Mathematics, PhD (Boston)

Course Requirements

Students entering with a bachelor's degree are required to take 48 semester hours of coursework divided between foundational and advanced offerings. Students entering the program will be allowed to place out of some (possibly all) of the six basic-level courses; the graduate coordinator together with the first-year graduate advisor will determine the allowable course substitutions and will advise the student which foundational courses to take. Students may satisfy requirements for Algebra 1 (MATH 5111) and Analysis 1: Functions of One Variable (MATH 5101) by taking qualifying exams in algebra 1 and in analysis 1 at the start of the program. Students may satisfy foundational course requirements if they demonstrate proficiency by passing an assessment exam in the course at the beginning of the semester or by demonstrating that they have taken a similar course and have adequate knowledge of the course material (syllabus and transcript are required; a brief oral examination is also required in that case). Academic advising will happen just before the start of each term and during the add/drop period in order to plan a student's course registration for the term. A complete listing of foundational and advanced courses is available from the Department of Mathematics and the graduate dean's office. Students are not permitted to register for more than two "readings" courses and three "topics" courses for credit toward the degree without explicit permission from the graduate dean. A minimum GPA of 3.000 is required for degree conferral.

Teaching Requirement

Some teaching experience is required while in the program. Students must attend university-led TA training at the start of the program; attend a one-semester TA training course conducted by faculty from the Department of Mathematics teaching committee; spend one semester shadowing faculty in the undergraduate classroom; and perform recitations and grading for the undergraduate course they are shadowing.

Qualifying Exams

Qualifying exam sessions are given once in spring and once in fall. Students will be required to pass four qualifying exams: algebra 1, analysis 1, and two other exams. The possible additional topics for qualifying exams are algebra 2, analysis 2, combinatorics, geometry, ordinary differential equations, partial differential equations, probability, statistics, topology, and algebraic geometry. A qualifying exam may be taken twice by any student. Additional attempts may be allowed at the discretion of the graduate committee with permission from the graduate dean in the College of Science. Two qualifying exams should be passed no later than the end of the second year and all four by the end of the third year.

Doctoral Candidacy

PhD candidacy is reached when all of the following conditions are met:

- Completion of eight advanced courses
- Identification of an unsolved research problem
- Successful passing of four qualifying exams
- Assignment of PhD supervisor and creation of a 1-page initial plan
- Completion of a 3-page plan of research
- Completion of a 10-page progress report and a one-hour defense of proposal, presented to supervisor and three faculty members of graduate committee

Dissertation Requirement

Each candidate must complete a dissertation that embodies the results of extended research and makes an original contribution to the field. This work should give evidence of the candidate's ability to carry out independent investigation and interpret, in a logical manner, the results of the research. There are two stages to this process:

- **Stage 1:** Students in the PhD program must have a dissertation supervisor within two years after joining the PhD program. The department views the failure of a student to find a supervisor within two years of joining the PhD program with concern and considers this sufficient cause to review the student's status in the PhD program. The process of obtaining a dissertation supervisor always involves two choices—the student chooses the supervisor, and the supervisor chooses the student. For this reason, the department does not guarantee a dissertation supervisor for every student, but the department recognizes its responsibility to help the student find a satisfactory match. This aid is usually provided by the student's graduate advisor, who should be familiar with the student's progress in finding a dissertation supervisor. The dissertation supervisor guides the student's further education as well as directs the student's dissertation. The dissertation itself must represent an original solution of a problem in the chosen area of mathematics that makes a significant contribution to the mathematical knowledge in that area. Students must enroll in Dissertation or Dissertation Continuation while fulfilling the dissertation requirements.
- **Stage 2 (dissertation defense):** The final oral examination on the dissertation is held in accordance with university regulations and given by a dissertation committee of four faculty members (three from the university, including the supervisor, and one from outside Northeastern University). The dissertation supervisor should propose this dissertation committee to the graduate committee for its approval at least one month before the PhD dissertation defense.

Program Requirements

Bachelor's Degree Entry

Complete all courses and requirements listed below unless otherwise indicated.

Milestones

Four qualifying examinations
Annual review
Teaching requirement
Doctoral candidacy
Dissertation committee
Dissertation proposal
Progress report and presentation
Dissertation defense

Prerequisites

Code	Title	Hours
Algebra and Analysis		
Complete 0–8 semester hours from the following:		0-8
MATH 5101	Analysis 1: Functions of One Variable	
MATH 5111	Algebra 1	

Advanced Coursework

Code	Title	Hours
Complete 32 semester hours from the advanced coursework list. Only two readings and three topics courses are allowed. (p. 3)		32

Tracks

Complete one of the following three tracks:

- Pure Track (p. 2)
- Discrete Track (p. 3)
- Probability and Statistics Track (p. 3)

