Graduate Programs in Mathematics
Policies and Degree Requirements

Revised August 2017

Overview

The Department of Mathematics at Virginia Tech offers graduate programs leading to the Master of Science (M.S.) and Doctor of Philosophy (Ph.D.) degrees. This guide is intended to provide concise descriptions of the programs, degree requirements, and department policies affecting graduate students. The Graduate School sets minimum requirements for each of the degrees and various rules and procedures for completing them. The Department of Mathematics prescribes additional requirements and policies for degrees in Mathematics. This document describes the departmental requirements. See the Graduate Policies and Procedures and Course Catalogue for a complete description of the requirements set by the Graduate School. Some general policies regarding Graduate Teaching Assistantship (GTA) positions are also described below. However a more complete guide to the responsibilities of a GTA is provided in the Graduate Teaching Assistant Manual.

There are sometimes circumstances which justify the waiver of some requirement or policy. The authority to waive Department of Mathematics policies rests with the Graduate Program Committee. Such requests should be made to the Graduate Program Director in writing after consultation with the student's advisor. For waivers of Graduate School rules, requests should be made to the Dean of Graduate Studies, often accompanied by a letter from the student's advisor or the Graduate Program Director. If you have questions, start with your advisor or the Graduate Program Director.

Throughout the year, policy changes and updates are provided through electronic mailings and information sessions such as the Graduate Student Issues Seminar, coordinated by the Senior GTAs. It is every student's responsibility to check their e-mail and mailboxes regularly for announcements.

Advising & General Requirements

Fall Orientation

The Department provides an orientation program for new graduate students during the week before classes start every fall. This includes *mandatory* orientation sessions offered by the Graduate School. You should receive a program over the summer. If you have not, please contact the Graduate Program Coordinator. If you started your program in January, contact the Graduate Program Coordinator to find out which sessions you must attend.

Advisor and Advisory Committee

Each new graduate student in the M.S. program is assigned a faculty member as his/her advisor. A student may change his/her advisor to a different Mathematics faculty member if he/she wishes. After receiving the consent of the new advisor, the student should inform the previous advisor, the Graduate Program Coordinator, and the Graduate Program Director and be sure to note the change on the next Graduate Student Activity Report (GSAR). The advisor helps the student design his/her Plan of Study and make any

associated decisions. In the student's first year the M.S. student and advisor select an advisory committee of 3 faculty members to help develop a M.S. Plan of Study.

A student in the Ph.D. program is expected to take his/her own initiative to identify an advisor. Often this involves a period of discussion of research interests and working styles. Advisors should be tenured or tenure-track faculty members with expertise suitable for the student's research area. Once an agreement is reached with an advisor, a committee of 4 faculty members is identified to help develop the Ph.D. Plan of Study.

A majority of advisory committee members should be mathematics faculty holding tenure track appointments. (Exceptions to this are possible with the Graduate Program Committee's approval.) The advisory committee provides advice and review of the Plan of Study and any subsequent revisions. Committee members also provide consultation and advice for the student's research. For M.S. students, the advisory committee administers the final exam (either Master's Thesis, Master's Presentation, or written Ph.D. Preliminary Exam options, see below). For Ph.D. students, the advisory committee members conduct the oral Preliminary Examination (see below), the final exam and certification of any additional requirements.

As allowed by the Graduate School policies, the faculty advisor can allow for substitute members or proxies at the time of Doctoral or Master's examinations, if appropriate. However, it is the responsibility of the student's Advisory Committee to evaluate Theses or Dissertations and to sign the ETD Approval Form.

The Graduate Program Committee oversees all advisory committees and student-advisor relationships, and has the authority to make changes to committee memberships if necessary. Students and faculty may discuss related issues with the Graduate Program Director and/or Department Head at any time [1].

Graduate students should consult with their advisors *at least once a semester* including the time of course registration, and additionally whenever any Plan of Study changes are contemplated. It is the student's responsibility to contact his/her advisor and to satisfy all degree requirements. Although the advisor's role is only to provide guidance, it is strongly recommended that students take advantage of faculty advice and involve it in their study plans. This can often eliminate delays in completing a student's program requirements.

