>^BME 69500</b>	<i>Advanced Mechanics of Materials</i>	Wallace	-
<b>*BME 69500</b>	<i>Advanced Engineering Analysis of Tissues</i>	Wallace	As 500-level SP16, SP18

### BME Seminar and Other Required Courses

<b>BME 50000</b>	BME Graduate Seminar		
<b>GRDM G505</b>	Research Ethics (1 credit)		
<b>^BME 59500</b>	<i>BME Critical Literature Analysis</i>		
<b>BME 69900</b>	Research Ph.D. Thesis		

\* Course to be developed from previous 500-level offering; course names are not yet verified.

^ New course to be developed.

### Primary and Related Courses

Ph.D. students must consult with their Faculty Advisor and choose 15 credit hours of “Primary” courses on their Plan of Study. Of these 15, 6 credits must be BME grad courses, and 3 must be 600 level courses. Primary courses are meant to be the most relevant to your research topic, and classes like Ethics, CLA, or Seminars cannot be considered as Primary.

Courses other than Primary are labeled as “Related” on the Purdue Plan of Study. Students entering with a Master’s degree can designate transfer credits as either Primary and Related. Students entering with a Master’s degree from IUPUI can retain the designations of Primary and Related on their transfer credits.

### Engineering Elective Courses

In general, IUPUI graduate courses at the 500 level and above offered by the ECE and MEE departments are acceptable as approved engineering elective courses. However, depending on the topic and content, some may not be approved as engineering electives. Please consult with your Faculty Advisor to confirm approved ECE and ME courses.

### Mathematics, Statistics, or Life Science Elective Courses

BME offers its graduate students considerable flexibility in selecting life science and discipline specific electives. There is, however, an implied expectation that course selections will follow a unified theme in BME that is consistent with the student's research thesis project.

The BME Graduate Committee has reviewed and approved the following courses for inclusion on a Plan of Study for the Ph.D. Degree in Biomedical Engineering. However, approval of the Faculty Advisor and Advisory Committee is needed for courses to apply toward the student's Plan of Study.

DEPARTMENT	Course #	Course Title
ANAT-D	50100	Human Gross Anatomy
ANAT-D	52700	Neuroanatomy
BIOL	56100	Immunology
BIOL	57310	Stem Cell Biology
BIOL	55600	Physiology I
BIOL	50700	Principles of Molecular Biology
BIOL	51600	Molecular Biology of Cancer
BIOL	57400	Molecular and Cell Bone Biology
BIOL	55900	Endocrinology
CHEM	53300	Intro to Biochemistry
CHEM	62100	Advanced Analytical Chemistry
GRAD-G	819	Basic Bone Biology
MATH	51000	Vector Calculus
MATH	51100	Linear Algebra w/ Applications
MATH	52500	Intro to Complex Analysis
MATH	53700	Applied Math Scientists/ENGR I
MATH	55200	Applied Numerical Methods II
PHSL-F	503	Human Physiology
STAT	51100*	Statistical Methods I*
STAT	51200	Applied Regression Analysis
STAT	51400	Design of Experiments
STAT	51900*	Introduction to Probability*
STAT	52300	Categorical Data Analysis
STAT	52800	Intro to Mathematical Statistics

\* STAT 51100 and 51900 cannot be used by students with BS BME from IUPUI on their Plan of Study due to overlap with BME32200.

### Course Petition

Courses on this list **do not require prior approval** and can be considered as acceptable for a Plan of Study. This assumes the selection adheres to the credit allocations and is thematically consistent with the student's research thesis project.

Furthermore, all graduate courses at the 500 level and above offered by the School of Science and the IU Schools of Medicine, Dentistry, Nursing, etc. that are NOT on the list can be approved for the Plan of Study. Students must first review the selection(s) with their Faculty Advisor and then petition the BME Graduate Education Committee (GEC) by notifying the Chair the advisory committee via email and filling out a *Course Request Petition Form*. The student must submit a course syllabus and an outline of lecture topics (if available), along with the form, to the BME Graduate Program Coordinator. The Faculty Advisor and BME GEC will then determine if the course has a sufficient life science focus and rigor to be added to an approved Plan of Study for the Ph.D. Degree in BME.