Dissertation

Code	Title	Hours
MATH 9990	Dissertation Term 1	
MATH 9991	Dissertation Term 2	

Program Credit/GPA Requirements

48–56 total semester hours required
Minimum 3.000 GPA required

PURE TRACK

Code	Title	Hours
Analysis		
MATH 5102	Analysis 2: Functions of Several Variables	4
Algebra		
MATH 5112	Algebra 2	4
Foundational Courses		
Complete up to 8 semester hours from the following:		0-8
MATH 5122	Geometry 1	
MATH 5352	Quantum Computation and Information	
MATH 7202	Partial Differential Equations 1	
MATH 7203	Numerical Analysis 1	
MATH 7241	Probability 1	

DISCRETE TRACK

Code	Title	Hours
Algebra		
MATH 5112	Algebra 2	4
Probability		
MATH 7241	Probability 1	4
Foundational Courses		
Complete up to 8 semester hours from the following:		0-8
MATH 5102	Analysis 2: Functions of Several Variables	
MATH 5111	Algebra 1	
MATH 5112	Algebra 2	
MATH 5352	Quantum Computation and Information	
MATH 7202	Partial Differential Equations 1	
MATH 7203	Numerical Analysis 1	
MATH 7342	Mathematical Statistics	

PROBABILITY AND STATISTICS TRACK

Code	Title	Hours
Analysis		
Complete 4 semester hours from the following:		4
MATH 5102	Analysis 2: Functions of Several Variables	
MATH 7203	Numerical Analysis 1	
Probability		
MATH 7241	Probability 1	4
or MATH 7342	Mathematical Statistics	
Foundational Courses		
Complete up to 8 semester hours from the following:		8
MATH 5102	Analysis 2: Functions of Several Variables	
MATH 5112	Algebra 2	
MATH 5352	Quantum Computation and Information	
MATH 7202	Partial Differential Equations 1	
MATH 7203	Numerical Analysis 1	
MATH 7241	Probability 1	
MATH 7342	Mathematical Statistics	

Advanced Coursework List

Code	Title	Hours
MATH 7205	Numerical Analysis 2	
MATH 7221	Topology 2	
MATH 7223	Riemannian Optimization	
MATH 7233	Graph Theory	
MATH 7234	Optimization and Complexity	
MATH 7243	Machine Learning and Statistical Learning Theory 1	
MATH 7301	Functional Analysis	
MATH 7311	Commutative Algebra	
MATH 7315	Algebraic Number Theory	
MATH 7316	Lie Algebras	
MATH 7320	Modern Algebraic Geometry	
MATH 7321	Topology 3	
MATH 7339	Machine Learning and Statistical Learning Theory 2	
MATH 7341	Probability 2	
MATH 7343	Applied Statistics	
MATH 7344	Regression, ANOVA, and Design	
MATH 7346 to MATH 7361		
MATH 7371	Morse Theory	

MATH 7976 to MATH 8986	
MATH 9984	Research
Topics	
Only three topics courses are allowed.	
MATH 7362	Topics in Algebra
MATH 7363	Topics in Algebraic Geometry
MATH 7364	Topics in Representation Theory
MATH 7375	Topics in Topology
MATH 7381	Topics in Combinatorics
Readings	
Only two readings courses are allowed.	
MATH 7721	Readings in Topology
MATH 7734	Readings in Algebra
MATH 7735	Readings in Algebraic Geometry
MATH 7736	Readings in Discrete Geometry
MATH 7741	Readings in Probability and Statistics
MATH 7771	Readings in Geometry

Advanced Entry Program Requirements

Course Requirements

Advanced students who enter the PhD program with a master's degree (or equivalent) will be allowed to place out of some (possibly all) of the six basic-level courses; the graduate coordinator together with the first-year graduate advisor will determine the allowable course substitutions and will advise the student which foundational courses to take. Students may satisfy requirements for Algebra 1 (MATH 5111) and Analysis 1: Functions of One Variable (MATH 5101) by taking qualifying exams in algebra 1 and in analysis 1 at the start of the program. Students may satisfy foundational course requirements if they demonstrate proficiency by passing an assessment exam in the course at the beginning of the semester or by demonstrating that they have taken a similar course and have adequate knowledge of the course material (syllabus and transcript are required; a brief oral examination is also required in that case). Academic advising will happen just before the start of each term and during the add/drop period in order to plan a student's course registration for the term. A complete listing of foundational and advanced courses is available from the Department of Mathematics and the graduate dean's office. Students are not permitted to register for more than two "readings" courses and three "topics" courses for credit toward the degree without explicit permission from the graduate dean. A minimum grade-point average (GPA) of 3.000 is required for degree conferral.

Teaching Requirement

Some teaching experience is required while in the program. Students must attend university-led TA training at the start of the program; attend a one-semester TA training course conducted by faculty from the Department of Mathematics teaching committee; spend one semester shadowing faculty in the undergraduate classroom; and perform recitations and grading for the undergraduate course they are shadowing.

