Mathematics

The Department of Mathematics offers two master's degrees, one in Mathematics and the other in Statistics, and two doctoral degrees, one in Mathematics and one in Statistics. Areas of study for Mathematics include: algebra, algebraic geometry, real and complex analysis, differential geometry, and topology. The areas of study for Statistics are: mathematical statistics, survival analysis, modeling, statistical computing for massive data, Bayesian regulation, bioinformatics, longitudinal and functional data analysis, statistical computation, asymptotic theory, objective Bayes, bootstrap, post-selection inference, and application of statistics to medicine. Because it is difficult to make up coherent programs for students entering in the middle of the year, students are ordinarily admitted only in the fall.

Graduate students have an opportunity when they first arrive to share common concerns and to become acquainted. One of the most attractive features of our program is the friendly and supportive atmosphere among the graduate students. Advanced courses in the Washington University math department can build on the common background shared by all students. As a result, these courses are richer and nearer to the level of PhD work than typical advanced courses.

Students typically complete the PhD program in five years. A student who comes here with advanced preparation may finish in less time. On the other hand, some students find that it is advisable for them to take preparatory work before attempting the qualifying courses. In special cases, the time schedule may be lengthened accordingly. Students should plan to develop a close relationship with their thesis advisers so that they may have a realistic idea of their progress.

Graduate study in mathematics is not for everyone. Entering students usually find that the time and effort required to succeed goes well beyond anything they encountered as undergraduates. Success requires both ample mathematical ability and the determination to grapple with a subject for many days or weeks until the light of understanding shines through. The experience can be daunting. Those who continue in their studies are largely those for whom the pleasure in attaining that understanding more than compensates for the required effort. For such persons, the life of a mathematician can be richly rewarding.

Email: bwick@wustl.edu or stenner@wustl.edu
Phone: 314-935-6760
Website: http://wumath.wustl.edu/graduate

Faculty

Chair

John E. McCarthy
Spencer T. Olin Professor of Mathematics
PhD, University of California, Berkeley
Analysis; operator theory; one and several complex variables

Directors

Brett Wick
Director of Graduate Studies; Professor of Mathematics
PhD, Brown University
Complex analysis, harmonic analysis, operator theory, and several complex variables

John Shareshian
Director of Undergraduate Studies; Professor of Mathematics
PhD, Rutgers University
Algebraic and topological combinatorics

Endowed Professor

John E. McCarthy
Spencer T. Olin Professor of Mathematics
PhD, University of California, Berkeley
Analysis; operator theory; one and several complex variables

Professors

Quo-Shin Chi
PhD, Stanford University
Differential geometry

Renato Feres
PhD, California Institute of Technology
Differential geometry; dynamical systems

José Figueroa-López
PhD, Georgia Institute of Technology
Statistics; probability and stochastic processes; mathematical finance

Steven G. Krantz
PhD, Princeton University
Several complex variables; geometric analysis

Rachel Roberts
PhD, Cornell University
Low-dimensional topology

John Shareshian
PhD, Rutgers University
Algebraic and topological combinatorics
Edward Spitznagel (http://wumath.wustl.edu/people/spitznagel_edward)  
PhD, University of Chicago  
Statistics; statistical computation; application of statistics to medicine

Xiang Tang (http://wumath.wustl.edu/people/tang_xiang)  
PhD, University of California, Berkeley  
Symplectic geometry; noncommutative geometry; mathematical physics

Brett Wick (http://wumath.wustl.edu/people/brett-wick)  
PhD, Brown University  
Analysis of several complex variables; harmonic analysis and operator theory

Mladen Victor Wickerhauser (http://wumath.wustl.edu/people/wickerhauser_mladen-victor)  
PhD, Yale University  
Harmonic analysis; wavelets; numerical algorithms for data compression

David Wright (http://wumath.wustl.edu/people/wright_david)  
PhD, Columbia University  
Affine algebraic geometry; polynomial automorphisms

Assistant Professors

Steven Frankel (http://wumath.wustl.edu/people/steven-frankel)  
Assistant Professor of Mathematics  
PhD, University of Cambridge