Plan of Study

The Plan of Study form is due by the end of the second academic semester for all Master's degree students, by the end of the first academic semester for combined BS/MS students, and by the end of the third academic semester for all doctoral students. Guidance in preparing Plan of Study forms for M.S. and Ph.D. programs are given below.

Evaluation of transfer credit (if any) is made in the process of developing the Plan of Study. Transferred credits must have earned grades of "B" or better and must have been earned while registered as a Graduate Student[2]. As outlined in the Graduate School guidelines, no more than 50% of course credits listed on a Plan of Study may be transferred. The Department requires that all transfer courses be at the 5000 level or higher.

Once approved by the Advisory Committee the Plan of Study is reviewed by the Graduate Program Director for departmental approval and then by the Graduate School. If changes become necessary, we strongly recommend that they all be made at one time, usually before the student's final semester. Full time students not engaged in thesis projects are expected to enroll in 9 hours of course work per semester (students on assistantships typically add MATH 5994 (M.S.) or 7994 (Ph.D.) credits to meet the requirement of 12 hours per semester). All courses on the Plan of Study must be taken with the A/F option except 5994 or 7994. Students should maintain a QCA of at least 3.0.

[1] The evaluation of faculty in their role as advisors and advisory committee members is the responsibility of the Personnel Committee.

[2] An exception is made for students admitted to the 5-year B.S./M.S. program. Credits must be earned at Virginia Tech after acceptance to the program.

Attending Colloquia and Seminars

The department expects every graduate student to attend colloquia and/or seminars at least 6 times each semester. The student may choose among Math Department colloquia and seminars and math-related colloquia and seminars in other departments. Graduate students are expected to attend Research Days, an annual event held in February, where faculty members give short presentations on their research areas.

The Graduate Student Activity Report includes a section in which the student reports the seminars and colloquia attended and in which the student's advisor signs off on the accuracy of the reported attendance. The department suggests that advisors engage their students in discussions of seminars and colloquia attended by the students and/or require their students to submit brief written summaries. Because colloquium and seminar attendance is important for students' professional development, it will be considered when the Graduate Program Committee makes decisions about admission to the Ph.D. program and extensions of support.

Scholarly Ethics and Integrity

The department encourages every first-year graduate student to attend lunch-time seminars on scholarly ethics and integrity for graduate students organized by senior graduate teaching assistants. The first-year graduate student must attend the lectures on ethics and integrity given by faculty members during *Research Days*. At the end of spring semester, every first-year graduate student must take an exam on ethics and integrity. The Graduate Program Committee will be in charge of forming relevant questions and discussion topics. Any student who fails attending the lectures or the exam will be required to repeat the entire exercise in the following year.

The Graduate Student Activity Report includes a section which indicates whether the student has met the ethics and integrity requirement. Meeting this requirement will be required before any degree is conferred.

Graduate Student Activity Report

Near the end of every fall, every continuing graduate student must fill out a Graduate Student Activity Report. On this document the student summarizes his/her academic and GTA activities for the year and indicates plans for the year ahead. The information provided is important for an annual evaluation by the Graduate Program Committee. It is also the vehicle by which a student registers the intent to take preliminary examinations, requests summer teaching assignments, and applies for admission to the Ph.D. program from the M.S. program.

Master of Science Degree Programs

The M.S. degree is designed to be completed in two years of graduate study. M.S. degrees are available under thesis and non-thesis options. Under the thesis option the student writes and defends a Master's Thesis under the direction of a faculty member. The time spent preparing the thesis is represented by 6 to 9 hours of Math 5994 (Research and Thesis) among the required courses. The hour and course requirements for each of these degrees are specified in the table below. The department also offers a special interdisciplinary plan for either the thesis or non- thesis M.S. degrees. This plan is intended for students having clearly defined interdisciplinary career goals. Additional flexibility in the formal requirements allows the student's advisory committee to customize a Plan of Study to the student's goals. It must be emphasized that the interdisciplinary plan is intended only for students who enter the graduate program with specific, interdisciplinary career objectives. The student desiring studies under this plan needs to take the initiative to develop an appropriate plan of study at the very outset of his/her graduate studies.