For the math course requirement there is considerable flexibility in terms of acceptable courses. For a math course to be approved, careful consideration is given to the level of analytical rigor in the course material and thematic consistency with the topic of the student's research thesis.

## **Transfer Credits**

It is a rule for all graduate degree programs in the Purdue system that no more than 12 graduate credit hours can be transferred onto a Plan of Study from an outside institution or some other IUPUI graduate degree program. Transfer courses are not included in the computation of the cumulative grade point index (cGPA). As a result, transfer courses cannot be used as Primary, but only as related electives.

## **12. CONCENTRATIONS**

Students accepted into the Ph.D. program will have the option to declare an area of concentration. Successful completion of concentration requires completing 9 credit hours of complementary, graded, graduate level coursework (500-level and above) aligned with an area of concentration, with transcript documentation. Initial areas of concentration described below, are represented within the IU School of Medicine by their respective center or institute. Future opportunities may expand these concentrations to fulfill student needs and interests.

*Musculoskeletal Health Concentration:* for students interested in developing supplemental knowledge on new treatments, cures, preventative strategies, diagnostic tools and technologies to address the increasing burden of bone, muscle, and cartilage disorders.

*Biomedical Imaging Concentration:* for students interested in developing supplemental knowledge of state-of-the-art imaging resources for use in human, molecular, and cell biology.

*Neuroscience Concentration:* for students interested in developing supplemental knowledge of devastating disorders of the nervous system including neurodegeneration, neuropsychiatric disorders, pain and spinal cord injury, and traumatic brain injury.

## **13. EXAMINATION REQUIREMENTS**

The Ph.D. student must successfully complete and pass a qualifying procedure followed by two major examinations during the course of the BME Ph.D. program as follows: (1) Ph.D. Qualifying Procedure, (2) the Preliminary Examination, and (3) the Final Examination. The word used to designate the student will change as the student progresses through this process. Upon entry into the Ph.D. program, and generically in this document, the student is designated as a "Ph.D. student". Following successful completion through the Qualifying process, the student will be designated as a "Qualified Ph.D. student". Successful completion of the Preliminary Examination changes the designation of the student to "Ph.D. Candidate".

### **1. Ph.D. Qualifying Procedure (PQP)**

All doctoral students are required to complete the Ph.D. Qualifying Process which aims to evaluate a student's ability to perform satisfactorily in their doctoral work and Qualifies the

student into the Ph.D. Program. Benchmarks of a successful trainee include demonstrated ability to integrate disparate scientific concepts into a cohesive and testable hypothesis, a mastery of relevant technical skills and experimental design and evidence of effective communication among academic peers. Thus, the BME Ph.D. Qualifying Process (PQP) is designed as a portfolio process which makes possible the comprehensive assessment of a student's progress toward achieving such benchmarks in professional development. The PQP portfolio is comprised of the following 5 documents:

1. The Qualifying Literature Assessment (QLA): a critical analysis of current literature related to their intended Ph.D. research area that is written in the format of a journal review article, along with an appendix that both details and explains the rationale for the proposed methodologies.
2. A current Plan of Study that is on file with the IUPUI Graduate School.
3. A current transcript that demonstrates (1) 2 required Critical Literature Analysis (CLA) courses and (2) reasonable progress toward completion of the doctoral Plan of Study and that documents Good Academic Standing.
4. A one page (double spaced, 11 point Arial font, 0.5 inch margins) personal statement summarizing career objectives and how current and planned activities in BME at IUPUI will help achieve these goals.
5. A current curriculum vitae demonstrating progress toward that professional career.

