

HANDBOOK FOR MATHEMATICS MAJORS

**General Information for All Mathematics Options
and a Description of the Traditional Option**

Department of Mathematics
Virginia Polytechnic Institute & State University

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Introduction

The purpose of this handbook is to advise you, the mathematics student, about the Mathematics Department and the curriculum for the Bachelor of Science degree in Mathematics. There are four different paths or options that you may follow towards a B.S. degree in Mathematics: (1) The Traditional Option, (2) The Applied Computational Mathematics Option (ACM), (3) The Applied Discrete Mathematics Option (ADM), and (4) The Mathematics Education Option.

The Traditional Option, as its name implies, yields a broad and flexible background in mathematics. The other three options are more specialized. The ACM Option is designed for students who are confident that they want to have an applied mathematics career in an area closely associated with physics, some form of engineering, etc. The ADM Option is designed for students who are confident that they want to have an applied mathematics career in an area closely associated with computer science. The Education Option is designed for students who are confident that they want to teach high-school or middle-school mathematics.

Often students will begin their studies in the Traditional Option, and later change to one of the other three options when they become surer of the path that they wish to pursue. One, however, can acquire many aspects of the three specialized options within the Traditional Option, because it also requires some degree of specialization in an applications area and provides career development features. The three specialized options are each less general but bring particular career paths into sharper focus. A student who is interested in graduate study should seek advice early and often about the degree option, coursework, and research experience that provide the best preparation for graduate work in the student's area of interest.

This handbook will give details about requirements that are common to all four options and it will also describe the graduation checklist for the Traditional Option. Three other handbooks, which describe the three other options, are available on the Mathematics Department website.

Department Location

The Mathematics faculty offices are located on the 4th and 5th floors of McBryde Hall. The departmental office is 460 McBryde. The receptionist on duty can answer many questions you may have and direct you to an appropriate person for answers to other questions. Our website (www.math.vt.edu) may also help to answer questions you may have.

Scholarships

To be considered for a university scholarship, students must complete an application in Scholarship Central: <https://vt.academicworks.com>. All students are encouraged to submit an application, which allows consideration for all scholarships across the university, including Math Department and College of Science scholarships. Applications should be completed by the end of January. Students are encouraged to provide additional information to assist with scholarship decisions by filling out the form at: <https://forms.gle/zWNBLYpR58HVmyWu8>. Decisions will be made either at the end of the spring semester or at the beginning of the fall semester.

The Math Department has several scholarship programs including the Carl A. Persinger Scholarship/Fellowship for Mathematics, Daniel S. Kim Memorial Scholarship, David P. Roselle Scholarship, John C. and Elsie M. Layman Scholarship, Lee R. and Regina Aultice Steeneck Endowed Scholarship, Marion V. Eckert and Charlotte H. Eckert Scholarship in Mathematics, Math Department Award, Patricia A. Caldwell Endowed Scholarship in Mathematics, Ray A. Gaskins Scholarship in Mathematics, Richard L. and Georgia W. Kimball - Norfolk Southern Scholarship, T.W. Hatcher Math Scholarship, The Kathleen Wampler & Forrest Dryden Rollins Scholarship in Mathematics, and the Wilbur Francis Wells Memorial Scholarship. Some of these scholarships have more than one recipient.

Through these scholarships, in a typical year the Mathematics Department awards over \$65,000 to 30+ students with a majority going to continuing students.

Governance of the Undergraduate Curriculum

The Undergraduate Mathematics Curriculum is ultimately governed by the Mathematics Faculty, the Department Chair, and the Associate Chair. However, the faculty, Chair, and Associate Chair are advised by the Undergraduate Program Committee (UPC) and advisory committees for each of the three specialized options. These committees are concerned with all matters pertaining to the curriculum of undergraduate mathematics majors. The committees discuss all suggested changes in requirements and all suggested changes in 3000- and 4000-level mathematics courses in the curriculum. Finally, the committees rule on requests by individual students to depart from the standard programs.

Academic Advisors

You are assigned a faculty advisor to help you in planning your undergraduate program, registering for classes, and many other aspects of undergraduate educational life. The Central Advising Team will keep records of your progress toward a degree. You should keep records as well, because it is also your responsibility to monitor your progress toward degree.

