Mathematics, PhD

Doctoral Candidacy

To earn a PhD at Washington University, a student must complete all courses required by their department; maintain satisfactory academic progress; pass certain examinations; fulfill residence and Mentored Experience Requirements; write, defend, and submit a dissertation; and file an Intent to Graduate. For a general layout of doctoral degree general requirements in Arts & Sciences, including an explanation of Satisfactory Academic Progress, students should review the Doctoral Degree Academic Information page of the Arts & Sciences *Bulletin.*

Program Requirements

- **Total Units Required: 72 units** (**Note:** Remission applies for a maximum of 72 graduate-level units.)
- **Degree Length: Five years**
  - **Note:** At least 48 hours spent in residence at Washington University. The student must spend at least one academic year as a full-time student; this requirement cannot be met wholly by summer sessions or part-time study. The student may, with departmental permission, transfer a part of the 72 hours from other universities (24 graduate credits for a PhD and only 6 credits for a master's). The typical load is 9 credit hours per semester. A grade point average of B or better is required in graduate course work.
  - **Note:** Students must be enrolled in 9 graduate credits each semester to retain full-time status. As students complete their course work, if enrolled in fewer than 9 graduate credits, they must enroll in a specific Arts & Sciences graduate course that will show 0 units but does count as full-time status. Students should connect with their department to ensure proper enrollment prior to Add/Drop.
  - **Funding note:** Graduate students in mathematics may ordinarily expect up to five years of support. Continuation of support each year is dependent upon normal progress toward the degree and satisfactory performance of duties.
    - For the well-prepared student, "normal progress" usually means the following:
      - At the end of the second year, the student should have successfully completed the specific course requirements and passed six qualifying exams.
      - At the end of the third year, the student should have completed the candidacy requirement.
      - By the end of the fourth year, the student should have completed the 72-hour course requirement and should be making substantial progress on a thesis.

Students must also complete Math 597 Teaching Seminar. This course prepares them for both Assistant to the Instructor work and academic teaching duties, which are integral to all scholarly activities. For a typical PhD student, the course is taken twice: once in the spring of the first year and again in the fall of the second year. Each student will have departmental duties (e.g., grading, proctoring) of no more than 15 hours per week as Assistant to the Instructor.

Students must also complete Math 598 Mathematical Professional Development.

No one can earn a doctorate merely by completing specified courses of study. The doctoral candidate must demonstrate high scholarship and the ability to perform significant original research in mathematics.

Please note that the sequence outlined above is for "well-prepared" students. The exact point at which any student enters the sequence depends on their ability and background. When warranted, deviation from the normal sequence is permissible, and a tailored program that fits the student's ability and background will be followed.

Required Courses

Specific course requirements: The 72 units of course work must include eight of the following nine courses:

Code	Title	Units
Math 5021	Complex Analysis I	3
Math 5022	Complex Analysis II	3
Math 5031	Algebra I	3
Math 5032	Algebra II	3
Math 5045	Geometry/Topology I: Algebraic Topology	3
Math 5047	Geometry/Topology III: Differential Geometry	3
Math 5051	Measure Theory and Functional Analysis I	3
Math 5052	Measure Theory and Functional Analysis II	3

Students may omit one of the following courses when satisfying the course requirement: Math 5022 Complex Analysis II, Math 5047 Geometry/Topology III: Differential Geometry, or Math 5052 Measure Theory and Functional Analysis II.

To satisfy the breadth requirement, the student must pass the required courses with a B (3.0) or better. The courses are typically offered in the following time frame:

Fall: Algebra I, Real Analysis, Complex Analysis I, Algebraic Topology, Differential Geometry

Spring: Algebra II, Functional Analysis, Complex Analysis II, Differential Topology

In exceptional circumstances, departmental permission may be requested to replace required courses with suitable alternatives. The student may also petition the department to waive one or more of these courses because of work completed previously.

It is in each student's best interest to take the courses that contain the material covered in the qualifying exams as soon as their individual program allows. Sequels to these courses, at the 500 level, are frequently offered. The qualifying exam courses are generally prerequisites to these 500-level courses.

Language requirement: All students must demonstrate proficiency in English.