The Qualifying Literature Assessment (QLA) aims to assess the readiness of students to conduct and communicate relevant research on a contemporary BME topic. It challenges the student to analytically synthesize and integrate multidisciplinary concepts. Students are required to submit a critical analysis of current literature in the form of a review article. While the student can choose their own topic, it is highly recommended that their topic be related to their intended Ph.D. research topic. Briefly, possible outcomes of the QLA assessment include:

**Full Pass:** The QLA document is deemed acceptable.

**Pass** (minor revision): All critical criteria are addressed and only minor improvements are requested. The student has up to 4 weeks to submit a revised QLA.

**Pass** (major revision): The QLA document lacks one or few critical criteria and is broadly void of detail and depth. One or few key aspects require significant improvement. The student has up to 10 weeks to submit a revised QLA document.

**Fail:** The QLA document lacks multiple critical criteria and is entirely without adequate detail and depth. The student may be terminated from the Ph.D. program at the end of the current semester. After consultation with the BME GEC and the student's Academic Advisory Committee, the student may be offered a second attempt that will be handled as though the student received a **Pass** (major revision).

**Timeline:** Ideally, the two CLA course sequence should be completed in the first year of academic study. Doctoral students who fail to successfully complete the CLA requirements will not be permitted to attempt the QLA. The summer following the first year of academic study is dedicated to completing the QLA and remaining portfolio documents. The entire portfolio is submitted to the Chair of the BME GEC before by August 1st before start of the following fall semester. Student will work on any revision needed during the subsequent semester.

Successful completion of the Portfolio Process no later than the start of the spring semester of the second year of academic study is considered satisfactory and timely progress toward candidacy. The consequences for delay in passing the Portfolio Process in a timely manner (approximately 6 months) will rest entirely with the student and may result in loss of departmental fellowship support.

More detailed information about CLA, QLA, and the PQP portfolio process will be made available to Ph.D. students at the end of their first year. The PQP process will be handled via a Canvas site and must be completed before progressing to the Preliminary Examination.

## **2. Preliminary Examination**

The Preliminary Examination is given at a formal meeting of the Qualified Ph.D. student's Doctoral Advisory Committee to determine whether a student is adequately prepared to conceive and undertake a suitable research topic. Students may not schedule their Preliminary Examination until after they have completed the PQP, filed their formal Doctoral Plan of Study, and formed their Doctoral Advisory Committee. Although the Preliminary Examination may include a written exam component at the discretion of the Doctoral Advisory Committee, it is normally an oral examination primarily associated with a written thesis proposal and its oral defense.

To ensure academic progress, the Preliminary Examination must be completed by a Traditional Admit Ph.D. student no more than 6 semesters into the Ph.D. program, and by a Direct Admit Ph.D. student no more than eight semesters into the program. If this deadline is not met, students must request an extension of the deadline using a form available in the BME Department giving the reason(s) for the delay and specific actions planned to remedy the situation. The form must be signed by all members of the Doctoral Advisory Committee and the Director of the BME Graduate Program. A completed form is required each semester past the deadline before registration for the subsequent semester is allowed. Successful completion of the Preliminary Examination marks the transition of the Qualified Ph.D. Student into a Ph.D. Candidate.

Doctoral students who fail to pass the Preliminary Exam will be terminated from the Ph.D. program at the end of the current semester. A second attempt to pass the Preliminary Exam is allowable at the discretion of the Doctoral Advisory Committee and the Major Professor. A student failing to pass the Preliminary Exam after two attempts will not be offered additional opportunity for reassessment and will be terminated from BME Ph.D. program at the end of the current semester.

## **3. Final Examination**

The Ph.D. dissertation must be prepared according to the standard Ph.D. dissertation format. Once the dissertation is prepared and all other requirements have been completed, the student must present and defend their work in a Final Examination (Ph.D. Dissertation Defense). The Final Examination Committee is typically the student's Doctoral Advisory Committee, and can include an external ad-hoc member.



## 14. GOOD ACADEMIC STANDING

All graduate students begin their program of study in Good Academic Standing. In order for graduate students to remain in Good Academic Standing, they must maintain minimum standards of academic performance that are set by the Biomedical Engineering Department. These expectations are in addition to the minimum standards of performance and personal behavior set forth by the IUPUI Graduate School.

