Another requirement for majors is participation in an undergraduate seminar, usually in the junior or senior year. In these seminars, students gain experience in learning an advanced topic and lecturing on it. In order to be eligible for departmental honors, majors must write a senior thesis.

Courses for First-Year Students

The systematic study of mathematics begins with one of the following three alternative calculus and linear algebra sequences:

| MATH UN1101 | CALCULUS I |
| MATH UN1102 | and Calculus II |
| MATH UN1201 | and Calculus III |
| MATH UN1202 | and Calculus IV |
| MATH UN2010 | and Linear Algebra |

| MATH UN1101 | CALCULUS I |
| MATH UN1102 | and Calculus II |
| MATH UN1205 | and Accelerated Multivariable Calculus |
| MATH UN2010 | and Linear Algebra |

| MATH UN1101 | CALCULUS I |
| MATH UN1102 | and Calculus II |
| MATH UN1207 | and Honors Mathematics A |
| MATH UN1208 | and Honors Mathematics B |

Credit is allowed for only one calculus and linear algebra sequence.

Calculus I, II is a standard course in single-variable differential and integral calculus; Calculus III, IV is a standard course in multivariable differential and integral calculus; Accelerated Multivariable Calculus is an accelerated course in multivariable differential and integral calculus.

While Calculus II is no longer a prerequisite for Calculus III, students are strongly urged to take it before taking Calculus III. In particular, students thinking of majoring or concentrating in mathematics or one of the joint majors involving mathematics should take Calculus II before taking Calculus III. Note that Calculus II is a prerequisite for Accelerated Multivariable Calculus, and both Calculus II and Calculus III are prerequisites for Calculus IV.

The third sequence, Honors Mathematics A - B, is for exceptionally well-qualified students who have strong Advanced Placement scores. It covers multivariable calculus (MATH UN1201 Calculus III - MATH UN1202 Calculus IV) and linear algebra (MATH UN2010 Linear Algebra), with an emphasis on theory.

MATH UN1003 College Algebra and Analytic Geometry does not count toward the degree. Students who take this course do not receive college credit.

Advanced Placement

The department grants 3 credits for a score of 4 or 5 on the AP Calculus AB exam provided students complete MATH UN1102 Calculus II or MATH UN1201 Calculus III with a grade of C or better. The department grants 3 credits for a score of 4 on the AP Calculus BC exam provided students complete MATH UN1102 Calculus II or MATH UN1201 Calculus III with a grade of C or better. The department grants 6 credits for a score of 5 on the AP Calculus BC exam provided students complete MATH UN1201 Calculus III or MATH UN1205 Accelerated Multivariable Calculus MATH UN1207 Honors Mathematics A with a grade of C or better. Students can receive credit for only one calculus sequence.
Placement in the Calculus Sequences

Calculus I
Students who have essentially mastered a precalculus course and those who have a score of 3 or less on an Advanced Placement (AP) exam (either AB or BC) should begin their study of calculus with MATH UN1101 CALCULUS I.

Calculus II and III
Students with a score of 4 or 5 on the AB exam, 4 on the BC exam, or those with no AP score but with a grade of A in a full year of high school calculus may begin with either MATH UN1102 Calculus II or MATH UN1201 Calculus III. Note that such students who decide to start with Calculus III may still need to take Calculus II since it is a requirement or prerequisite for other courses. In particular, they MUST take Calculus II before going on to MATH UN1202 Calculus IV. Students with a score of 5 on the BC exam may begin with Calculus III and do not need to take Calculus II.

Those with a score of 4 or 5 on the AB exam or 4 on the BC exam may receive 3 points of AP credit upon completion of Calculus II with a grade of C or higher. Those students with a score of 5 on the BC exam may receive 6 points of AP credit upon completion of Calculus III with a grade of C or higher.

Accelerated Multivariable Calculus
Students with a score of 5 on the AP BC exam or 7 on the IB HL exam may begin with MATH UN1205 Accelerated Multivariable Calculus. Upon completion of this course with a grade of C or higher, they may receive 6 points of AP credit.

Honors Mathematics A
Students who want a proof-oriented theoretical sequence and have a score of 5 on the BC exam may begin with MATH UN1207 Honors Mathematics A, which is especially designed for mathematics majors. Upon completion of this course with a grade of C or higher, they may receive 6 points of AP credit.

