Department of Mathematics and Statistics
Program for the Upper Two Years

for February 2018

Applying to the Department

Students considering a major or minor in the Department should attend the departmental sophomore meeting early in the spring semester. They should also enter their information into the Sophomore Portal and choose "Mathematics" as one of their majors or minors. These students will be assigned a Sophomore Plan Advisor in the Department. Students intending to major in the Department are expected to meet with and discuss their proposed major with this advisor. Students intending to minor are encouraged, but not required, to meet with this advisor.

The Course Major

Acceptance as a Course 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)
- 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.

The requirements to be accepted as a course major are the following:
1. 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.
2. At least one grade in courses taken in the Department to date 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.

Graduation Requirements: Course Major in Mathematics

- At least 10 credits in mathematics and statistics courses
- At least 5 credits in mathematics and statistics courses 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.)
- Credit or placement for the following course groups:
      15; 25 or 26; 27 or 28;   33, 34 or 35;
- Credit for
    - Introduction to Real Analysis (Math 63)
    - Introduction to Modern Algebra (Math 67)
    - Senior Conference (Math 97)

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.*

Graduation Requirements: Course Major in Mathematics with an Emphasis in Statistics

- At least 10 credits in mathematics and statistics courses
- Credit or placement for the following course groups:
    15; 25 or 26; 27 or 28;   33, 34 or 35;
- Credit for
    - CS 21
    - Introduction to Real Analysis (Math 63)
    - Statistical Methods II (Stat 21)
    - Probability (Stat 51)
    - Mathematical Statistics I (Stat 61)
    - Mathematical Statistics II (Stat 111)
    - Senior Conference (Math 97)

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 computer programming.

- Students interested in Applied Math should consider taking Differential Equations (Math 44), Probability (Stat 51), Partial Differential Equations (Math 54), Mathematical Modeling (Math 56), Real Analysis (Math 63), Fundamentals of Applied Math (Math 66), and Complex Analysis (Math 103), along with Introduction to Computer Science (CS 21).

Credit/No Credit Policy

At most one upper level course counted toward the major can be taken credit/no credit. This does not include courses that are only offered credit/no credit, but does include courses for which the grade is uncovered after completion of the course. In any case, no seminar may be taken credit/no credit.

The Mathematics Course Minor and the Statistics Course Minor

Acceptance as a Course Minor

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.

Graduation Requirements: Course Minor in Mathematics

- At least 6 credits in mathematics and statistics courses. Those courses offered by the Department that do not count towards the course major also do not count towards the course minor.
- Credit or placement for the following course groups:
  15; 25 or 26; 27 or 28;   33, 34 or 35;
- At least 3 credits in mathematics and statistics courses for courses numbered over 43. (Note the difference from the course major requirement, which is 5 courses over 40.)
  - At least 2 of these 3 credits must be taken at Swarthmore.
  - One of these 3 credits must be either Introduction to Real Analysis (Math 63) or Introduction to Modern Algebra (Math 67)

Graduation Requirements: Course Minor in Statistics

- At least 6 credits in mathematics and statistics courses. Those courses offered by the Department that do not count towards the course major also do not count towards the course minor.
- Credit or placement for the following course groups:
  15; 25 or 26; 27 or 28;   33, 34 or 35;
- Credit for each of the following courses:
  - CS 21
  - Stat 21
  - Stat 51
  - Stat 61

- At least one of Stat 51 or Stat 61 must be taken at Swarthmore College.

Credit/No Credit Policy
The same rule applies to minor as it does to majors: at most one upper level course counted toward the minor can be taken credit/no credit. This does not include courses that are only offered credit/no credit, but does include courses for which the grade is uncovered after completion of the course. In any case, no seminar may be taken credit/no credit.

The Honors Program

All current sophomores who wish to apply for Honors should indicate this in the Sophomore Portal and should work out a tentative Honors program with their departmental advisor.

The Honors Major

Acceptance as an Honors Major

The requirements to be accepted as an honors major are the same as those to be accepted as a course major except that such students should have a grade point average in mathematics and statistics courses to date of at least B+.

Graduation Requirements: Honors Major
- At least 10 credits in mathematics and statistics courses
- Credit or placement for the following course groups:
  15; 25 or 26; 27 or 28; 33, 34 or 35;
- Three preparations of two credits each, for a total of six distinct credits, in the following areas:
  - Real Analysis (Math 63 and 101) *or* Complex Analysis (Math 63 and 103)
  - Modern Algebra (Math 67 and 102)
  - One of:
    - Geometry (either Math 55 or 75, and Math 106)
    - Statistics (Stat 61 and 111)
    - Topology (Math 104, a 2-credit seminar)

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 many 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 examined in 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 be examined in something else.

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

The Honors Minor

Acceptance as an Honors Minor

The requirements to be accepted as an honors minor are the same as those to be accepted as a course major except that such students should have a grade point average in mathematics and statistics courses to date of at least B.

Graduation Requirements: Honors Minor
- Credit or placement for the following course groups:
    - 15; 25 or 26; 27 or 28;   33, 34 or 35;
- One preparations consisting of two credits in one of the following areas:
    - Real Analysis (Math 63 and 101)
    - Complex Analysis (Math 63 and 103)
    - Modern Algebra (Math 67 and 102)
    - Geometry (either Math 55 or 75, and Math 106)
    - Statistics (Stat 61 and 111)
    - Topology (Math 104, a 2-credit seminar)

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 21).

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 major with an emphasis in statistics, or wish to add a minor in math/stat – all these things require a new application. The past procedure in our department is to submit a petition that amounts to a mini sophomore paper; the college is moving towards having this done via the sophomore portal. 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 Plan.

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 will inform you of new offerings by email and by postings on the Registrar's Course Announcements webpage.

Upper Level Courses offered each year

Fall Semester
    Math 63   Introduction to Real Analysis
    Math 67   Introduction to Modern Algebra
    Stat 51   Probability
    Math 97   Senior Conference

Spring Semester
    Math 43, 44   Differential Equations (without and with a linear algebra prerequisite;
                       44 is more theoretical and strongly preferred for majors)
    Stat 61   Mathematical Statistics I
    Math 101   Real Analysis II
    Math 102   Modern Algebra II
    Stat 111   Mathematical Statistics II

Stat 41 (Topics in Statistics) will be offered at least one semester each year.

Upper Level Courses offered once every two years (or additional sections added every other year)

Fall 2018

    Math 58   Number Theory
    Math 55 or 75 Intermediate or Advanced Topics in Geometry
    Math 69   Combinatorics
    Math 101   Real Analysis II - tentative

Spring 2019

    Math 53 or 73 Intermediate or Advanced Topics in Analysis
    Math 66   Fundamentals of Applied Math
    Math 67   Modern Algebra I – tentative
    Math 106   Advanced Topics in Geometry

Fall 2019

    Math 56   Mathematical Modeling
    Math 102   Modern Algebra II - tentative
    Math 103   Complex Analysis

Spring 2020

    Math 54   Partial Differential Equations
    Math 57 or 77 Intermediate or Advanced Topics in Algebra
    Math 63   Real Analysis I - tentative
    Math 104   Topology (2-credit)

Faculty leave schedules
The following continuing faculty are projected to be on sabbatical during at least part of the next two academic years.
        For 2018-19: V. Barranca, R. Gomez , C. Grood, T. Hunter
        For 2019-20: N. Giansircusa, M. Mavinga, L. Schofield