

Weldon School of Biomedical Engineering
PhD Qualifying Examination and Mentoring-Committee Process

Full Description of Rationale, Expectations, Logistics/Process, and Resources

Rationale:

A series of milestones have been developed to facilitate the training of our PhD students on their pathway to becoming independent researchers in biomedical engineering. The following skills are hallmarks of a Purdue PhD in Biomedical Engineering and place our students in a position to succeed and become leaders in one or more of many possible career paths (e.g., academia, industry, clinical, global health):

- Critically analyze the literature and identify research gaps in an area of Biomedical Engineering
- Develop a meaningful research question with a testable hypothesis
- Design rigorous and reproducible experiments to test this hypothesis and fill the identified gap
- Develop and/or use technology to perform these experiments and generate publishable data
- Critically analyze, interpret, and disseminate their own data to move the field forward in fundamental, translational, or clinically relevant ways.
- Participate in all training, research, and related translational activities in an ethical manner

The PhD milestones are checkpoints for students to demonstrate expected competencies in the above skills as they progress through the three stages of our PhD program: *Pre-Qual*, *Post-Qual*, and *PhD Candidacy*). They are also critical opportunities to identify areas of professional growth for each trainee and for the faculty to provide them with the mentoring they need.

This document provides guidance to both students and faculty for understanding the expected standards of performance for the *first milestone in our PhD Training Program – The Qualifying Exam*, which consists of both Written and Oral components that are evaluated by a Mentoring and Qualifying Committee. Successful completion of the Qualifying Exam will advance a *Pre-Qual PhD student* into the second stage of our PhD program as a *Post-Qual PhD student*.

Expectations:

The expectations we have set for passing the Qualifying Exam represent a rigorous but attainable bar that is defined by our experience with the level of competency required to ensure likely success in the remainder of our PhD Training Program.

Purpose of the Qualifying Exam

Any independent researcher must be able to propose significant research questions based on existing gaps in the field, which are identified through critical analyses of the literature. This skill is fundamental to any area of BME research, and is thus a major focus of the Qualifying Exam. We do not expect students to be able to propose a full thesis project at the end of their first stage of PhD training. We have found that a solid foundation in fundamentals of the field and the abilities to: 1) critically analyze a small subset of literature on a specific topic of interest, 2) identify gaps in the literature, and 3) plan a research strategy to address that gap by formulating a specific research question with a testable hypothesis are skills that are indicative of future success in PhD-level careers. Thus, these expectations define the bar we have set for advancement to the Post-Qual stage of our PhD training program.

The written and oral components of the qualify exam and mentoring-committee process are designed to evaluate whether the student has reached the bar for competency required to advance to the Post-Qual stage, as well as to discuss appropriate coursework, technical training, and professional development for the student given their desired career path and goals.

The specific goals of our qualifying exam and associated mentoring-committee process are:

- to ensure all doctoral students have appropriate competency in the following areas:
 - Technical foundations in fundamental principals
 - Critical analysis and synthesis of literature
 - Gap or needs identification
 - Development of a specific research question with a testable hypothesis to address the gap/need
 - Appropriate and realistic experimental design to test the hypothesis (in the form of a Research Strategy - not specific thesis aims)
 - Technical and Scientific Communication
 - Ethical and responsible conduct of research
- to identify areas of professional growth for each student
- to help the student in development of a training plan to best support their career development

Logistics/Process:

Choice of Core Primary Literature on which to base the Qualifying Exam

The qualifying exam is NOT intended to represent the development of an entire thesis proposal, but rather a small-scope topic that addresses the specific goals of our qualifying exam (listed above) and has the potential to lead to the ultimate full thesis proposal. The requirement is that the student can demonstrate the expected competencies required to advance to the Post-Qual student stage of our PhD training program. As such, the student should work with their primary mentor to pick a set of five (5) primary-literature papers as a core basis of evaluation for the qualifying exam. These five papers, along with 1-2 relevant review papers, will be settled by the middle of a student's first semester in the PhD program, with October 31st or March 15th deadlines to submit them as part of the PhD Qualifying Pre-Registration Form. These core papers will form the basis for subsequent assignments in the Research Fundamentals courses in the Fall and Spring semesters, which are designed to help the student develop their written qualifying-exam document and oral presentation. Expanding from the core 5 papers, the student will find an additional 5-10 primary papers independently from their research advisor. Together with the core 5 papers, these papers will form the small set of literature that the student will critically analyze and synthesize to identify the scientific gaps they wish to pursue.

