

# Ph.D. in Mathematics

Earning a Ph.D. degree in mathematics at MSU requires a Ph.D. student to complete required coursework as well as achieve the following milestones, in consultation with their Graduate Committee.

1. Form a Graduate Committee of at least five members.
2. Earn a Pass on the Ph.D. Qualifying exam demonstrating competence in linear algebra and analysis.
3. Earn a Pass on the Ph.D. Written Comprehensive exam demonstrating competence in two principal subjects of mathematics.
4. Earn a Pass on the Ph.D. Oral Comprehensive exam demonstrating preparedness for original research in mathematics.
5. Write and defend a Ph.D. dissertation demonstrating mastery of, and contribution to, an advanced topic in mathematics.

For additional information about the program, please refer to <http://www.math.montana.edu/>.

## Ph.D. Admission Requirements

Admission to the program is based on a holistic assessment of a student's total academic record as well as demonstrable promise to complete a Ph.D. in mathematics at MSU. The minimum requirements for an applicant to be considered for admission to the Ph.D. program are as follows.

- By the time of entry into the Ph.D. program, the applicant must have received a Bachelor's degree from an accredited college or university in the U.S., or equivalent from a non-U.S. institution.
- The applicant must have earned an overall grade-point average of 3.0 (B), or equivalent, in the most recent two years of study.
- The applicant must have received a grade of B or better in the following courses, or an equivalent grade from an equivalent course. (Please refer to the MSU course description within each link for a list of topics covered in the course.)
  1. A proof-based course in Linear Algebra (M 333),
  2. A proof-based course in Advanced Calculus or Introduction to Analysis I (M 383).
  3. A record of undergraduate coursework in rigorous proof-based mathematics (or M.S. level coursework if applicable).
- A second semester of Analysis is preferred, but not required.

**International Students:** Please refer to The Graduate School's page International Application Process ([http://www.montana.edu/gradschool/policy/admissions\\_intl.html](http://www.montana.edu/gradschool/policy/admissions_intl.html)) for a detailed description of additional admission requirements, such as demonstrating English proficiency which apply to some countries.

- In order to be eligible for admission to the program, the department requires that the applicant demonstrate a minimum score on one of the following TOEFL (<http://www.toefl.org/>): 80-internet-based [iBT] or 550-PBT, or IELTS (<http://www.ielts.org/>): 6.5: 54, or Duolingo (<http://englishtest.duolingo.com/>): 120.
- In order to be eligible for a Graduate Teaching Assistantship position, the applicant must provide documentation of a minimum score of TOEFL (<http://www.toefl.org/>): 93-internet-based [iBT] or 550-

PBT, or IELTS (<http://www.ielts.org/>): 7.0: 65, or Duolingo (<http://englishtest.duolingo.com/>): 135

## Departmental Requirements

Described below are the Department of Mathematical Sciences requirements for the Ph.D. in Mathematics. These departmental requirements supplement those set forth by the Graduate School's degree requirements for doctoral students ([http://www.montana.edu/gradschool/policy/degreq\\_doctoral.html](http://www.montana.edu/gradschool/policy/degreq_doctoral.html)).

To earn a Ph.D. in Mathematics does not require a student to demonstrate ability to speak, read, or write in a language other than English.

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## Ph.D. Committee

A Ph.D. student will be expected to form a Graduate Committee according to the following guidelines.

- The Ph.D. committee, or Graduate Committee, must include a minimum of five members excluding the optional Graduate Representative.
- A student must form a Graduate Committee before attempting any component of the Ph.D. Qualifying exam.
- The Committee Chairperson (Advisor) must be a Tenure Track faculty member within MSU's Department of Mathematical Sciences.

## Course Requirements

- A minimum of 60 credit hours are required (up to 30 credits can be from a Master's degree program).
- A minimum of 18 credit hours of Doctoral Thesis (M 690) .
- The Ph.D. student's Program of Study listing their intended coursework must be approved by the student's Graduate Committee.

