

Department of Mathematics and Statistics

Program for the Upper Two Years

for January 2012

Applying to the Department

Anyone considering a major *or minor* in the Department should attend the departmental sophomore meeting early in the spring semester. The Department has a pre-application form that you should fill out online at

<http://www.swarthmore.edu/x33785.xml>

In our department, this form replaces the Registrar's Request for Sophomore Paper Advisor form; that's why you must fill it out. If you intend to major with us, in response to this form the Department will contact you and assign you to a Sophomore Paper advisor. If you intend to minor, you are encouraged to request and meet with an advisor.

Why Study in Our Department? What are the Goals?

Mathematics and Statistics are among the great achievements of human intellect and at the same time powerful tools. As Galileo said, the book of the universe "is written in the language of mathematics." The goal of the Department is to enable students to appreciate these achievements and use their power. To that end, majors and minors in the Department receive a firm foundation in pure mathematics and the opportunity to apply it – to statistics, physical science, biological science, computer science, social science, operations research, education, and finance – the list grows.

Students typically enter our department with strong skills, but there is always room for improvement and new knowledge. Majors and minors grow in:

- Reasoning skills: logical argument and abstraction.
- Formulation skills: developing mathematical models.
- Communication skills: expressing mathematical ideas and information clearly and precisely on paper, orally, and electronically.
- Comprehension skills: absorbing mathematical ideas and information presented on paper, orally, and electronically.
- Computation skills: mental, by hand, and by machine, as appropriate.

Through core courses students learn fundamental concepts, results, and methods. Through elective courses they pursue special interests. In the process students develop a further appreciation for the scope and beauty of our discipline.

Graduates of the Department follow many careers paths, leading them to graduate school, in mathematics, statistics, or other fields, to professional schools, or to the workplace.

The Mathematics Major

Acceptance into the Major

The normal preparation for a major in mathematics is to have obtained credit for, or placement out of, at least four of the following five course groups by the end of the sophomore year: Calculus I (Math 15), Calculus II (Math 25 or 26), Discrete Mathematics (Math 29), Linear Algebra (Math 27 or any flavor of 28), and Several Variable Calculus (Math 33, 34, or 35). In any event, all majors must complete the Linear Algebra and Several Variable Calculus requirement by the end of the first semester of the junior year.

To be accepted as a major or a minor, a candidate normally should have a grade point average of at least C+ in courses taken in the Department to date, including courses in the fall term of the first year, for which we have shadow grades. A candidate should have at least one grade at the B level. Students should be aware that upper-level courses in mathematics are typically more demanding and more theoretical than the first- and second-year courses. This is an important factor in considering borderline cases. In some cases, applicants may be deferred pending successful work in courses to be designated by the Department.

Basic Requirements

By graduation, a mathematics major must have at least 10 credits in mathematics and statistics courses; at least 5 of the credits counted in the 10 must be for courses numbered over 40. (Certain courses – mostly those numbered under 10 – do not count toward the major in any event. These are so indicated under the course listings in the College Bulletin.) Furthermore, every major is required to have credit for, or place out of, the following course groups:

15; 25 or 26; 27 or 28; 33, 34 or 35; 63; 67.

In the multivariate group {33,34,35}, it is *strongly preferred* that candidates for the major take 34 or 35, that is, one of the linear algebra based versions.

Note that placement counts for satisfying the requirements but not for the 10-credit rule. Those students who are placed out of courses without credit must take other courses to obtain 10 credits. If you believe you are eligible for credit for courses taken before Swarthmore (because of AP or IB scores) but these credits are not showing on your transcript, please attend to this matter now. Your application to our department may otherwise be held up.

The two *required core courses*, Introduction to Real Analysis (Math 63) and Introduction to Modern Algebra (Math 67), are offered every fall semester, and we try to create enough sections to keep them relatively small and seminar-like. We hope, but cannot promise, to offer one or the other of 63 and 67 each spring as well. At least one of these two courses should be taken no later than the fall of the junior year. Majors are expected to complete both Math 63 and 67 *before* the spring semester of the senior year; permission to delay taking either course until the senior spring must be requested in writing as early as possible but in any event no later than the beginning of the fall semester of the senior year. Finally, course majors must also pass the comprehensive requirement, Senior Conference (Math 97). *This is given in the fall only and must be taken at Swarthmore.*

The above requirements allow room to choose a special emphasis within the major, if one wishes. Students with special interests in statistics, computer science, or education, or who are thinking of graduate work in social or management science, discrete mathematics, operations research, or an MBA, should consult the current College Bulletin for more information and sample programs. In some circumstances, students who choose a special emphasis are required to take only one of 63 and 67. Also, students who major with a concentration in statistics may count Stat 31 as one of their 5 courses numbered over 40. In any event, all course majors must take the Senior Conference.