Qualifying Exams

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Doctoral Candidacy

PhD candidacy is reached when all of the following conditions are met:

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Each candidate must complete a dissertation that embodies the results of extended research and makes an original contribution to the field. This work should give evidence of the candidate's ability to carry out independent investigation and interpret, in a logical manner, the results of the research. There are two stages to this process:

- **Stage 1:** Students in the PhD program must have a dissertation supervisor within two years after joining the PhD program. The department views the failure of a student to find a supervisor within two years of joining the PhD program with concern and considers this sufficient cause to review the student's status in the PhD program. The process of obtaining a dissertation supervisor always involves two choices—the student chooses the supervisor, and the supervisor chooses the student. For this reason, the department does not guarantee a dissertation supervisor for every student, but the department recognizes its responsibility to help the student find a satisfactory match. This aid is usually provided by the student's graduate advisor, who should be familiar with the student's progress in finding a dissertation supervisor. The dissertation supervisor guides the student's further education as well as directs the student's dissertation. The dissertation itself must represent an original solution of a problem in the chosen area of mathematics that makes a significant contribution to the mathematical knowledge in that area. Students must enroll in Dissertation or Dissertation Continuation while fulfilling the dissertation requirements.
- **Stage 2 (dissertation defense):** The final oral examination on the dissertation is held in accordance with university regulations and given by a dissertation committee of four faculty members (three from the university, including the supervisor, and one from outside Northeastern University). The dissertation supervisor should propose this dissertation committee to the graduate committee for its approval at least one month before the PhD dissertation defense.

Complete all courses and requirements listed below unless otherwise indicated.

Milestones

Four qualifying examinations
Annual review
Teaching requirement
Doctoral candidacy
Dissertation committee
Dissertation proposal
Progress report and presentation
Dissertation defense

Code	Title	Hours
Complete 0–16 semester hours of the following courses:		0-16
MATH 5101	Analysis 1: Functions of One Variable	
MATH 5102	Analysis 2: Functions of Several Variables	
MATH 5111	Algebra 1	
MATH 5112	Algebra 2	

Advanced Coursework

Code	Title	Hours
Complete 32 semester hours from the advanced coursework list. Only two readings and three topics courses are allowed. (p. 3)		32

Tracks

Complete one of the following three tracks:

- Pure Track (p. 2)
- Discrete Track (p. 3)
- Probability and Statistics Track (p. 3)

Dissertation

Code	Title	Hours
MATH 9990	Dissertation Term 1	
MATH 9991	Dissertation Term 2	

Program Credit/GPA Requirements

32–56 total semester hours required
Minimum 3.000 GPA required

PURE TRACK

Code	Title	Hours
Foundational Courses		
Complete 0–8 semester hours from the following:		0-8
MATH 5122	Geometry 1	
MATH 5352	Quantum Computation and Information	
MATH 7202	Partial Differential Equations 1	
MATH 7203	Numerical Analysis 1	
MATH 7241	Probability 1	

DISCRETE TRACK

Code	Title	Hours
Foundational Courses		
Complete 0–8 semester hours from the following:		0 - 8
MATH 5102	Analysis 2: Functions of Several Variables	
MATH 5111	Algebra 1	
MATH 5112	Algebra 2	
MATH 5352	Quantum Computation and Information	
MATH 7202	Partial Differential Equations 1	
MATH 7203	Numerical Analysis 1	
MATH 7241	Probability 1	
MATH 7342	Mathematical Statistics	

PROBABILITY AND STATISTICS TRACK

Code	Title	Hours
Foundational Courses		
Complete 0–8 semester hours from the following:		0 - 8
MATH 5102	Analysis 2: Functions of Several Variables	
MATH 5112	Algebra 2	
MATH 5352	Quantum Computation and Information	
MATH 7202	Partial Differential Equations 1	
MATH 7203	Numerical Analysis 1	
MATH 7241	Probability 1	
MATH 7342	Mathematical Statistics	

ADVANCED COURSEWORK LIST

Code	Title	Hours
MATH 7205	Numerical Analysis 2	
MATH 7221	Topology 2	
MATH 7223	Riemannian Optimization	
MATH 7233	Graph Theory	
MATH 7234	Optimization and Complexity	
MATH 7243	Machine Learning and Statistical Learning Theory 1	
MATH 7301	Functional Analysis	
MATH 7311	Commutative Algebra	
MATH 7315	Algebraic Number Theory	
MATH 7316	Lie Algebras	
MATH 7320	Modern Algebraic Geometry	
MATH 7321	Topology 3	
MATH 7339	Machine Learning and Statistical Learning Theory 2	
MATH 7341	Probability 2	
MATH 7343	Applied Statistics	
MATH 7344	Regression, ANOVA, and Design	
MATH 7346 to MATH 7361		
MATH 7371	Morse Theory	
MATH 7976 to MATH 8986		

MATH 9984	Research
Topics	
Only three topics courses are allowed.	
MATH 7362	Topics in Algebra
MATH 7363	Topics in Algebraic Geometry
MATH 7364	Topics in Representation Theory
MATH 7375	Topics in Topology
MATH 7381	Topics in Combinatorics
Readings	
Only two readings courses are allowed.	
MATH 7721	Readings in Topology
MATH 7734	Readings in Algebra
MATH 7735	Readings in Algebraic Geometry
MATH 7736	Readings in Discrete Geometry
MATH 7741	Readings in Probability and Statistics
MATH 7771	Readings in Geometry