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## Mathematics Ph.D. Qualifying Examination

The Ph.D. Qualifying exam is a tool to ensure that Ph.D. students have demonstrated competence in Linear Algebra and Analysis to the degree necessary to pursue a Ph.D. in mathematics.

The Ph.D. Qualifying exam is described and recorded as follows.

- The Ph.D. Qualifying exam consists of two 3-hour written exam components. (It is identical to the M.S. Mathematics Written Comprehensive exam.)
- The components of the Ph.D. Qualifying exam test competency with the contents of the following respective courses.
  1. Principles of Mathematical Analysis (M 505).
  2. Advanced Linear Algebra (M 503)
- Each attempt of a given component is graded as a Ph.D. Pass, M.S. Pass, or Fail.
- To pass the Ph.D. Qualifying exam is to earn a Ph.D. Pass on both components of the Ph.D. Qualifying exam.

A student may attempt, or reattempt, components of the Ph.D. Qualifying exam according to the following policies.

- A Ph.D. student must attempt both components of the Ph.D. Qualifying exam within one (1) year of entry into the program.

- There are two exam periods for each component of the Ph.D. Qualifying exam: one in August and one in January (the exact dates are determined by the Department).
- A Ph.D. student can attempt a given component of the Ph.D. Qualifying exam at most twice (2); a student's second attempt of a given component of the Ph.D. Qualifying exam must take place in the next exam period.
- If, after two (2) attempts, a Ph.D. student does not earn a Ph.D. Pass on a given component of the Ph.D. Qualifying exam, they will be dismissed from the Ph.D. program at the end of the term in which the exam is attempted and the Fail is recorded. However, the student may have the option to enter the M.S. in Mathematics program according to the following criteria.
  - If, after two (2) attempts, a Ph.D. student earns an M.S. Pass on at least one (1) component of the Ph.D. Qualifying exam, and an M.S. Pass or Ph.D. Pass on the other component, they may enter the M.S. Mathematics program, and their Passes will fulfill their M.S. Written Comprehensive exam requirement of the M.S. Mathematics degree program.
- If a student enrolled in the M.S. Mathematics program attempts the Ph.D. Qualifying exam (equivalently, the M.S. Written Comprehensive exam), these attempts will count as attempts of the Ph.D. Qualifying exam.

Any exceptions to the above policies must be approved by the student's Graduate Committee and must have the consent of the Department Head.

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### Mathematics Ph.D. Comprehensive Exam

The Ph.D. Comprehensive examination consists of two exams: the Ph.D. Written Comprehensive exam and the Oral Comprehensive exam.

#### Ph.D. Written Comprehensive Exam

The Ph.D. Written Comprehensive exam is a tool to ensure that Ph.D. students have demonstrated competence in two principal subjects in mathematics.

The Ph.D. Written Comprehensive exam is described and recorded as follows.

- The Ph.D. Written Comprehensive exam consists of two components. Each component is a 4-hour written exam.
- The content of each component is selected from the following list
  1. Measure Theory (M 547) - Complex Analysis (M 551)
  2. General Topology (M 511) - Geometry & Algebraic Topology (M 512)
  3. Dynamical Systems I (M 595) - Dynamical Systems II (M 596)
  4. Functional Analysis I (M 584) - Functional Analysis II (M 585)
  5. Numerical Solution of Partial Differential Equations I (M 581) - Numerical Solution of Partial Differential Equations II (M 582)
  6. Partial Differential Equations I (M 544) - Partial Differential Equations II (M 545)
  7. Methods of Applied Mathematics I (M 560) - Methods of Applied Mathematics II (M 561)
  8. At most one component not from the list above.

- To implement this option, the student must file a petition form in consultation with their Graduate Committee.

- Each attempt of a given component is graded as Pass or Fail
- To Pass the Ph.D. Written Comprehensive exam is to earn a Pass on both components of the Ph.D. Comprehensive exam.

