GRADUATE PROGRAMS IN MATHEMATICS
Policies and Degree Requirements
March, 2004

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 brochure describes primarily 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. For departmental rules the authority for this rests with the Graduate Program Committee. Requests for special consideration should be made through the Graduate Program Director. For 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.

Each Fall, just prior to the start of classes, the Department provides orientation programs for new graduate students. 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.

Advising & General Requirements

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. The advisor helps the student design his/her program 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 review the program of study and any subsequent changes.

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 faculty members with expertise suitable for the student’s research area. Once an agreement is reached with an advisor, a committee of 5 faculty members is identified and the Ph.D. program of

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1 Exceptions are possible, with the Department Head’s approval.
study is developed. This should be completed by the end of the first year in the Ph.D. program.

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 program of study and any subsequent revisions. For Ph. D. committees the advisory committee members conduct the oral examination and certification of any additional requirements, by substitute or proxy if appropriate. Committee members also provide consultation and advice for the student’s thesis project, and serve on the thesis defense committee, again by substitute or proxy if appropriate. 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 time².

Evaluation of transfer credit (if any) is made in the process of developing the program of study. Once signed by the advisory committee the program 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 in the student's final semester.

Graduate students should consult with their advisors at least once a semester at the time of registration for classes, and additionally whenever any schedule 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 a foolish student who neglects to take advantage of that advice and plans his/her studies without guidance. Full time students not engaged in thesis projects are expected to enroll in 9 hours of course work per semester. Grades of C or less are considered substandard. Students should maintain a QCA of at least 3.0.

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 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 program 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

² The evaluation of faculty in their role as advisors and advisory committee members is the responsibility of the Personnel Committee.
develop an appropriate program of study at the very outset of his/her graduate studies.

**Hour Requirements** For any of the degree options the student's Program 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 6 hours of transfer credit may be used, subject to the advisory committee’s approval and Graduate School guidelines.)

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**Explanation of Course Categories (these categories are not mutually exclusive):**
- **4000 approved** This means 4000-level courses which are approved for graduate credit. Such courses are identified in the Graduate Policies and Procedures and Course Catalogue.
- **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 10 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 Program 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 include in his/her Program of Study, each of the following:
1. Abstract Algebra (4124)
2. Elementary Real Analysis (4225,4226)
3. 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 Program 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)

**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 program 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 program 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 some form of 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 agrees to chair the student's advisory
committee and direct the student's dissertation is a major consideration. These
internal applicants are weighed against new applicants to the program who have
completed a master's degree elsewhere.

**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 42 hours of transfer credit can be used, 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 4124
- Elementary Real Analysis 4225, 4226
- Elementary Complex Analysis 4234
- Elementary Topology 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 PHYSICS 5354
- Classical Electricity and Magnetism PHYSICS 5405, 5406
- Quantum Mechanics PHYSICS 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** 6755, 6756

Many students also include Abstract Algebra (MATH 5125, 5126), Statistical Mechanics (PHYSICS 5705, 5706), or one of the applied math sequences 5245, 5246; 5425, 5426; 5435, 5436 in their programs 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 program of study or to take and pass two such examinations in addition to writing and successfully defending a M.S. thesis in Mathematics. 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**

(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 early in the Fall semester and once in 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 program 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 program 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 or in one of the Department’s tutoring or computer labs. 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 two classes (of the same course) during one semester and one class during the other semester. 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.

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.
Other Publications

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

- **Graduate Policies and Procedures and Course Catalogue** (Virginia Tech) (http://www.vt.edu/academics/gcat/)
- **Introduction to Graduate Study in Mathematics: Advanced Degree Programs at Virginia Tech** (Department of Mathematics, http://www.math.vt.edu/academic/graduate/introduction/introduction.html)
- **The Graduate Teaching Assistant Manual** (Department of Mathematics, see link to SGTA Homepage under “Graduate Program” at http://www.math.vt.edu)
- **Master's Presentation Guidelines** (Department of Mathematics, http://www.math.vt.edu/people/day/advice/MSPresent.pdf )
- **Teaching Mathematics: A Handbook for Graduate Teaching Assistants**

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