If English is not the student's native language, they must pass an oral English proficiency exam with a grade of 3 or better. If the student does not score a 3 the first time they take the exam, the director of English Language Programs for Arts & Sciences will recommend that the student take one or more classes to improve reading, writing, pronunciation, listening, or speaking skills. After the recommended classes have been completed, the student is required to retake the English proficiency exam. Once the student has demonstrated the ability to handle teaching a class (by scoring a 3 or better on the exam), they will qualify for Assistant to the Instructor or Course Instructor duties.

Qualifying examinations and candidacy requirements: The qualifying exam and candidacy requirement constitute two separate requirements. The qualifying exam is a series of six written tests that cover a range of topics; the candidacy requirement is an oral presentation and thesis proposal.

The written tests cover the material in one semester of courses:

Code	Title	Units
Math 5021	Complex Analysis I	3
Math 5022	Complex Analysis II	3
Math 5031	Algebra I	3
Math 5032	Algebra II	3
Math 5045	Geometry/Topology I: Algebraic Topology	3
Math 5046	Geometry/Topology II: Differential Topology	3
Math 5047	Geometry/Topology III: Differential Geometry	3
Math 5051	Measure Theory and Functional Analysis I	3
Math 5052	Measure Theory and Functional Analysis II	3

To satisfy the written exam requirement, the student must pass six out of the nine possible qualification exams with the requirement that two be from each of these subgroups:

- Math 5021 Complex Analysis I, Math 5022 Complex Analysis II, Math 5051 Measure Theory and Functional Analysis I, or Math 5052 Measure Theory and Functional Analysis II
- Math 5045 Geometry/Topology I: Algebraic Topology, Math 5046 Geometry/Topology II: Differential Topology, or Math 5047 Geometry/Topology III: Differential Geometry
- Math 5031 Algebra I, Math 5032 Algebra II

To satisfy the qualification examination requirement, the student must pass the final exam for the course with an A- or better.

Because each course varies somewhat in content from year to year, it is recommended that the student take the exams at the conclusion of the course in which they are enrolled. No advantage is gained by delaying the exam. It is required to finish all six qualification exams by the end of the second year of study.

Some students will enter the PhD program with previously acquired expertise in one or more of the required courses. This situation sometimes happens with students who transfer from other PhD programs or who come from certain foreign countries. Such students may formally petition the chair of the graduate committee to be exempted from the appropriate course and its qualifying exam. The petition must be accompanied by hard evidence (e.g., published research, written testimony from experts, records of equivalent courses, examinations and the grades achieved on them). The graduate committee will make the final judgment on all exemption requests.

Once the written phase of the qualifying process is complete, the student is ready to begin specialized study. By the third year of study, the student must complete the candidacy requirement. The student must form a preliminary thesis committee called a *Research Advisory Committee* that includes their advisor and at least two other faculty members. In discussion with the advisor and the preliminary thesis committee, the student will select a topic and a body of literature related to this topic. The student will prepare a one-hour oral presentation related to the topic and a two-page thesis proposal that demonstrates mastery of the selected topic. The oral presentation is designed to expedite specialized study and to provide guidance toward the thesis. The preparatory work for the thesis proposal often becomes the foundation on which the thesis is constructed.

After the student completes the candidacy requirement, work on the thesis begins.

The dissertation and thesis defense: The student's dissertation is the single most important requirement for the PhD degree. It must be an original contribution to mathematical knowledge and is the student's opportunity to conduct significant independent research.

It is the student's responsibility to find a thesis advisor who is willing to guide their research. Since the advisor should be part of the candidacy requirement, the student should have engaged an advisor by the beginning of the third year of study.

Once the department has accepted the dissertation (on the recommendation of the thesis advisor), the student is required to defend their thesis through a presentation accompanied by a question-and-answer period.

For information about preparing the thesis and its abstract as well as the deadlines involved, including the creation of the Research Advisory Committee and the Dissertation Defense Committee, please consult the Office of Graduate Studies, Arts & Sciences. Please use these additional relevant resources: the Doctoral Dissertation Guide, the Forms page, and the Policies and Procedures page.