Todd Kuffner (http://wumath.wustl.edu/people/kuffner_todd)  
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PhD, Imperial College London  
Statistics; likelihood and asymptotics, econometrics

Yanli Song (http://wumath.wustl.edu/people/yanli-song)  
Assistant Professor of Mathematics  
PhD, Pennsylvania State University

Ari Stern (http://wumath.wustl.edu/people/sterntari)  
Assistant Professor of Mathematics  
PhD, California Institute of Technology  
Geometric numerical analysis, computational mathematics

Michael Wendl (http://wumath.wustl.edu/people/wendl_michael)  
Assistant Professor of Genetics, The Genome Institute; courtesy appointment, Mathematics Department  
PhD, Washington University  
Combinatorics, PDEs, probability, and statistical genetics

Associate Professors

Roya Beheshti Zavareh (http://wumath.wustl.edu/people/beheshti-zavareh_roya)  
PhD, Massachusetts Institute of Technology  
Algebraic geometry

Brian E. Blank (http://wumath.wustl.edu/people/blank_brian-e)  
PhD, Cornell University  
Representations of Lie groups; harmonic analysis

Jimin Ding (http://wumath.wustl.edu/people/ding_jimin)  
PhD, University of California, Davis  
Statistics

Matthew Kerr (http://wumath.wustl.edu/people/kerr_matthew)  
PhD, Princeton University  
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Gregory Knese (http://wumath.wustl.edu/people/gregory-knese)  
PhD, Washington University  
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Nan Lin (http://wumath.wustl.edu/people/lin_nan)  
PhD, University of Illinois at Urbana-Champaign  
Statistics

Jack Shapiro (http://wumath.wustl.edu/people/shapiro_jack)  
PhD, City University of New York  
Algebraic K-theory

Professors Emeriti

William M. Boothby (http://wumath.wustl.edu/people/boothby_william-m)  
PhD, University of Michigan  
Differential geometry

Lawrence Conlon (http://wumath.wustl.edu/people/conlon_lawrence)  
PhD, Harvard University  
Differential topology

Ron Freiwald (http://wumath.wustl.edu/people/freiwald_ron)  
PhD, University of Rochester  
General topology

Gary R. Jensen (http://wumath.wustl.edu/people/jensen_gary-r)  
PhD, University of California, Berkeley  
Differential geometry

Robert McDowell (http://wumath.wustl.edu/people/mcdowell_robert)  
PhD, Purdue University  
General topology

Richard Rochberg  
PhD, Harvard University  
Complex analysis, interpolation theory

Guido L. Weiss (http://wumath.wustl.edu/people/weiss_guido-l)  
PhD, University of Chicago  
Interpolation of operators; harmonic analysis, Lie groups
Edward N. Wilson [http://wumath.wustl.edu/people/wilson_edward-n]  
PhD, Washington University  
Harmonic analysis, differential geometry

William Chauvenet Postdoctoral Lecturers

Patricio Gallardo [http://wumath.wustl.edu/people/patricio-gallardo]  
PhD, Stony Brook University

Michael Hartz [http://wumath.wustl.edu/people/michael-hartz]  
PhD, University of Waterloo

Yakov Berchenko-Kogan [http://wumath.wustl.edu/people/yakov-yasha-berchenko-kogan]  
PhD, Massachusetts Institute of Technology

James Pascoe [http://wumath.wustl.edu/people/james-pascoe]  
NSF Postdoctoral Fellow  
PhD, University of California, San Diego  
Several complex variables

Associate Director of Undergraduate Studies

Blake Thornton [http://wumath.wustl.edu/people/thornton_blake]  
PhD, University of Utah

Program Coordinator

Lisa M. Kuehne [http://wumath.wustl.edu/people/kuehne_lisa]  
Program Coordinator, University College & Center for Advanced Learning  
AM Mathematics, Washington University  
Undergraduate Mathematics Education

Degree Requirements

AM in Mathematics

General requirements: 36 units of courses and an optional thesis. 3 units may be for thesis research. The minimum residence requirement is one full academic year of graduate study. A grade point average 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 grade point average of 3.5 or higher in the first 18 units of courses satisfying the program requirements.