Choice of Research Question

Students are encouraged to develop their qualifying exam Research Question based on the research they plan to pursue for their thesis (although this is not required). This topic should be chosen to allow the student to develop an original experiment that will advance the current state of the chosen research field. The student's proposed research can be related to ongoing work in the mentor's lab or work previously performed by the student, but must ultimately represent a novel research question. While it may be related to ongoing work by others in the lab, the student should complete the qualifying exam without significant input from the faculty mentor(s) after the initial set of core papers are selected on the PhD Qualifying Pre-Registration Form. As such, it is expected that the specific research question will be distinct from or a novel formulation of a research question that has already been proposed and/or funded by the mentor.

Specifically, student proposals must satisfy all of the following criteria:

- 1) No research question can be identical with the student's past (prior to starting the PhD) research projects.
- 2) No research questions can be identical to any goal of ongoing or proposed research projects in the mentor's lab being conducted by the mentor, postdocs, graduate students, undergraduates, or technicians.
- 3) The research questions must be different from those of research groups actively collaborating with the mentor's laboratory.

- 4) be based on the small set of primary literature (i.e., 5 papers chosen by mentor and student, plus 5-10 additional identified by the student).

Research Fundamentals (Qualifying Prep) courses (Fall and Spring)

To develop skills in critical reading, analysis, and synthesis of the literature, students are required to take our two Research Fundamentals courses in their first year. Both courses will include (among other topics) reading and writing assignments. Topics will include: fundamentals of reading and critically analyzing individual primary literature; synthesis of a set of related literature to identify significant gaps in a research area; research question and testable hypothesis development towards rigorous experimental design for addressing open research questions.

These two courses are designed to teach students the fundamental skills they need for developing their own research questions and testable hypotheses, and will help in writing their qualifying exam document. Students with significant prior research experience (i.e., independent development of research question and hypothesis, as in a MS thesis) can request (with mentor signature) a waiver for one or both of these courses. Waiver of this course requirement is intended to be an exception and not a general rule. Information that will be required includes evidence for prior training and skill attainment in the specific goals of our qualifying exam.

Mentoring and Qualifying Committee Makeup

Because our training program emphasizes rigorous and consistent mentoring throughout a student's training, the qualifying-mentoring committee is largely made up of members of the student's thesis committee. Specifically, the qualifying-mentoring committee will consist of:

- The primary research advisor(s)
- 1 additional BME-affiliated faculty member chosen by the student in collaboration with their research advisor(s), who is likely to be on the thesis committee
- 1 outside member (affiliated with BME, but outside the student's thesis committee) chosen by the BME Graduate Committee. This choice will ensure at least 2 research areas are covered on a student's qualifying-exam committee for breadth and uniformity of evaluation across the School.

Part of the oral component of the qualifying exam is a discussion of future coursework, and thus this committee also serves as the student's POS committee (required by graduate school). If the student and mentor(s) wish, additional faculty members inside or outside of Purdue (e.g., key collaborators) may be included in the committee. This committee will thus consist of at least 3 members (4 if co-advisor exists), and except for the outside member will include likely members of the student's ultimate thesis committee. However, complete flexibility exists as the student advances through the training program (i.e., flexibility for both the student and committee members as to the eventual makeup of the thesis committee).

Timing and Logistics of the Qualifying Exam

The default time to take the qualifying exam (submission of written document, and oral defense of document) is in the second half of the Spring semester of Year 1. However, given the diversity of backgrounds and experience of our entering PhD students, flexibility exists for taking the qualifying exam earlier or later than the default (in either case, a request for alternative timing may be submitted to the Graduate Committee by the student and advisor stating the rationale). In either case, a reasonable non-default timing for starting the qualifying exam will not be used in judgement of student progress in the program.

The PhD Qualifying Pre-Registration Form must be submitted by Oct 31st, which defines the core 5 papers on which the qualifying-prep assignments in the Research Fundamentals courses and the qualifying exam itself will be centered. By February 1st, (September 15th for Fall) the PhD Qualifying Exam Registration Form must be submitted, which will set the date of the spring Mentoring Committee

meeting, and will state whether or not this will be the Qualifying Exam. Students opting to delay the Qualifying Exam still must hold a Mentoring Committee meeting in Year 1. The deadline for the mentoring meeting will be May 15th and the new qualifying exam will be December 20th. Submission of the electronic Plan of Study (POS) is due June 1 (whether or not the Qualifying Exam is delayed).