In addition to your assigned academic advisor, the Mathematics Department has a designated Career Advisor, Dr. Lizette Zietsman. She will work with your academic advisor to provide information that will aid you in planning a career-oriented program. Regular email notices about career opportunities, career fairs, and campus interviews will be sent to students. In addition, you can explore the career resources posted on the Math Department's website.

The Undergraduate Mathematics Curriculum

The curriculum of each of the four degree options is designed to give you a solid foundation in the basic areas of mathematics with supporting background in applied areas. The specific requirements are:

University:

- (1) All students are required to maintain an average grade of 2.0 (2.0 GPA) in all attempted courses, **and** for all courses in the student's major. The in-major GPA is available on your DARS report.
- (2) No course used to fulfill major, minor, or University/College Curriculum for Liberal Education or Pathways requirements may be taken pass/fail (unless the course is only offered P/F).
- (3) Only students with GPA of 2.0 or above and who have completed at least 30 credit hours at Virginia Tech may take elective courses pass/fail (unless the course is only offered P/F). Students may count no more than 12 credits of elective courses at Virginia Tech as P/F. This limit does not include courses only offered P/F.
- (4) Of the 120 credits required for graduation, a student may count no more than 2 credits of Physical Education Service Activities (listed under HNFE) credit, no more than 8 credits of Music Ensemble (MUS 3314 and 3414), and no more than 12 credits of Independent Study and/or Undergraduate Research (2974, 2994, 4974, 4994). There is a University foreign language requirement – see the Undergraduate Catalog for details.

College: The College of Science requires a total of 120 credits. Refer to the checksheet for each mathematics degree option for details.

Department (Satisfactory progress toward the B.S. in Mathematics): Satisfactory progress toward the Bachelor of Science degree in Mathematics involves required 1000-level and 2000-level math classes and MATH 3034. Refer to the checksheet for any of the mathematics degree options for details on specific progress to degree requirements.

Department (Traditional Option¹): The university and college requirements are supplemented by the following departmental requirements:

- (1) A minimum of 44 credits of mathematics, including MATH 1225-1226, 2204, 2114, 2214, 3034, 3124, 3214, 3224, 3144, and 12 credits of 4000-level mathematics subject to the restrictions on the Guide Sheet at the end of this booklet.

(2) A minimum of 12 credits of math-related coursework. See “Math-Related Courses” on the next page of this handbook.

(3) A minimum of 3 credits from a computer programming course. MATH 1454 or MATH 3054, Intro to / Programming for Mathematical Problem Solving, are very good options for this.

Comments on the Traditional Curriculum

A. Math Requirements:

MATH 1225 and 1226 are the standard mathematics courses for your freshman year. These courses introduce you to the language, techniques and applications of single-variable calculus. Credit is available for MATH 1225 and 1226 through the C.E.E.B. calculus advanced-placement test. Incoming freshmen should check with the summer orientation advisor(s) about AP credit and about credit-by-examination.

Paralleling the standard versions of MATH 2214, 2114, and 2204 are "honors" sections of the same material. Honors sections cover the material in more depth than standard courses and may include a few extra topics. However, there is no material presented in regular sections that is not also covered in honors sections. If you are interested in honors classes and you are not in the Honors College, you will need a recommendation to take the honors course at VT. For continuing students, this recommendation is in the form of a letter sent to our Undergraduate Program Coordinator, Sadie Powell. For new students, consult with an orientation advisor.

In addition to MATH 2214, 2114, and 2204, MATH 3034 should be taken during the sophomore year. Much of MATH 3034 is an introduction to creating logical proofs. This course bridges a gap between the largely calculation-based nature of the calculus sequence and the fundamental-reasoning nature of the junior-level courses. The difference between calculus and higher-level mathematics courses is analogous to the difference between high school algebra and high school geometry.

The junior-level courses are MATH 3124 (modern algebra), MATH 3214 (a course in the calculus of several variables), MATH 3224 (a proof-based perspective on single-variable calculus), and MATH 3144 (an advanced treatment of the linear algebra begun in 2114). These courses should not be viewed as applied courses, but rather as courses that build mathematical foundations necessary for most senior-level courses. Exceptional students may substitute MATH 4124 for 3124, MATH 4225 for Math 3224, and/or MATH 4226 for Math 3214.

