Degree Requirements

Master of Arts in Mathematics

General requirements: There are 36 units of graduate-level course work required, with or without a thesis; 6 units may be for thesis research. The minimum residence requirement is one full academic year of graduate study. If the department consents, a student may transfer up to 6 units from other universities. A grade-point average of B or better must be maintained in graduate course work.

Course requirements: There are four basic graduate course sequences in pure mathematics: Math 5021–5022, 5031–5032, 5045–5046 or 5047, and 5051–5052. A candidate for the AM in Mathematics must include two of these sequences (12 units) in the required 36 units. Each student, in consultation with their advisor, selects the remaining 24 units according to the student’s interests and needs.

Master of Arts in Statistics

General requirements: There are 36 units of course work required and an optional thesis; 3 units may be for thesis research. The minimum residence requirement is one full academic year of graduate study. A GPA of B or better must be maintained in graduate courses.

Optional thesis requirements: To be eligible for the thesis option, a student must maintain a cumulative GPA of 3.5 or higher in the first 18 units of courses satisfying the program requirements.

Course requirements: The student must take (or have taken) the following six required courses in mathematics or their equivalents:

<table>
<thead>
<tr>
<th>Required</th>
<th>Units</th>
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<tbody>
<tr>
<td>Probability; Mathematical Statistics</td>
<td>6</td>
</tr>
<tr>
<td>or Theory of Statistics I &amp; II</td>
<td></td>
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<tr>
<td>plus:</td>
<td></td>
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</tbody>
</table>

If an equivalent course has been taken and proficiency in the course material has been demonstrated, other 400-level and above electives may be substituted in consultation with the advisor. Additional 400-level or higher electives will be chosen by the student in consultation with their advisor to make up the 36 units.

PhD in Mathematics

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

General requirements: Completion of the PhD requires four full years of graduate study (72 units), with at least 48 units completed 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 maximum of 24 graduate credits from other universities. The typical course load is 9 credit units per semester. A GPA of B or better is required in graduate course work.

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 the satisfactory performance of duties.

For the well-prepared student, "normal progress" usually means the following:

- At the end of the second year, the student has successfully completed the specific course requirements and passed six qualifying exams.
- At the end of the third year, the student has successfully completed the candidacy requirement.
- At the end of the fourth year, the student has completed the 72-unit course requirement and is making substantial progress on a thesis.

Students must also complete the Teaching Seminar course (L24 597). This course prepares them for both Assistant to the Instructor work and academic teaching duties, which are integral to all scholarly activities. The course spans three semesters,
usually starting in the second semester. 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 a Professional Development course (L24 598).

Please note that the sequence outlined above is for "well-
p repared" 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.

**Specific course requirements:** The 72 units of course work
must include eight of the following nine courses: Math 5031–
5032 (Algebra I and Algebra II), Math 5051–5052 (Real Analysis
and Functional Analysis), Math 5021–5022 (Complex Analysis
I & II), and Math 5045–5047 (Algebraic Topology, Differential
Topology, and Differential Geometry). Students may omit one of
the following courses when satisfying the course requirement:
Math 5022, 5047, or 5052. To satisfy the breadth requirement,
the student must pass the required courses with a B 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 the English Language Program at the International
Office 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:
5021, 5022, 5031, 5032, 5045, 5046, 5047, 5051 and 5052. 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 Math 5021, 5022, 5051 or 5052; two be from
Math 5045, 5046 or 5047; and two be from Math 5031 and 5032.
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 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 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. This 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, please consult the Office of Graduate Studies, Arts & Sciences.

### PhD in Statistics

#### Degree Requirements Summary

A total of 72 graduate units are required, consisting of the following:

- 24 required course work units total in fundamental topics and exam fields
- 12 elective course work units
- Three qualifying exams: two in statistics, one in mathematics
- Teaching Requirement for PhD Students from the Office of Graduate Studies, Arts & Sciences
- Oral presentation
- Dissertation research, thesis preparation, and defense (30 course work units)

#### General requirements: Completion of the PhD requires four full years of graduate study (72 units), with at least 48 units 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 maximum of 24 graduate credits from other universities. The typical course load is 9 credit units per semester. A GPA of B or better is required in graduate course work.

Graduate students in statistics may ordinarily expect up to five years of support. Continuation of support each year is dependent upon normal progress toward the degree and the satisfactory performance of duties. Teaching experience is an increasingly important component of graduate education for students who seek academic employment. The PhD in statistics program provides the opportunity for students to work as Assistants to the Instructor and to learn how to teach technical topics to students with a wide range of backgrounds.

For the well-prepared student, “normal progress” usually means the following:

- At the end of the second year, the student has successfully passed the two statistical qualifying exams associated with Math 5061–5062 and Math 5071–5072 as well as the mathematical qualifying exam associated with Math 5051–5052. They have also completed the courses Math 459 and Math 475.
- At the end of the third year, the student has completed the candidacy requirement.
- At the end of the fourth year, the student has completed the 72-unit course requirement and is making substantial progress on a thesis.