Hour Requirements

For any of the degree options the student's Plan of Study must show 30 hours. The courses which make up these 30 hours must meet the constraints indicated in the following table. (Up to 50% of course credit hours

at the 5000 level may be transferred, subject to the advisory committee's approval and Graduate School guidelines.)

	Non-Thesis (Standard)	Non-Thesis (Interdisciplinary)	Thesis (Standard)	Thesis (Interdisciplinary)
4000	at most 6	at most 6	at most 6	at most 6
5000 Math (only)	at least 18	at least 18	at least 12	at least 12
5000 Math or Related	at least 24		at least 15	
5000 (any, excluding 5994)		at least 24		at least 15
5994	0	0	6 to 9	6 to 9
5000 overall (incl. 5994)			(at least 24)	(at least 24)
Total	30	30	30	30

Explanation of Course Categories (these categories are *not* mutually exclusive):

5000 Math (only): This refers exclusively to Mathematics courses numbered 5000 or higher, excluding 5994 and 5974. Graduate courses offered by other departments may not be used here, unless cross-listed as Mathematics courses.

5000 Math or Related: This refers to courses which are numbered 5000 or higher either in the Mathematics Department or from other departments, and which are mathematically related in the judgment of the student's advisor and committee. 5994 and 5974 are excluded.

5000 (any, excluding 5994): This refers to any courses numbered 5000 or higher, but not including 5994. Hours of 5994 may not be part of the required 30 hours for a non-thesis degree.

5994: Most students take many more than 9 hours of 5994. Only for thesis degrees may such hours be included in the required 30.

5000 overall (incl. 5994): This refers to any courses numbered 5000 or higher, including 5994.

Course Requirements

Standard Degree:

The specific selection of courses used on the Plan of Study is formulated by the student and his/her advisor, and must be approved by the student's advisory committee and the Graduate Program Director. The Mathematics Department requires that the selected courses meet the following two criteria.

A. Background. The student must have previously taken the equivalent of, or else successfully complete while in the M.S. program, each of the following:

- Abstract Algebra (4124)
- Elementary Real Analysis (4225,4226)
- A course that involves computation in a significant way. (Such a course must include work in which the student develops an algorithm, codes it into software, and then uses it to solve a problem. Some possibilities are 4445, 4446, 4414, 5465, 5466, 5485, 5486 or appropriate Computer Science courses.)

B. Concentration. The Plan of Study must include one of the following course sequences.

- Abstract Algebra (5125-6)
- Calculus of Variations (5545-6)
- Complex Analysis (5235-6)
- Functional Analysis (6255-6)
- Numerical Analysis (5465-6)

- Ordinary Differential Equations (5245-6)
- Real Analysis (5225-6)
- Applied PDEs (5425-6)
- Numerical Methods for PDEs (5474,5484)
- Mathematical Methods for Modeling and Simulation of Biological Systems (5515-6)

Interdisciplinary Plan:

The interdisciplinary plan is intended (only) for students having clearly defined, interdisciplinary career goals that cannot be adequately served under the course requirements for the standard degree options above. Instead the student's advisory committee (which should include at least one faculty member from the related discipline) designs a plan of study that combines a core of mathematics study with a coherent selection of course work from a related discipline and that is tailored to the student's specific interdisciplinary goals. (For example, an interdisciplinary degree in bioinformatics might require advanced work in biology, statistics, and/or computer science in addition to graduate work in mathematics.) The judgments of how to make a coherent choice of courses from more than one discipline, while ensuring a level of quality comparable to the level of the standard degree options, are entrusted to the committee. The only specific course requirement is that the plan of study includes Elementary Real Analysis 4225, 4226 if the student has not previously had its equivalent.