- The GPA requirement on the final Plan of Study must be 3.2 or higher, with no grade less than B-
- Ph.D. students must earn grades of “Satisfactory” in thesis research credit hours
- Ph.D. students must satisfactorily complete the two (2) credit Critical Literature Analysis requirement within the first two semesters of your academic program
- Ph.D. students are required to register for four (4) semesters of the BME Graduate Seminar (BME 50000) and pass with a Satisfactory grade
- Ph.D. students must make continuous and significant progress each semester toward completion of your degree requirements
- Ph.D. students must complete all degree requirements and graduate within the required deadlines.

If a student earns grades less than “Satisfactory” in thesis research credit hours, a student would be put on probationary status prompting the BME Graduate Committee to recommend a remediation plan to the student’s Academic or Doctoral Advisory Committee. If a grade less than “Satisfactory” persists after remediation, the BME Graduate Committee will review the case and determine if removal from the Ph.D. program is required.

Other reasons that could result in a student’s loss of Good Academic Standing include:

- Any incidences of Academic Misconduct
- Failure to submit their Plan of Study in time (by second semester of the program)
- Failure to rectify any Incomplete grades promptly in their academic program

Failure to satisfy the above requirement will result in loss of Good Academic Standing, and prevent graduation. Students who lose Good Academic Standing for two semesters (consecutive or not), will be placed on Academic Probation. A student on Academic Probation will not be permitted to register for further graduate courses until an academic review has been carried out by the BME GEC. The outcome of this review may be either dismissal from their graduate degree program, or a list of expectations the student must achieve in the next semester (for example, minimum academic performance in specific graduate courses).

If these requirements are violated for a total of three semesters, the BME GEC, in consultation with the student’s Advisory Committee and Major Professor, reserves the right to terminate the student from the Ph.D. program at the end of the current semester.

### Minimum Grade Requirements

Without exception, the Ph.D. in BME will not be awarded to a graduate student with a cumulative program grade point average (cGPA) below 3.2 (4.00 scale) with no grade less than B-. The cumulative program grade point average is calculated using the courses that are listed on the approved Plan of Study. If a course is taken more than once while the student is enrolled as a graduate student, only the most recent grade received in the course will be used in computing the cGPA. Transfer courses are not included in the computation of the cGPA. Any course on the Plan of Study that carries a grade of “D” or “F” must be repeated.

## 15. THESIS PREPARATION AND FINAL EXAMINATION

The Doctoral Advisory Committee is responsible for the carrying out the Final Examination in accordance to the Ph.D. degree requirements. The primary duties of this committee as it relates to the Final Examination extend to assisting the Ph.D. Candidate to finalizing the Doctoral Plan of Study to enable final submission of the document for partial fulfill of the Ph.D. degree. As during the Preliminary Examination, this committee will conduct the Final Examination to determine whether all necessary requirements related to the Ph.D. degree are satisfied by the Ph.D. Candidate in their coursework and research.

It is the responsibility of the Ph.D. Candidate to distribute the Ph.D. dissertation for review to the members of the Doctoral Advisory Committee in good time. Each member of the Committee should receive a copy of the Thesis document **at least one month prior** to the final oral examination.

- All Candidates preparing a Thesis document and a final oral examination *must attend* a Thesis/Defense Preparation Briefing. These sessions are regularly offered by the Office of Graduate Programs in the School of Engineering and Technology with dates, times, and locations posted each semester. Each graduate student is expected to complete this briefing prior to composing the first draft of the Thesis. Generally, the student and major professor begin working through drafts of the Thesis at least 2-3 months before the anticipated date of the Final Oral Examination. Therefore, it would be prudent to complete a Thesis/Defense Preparation Briefing the semester before the anticipated date of the Final Oral Examination.
- All requirements and deadlines must be met for successful completion of Final Oral Examination and Thesis deposit for graduation.
- Candidates must complete and submit form GS Form-8, *Request for Appointment of Examining Committee*, to the Graduate Program Coordinator in the BME Department **at least four weeks prior** to the anticipated Final Oral Examination date. The Purdue Graduate School requires that the date, time, and location of the Final Oral Examination be registered at least three weeks in advance of the oral examination.
- Candidates must initiate form GS Form-7, *Report of Ph.D. Examining Committee*, and form GS Form-9, the *Electronic Thesis Acceptance Form* before their Oral Examination. The forms will be completed by Doctoral Advisory Committee members following the oral presentation of the Final Examination. Students should consult with the BME Graduate Program Coordinator.