Qualifying Examinations

Progress toward the PhD is contingent upon the student passing examinations that are variously called *preliminary, qualifying, general, comprehensive,* or *major field exams.* The qualifying process varies according to the program. In some programs, it consists of a series of incremental, sequential, and cumulative exams over a considerable time. In others, the exams are held during a relatively short period of time. Exams may be replaced by one or more papers. The program, which determines the structure and schedule of the required examinations, is responsible for notifying the Office of Graduate Studies, Arts & Sciences, of the student's outcome, whether successful or unsuccessful.

Mentored Experience Requirements

Doctoral students at Washington University must complete a department-defined Mentored Experience. The Mentored Experience Requirement is a doctoral degree milestone that is notated on the student's transcript when complete. Each department has an established Mentored Experience Implementation Plan in which the number of units that a student must earn through Mentored Teaching Experience(s) and/or Mentored Professional Experience(s) is defined. The Mentored Experience Implementation Plans outline how doctoral students within the discipline will be mentored to achieve competencies in teaching at basic and advanced levels. Some departments may elect to include Mentored Professional Experiences as an avenue for completing some units of the Mentored Experience Requirement. Doctoral students will enroll in LGS 6XXX Mentored Teaching Experience or LGS 7020 Mentored Professional Experience to signify their progression toward completing the overall Mentored Experience Requirement for the degree.

The Doctoral Dissertation

A Research Advisory Committee (RAC) must be created no later than the end of the student's third year; departments may set shorter timelines (e.g., by the end of the student's second year) for this requirement. As evidence of the mastery of a specific field of knowledge and of the capacity for original scholarly work, each candidate must complete a dissertation that is approved by their RAC.

A Title, Scope & Procedure Form for the dissertation must be signed by the committee members and by the program chair. It must be submitted to the Office of Graduate Studies, Arts & Sciences, at least 6 months before the degree is expected to be conferred or before beginning the fifth year of full-time enrollment, whichever is earlier.

A Doctoral Dissertation Guide & Template that give instructions regarding the format of the dissertation are available on the website of the Office of Graduate Studies, Arts & Sciences. Both should be read carefully at every stage of dissertation preparation.

The Office of Graduate Studies, Arts & Sciences, requires each student to make the full text of the dissertation available to the committee members for their review at least 1 week before the defense. Most degree programs require 2 or more weeks for the review period; students should check with their faculty.

The Dissertation Defense

Approval of the written dissertation by the RAC is necessary before the student can orally defend their dissertation. The Dissertation Defense Committee that observes and examines the student's defense consists of at least five members, who normally meet these criteria:

- Three of the five must be full-time Washington University faculty members or, for programs offered by Washington University-affiliated partners, full-time members of a Washington University-affiliated partner institution who are authorized to supervise PhD students and who have appropriate expertise in the proposed field of study; one of these three must be the PhD student's primary thesis advisor, and one may be a member of the emeritus faculty. A fourth member may come from inside or outside the student's program. The fifth member must be from outside the student's program; this fifth member may be a Washington University research professor or lecturer, a professor from another university, or a scholar from the private sector or government who holds a doctorate and maintains an active research program.
- Three of the five normally come from the student's degree program; at least one of the five must not.

All committees must be approved by the Office of Graduate Studies, Arts & Sciences, regardless of whether they meet the normal criteria.

The committee is appointed by the Office of Graduate Studies, Arts & Sciences, upon the request of the degree program. The student is responsible for making the full text of the dissertation accessible to their committee members for their review in advance of the defense. Faculty and graduate students who are interested in the subject of the dissertation are normally welcome to attend all or part of the defense but may ask questions only at the discretion of the committee members. Although there is some variation among degree programs, the defense ordinarily focuses on the dissertation itself and its relation to the student's field of expertise.

Submission of the Dissertation

After the defense, the student must submit an electronic copy of the dissertation online to the Office of Graduate Studies, Arts & Sciences. The submission website requires students to choose among publishing and copyrighting services offered by ProQuest's ETD Administrator. The degree program is responsible for delivering the final approval form, signed by the committee members at the defense and then by the program chair or director, to the Office of Graduate Studies, Arts & Sciences. Students who defend their dissertations successfully have not yet completed their PhD requirements; they finish earning their degree only when their dissertation submission has been accepted by the Office of Graduate Studies, Arts & Sciences.

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