It is important that the student interested in this option take the initiative to form the advisory committee and plan a program of courses at the very beginning of his/her graduate studies. This option is not intended for students seeking general training in applied mathematics, and should not be used to circumvent the standard requirements for students who properly belong in one of the standard options.

Final Examinations:

All graduate degrees require the completion of a final examination. The examination must be scheduled with the Graduate School at least two weeks prior to the date of the examination itself. For students in the thesis option, the final examination is a "thesis defense," i.e. an oral presentation of the thesis and response to questions from the student's committee. For students in the non-thesis option the department requires the completion of a Master's Presentation (described in a separate document). Alternatively, the Department will accept the completion of two Ph.D. preliminary examinations as satisfaction of the final exam requirement. Interdisciplinary plan students take an exam (usually oral) designed and administered by their advisory committee. For all M.S. options, final exam paperwork must be submitted to the Mathematics Department for forwarding to the Graduate School.

Doctoral Programs

The Ph.D. degree program is intended to provide a level of training and knowledge suitable for advanced, independent research. In completing the program the student moves beyond the relatively passive role of receiving knowledge presented in courses to become an active, self-motivated scholar. The doctoral program is designed, therefore, for those with the talent and determination to achieve this level of fluency in advanced mathematics. The Mathematics Department offers Ph.D. degrees under two plans: mathematics and mathematical physics.

A full-time graduate student working for a Ph.D. should expect to complete the doctorate within four years after the Master's degree. Permission from the Graduate School is required for residency extending beyond seven years.

Entry to the Doctoral Program:

Students in their second year of the M.S. program may apply for admission to the Ph.D. program. These applications are evaluated by the Graduate Program Committee, using such criteria as performance in the M.S. program, progress toward completion of Ph.D. preliminary examinations, and faculty recommendations

on the student's preparedness for doctoral studies. The endorsement of a faculty member who is willing to chair the student's advisory committee and direct the student's dissertation is a major consideration.

Hour Requirements:

The Ph.D. requires the completion of 90 hours, of which between 30 and 60 must be research and dissertation (7994). At least 27 hours must be mathematics courses (excluding research and dissertation) numbered 5000 or higher. Up to 50% of these 5000 or higher course hours can be transferred, subject to the advisory committee's approval and Graduate School guidelines. Courses used toward a M.S. in mathematics may be used toward a Ph.D. as well.

Course Requirements:

There are no specific course requirements for the Ph.D. degree. The actual selection of courses is the prerogative of the student's advisory committee. However the intent is that each program be broadly based. The following recommendations are offered for each of the two program options.

Mathematics: It is strongly recommended that each student have the following courses or their equivalent in his/her background.

Introduction to Abstract Algebra	MATH 4124
Elementary Real Analysis	MATH 4225-4226
Elementary Complex Analysis	MATH 4234
Elementary Topology	MATH 4324

Mathematical Physics: The Ph.D. option in mathematical physics is offered jointly by the Mathematics and Physics Departments. This program requires extensive preparation in both mathematics and physics. The student's background should include the following or their equivalent:

Introduction to Abstract Algebra	MATH 4124
Elementary Real Analysis	MATH 4225-4226

Typical core courses for the program are:

Real Analysis	MATH 5225, 5226
Functional Analysis	MATH 6225, 6256
Classical Mechanics	PHYS 5354
Classical Electricity and Magnetism	PHYS 5405, 5406
Quantum Mechanics	PHYS 5455, 5456

A sequence (listed under both Math and Physics) that is usually taken concurrent with the student's research is: Mathematical Foundations of Quantum Mechanics PHYS 6755, 6756

Many students also include Abstract Algebra (MATH 5125, 5126), Statistical Mechanics (PHYS 5705, 5706), or one of the applied math sequences 5245, 5246; 5425, 5426; 5435, 5436 in their plans of study.