Course requirements: There are four basic graduate sequences in pure mathematics:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Math 5021</td>
<td>Complex Analysis I</td>
<td>6</td>
</tr>
<tr>
<td>&amp; Math 5022</td>
<td>and Complex Analysis II</td>
<td></td>
</tr>
<tr>
<td>Math 5031</td>
<td>Algebra I</td>
<td>6</td>
</tr>
<tr>
<td>&amp; Math 5032</td>
<td>and Algebra II</td>
<td></td>
</tr>
<tr>
<td>Math 5041</td>
<td>Geometry I</td>
<td>6</td>
</tr>
<tr>
<td>&amp; Math 5042</td>
<td>and Geometry II</td>
<td></td>
</tr>
<tr>
<td>Math 5051</td>
<td>Measure Theory and Functional Analysis I</td>
<td>6</td>
</tr>
<tr>
<td>&amp; Math 5052</td>
<td>and Measure Theory and Functional Analysis II</td>
<td></td>
</tr>
</tbody>
</table>

A candidate for the AM in Mathematics must include two of these sequences (12 units) in the required 36 units. The student, in consultation with their adviser, selects the remaining 24 units according to the student's interests and needs.

The AM examination: Candidates for the AM degree must pass at least two of the four PhD qualifying exams. Under exceptional circumstances, the graduate committee may allow the student to substitute the PhD qualifying exams mentioned above with a comprehensive examination on the contents of Math 4111 Introduction to Analysis–Math 4121 Introduction to Lebesgue Integration, Math 4171 Topology I–Math 4181 Topology II, and Math 429 Linear Algebra–Math 430 Modern Algebra.

AM in Statistics

General requirements: 36 units of courses and a thesis. 3 units may be for thesis research. The minimum residence requirement is one full academic year of graduate study. A grade point average of B or better must be maintained in graduate courses.

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

<table>
<thead>
<tr>
<th>Code</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Math 493</td>
<td>Probability</td>
<td>6</td>
</tr>
<tr>
<td>&amp; Math 494</td>
<td>and Mathematical Statistics</td>
<td></td>
</tr>
<tr>
<td>or Math 5061</td>
<td>Theory of Statistics I</td>
<td></td>
</tr>
<tr>
<td>&amp; Math 5062</td>
<td>and Theory of Statistics II</td>
<td></td>
</tr>
<tr>
<td>Math 439</td>
<td>Linear Statistical Models</td>
<td>3</td>
</tr>
<tr>
<td>Math 4392</td>
<td>Advanced Linear Statistical Models</td>
<td>3</td>
</tr>
<tr>
<td>Math 459</td>
<td>Bayesian Statistics</td>
<td>3</td>
</tr>
<tr>
<td>Math 475</td>
<td>Statistical Computation</td>
<td>3</td>
</tr>
</tbody>
</table>

or a suitable substitute elective approved by the department.

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

PhD in Mathematics

General requirements: Completion of the PhD requires four full years of graduate study, 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 part of the graduate units from other universities. A grade point average of B or better is required in graduate courses. 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. Students must also complete the Teaching Seminar course (Math 597), which prepares them for the mentored teaching experience, which is an integral part of scholarly activity. The course spans three semesters usually starting in the second semester.

**Specific course requirements:** Courses must include four basic graduate sequences:

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<td>&amp; Math 5052</td>
<td>and Measure Theory and Functional Analysis II</td>
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</table>

**Language requirement:** For the PhD, the department requires two of these languages: English, French, German or Russian. If the student's native language is English, then they must demonstrate competence in one of the other three languages by either:

- submitting an undergraduate transcript showing one year of these languages passed with a grade of C or better;
- taking a one-semester course in one of these languages while a graduate student at Washington University, and passing with a grade of B or better; or
- passing one of the annual written exams given by the department in mathematical French or German or Russian, as decided by the thesis adviser.

**Qualifying examinations:** The qualifying exam is in two parts; one is a series of four written tests covering a range of topics, and one is an oral exam on two selected topics. The written tests cover the material in the four basic course sequences. Each spring, at the end of each sequence, all students enrolled in the course take a two-hour final exam; this exam usually covers the second half of the sequence. Doctoral candidates take an additional one-hour exam which covers the entire sequence. To pass the qualifying exam in one of the four areas, the student must pass the three-hour combined exam.