If the qualifying exam is taken and not passed, students have the option to retake the qualifying exam one semester later to progress to the second stage of our training program. Except in extenuating circumstances, a student will not be allowed to take the qualifying exam a third time, but rather will be mentored towards an MS degree option or an alternative program. In some cases, the outcome of the first take of the qualifying exam and mentoring discussion will identify that the student is not in the best lab for their skills and career goals, in which case Grad Committee and departmental mentoring will be available to assist in finding a better placement for the student.

Scheduling the Exam

Scheduling Tool

Use a scheduling tool like [when2meet](#), [doodle](#) etc. when reaching out to your mentoring committee to schedule your exam time. Using a scheduling tool, we reduce the amount of back and forth emails and will simplify finding a date that will work for everyone.

Reserving a Conference Room

The MJIS conference room online scheduling system is RAT – Resource Allocation Tool and the link is https://engineering.purdue.edu/ECN/Resources/Tools/RAT/index_local. **One caveat: This website can only be accessed if you are logged in on an MJIS computer.** Once at the link, click on Biomedical Engineering – Lab Group Meetings and login with your Purdue career account login and password (Boilerkey not needed). Use the calendar to identify a room (see the options below*), determine if it is available on the day and time you need and to submit a reservation request if so.

***MJIS Lab Group Meeting Room 2001** (Room) - This meeting room is the largest in MJIS and is a restricted access area. There are 30 tables and 60 chairs available for use. It is equipped with a computer, wireless keyboard and mouse, cordless presenter, wireless microphone, projection screen, projector, polycom, sound system, VCR, DVD player, document camera, internet access, single-line telephone (49-61309), white boards and adjustable window shades.

***MJIS Lab Group Meeting Room 2041** (Room) - This room can seat up to fourteen people and has five tables and twelve chairs. It is equipped with a white board, laptop projector, single-line telephone (49-61331) and internet access.

***MJIS Lab Group Meeting Room 3041** (Room) - This room can seat up to a maximum of 14 people and has five tables and 14 chairs. It is equipped with a white board, laptop projector, single-line telephone (49-61421) and internet access. to 5:00 pm on Friday. The key must be returned at 8:00 am on the day following your event.

If there are no available rooms in the building for the time you need, reach out to the graduate programs office for additional options of rooms in building nearby.

Preparation of the Written Document

The first part of the qualifying exam process is the evaluation of a written document that is intended to demonstrate student competency in the areas listed above as well as their research and academic progress and career goals. Preparation of this document will be aided by lectures, discussions, and assignments in the first-year Research Fundamentals courses. The intention is that this document will also serve as a stepping stone towards an initial paper (e.g., review or data paper) as well as toward the student's Thesis Proposal and Training Plan (submitted as part of the Preliminary Exam). The written Qualifying Exam document is expected to be written independently by the student and contain solely their original critical analysis and synthesis of the literature surrounding their research area.

Plagiarism scanning

All written documents will be passed through plagiarism-detection software by the student's faculty advisor prior to distribution to the committee. Students are encouraged to pass their document through such software on their own during the writing process to be aware of writing/paraphrasing styles that trigger flags for plagiarism, and to adjust their paraphrasing styles appropriately prior to submission. See additional plagiarism resources in the Relevant Resources section. Plagiarism in the qualifying-exam document will be grounds for failure of the exam, and will be reported to the Office of the Dean of Students (ODOS) and Office of Student Rights and Responsibilities (OSRR).