All of the following determine how a student may attempt, or reattempt, a component of the Ph.D. Written Comprehensive exam.

- A Ph.D. student must attempt exactly two components, both of which must be approved by the student's Graduate Committee.
- A Ph.D. student must attempt both components of the Ph.D. Written Comprehensive exam within two (2) years of entry into the Ph.D. program.
- The exam period for each component of the Ph.D. Written Comprehensive exam is in August (the exact dates are determined by the Department).
- The exam period in which a Ph.D. student attempts a component of the Ph.D. Written Comprehensive exam cannot be sooner than the exam period in which the student attempts the Ph.D. Qualifying exam.
- A Ph.D. student can attempt a given component of the Ph.D. Written Comprehensive exam at most twice (2); a student's second attempt of a given component of the Ph.D. Written Comprehensive exam must take place in the next exam period.
- If a Ph.D. student earns a Fail on two attempts of a given component of the Ph.D. Written Comprehensive exam, their graduate study will be terminated, and they will be dismissed from the Ph.D. program at the end of the term in which the exam is attempted and the Fail is recorded.

Any exceptions to the above policies must be approved by the student's Graduate Committee, must have the consent of the Department Head, and must comply with the Graduate School's requirements [https://www.montana.edu/gradschool/policy/degreq\\_doctoral.html](https://www.montana.edu/gradschool/policy/degreq_doctoral.html)

#### Ph.D. Oral Comprehensive Exam

The Oral Comprehensive exam involves three components, described as follows.

1. The oral presentation component is a 1-hour presentation in which the student's Graduate Committee is present, and the general public is invited to be in the audience. Typically, the Oral Comprehensive exam is a thesis topic proposal in which the student's ability to conduct the proposed research is assessed by their Graduate Committee.
2. The Question and Answer component of the exam takes place after the presentation, and it is closed to the general public: only the student and the student's Graduate Committee (including a Graduate Representative if that is requested by the student) are present.
3. The written component is a professionalized document, written by the student. All members of the student's Graduate Committee must have access to this document at least one (1) week prior to the oral presentation component.

The Oral Comprehensive exam is graded by a student's Graduate Committee as Pass or Fail.

All of the following determine how a student may attempt and reattempt the Oral Comprehensive exam components.

- A Ph.D. student cannot attempt the Oral Comprehensive exam before they pass the Ph.D. Written Comprehensive exam.
- In consultation with their Graduate Committee, a Ph.D. student sets a date to attempt the Oral Comprehensive exam.
- A Ph.D. student cannot attempt the Ph.D. Oral Comprehensive exam more than twice (2).
- A Ph.D. student's second attempt of the Ph.D. Oral Comprehensive exam must take place within one (1) year of their first attempt.
- If a Ph.D. student earns a Fail on two attempts of the Ph.D. Oral Comprehensive exam, their graduate study will be terminated, and they will be dismissed from the Ph.D. program at the end of the term in which the exam is attempted and the Fail is recorded.

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### **Mathematics Ph.D. Dissertation Requirements**

A Ph.D. student's Dissertation is a document prepared by the student that is suitable for publication in a peer-reviewed venue. The Dissertation is expected to record the results of extended research by the student, be an original contribution to knowledge, and include new material worthy of publication. All members of the student's Graduate Committee must have access to a final draft of the Dissertation **at least four (4) weeks** prior to the Final Defense. The student's Dissertation must be submitted to the Graduate School in final form as an electronic dissertation no later than 14 working days before the end of the term in which graduate work is completed.

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### **Mathematics Ph.D. Final Defense**

Department policies on the final defense and all other administrative procedures regarding the degree completion are exactly those as set out by The Graduate School with the exception of the following. The Final Defense is to be organized by the student and their Advisor. If any member of their Graduate Committee has had insufficient time to prepare, a Final Defense must not take place and must be rescheduled.