Bioinformatics: The university's Ph.D. program in Genomics, Bioinformatics, and Computational Biology (GBCB) is distinct from the Mathematics Ph.D. program. Math students may choose to concentrate on one or more of those fields while pursuing a Ph.D. in Mathematics. To enter the GBCB Ph.D. program students should apply through the Graduate School.

Preliminary Examinations:

The Mathematics Department employs preliminary examinations to help insure the level of preparation of doctoral candidates. Each candidate is required to take and pass written examinations in three fields closely allied with the student's plan of study or to take and pass two such examinations in addition to writing and successfully defending a M.S. thesis in Mathematics at Virginia Tech. The available examination topics are

- Abstract Algebra
- Calculus of Variations and Optimal Control

- Complex Analysis
- Functional Analysis
- Numerical Analysis
- Ordinary Differential Equations
- Real Analysis
- Applied PDEs
- Numerical Methods for PDEs
- Mathematical Methods for Modeling and Simulation of Biological Systems

(An exam in Topology has also been offered, although suitable preparation for this topic requires some individual study beyond existing courses. An exam in Mathematics Education has been offered recently.)

Preliminary examinations are given twice a year, once in the summer and once before the beginning of the Spring semester. A student who does not pass a given examination on the initial attempt is permitted to be re-examined once more at a later date; but a student may not substitute an examination on a different topic for one the student has previously failed.

After successful completion of the written examinations, the student must take a comprehensive oral examination, administered by the student's advisory committee. Under ordinary circumstances, a doctoral candidate is expected to take this oral examination before the start of the third year after entering the Ph.D. program.

Dissertation:

The dissertation is the centerpiece of the Ph.D.–it is the fundamental research experience that doctoral studies lead to. Students should start considering possible thesis advisors as soon as they enter the Ph.D. program. The process of identifying a thesis advisor will involve some discussion of research interests and perhaps a period of interaction allowing the student and potential advisor to become familiar with each other before an agreement to work together is reached. Once an agreement is reached with an advisor, an advisory committee is formed to oversee the writing of the doctoral dissertation and to judge its acceptability. The doctoral candidate will be expected to enroll in Math 7994 whenever actively engaged in dissertation research/writing.

The dissertation project takes the student beyond the relatively passive role of receiving knowledge presented in courses to become an active, self-motivated scholar. The doctoral student becomes responsible for his/her own mastery of a research topic to the point of making an original and significant contribution to it. The student's advisor provides guidance and advice as appropriate for the student's project. The scope of this guidance includes formulating the goals of the project, choice and use of research methods, making the various judgments that arise in the course of the project and preparation of the final thesis according to appropriate standards. The work of the dissertation is expected to be of such quality as to merit publication in a scholarly journal, after appropriate revisions. When the dissertation research and writing are completed, a doctoral candidate must defend the thesis at a final oral examination. It should be noted that this final examination is open to the entire faculty of the university and that questions may be asked that do not pertain directly to the thesis being defended.

Additional Requirements:

The student's advisory committee may prescribe additional requirements beyond the above course and examination requirements. These may include reading proficiency in a foreign language, competency with particular computer languages or software tools, specific course requirements in addition to those described above, and/or whatever other training, skills, or experiences the committee judges to be important to the candidate's chosen research direction and career plans. Such additional requirements should be stipulated in writing at the time of submission of the student's plan of study with signatures of all members of the

advisory committee as well as the student. Changes to these requirements will require the consent of the advisory committee, following the same rules as for changes to the plan of study itself.

Assistantships

Most graduate students in the Mathematics Department are supported by a graduate teaching assistantship (GTA) or other kinds of assistantships. Except in special circumstances, these are awarded during the winter and spring for the following academic year and are continued each year that satisfactory progress is made toward the degree. An annual evaluation of students' progress is made by the Graduate Program Committee during the winter. Several rules and policies applying to those holding assistantships are described below.

Students must enroll for 12 hours while on an assistantship for the Fall and Spring Semesters. (There are no hour requirements for students on assistantships during summer sessions.) Students not engaged in thesis projects are expected to enroll in 9 hours of course work per semester, and an additional 3 hours of research and thesis to complete the 12 hours. (This applies even to students on a non-thesis plan.) Students on GTAs must keep their grade point average above 3.0.