There are a wide variety of 4000-level courses. The student should select these courses to augment a chosen applications area. One may also choose fundamental extensions of junior-level courses in preparation for graduate school. Twelve credits are required. Six of these credits must come from a sequence or cluster listed on the Guide Sheet at the end of this handbook. Not more than one course is allowed from 4044 and 4334. Not more than one course is allowed from 4564 and 4425. 4574, 4625, 4626, 4644, 4654, and 4664 are not allowed. With departmental permission, advanced students are also allowed to take graduate courses.

See the mathematics course requirements for the other three options in their respective handbooks.

B. Math-Related Courses:

A coherent program of courses in fields other than mathematics, but in which mathematics is used significantly, is valuable as part of a general education in mathematics and is extremely valuable for employment opportunities. In light of this, you are required to work with your advisor to complete a plan of “math-related courses.” The plan should be submitted at the beginning of your third year at Virginia Tech.

The plan must meet the following requirements:

1. It must contain at least 12 credits of course work.
2. These courses should be from departments other than Mathematics. (Independent Study or Field Study course is sometimes allowed as a math-related course.)
3. The plan must exhibit depth in at least one application area.

4. The plan must contain courses in an area to which mathematics can be applied. Popular concentrations recently have been in computational modeling and data analytics, statistics, actuarial science, and physics.

A math-related course plan form, to be filled out with the help of your advisor, can be found on the Math Department advising website.

C. Electives:

There are at least 21 credits of free electives in this curriculum. (You may obtain more electives by selecting math-related courses which also satisfy other requirements.) Exercise care in choosing your electives. You have opportunities at a university which exist nowhere else. Choosing electives is one way for you to tailor your formal education individually. The ability to choose your own applications area and free electives makes this degree both strong and flexible.

(Usually if you do not have a prerequisite for a course, you should not take the course. Sometimes, however, the listed prerequisites are not absolutely necessary or are made unnecessary by other work you have done. To corroborate the necessity of the prerequisite, you can contact a faculty member from the department teaching the course.)

SPECIAL OPPORTUNITIES FOR ALL MATHEMATICS MAJORS

The Honors Program

Several academic departments in the College of Science, including the Mathematics Department, offer special Honors sections of their courses. In addition to special sections of some courses, the Honors Office sponsors a colloquia series each semester. The colloquia explore special topics not in the University Curriculum. Details about the Honors College can be found at <http://www.honorscollege.vt.edu>. Students may also contact the Mathematics Department Honors Advisor, Dr. Nick Loehr.

Undergraduate Research

Mathematics majors are encouraged to sign up for MATH 4994 - Undergraduate Research to obtain an experience in mathematical research. The department currently sponsors the John C. and Elsie M. Layman Prize competition, held on Reading Day each spring semester, for the best project and paper in Undergraduate Research. For more information, students may contact the Math Department Undergraduate Research Coordinator, Dr. Matthias Chung.

Accelerated Undergraduate/Graduate Degree Program in Mathematics

The Accelerated Undergraduate/Graduate Degree program is intended to allow especially talented undergraduate students to progress quickly into graduate-level study. The principal feature of the program is that it allows the students to use 12 credits of graduate work simultaneously toward the completion of their bachelor's degree and a program of study leading to a master's degree. It is this ability to complete the final year of undergraduate work with the same courses that comprise the first year of graduate work that makes it possible to finish both degrees in five years. For more information, students should contact the Math Department Graduate Admissions Chair, Tao Lin and consult: https://www.math.vt.edu/content/dam/math_vt_edu/documents/accel-u-g-degree.pdf .

Dual Majors

The Registrar has permission to list two majors on your undergraduate transcript if you satisfy graduation requirements for two curricula and request the Registrar to list both. Dual majors with computer science, engineering, statistics, computational modeling and data analytics, or physics are popular choices that yield excellent

degrees. You may obtain two diplomas by taking an additional 30 credits of coursework beyond the requirements of the primary major.

Minors

Any department which offers a major may offer a minor. If you desire a minor in a particular discipline, consult the appropriate checksheet for requirements. Minors will be listed on your undergraduate transcript.