Students must also complete the Teaching Seminar course (L24 597). This course prepares them for both Assistant to the Instructor work and academic teaching duties, which are integral to all scholarly activities. The course spans three semesters, usually starting in the second semester. 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 a Professional Development course (L24 598).

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.

#### Specific course requirements: The 72 units of course work must include two basic graduate-level sequences in statistics: Math 5061 Theory of Statistics I–Math 5062 Theory of Statistics II and Math 5071 Advanced Linear Models I–Math 5072 Advanced Linear Models II; the following statistics courses: Math 459 Bayesian Statistics and Math 475 Statistical Computation; and the following graduate-level mathematics sequence: Math 5051–5052. In exceptional circumstances, departmental permission may be requested to replace one of these sequences with a suitable alternative. The student may also petition the department to waive one or more of these sequences because of work completed previously.

Prerequisites, if needed, are advanced undergraduate courses in abstract linear algebra and real analysis. Such courses would count as 0 credits toward the PhD degree.

It is in each student’s best interest to take the three sequences 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.

Prior to finding a research advisor, students are welcome to take any of the Department of Mathematics and Statistics 400- and 500-level statistics electives, and they may also take reading courses with statistics faculty members (Math 500/Math 590). Statistics electives offered by the department include the following:
Some popular elective courses offered by other departments may be helpful for their research and professional development. Elective courses taken in other departments allow students to supplement their statistics course work with other topics that may be useful for the student's research program. Elective courses taken in other departments allow students to supplement their statistics course work with other topics that may be useful for the student's research program. Some popular elective courses offered by other departments include the following:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Math 420</td>
<td>Experimental Design</td>
<td>3</td>
</tr>
<tr>
<td>Math 434</td>
<td>Survival Analysis</td>
<td>3</td>
</tr>
<tr>
<td>Math 449</td>
<td>Numerical Applied Mathematics</td>
<td>3</td>
</tr>
<tr>
<td>Math 456</td>
<td>Topics in Financial Mathematics</td>
<td>3</td>
</tr>
<tr>
<td>Math 459</td>
<td>Bayesian Statistics</td>
<td>3</td>
</tr>
<tr>
<td>Math 460</td>
<td>Multivariate Statistical Analysis</td>
<td>3</td>
</tr>
<tr>
<td>Math 461</td>
<td>Time Series Analysis</td>
<td>3</td>
</tr>
<tr>
<td>Math 462</td>
<td>Mathematical Foundations of Big Data</td>
<td>3</td>
</tr>
<tr>
<td>Math 475</td>
<td>Statistical Computation</td>
<td>3</td>
</tr>
<tr>
<td>Math 495</td>
<td>Stochastic Processes</td>
<td>3</td>
</tr>
<tr>
<td>Math 551</td>
<td>Advanced Probability I</td>
<td>3</td>
</tr>
<tr>
<td>Math 552</td>
<td>Advanced Probability II</td>
<td>3</td>
</tr>
<tr>
<td>Math 523C</td>
<td>Information Theory and Statistics</td>
<td>3</td>
</tr>
</tbody>
</table>

CSE 541T Advanced Algorithms 3
MSB M19-550 Randomized Controlled Trials 3
MSB M21-623 Advanced Topics in Biostatistics 3
Econ 5145 Advanced Theoretical Econometrics 3

**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 the English Language Program at the International Office 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 three 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 the two basic statistics course sequences, Math 5061–5062 and Math 5071–5072, and in the mathematics sequence Math 5051–5052. Each spring, at the end of the Math 5061–5062 and Math 5071–5072 sequences, all students enrolled in these courses take a two-hour final exam; this exam usually covers the second half of the sequence. Doctoral candidates take an additional one-hour exam that covers the entire sequence. To pass the qualifying exam, the student must pass the three-hour combined exam. In the case of the Math 5051–5052 sequence, to satisfy the qualification examination requirement, the student must pass the final exam for the course with an A- or better.

Because each sequence varies somewhat in content from year to year, it is recommended that the student take each set of exams at the conclusion of the sequence in which they are enrolled. No advantage is gained by delaying the exam for a year. It is desirable to make every effort to finish all three 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 three basic sequences. This 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. The candidacy requirement is designed to expedite this process. Along with a committee of at least two faculty members, the student selects one major and one minor topic and a body of literature dealing with each. The student then usually spends a semester studying the selected material. At the end of this period, the student demonstrates mastery of the two selected topics by means of satisfactory oral expositions to a faculty committee. One member of this committee will in all likelihood become the student's thesis advisor and may have already agreed to be the advisor. The preparatory work for the presentation often becomes the foundation on which the thesis is constructed.

After the student completes the oral presentation, 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 the knowledge of statistics, probability, and/or applied probability. This 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 oral presentation committee, 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.