**The dissertation and final oral exam:** The student's dissertation is the single most important requirement for the PhD degree. It must be an original contribution to mathematical knowledge and the student's opportunity to conduct significant independent research. Once the department has accepted the dissertation (on the advice of the thesis adviser), the student is required to pass a final oral examination. Part of this procedure is a question/answer period in which the student is expected to "defend" the thesis. For information about preparing the thesis and its abstract, and about the deadlines involved, please consult the following items from the Graduate School: the Forms (http://graduateschool.wustl.edu/forms) webpage and the Policies and Guides (http://graduateschool.wustl.edu/policies-and-guides) webpage (which includes the Doctoral Dissertation Guide). For a sample thesis TeX file and style file, visit the Department of Mathematics (http://wumath.wustl.edu/links) website.

**PhD in Statistics**

**Degree Requirements Summary**

Required graduate units, consisting of:

- 24 required units (excludes research units) total in fundamental topics and exam fields
- 12 elective units (excludes research units)
- 6 course units for staffing a walk-in statistical consulting center to be setup by the department
- 4 qualifying exams: 2 in statistics, 2 in mathematics
- Graduate School Teaching Requirement for PhD Students
- Major and minor oral presentation
- Dissertation research, thesis preparation, and defense (30 course units)

**General requirements:** The PhD in Statistics general requirements mirror the PhD in Mathematics. For a more detailed explanation, please visit the PhD in Statistics (http://wumath.wustl.edu/graduate-new/placement-graduate-students/degree-programs-and-requirements/phd-statistics) webpage.

**Specific course requirements:** Courses must include two basic graduate statistics sequences:

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<td>Math 5061</td>
<td>Theory of Statistics I</td>
<td>6</td>
</tr>
<tr>
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<td></td>
</tr>
<tr>
<td>Math 439</td>
<td>Linear Statistical Models</td>
<td>6</td>
</tr>
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<td>and Advanced Linear Statistical Models</td>
<td></td>
</tr>
</tbody>
</table>

and any two of the following pure math sequences:

<table>
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Mathematics (01/11/18)

<table>
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<tr>
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<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Math 5031 &amp; Math 5032</td>
<td>Algebra I and Algebra II</td>
<td>6</td>
</tr>
<tr>
<td>Math 5041 &amp; Math 5042</td>
<td>Geometry I and Geometry II</td>
<td>6</td>
</tr>
<tr>
<td>Math 5051 &amp; Math 5052</td>
<td>Measure Theory and Functional Analysis I and Measure Theory and Functional Analysis II</td>
<td>6</td>
</tr>
</tbody>
</table>

Prerequisites, if needed, are Math 429 Linear Algebra (0 units toward the degree) and Math 233 Calculus III (0 units toward the degree).

**Language requirement:** A student whose native language is not English must demonstrate proficiency in English. The student also is expected to become proficient in spoken English. In particular, any student who expects to gain teaching experience while pursuing a degree will need to do this as soon as possible. All students are expected to fulfill the language requirement during their first two years of graduate study.

**Qualifying examinations:** The qualifying exam is in two parts. One is a series of four written tests covering a range of topics, and one is an oral exam on two selected topics. The written tests cover the material in the four basic course sequences. Each spring, at the end of each sequence, all students enrolled in the course take a two-hour final exam; this exam usually covers the second half of the sequence. Doctoral candidates take an additional one-hour exam which covers the entire sequence. To pass the qualifying exam in one of the four areas, the student must pass the three-hour combined exam.

**The dissertation and final oral exam:** The student's dissertation is the single most important requirement for the PhD degree. It must be an original contribution to mathematical knowledge and the student's opportunity to conduct significant independent research. The student is required to pass a final oral examination, and part of this procedure is a question/answer period in which the student is expected to "defend" the dissertation. For information about preparing the thesis and its abstract, and about the deadlines involved, please consult the Graduate School's academic information (http://bulletin.wustl.edu/grad/gsas/phd/academic) section of this Bulletin.