The Cooperative Education and Internship Program

As a math major, you are encouraged to participate in the Cooperative Education and Internship Program. This program allows you to integrate some work experiences with your academic studies. You can gain experience as well as help finance your education with a co-op. For more details contact the Career and Professional Development office in the Smith Career Center, see the Mathematics Career Advisor, and consult the following website: <https://career.vt.edu/experience/ceip.html>

Activities

Undergraduate and graduate students in mathematics are invited to join the Virginia Tech university chapters of MAA (The Mathematical Association of America), Association for Women in Mathematics (AWM), and SIAM (Society for Industrial and Applied Mathematics). The activities of these chapters include talks on mathematics used in government and industry, as well as social, recreational, and charitable activities.

Virginia Tech has a chapter of Pi Mu Epsilon, a national organization whose purpose is the promotion of scholarly activity in mathematics. Outstanding math majors may be nominated for membership in this organization in their junior or senior years.

The Putnam Mathematics Examination

Each December a nation-wide mathematics examination, the William Lowell Putnam Competition, is given. The examination is graded for individual performances and carries a considerable amount of prestige. In addition, each participating school selects three students whose composite score represents the school. Cash prizes are awarded to participating Virginia Tech students based on their scores.

The Putnam Competition only covers material from undergraduate mathematics, including concepts from analysis, linear algebra, and number theory. In this regard, the problems are “elementary”, but often quite tricky. The best way to prepare for the examination is to practice on previous examinations or similar problems. To this end, problem seminars are organized in the fall to work through previous examinations and to select a team for the upcoming examination. These seminars and the experience of the examination can be a rewarding mathematical experience. Students will improve their math skills and develop self-reliance in mathematics. For further information, contact Dr. Martin Klaus, 472 McBryde, klaus@math.vt.edu.

Virginia Tech Regional Math Contest

The Virginia Tech Regional Math Contest is sponsored each fall by the Mathematics Department and is open to all undergraduates at Virginia Tech. More than 200 colleges and universities throughout VA, DC, GA, IL, MD, NJ, NY, OH, NC, PA, SC, TN, WV, and other states are invited to participate each year. Now approaching its 40th year, the contest began in 1979 and has grown to include over 100 schools with over 700 contestants in a typical year. The contest is similar in nature to the Putnam examination, although it is intended to be easier. Cash prizes are awarded, including local cash prizes for which only Virginia Tech students are eligible. For further information, contact Dr. Peter Linnell, 516 McBryde, plinnell@math.vt.edu.

Mathematical Contest in Modeling

In the Mathematical Contest in Modeling (MCM), three-person teams are given 96 hours to develop mathematical models to solve a real-world problem, evaluate their solution, and write a research paper describing the results. These papers are generally around thirty pages long. The questions are open-ended and over a broad range of topics. Past problems include fingerprint identification, submarine tracking, air traffic control, and velociraptor hunting strategies. The following handbook provides detailed information on this prestigious competition, in which Virginia Tech teams have done very well in recent years:

https://www.math.vt.edu/content/dam/math_vt_edu/documents/mcmguide.pdf

Senior Awards

In each of the four degree options, one student is selected each year as the outstanding senior. An overall Outstanding Senior is also selected. These students are given special recognition at the commencement exercises for that class.

Preparation for Post-Graduate Endeavors

Whether you plan to seek employment immediately upon graduation or attend graduate school, you need to start investigating and planning early in your undergraduate career. There is great value in attending career fairs and having summer internships, particularly internships that take place the summer prior to graduation. You should consult with an advisor in the Career and Professional Development office, the Math Department career advising website <https://www.math.vt.edu/undergrad-math/advising/career-advising.html>, and the Mathematics Career Advisor, Dr. Lizette Zietsman. (See the Career and Professional Development website: <http://www.career.vt.edu>)

If you are seeking employment, the Career and Professional Development office runs resume writing seminars and will also be happy to review your resume with you. (Remember the old cliché, “You never get a second chance to make a good first impression.”) You can pick up a free Career Planning Guide at the Career and Professional Development office in the Smith Career Center and you are strongly encouraged to use the Handshake platform, which connects students and employers. <http://career.vt.edu/job-search/Handshake.html>

In the present economic climate, many jobs are found by directly contacting companies; even ones who are not interviewing on campus or ones who do not say they will interview mathematics majors. Talk to a career advisor or a Career and Professional Development representative about the best ways to make these contacts.