Format Requirements:

- 5-10 pages single spaced (including figures, but not including reference section and the additional material described below).
- 11 pt font size or larger. Font must be no more than 15 characters per linear inch (including characters and spaces). At least 0.5-inch margins.
- Reference style can be:
 - IEEE, listed and numbered in order of citation, not alphabetically. (https://owl.purdue.edu/owl/research_and_citation/ieee_style/ieee_overview.html)
 - AMA format, also listed and numbered in order of citation, not alphabetically, but numbers are cited in text in superscript (https://owl.purdue.edu/owl/research_and_citation/ama_style/index.html)
 - or APA format, cited in text with author, date and listed in bibliography in alphabetical order (https://owl.purdue.edu/owl/research_and_citation/apa_style/apa_formatting_and_style_guide/general_format.html)

Content:

- **Executive Summary or Specific Goals/Aims (.5 pages).** Concisely identify a significant research question and a testable hypothesis that will address an identified need/problem. Specify the broad goal and research strategy of the proposed project that will be used to test the hypothesis.
- **Scientific Premise of Proposed Work (~2 pages).** Critical analysis and synthesis of 10-15 primary papers from the literature to identify significant scientific gaps, culminating in a concise and explicit statement of a research question and testable hypothesis. *Note: the ~2-page length of this section (similar to a grant proposal) does NOT imply a lack of depth is expected in your critical analysis; rather, the 2-page length requires concise and organized writing about a thorough critical analysis leading to clear gap identification and hypothesis development (you will work on these skills in the Research Fundamentals courses).*
- **Proposed Research Strategy (~1 page).** Describe an experimental strategy that will be used to test the stated hypothesis and fill the identified gap. This section does NOT need to be a full set of specific thesis aims, but rather an appropriate research strategy (an experiment described at a

broad level, but with enough detail to demonstrate the feasibility and appropriateness of scope, e.g., rough number of subjects, design specs). Describe the procedures to be used, the data to be collected, the planned analyses of data, and how the data will be interpreted to test your hypothesis/research question. Again, this does NOT need to be a full thesis proposal, only a simple description that is just detailed enough to demonstrate that the proposed work is rigorously designed to test your hypothesis/research question (i.e., to demonstrate required competency to advance to the Post-Qual PhD student stage).

- **Caveats, Potential Problems, and Alternative Approaches (0.25-0.5 pages).** Discuss any potential issues you see in the proposed work and how you will address them if they arise.
- **Ethical Considerations (0.5 pages).** Describe the ethical considerations you will need to address in the proposed work. This does NOT need to be a full Vertebrate Animals or Human Subjects section, but rather a description of any relevant ethical considerations for your work and broadly how you will address them. The purpose at this qualifying stage is simply to demonstrate your awareness of the relevant ethical considerations for your work; the prelim exam will evaluate your ability to address them.
- **TimeLine of Proposed Work (0.25 pages).** Describe the planned timeline of your proposed work to demonstrate appropriateness of scope.
- **Progress Report (1-2 pages).** Describe the research progress you have made to date in the PhD program and how it addresses the feasibility of your proposed work and/or supports your hypothesis. If you have data, this should be presented and critically analyzed. If you do not have data yet (this is completely fine), describe your progress to date and critically analyze what is working and not working to demonstrate that adequate research progress has been made.
- **References** (does not count for page limit).

Other Documents to Include in your Written Qualifying Exam package (not included in page limit):

- **Unofficial transcript**
- **Plan-of-Study (POS) document:** courses taken and planned, with alternates.
- **Individual Development Plan (IDP).** This must be discussed and signed by your primary advisor prior (due Oct 31st) to distribution to the Qualifying-Mentoring Committee.

Evaluation of the Written Document

The written document is submitted to the committee at least two (2) weeks before the Mentoring-Qualifying Committee meeting. Based on the well-defined expectations in this Qualifying Process document and the Mentoring-Qualifying Committee Meeting Rubric, all faculty on the committee will provide constructive written feedback to the committee Chair (mentor) at least two days prior to the Mentoring-Qualifying Committee meeting so that the committee is aware of significant concerns that need to be addressed during the mentoring meeting/oral exam. The Chair will compile all feedback and provide it to all committee members prior to the committee meeting. The rubric provided by the Graduate Committee is based on the stated expectations and includes checkbox response on progress (e.g., below, at, above expectations), as well as space for bullet comments on strengths and weaknesses in each major category (e.g., appropriate literature analysis, scope of hypothesis/needs statement, technical writing). This feedback is ultimately combined with feedback on the mentoring meeting/oral exam and provided to the student to help them understand their performance and areas for growth.

Structure of Oral Component: Qualifying Exam and Mentoring Committee Meeting

A two-hour (non-public) meeting must be held before the specified deadline for the semester in which the student has registered to take the Qualifying Exam (Spring: May 15th; Fall: Dec 20th).