- Candidates must adhere to the standards set forth in the *Manual for the Preparation of Graduate Theses* published by the Purdue Graduate School and available from the department Graduate Program Coordinator.
- It is incumbent upon the Candidate to adhere to the requirements and guidelines stated in this manual. The Purdue Graduate School will not accept a Thesis that has improper or inappropriate formatting. In such cases, the Thesis will be returned to the Candidate for revision before the Ph.D. degree can be conferred.
- Candidates must check with their research advisors to determine whether their Thesis needs to be kept confidential. If confidentiality is required, form GS-15, *Request for Confidentiality* must be filed with the BME Graduate Program Coordinator upon completion of the Final Oral Examination.
- The Candidate must personally meet with the Graduate Program Coordinator for verification of Thesis document format.
- The final, approved Thesis document for the Purdue Graduate School must be deposited at the IUPUI Graduate Office by the published semester deadline. More detailed instruction will be provided to graduating Candidate during their final semester.
- Candidate should **allow at least 2 days** to complete all of the final revisions for Thesis formatting and administrative paperwork related to the Thesis deposit process. While all of this takes place after successful completion of the Oral Examination, a Ph.D. degree cannot be conferred until the Thesis has been officially recorded with the Purdue University Graduate School.

## 16. ADVANCE, FINAL, AND LATE REGISTRATION

Each semester a graduate student can pre-register for courses offered in the following semester during the advance registration period of the current semester. Students already in residence are strongly urged to advance register. New students may advance register if they come to campus during the semester before starting graduate work.

If advance registration is not possible, students should register during the final registration period. Final registration follows the same procedure as advance registration and is held during the week preceding the beginning of classes.

Any student who has not utilized the advance or final registration periods must schedule under late registration which begins the first day of classes and continues for one week. Penalty fees will apply and the student should consult the Bursar's Office.

### Dropping/Adding Courses

Each graduate student is expected to be aware of all procedures, late fees, refund deadlines, etc. associated with dropping/adding of courses. Students may drop/add courses online during the open registration period. However, once the open registration period ends, students must use electronic Drop/Add forms to change a course. Information on procedures and deadlines are available on the IUPUI Registrar's website.

## 17. CHANGES IN ACADEMIC PROGRAM

As a student progresses through their course work and research, there may arise conditions that make it necessary to make changes to their approved Plan of Study and/or changes to their research objectives. To make changes to an approved Plan of Study, the Request for Change to the Plan of Study Form (GS-13) must be electronically submitted through the PCA. This form is also used to request a change of Faculty Advisor or other members of the Doctoral Advisory Committee. The following rules must be observed:

- A course **cannot** be removed from an approved Plan of Study once the course has been taken and a grade of "D" or lower has been received. This course must be repeated, and the student must receive a grade of "C" or better before the course can be removed from an approved Plan of Study. This rule is mandated by the Purdue Graduate School.
- Any change to a Plan of Study and subsequent filing of form GS-13 requires approval of the student's Doctoral Advisory Committee, Director of the Graduate Program, and the Chair of the Biomedical Engineering Department.

## 18. ACADEMIC STATUS

To qualify as a **Full Time Student**, a student must be enrolled in at least eight (8) credit hours or hold a Student Academic Appointment as a research or teaching assistant and being enrolled in at least six (6) credit hours. All international students must be enrolled full-time to meet their student visa requirements.