IMPORTANT: Be sure that you never attend an interview without being fully informed about the company/agency and its work.

If you plan to go to graduate school, you should make preliminary inquiries about graduate schools early in your academic career. Talk regularly to your academic advisor and also talk to professors that may have attended the graduate school(s) in which you are interested. Many graduate schools require the Graduate Record Examination. Plan to take it in October of your senior year. Finally, allow enough time for professors to write your letters of reference.

You may wish to consider graduate work in a field other than mathematics; probably in the area of your applied concentration. One need not have a B.S. in a discipline in order to do graduate work in that area. There will, of course, be certain basic courses that you will be expected to have had. You or your advisor can easily check with the other discipline about these courses.

Some of the general areas where majors in mathematics find employment are listed below. After each title, some courses which should help you in the area are listed.

Data Analysis, with applications to science, business, or finance

Take CS 1114, STAT 3005-3006, CMDA 3654, and CMDA 4654.

Actuarial Science

The Statistics Department offers a minor in actuarial science that includes courses in probability and statistics (STAT 3005-3006, STAT 4105, STAT 4214, STAT 4534, and STAT 4706), economics (ECON 2005-6), and finance (FIN 3104, FIN 3134). Go to <https://www.stat.vt.edu/academics/undergraduate/actuarial-science.html> for more information.

Business

Include the same courses as for actuarial science, with perhaps less emphasis on statistics and more on economics. Business Law (FIN 3055-6) is a nice elective for a career in business.

Operations Research

Include courses in probability and statistics (Stat 4105-6 or 4705-6), computer science (at least CS 1044, 1054, and 1114), operations research (ISE 2404, 3414, 3424, 3614, 4404), and numerical analysis (Math 4445-6).

Statistics

Take theoretical statistics (Stat 4105-6) and choose from specific areas. A statistics minor would be valuable.

Computer Science, such as Software Engineering

Take CS 1114. Plan to get a CS minor, or very close to it. Use the CS minor checksheet for further guidance.

Finance

Take ACIS 2004, FIN 3104, and FIN 4174. Other recommended courses are ECON 2005-2006, FIN 4114, FIN 4124, and FIN 4144. The Finance courses rely on a statistical foundation such as is found in STAT 2004 or 3104.

MATHEMATICS GUIDE SHEET

FOR THE

TRADITIONAL OPTION

4000-level Mathematics Courses

1. Twelve credits must be 4000-level. (5000-level mathematics course substitutes can be discussed with your advisor.)
No 46xx course may be used for these required 12 credits.
2. At most one of 4044 and 4334 is allowed. At most one of 4425 and 4564 is allowed.
3. Math 4574 may not be taken for credit by mathematics majors.
4. A sequence or cluster must be completed from one of the following two-course sets:
[4225-6]; [4245-6]; [4425-6]; [4445-6]; [4225, 4234]; [4245, 4254]; [4245, 4454]; [4245, 4425]; [4245, 4564];
[4414, 4445]; [4414, 4446]; [5454, 5464]; [any two of 4124, 4134, 4144, 4175, 4176, 5114]
5. 4974, 4984, and 4994 can be used *only* with the express approval of the Undergraduate Program Committee.

ADVICE

Pass-Fail: All courses required by a major and all general education (CLE or Pathways) courses must be taken for grade.

- 1: Refer to the Mathematics Traditional Option checksheet for requirements of enrollment in MATH 3034.
- 2: Math-related courses are (a) usually technical and (b) always in an area to which mathematics can be applied.
- 3: Refer to the Mathematics Traditional Option checksheet for programming course requirements.
- 4: The appropriate freshman English placement is done automatically by the English Department.

Foreign Language – see the University Catalog for details.

Courses in Curriculum for Liberal Education / Pathways categories must come from the approved lists found in the Timetable of Classes.

- 5: There are at least 21 credits of electives; usually more if departmental and college requirements are combined. The Mathematics Department recommends more mathematics courses than the minimum number or more math-related courses.