Transfers Inside the Calculus Sequences
Students who wish to transfer from one calculus course to another are allowed to do so beyond the date specified on the Academic Calendar. They are considered to be adjusting their level, not changing their program. However, students must obtain the approval of the new instructor and their advising dean prior to reporting to the Office of the Registrar.

Grading
No course with a grade of D or lower can count toward the major, interdepartmental major, or concentration. Students who are doing a double major cannot double count courses for their majors.

Departmental Honors
In order to be eligible for departmental honors, majors must write a senior thesis. To write a senior thesis, students must register for MATH UN3999 Senior Thesis in Mathematics in the fall semester of their senior year. Normally no more than 10% of graduating majors receive departmental honors in a given academic year.

Professors
- Mohammed Abouzaid
- David A. Bayer (Barnard)
- Simon Brendle
- Ivan Corwin
- Panagiota Daskalopoulos
- Aise Johan de Jong
- Robert Friedman (Department Chair)
- Dorian Goldfeld
- Brian Greene
- Richard Hamilton
- Michael Harris
- Ioannis Karatzas
- Mikhail Khovanov
- Igor Krichever
- Chiu-Chu Liu
- Dusa McDuff (Barnard)
- Walter Neumann (Barnard)
- Andrei Okounkov
- D. H. Phong
- Henry Pinkham
- Ovidiu Savin
- Michael Thaddeus
- Eric Urban
- Mu-Tao Wang

Associate Professors
- Daniela De Silva (Barnard Chair)
- Julien Dubedat

Assistant Professors
- Amol Aggarwal
- Chao Li
- Francesco Lin
- Giulia Sacca
- Will Sawin

J.F. Ritt Assistant Professors
- Andrew Ahn
- Konstantin Aleshkin
- Evgeni Dimitrov
- Alexandra Florea
- Florian John
- Yash Jhaveri
- Inbar Klang
- Shotaro Makisumi
- Konstantin Matetski
- S. Michael Miller
- Henri Roesch
- Nicholas Salter
- Gus Schrader
- Akash Sengupta
Major in Mathematics
The major requires 40-42 points as follows:

Select one of the following three calculus and linear algebra sequences (13-15 points including Advanced Placement Credit):

<table>
<thead>
<tr>
<th>Sequence 1</th>
<th>Sequence 2</th>
<th>Sequence 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH UN1101 - MATH UN1102 - MATH UN1201 - MATH UN1202 - MATH UN2010</td>
<td>MATH UN1101 - MATH UN1102 - MATH UN1205 - MATH UN2010</td>
<td>MATH UN1101 - MATH UN1102 - MATH UN1207 - MATH UN1208</td>
</tr>
<tr>
<td>CALCULUS I and Calculus II and Calculus III and Calculus IV and Linear Algebra</td>
<td>CALCULUS I and Calculus II and Accelerated Multivariable Calculus and Linear Algebra</td>
<td>CALCULUS I and Calculus II and Honors Mathematics A and Honors Mathematics B</td>
</tr>
</tbody>
</table>

15 points in the following required courses:

<table>
<thead>
<tr>
<th>Course 1</th>
<th>Course 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH UN3951 - MATH UN3952</td>
<td>MATH GU4032</td>
</tr>
<tr>
<td>Undergraduate Seminars in Mathematics I and Undergraduate Seminars in Mathematics II (at least one term)</td>
<td>INTRO MODERN ANALYSIS I</td>
</tr>
</tbody>
</table>

12 points in any combination of mathematics and cognate courses. **

* Students who are not contemplating graduate study in mathematics may replace one or both of the two terms of MATH GU4061- MATH GU4062 by one or two of the following courses: MATH UN2500 Analysis and Optimization, MATH UN3007 Complex Variables, MATH UN3028 Partial Differential Equations, or MATH GU4032 Fourier Analysis.

** A course not taught by the Mathematics Department is a cognate course for the mathematics major if either (a) it has at least two semesters of calculus as a stated prerequisite and is a 2000-level (or higher) course, or (b) the subject matter in the course is mathematics beyond an elementary level, such as PHIL UN3411 Symbolic Logic, in the Philosophy Department, or COMS W3203 Discrete Mathematics: Introduction to Combinatorics and Graph Theory, in the Computer Science Department. In exceptional cases, the director of undergraduate studies may approve the substitution of certain more advanced courses for those mentioned above.