Notes

- *Transfer credits.* Courses taken elsewhere may count for the major. However, the number of upper-level transfer credits for the major is limited. Normally, *at least 3 of the 5 upper-level courses used to fulfill the major must be taken at Swarthmore, including at least one of the core courses Math 63 and Math 67.* Exceptions should be proposed and approved during the sophomore paper process, not after the fact. Also, the usual College rules for transfer credit apply: You must see the professor in charge of transfer twice: in advance to obtain authorization, and afterwards to get final approval and a determination of credit. In particular, for Math 63 and 67, you are responsible for the syllabus we use. If your course elsewhere turns out not to cover it all, you will not get full credit (even though the transfer course was authorized beforehand) and you will not complete the major until you have demonstrated knowledge of the missing topics. Similarly, for honors preparations you are responsible for the syllabi we use; we will not offer special honors exams based on work done at other institutions.
- *Foreign study.* Students planning to study abroad should obtain information well in advance about the courses available at the institution they plan to attend and check with the Department about selecting appropriate courses. It may be difficult to find courses abroad equivalent to our core upper-level courses, or to our honors preparations, since curricula in other countries are often organized differently.
- Mathematics majors are encouraged to study in some depth an additional discipline that makes use of mathematics. We also recommend that they acquire some facility with computers. Students bound for graduate work should obtain a reading knowledge of French, German, or Russian.

The Mathematics Course Minor and the Statistics Course Minor

Acceptance into the minors

The requirements for acceptance into either course minor are the same as for acceptance into the major. Students may not minor in both mathematics and statistics.

Basic requirements to complete the mathematics course minor

By graduation, a mathematics course minor must have at least 6 credits in mathematics and statistics courses. Those courses offered by the Department that do not count towards the major also do not count towards the course minor. Furthermore, every mathematics course minor is required to have credit for, or place out of, the following course groups:

15; 25 or 26; 27 or 28; 33, 34 or 35.

Every mathematics course minor must obtain at least two credits in mathematics or statistics courses whose numbers are greater than 44. (Note the difference from the majors requirement, which is 5 courses over 40.) At least one of these two credits must be obtained from Math 63 or Math 67. Also, at least one of these two credits must be taken at Swarthmore.

Basic requirements of the statistics course minor

By graduation, a statistics course minor must have at least 6 credits in mathematics and statistics courses. Those courses offered by the Department that do not count towards the major also do not count towards the statistics course minor. Furthermore, every statistics course minor is required to have credit for, or place out of, the following course groups:

15; 25 or 26; 27 or 28; 33, 34 or 35.

Every statistics course minor must receive credit for, or place out of, Stat 31 and Stat 61. At least one of Stat 31 or Stat 61 must be taken at Swarthmore. From time to time, the Department may offer variants of Stat 31, e.g., Stat 32 in Spring 2011. When the Department specifically so states (for instance, on the Registrar's course announcements webpage), such a variant has exactly the same status as Stat 31 with regard to meeting requirements. Note that CS 21 is a prerequisite for Stat 31.

The Honors Program

All current sophomores who wish to apply for Honors should indicate this in their Sophomore Paper, should work out a tentative Honors program with their departmental advisor, and should submit the College's Honors Program Application along with their Sophomore Paper. All Sophomore Paper forms and Honors forms are available from the Registrar or the Registrar's website.

The Honors Major

Basic requirements

To be accepted as an Honors major in mathematics, a student should have a grade point average in mathematics and statistics courses to date of at least B+. An Honors math major program consists of three preparations of two credits each, for a total of six distinct credits. One preparation must be in Algebra and one in Analysis (Real or Complex). The student must also satisfy all requirements of the mathematics major (e.g., 10 credits) with the exception of the comprehensive requirement (Math 97, Senior Conference).

Preparations

The Department offers preparations in the fields listed below. Each preparation is subject to External Examination, including a 3-hour written examination and a 45-minute oral examination. Each preparation consists of a specified pair of credits. The specified credits are listed after each field.

Algebra (67 and 102)
Real Analysis (63 and 101)
Complex Analysis (63 and 103)

Discrete Mathematics (69 and either 59 or 79)
Geometry (either 55 or 75, and 106)
Probability (61 and 105)
Statistics (61 and 111)
Topology (104, a 2-credit seminar)

Since no course is allowed to count in two Honors preparations, it is not possible for a student to offer both Real Analysis and Complex Analysis as fields. Similarly, one may take only one of Probability and Statistics as fields.

The External Examination component of the program is meant to prompt students to learn their core subjects really well and to show the examiners that they have done so – that is, show that they deserve Honors. However, no three fields cover everything a strong student would ideally learn as an undergraduate. Honors majors should consider including in their studies a number of advanced courses and seminars beyond what they present for Honors.