This meeting will consist of (student present for #s 1-3, and 5):

1. a ~30-min oral presentation of the material in the written qualifying submission (written document, coursework taken and planned, career-path plans, and desired professional development).
2. ~45-min discussion on student's proposal and relevant technical background, and
3. ~30-min discussion on coursework- and IDP-related issues
4. ~10-min private discussion among the committee [student excused], and completion of group rubric with constructive feedback
5. ~5-min discussion with student of rubric feedback

The committee, through questions and discussion, will be responsible for evaluating the student's competency in:

1. Breadth of BME fundamentals (*defined by Grad Committee, applied to all students*)
2. Technical depth in research topic (*specific to student and assessed by committee*). Note: Questions on course material and technical foundations critical to topic area are expected to be asked by committee in order to identify gaps in training and suggest further courses or further training.
3. Identification of research gap and ethical issues
4. Development of research question and testable hypothesis
5. Critical analysis and interpretation of data

Other Mentoring Components of the Oral-Exam Meeting

Discussion of academic progress to date and planning of course work

A joint discussion with all committee members of the POS course work is often valuable in ensuring the student is taking the most relevant and valuable courses to develop the technical skills and knowledge required to become an independent researcher in the student's chosen research area. The outcome of this discussion should be a settled (signed) POS document, with a complete list of courses (including several alternates). The benefits of a joint meeting are to provide integrated advice for the student based on the broader perspectives several faculty members can provide. An official POS must be approved and filed electronically with the Graduate School by the end of the second semester of Year 1 (June 1 for Fall entrants).

Discussion of IDP and career development path advising documents

An important part of the mentoring committee meeting is to ensure the training plan being developed includes the most appropriate activities to provide the student with the training needed to achieve their technical research as well as their career goals. This will include discussion of the student's IDP and relevant professional development activities within BME, the College, the University, and beyond. The relevant Career Development Path Advising documents should be discussed to ensure the student is aware of and planning for the experiences needed to succeed in their chosen career path.

Overall Feedback and Potential Outcomes of the Qualifying Exam

At the end of the meeting, the committee will discuss privately the student's level of competency in key areas based on both the written and oral components of the exam. The Chair (primary mentor) will complete a group rubric based on this discussion, noting any lack of consensus on the form. Each committee member will sign the group form, and provide brief individual feedback on the key strengths and areas for growth (1-2 sentences each). The Chair and Committee will then discuss the outcome with the student based on the rubric to ensure everyone is on the same page as to outcomes, and the rubric is filed with the BME Graduate Office to ensure appropriate expectations for the BME Qualifying Exam were applied to the outcome decision (with copies delivered to the student and all committee members).

Possible outcomes are:

- Pass
 - Specific courses can be suggested or required.
- Provisional pass (i.e., one or the other component)
 - Written document revision required (based on specific feedback) within 3 weeks. All revisions must demonstrate significant improvement as documented by committee re-review and rubric completion
 - Oral exam must be repeated within 2 months (based on same written document).
- No Pass (both components have significant issues, or plagiarism or other academic misconduct occurred)
 - Repeat whole process in next semester (not summer)
- Fail (if student does not pass on 2nd attempt)
 - Student would move to MS option or appropriate alternative program, with guidance and mentoring from BME Grad Program.

Relevant Forms

- [Individual Development Plan \(IDP\) Year 1](#)
- PhD Qualifying Pre-Registration Form (Due October 31st)
- PhD Qualifying Exam Registration Form (Due February 1st)
- Plan of Study Submission Worksheet
 - [BME](#)
 - [IBSc](#)
- Qualifying Exam Assessment Rubric

Relevant Resources

- Preparatory (reading and writing) courses in Fall and Spring semester of Year 1
- [Approved PhD Course List](#)
- [Career Development Path Advising Documents](#)
- [Purdue Writing Lab \(OWL\)](#)
- [Academic Dishonesty Policy](#)
- [Tips to Avoid Plagiarism](#)

Questions should be addressed to:

- *Logistical:* Graduate Program Administrative Assistant (Sandy May) or Graduate Assistant (Elizabeth Rowen)
- *Professional development:* Associate Director, Grad Programs (Tammy Siemers)
- *Concerns, constructive comments:* Director of Graduate Programs (Michael Heinz); Associate Head of Academic Programs (Tamara Kinzer-Ursem)