Students making satisfactory progress are normally allowed GTA support for 2 years of work in the M.S. program and 4 years of work in the Ph.D. program. Support beyond these periods is only granted by special permission of the Graduate Program Committee.

A GTA is an employee of the Mathematics Department and must follow the guidelines set by the Department for performance of his/her duties. All GTAs are expected to complete the Department's teaching certification process during their first year in the program. Those who fail to complete teaching certification by the end of the first year or who fail to demonstrate the skills and work habits necessary for satisfactory performance as a GTA risk losing financial support. The Graduate School imposes additional certification requirements for international students. The Graduate Teaching Assistant Manual contains more on the departmental certification process and guidelines.

Graduate Assistants who have not completed the teaching certification process are generally given assisting duties with an instructor of a large class, in one of the Department's tutoring or computer labs, or in the Math Emporium. Graduate Assistants who have completed the teaching certification process may be assigned to teach their own classes under the supervision of the GTA Coordinator. The usual teaching load is one class during Fall and one class during Spring[3]. Graduate Assistants who are teaching for the first and second time are assigned a faculty mentor who will observe the class a few times, review tests and grades, and provide a written evaluation to the GTA Coordinator at the end of the semester. After two semesters of teaching experience, GTAs who are teaching participate in the peer mentor program administered by the senior GTAs. Both the faculty mentor program and the peer mentor program are overseen by the GTA Coordinator, who observes every teacher in the classroom, reviews mid-term and end-of-semester student evaluations, and provides support for all aspects of a GTA's teaching responsibilities. Graduate Assistants who will be teaching for the first time should plan to come to campus one week before the start of classes in August to participate in a teaching orientation and training workshop as required by the Graduate School and the terms of the GTA agreement. In addition to the academic year assistantships, there are a limited number of positions in the summer. Graduate students may apply to teach or assist in one class during the summer.

Each year every graduate student fills out a Graduate Student Activity Report. On this document the student summarizes his/her academic and GTA activities for the year and indicates plans for the year ahead. The information provided is important for the annual evaluation by the Graduate Program Committee. It is also the vehicle by which a student registers the intent to take preliminary examinations, requests summer teaching assignments, and applies for admission to the Ph.D. program from the M.S. program.

Other Publications

Other publications with important information for graduate students and GTAs are the following:

[3]GTAs beyond their first year who have not passed the teaching certification or who are not teaching will be given increased duties to ensure that their workload is no less than that of a GTA who is assigned to teach.

Graduate Policies and Procedures and Course Catalogue (Virginia Tech)
(www.graduateschool.vt.edu/graduate_catalog)

Introduction to Graduate Study in Mathematics: Advanced Degree Programs at Virginia Tech (Department of Mathematics)
(www.math.vt.edu/grGeneralInfo.php)

The Graduate Teaching Assistant Manual (Department of Mathematics, see link to SGTA Homepage under "Graduate Program" at www.math.vt.edu)

Master's Presentation Guidelines (Department of Mathematics)
www.math.vt.edu/people/day/advice/MSpres(20120214).pdf

Teaching Mathematics: A Handbook for Graduate Teaching Assistants

Contact Information

Department of Mathematics:

460 McBryde Hall	(540) 231-6536
Virginia Tech	info@math.vt.edu
Blacksburg, VA 24061-0123	www.math.vt.edu

Graduate School:

Graduate Life Center	(540) 231-6691
Virginia Tech	www.graduateschool.vt.edu
Blacksburg, VA 24061-0325	

University Non-discrimination Statement: Virginia Tech does not discriminate against employees, students, or applicants for admission or employment on the basis of race, gender, disability, age, veteran status, national origin, religion, sexual orientation, or political affiliation. Anyone having questions concerning discrimination should contact the Office for Equity and Inclusion at (540) 231-7500.