Especially strong students who do a lot of advanced courses may petition to substitute an advanced preparation for either Algebra or Analysis. For instance, a student who has taken essentially all our seminars might petition to “stand” for Algebra, Topology, and Geometry, omitting an analysis examination. However, all honors students must *take* the algebra sequence and one of the analysis sequences, even if they are given permission to stand for something else.

Senior Honors Study/ Portfolio. None is required or offered.

The Honors Minor

To be accepted as an Honors minor in mathematics, a student should have a grade point average in mathematics and statistics courses to date of at least B, and must have credit for, or placement out of the same course groups as before:

15; 25 or 26; 27 or 28; 33, 34 or 35.

For the Honors portion of their programs, minors should complete one preparation consisting of two credits. The fields are the same as those for the Honors major. All prospective minors who are majoring in a subject related to mathematics or statistics are encouraged to consult with a member of the Department to see which preparation is most appropriate to their interests. Honors minors are encouraged to take at least one of Math 63 and 67 even if it is not part of their Honors preparation. Also, students who are doing an Honors math minor as a way of showing a strength in statistics (i.e., by taking Stat 61 and 111 as their preparation) are encouraged to take a data-driven stat course as well (e.g., 11 or 31).

Program Changes and Late Applications

Students often wish to change their proposals after sophomore spring. Changes in particular courses or honors preparations do not require a new application, but changes in type of program do. For instance, if you wish to change from a course major to an honors major, or from a regular course major to a statistics concentration, or wish to add a minor in math/stat – all these things require a new application. The procedure in our department is to submit a petition that amounts to a mini sophomore paper. Please contact the chair for details.

Progress towards the Degree

The progress of majors and minors in the Department may be reviewed from time to time. Students not making satisfactory progress may be encouraged or required to modify or drop their programs.

Schedule of Upper-Level Mathematics and Statistics courses

Upper level courses in math/stat follow a 2-year periodic schedule. Many courses are offered in alternate years only (for instance, all topics courses), and topics courses have basic and advanced versions (depending on whether they have some core course as a prerequisite). Thus students must take some care to arrange their schedules so that they can take the courses that best meet their interests in the semester that those courses are offered. Students and their assigned departmental advisors should talk this over as part of the preparation for the Sophomore Paper.

For instance, one of the versions of Topics in Analysis is given in the spring of odd-numbered years. However, *which* version may not be decided until a few months before. Therefore, it is wise to assume that the advanced version will be offered and to base schedules on the assumption that the corresponding core course must be taken first. The Department announces which versions of topics courses shall be given as soon as it knows.

Below we list courses that we are confident we can offer in the semesters stated. We are hoping to increase our advanced offerings. We will inform you of new offerings by email and by postings on the Registrar's Course Announcements webpage. Also, just as in recent years we have moved to extra offerings of our core math courses in off semesters, we hope to move to offering key statistics courses in off semesters. That is, we hope to have some offerings of Stat 31 in the fall and some offerings of Stat 61 in the spring. However, we cannot promise this and thus do not list it below.

Upper Level Courses offered each year

Fall Semester

Math 63	Introduction to Real Analysis (and a spring offering every even-numbered year)
Math 67	Introduction to Modern Algebra (spring offering every odd-numbered year)
Stat 61	Probability and Mathematical Statistics I
Math 97	Senior Conference

Spring Semester

Stat 31	Data Analysis and Visualization
Math 43, 44	Differential Equations (without and with a linear algebra prerequisite; 44 is more theoretical and strongly preferred for majors)
Math 101	Real Analysis II (one-credit seminar; see next section for a fall offering)
Math 102	Modern Algebra II (one-credit seminar; see next section for a fall offering)
Stat 111	Mathematical Statistics II

Upper Level Courses offered once every two years

Fall 2012

Math 58	Number Theory
Math 55 or 75	Intermediate or Advanced Topics in Geometry (probably with emphasis on modern geometry, leading to Math 106 in the spring)
Math 69	Combinatorics (core discrete mathematics)
Math 101	Real Analysis II

Spring 2013

Math 53 or 73	Intermediate or Advanced Topics in Analysis
Math 67	Modern Algebra I
Math 105	Probability
Math 106	Advanced Topics in Geometry

Fall 2013

Math 56	Modeling
Math 59 or 79	Intermediate or Advanced Topics in Discrete Mathematics
Math 102	Modern Algebra II
Math 103	Complex Analysis

Spring 2014

Math/CS 46	Theory of Computation (given by CS; counts towards the Math major)
Math 54	Partial Differential Equations (may become a more general applied math)
Math 57 or 77	Intermediate or Advanced Topics in Algebra
Math 63	Real Analysis I
Math 104	Topology (2-credit)

Faculty leave schedules

The following continuing faculty are projected to be on sabbatical or administrative leave during at least part of the next two academic years.

For 2012-13: D. Bergstrand, G. Campbell, L. Chen, L. Schofield, H. Shapiro, D. Shimamoto
For 2013-14: C. Grood, J. Talvacchia, S. Wang