Students who do not enroll in classes for three (3) consecutive academic sessions, including summer sessions, will be automatically assigned an **Inactive Academic Status** and are no longer considered to be in Good Academic Standing by the BME GEC. While under an Inactive Academic Status, no progress can be made toward completion of their degree requirements. In order to be removed from an Inactive Academic Status and returned to an Active Academic Status, the student must complete a new application with the Graduate School requesting re-admission. While all other supporting application materials (GRE, transcripts, etc.) are *not required* for re-admission to the Graduate School, these and other materials may be required for re-admission into the Biomedical Engineering Department and return to Good Academic Standing in the graduate degree program. Students should consult with the BME GEC to clarify and confirm Committee expectations in order to return to Good Academic Standing in their graduate degree program.

Students must wait for their applications for re-admission to be officially approved by the Purdue University Graduate School before enrolling for classes. Registration activities that take place while under Inactive Academic Status and before a new application for re-admission has been officially approved by the Graduate School are considered invalid and will not count toward graduate credit.

## 19. RESIDENCY REQUIREMENT

The course credit requirement for the BME Ph.D. degree is 90 credit hours. All Purdue Degrees must meet a course credit residency requirement. Purdue Doctoral programs,

including the Ph.D in BME at IUPUI, require that at least 1/3rd of the course credits be earned on the campus awarding the degree. Thus, at least 30 credit hours on the Doctoral Plan of Study must be earned at IUPUI. Academic credit includes all course credit hours that appear on the Plan of Study, other graduate course credit hours earned with a “B-” or better that appear on the IUPUI transcript, and Ph.D. thesis research (BME 69800 and BME 69900) credit hours earned with a “S” that appear on the IUPUI transcript. Course credits obtained online or via televised instruction are considered to be obtained in residence, on the campus from which they were broadcasted.

## **20. MILESTONE CHECKLIST & TIMELINE**

### **Prior to First Registration**

- Meet with faculty advisor and Graduate Programs office for advice on possible courses to take in the first semester.
- Register for courses through one.iu.edu.

### **Year 1**

#### **Fall**

- Satisfy Graduate School admission conditions as outlined in your admission letter
- Form Academic Advisory Committee no later than October 1 of the Fall term (Student and Faculty Advisor's Responsibility)
- Take the CLA course
- Take the BME Seminar course (1)
- Preliminary PoS

#### **Spring**

- Meet with Academic Advisory Committee and obtain approval for preliminary PoS - Beginning of Spring Term (Student's Responsibility)
- Submit PoS by the 6th week of Spring Term (Student's Responsibility)
- Take the BME Seminar course (2)
- PQP Portfolio assigned to Student beginning of Spring Term (Program Responsibility)
- Start working on PQP Portfolio and Qualifying Literature Assessment (QLA)

### **Summer**

- Submit QLA end of summer, on August 1st. (Student's Responsibility)

### **Year 2**

#### **Fall**

- Take the BME Seminar course (3)
- Evaluations of QLA is returned to students at end of August
- Revise QLA as needed. (4 weeks for minor revision, 10 weeks for major revision)
- Evaluate revised QLA (2 weeks max)
- Results of revised QLA (Approved, Fail, or Minor revision in 4 weeks)
- Results of 2nd revision of QLA if needed (Approve, Fail) by end of Fall term
- Begin formulating Doctoral Advisory Committee

#### **Spring**

- Complete the Ph.D. Qualifying Procedure (beginning of Spring Term)

- Finalize Doctoral Advisory Committee by the middle of the semester and update PoS with members of the Doctoral Advisory Committee
- Take the BME Seminar course (4)

### **Year 3**

- Students should complete all course requirements by Year 3
- Transition to full time Research
- Maintain contact with Doctoral Advisory Committee

### **Year 4**

Fall/Spring

- Regular meetings with Doctoral Advisory Committee as needed
- Work on Ph.D. Preliminary Examination

### ***Summer***

- Complete Ph.D. Preliminary Examination
- Direct-Admit students seeking an en-passant MS BME degree should seek approval from their Doctoral Advisory Committee and file the necessary paperwork

### **Year 5**

Fall/Spring/Summer

- Regular meetings with Doctoral Advisory Committee as needed
- Begin work on Final exam, Thesis defense

### **Prior to Final Semester**

- Review your plan of study to ensure all degree requirements are met.
- Discuss your future plans with your faculty advisor and the BME Graduate Programs office.
- Review instructions on scheduling your final exam to see if you have any questions in advance of final semester.
- Review IUPUI graduation deadlines to see if you have any questions in advance of final semester.

## Appendix A. List of Terms

**Ph.D. Student:** Generic Ph.D. Student, generally in their first or early in their 2nd year

**Direct-Admit Ph.D. Student:** Students admitted directly from their undergraduate degree (with BS only)

**Traditional-Admit Ph.D. Student:** Students admitted with an earned a MS BME degree

**En-Passant MS degree:** Non-thesis, course only MS degree earned by Direct-Admit Ph.D. students double counting up to 30 credit hours of coursework to satisfy the requirements of a MS BME.

**Qualified Ph.D. Student:** Ph.D. student who completed their PQP

**Preliminary PoS:** PoS defined with the Academic Advisory Committee and filed as a Ph.D. student before forming a Doctoral Advisory Committee

**Ph.D. Qualifying Procedure (PQP):** QLA + AAC meeting to define the Doctoral Plan of Study and Doctoral Advisory Committee

**Ph.D. Candidate:** Qualified Ph.D. Student who successfully completed their Preliminary Exam but has not completed their Final Exam

**Advisory Committee:** A generic term that means Academic Advisory Committee or Doctoral Advisory Committee, whichever is appropriate.

**Academic Advisory Committee (AAC):** Committee of 3 or more faculty members who advise the Ph.D. student before the student Qualifies to the Ph.D. Program and forms their Doctoral Advisory Committee.

**Doctoral Advisory Committee:** Committee of 4 or more faculty that advises the Qualified Ph.D. Student or Ph.D. Candidate and conducts the Preliminary and Final Exam

## Appendix B. Help with Plan of Study (GS-6) for Ph.D. Degree in BME

A few helpful suggestions include:

1. Mark **(X)** Thesis or Non-Thesis Option on the plan.
2. List a total of 7 courses and arrange the courses into two separate groups. Group courses in the Primary area first followed by the group of courses in the Related area. Consult with your advisor on the Primary and the related area courses. For each of the courses listed designate “**P**” for Primary and “**R**” for Related under the column for Area on the far left column. Do not include Research Thesis credits.
3. For the column labeled “**Date Completed or to be Completed**”, only the month and year is required. There is no need to include a specific date of completion.
4. For the column labeled “**Regular Registration**”, a check indicates that this particular course was or will be completed after official admission to graduate program, i.e., courses taken following admission to the IUPUI Graduate School AND the graduate program in BME.
5. For the column labeled “**Non-degree Regis**”, a check indicates that this particular IUPUI course was completed as a non-degree graduate student BEFORE being admitted into the BME program.
6. The column labeled “**Other or Transfer From**” refers to those courses taken at another institution that are to be transferred to the Plan of Study. The name of the institution (other than IUPUI) which offered the courses must be recorded. This is required for Purdue graduate courses taken at a campus other than IUPUI as well as all online course offerings from Purdue (e.g., via the Engineering Professional Education online program) and requires prior approval from the student's Advisory Committee. In addition, had the student started their degree program in a department at IUPUI other than BME (e.g., Psychology) and decided to switch to BME, the course(s) completed in the Biology department would also be considered transfer courses and must be indicated as such in the “**Other or Transfer From**” column. Similarly, this also applies to graduate courses taken as an undergraduate, that are not applied to any undergraduate degree program.

With respect to item #6: **It is a rule for all graduate degree programs in the Purdue system that no more than 12 credit hours can be transferred onto a Plan of Study** from an outside institution or some other IUPUI graduate degree program (for example, Biology in the example above) beyond the 21-30 credit hour exemption for Masters Degree credit applied to the Ph.D. plan of study.



## **Appendix C. Sample Plans of Study (Direct-Admit Ph.D. Student)**

## **Appendix D. Sample Plans of Study (Traditional-Admit Ph.D. Student)**