The program of study should be planned with a departmental adviser before the end of the sophomore year. Majors who are planning on graduate studies in mathematics are urged to obtain a reading knowledge of one of the following languages: French, German, or Russian.

Majors are offered the opportunity to write an honors senior thesis under the guidance of a faculty member. Interested students should contact the director of undergraduate studies.

Major in Applied Mathematics
The major requires 38-40 points as follows:

Select one of the following three calculus and linear algebra sequences (13-15 points including Advanced Placement Credit):

<table>
<thead>
<tr>
<th>Sequence 1</th>
<th>Sequence 2</th>
<th>Sequence 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH UN1101 - MATH UN1102 - MATH UN1201 - MATH UN1202 - MATH UN2010</td>
<td>MATH UN1101 - MATH UN1102 - MATH UN1205 - MATH UN2010</td>
<td>MATH UN1101 - MATH UN1102 - MATH UN1207 - MATH UN1208</td>
</tr>
<tr>
<td>CALCULUS I and Calculus II and Calculus III and Calculus IV and Linear Algebra</td>
<td>CALCULUS I and Calculus II and Accelerated Multivariable Calculus and Linear Algebra</td>
<td>CALCULUS I and Calculus II and Honors Mathematics A and Honors Mathematics B</td>
</tr>
</tbody>
</table>

Select one of the following three courses:

<table>
<thead>
<tr>
<th>Course 1</th>
<th>Course 2</th>
<th>Course 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH UN2500</td>
<td>MATH GU4032</td>
<td>APMA E4901</td>
</tr>
<tr>
<td>Analysis and Optimization</td>
<td>Fourier Analysis</td>
<td>Seminar: Problem in Applied Mathematics (junior year)</td>
</tr>
</tbody>
</table>

18 points in electives, selected from the following (other courses may be used with the approval of the Applied Mathematics Committee):

<table>
<thead>
<tr>
<th>Course 1</th>
<th>Course 2</th>
<th>Course 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH UN2500</td>
<td>MATH UN3007</td>
<td>MATH UN3027</td>
</tr>
<tr>
<td>Analysis and Optimization</td>
<td>Complex Variables</td>
<td>Ordinary Differential Equations</td>
</tr>
<tr>
<td>or MATH GU4065</td>
<td>or APMA E4204</td>
<td>or MATH UN3028</td>
</tr>
<tr>
<td>Honors Complex Variables</td>
<td>Functions of a Complex Variable</td>
<td>Partial Differential Equations</td>
</tr>
<tr>
<td>or APMA E4200</td>
<td>or MATH GU4032</td>
<td>Partial Differential Equations</td>
</tr>
<tr>
<td>or APMA E6301</td>
<td>or APMA E4300</td>
<td>Analytic methods for partial differential equations</td>
</tr>
<tr>
<td>or MATH GU4032</td>
<td>or Computational Math: Introduction to Numerical Methods</td>
<td>Fourier Analysis</td>
</tr>
<tr>
<td>or APMA E4300</td>
<td>or APMA E4101</td>
<td>Introduction to Dynamical Systems</td>
</tr>
</tbody>
</table>
Major in Computer Science–Mathematics

The goal of this interdepartmental major is to provide substantial background in each of these two disciplines, focusing on some of the parts of each which are closest to the other. Students intending to pursue a Ph.D. program in either discipline are urged to take additional courses, in consultation with their advisers.

The major requires 20 points in computer science, 19-21 points in mathematics, and two 3-point electives in either computer science or mathematics.

**Computer Science**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>COMS W1004</td>
<td>Introduction to Computer Science and Programming in Java</td>
</tr>
<tr>
<td>or COMS W1007</td>
<td>Honors Introduction to Computer Science</td>
</tr>
<tr>
<td>COMS W3134</td>
<td>Data Structures in Java</td>
</tr>
<tr>
<td>or COMS W3137</td>
<td>Honors Data Structures and Algorithms</td>
</tr>
<tr>
<td>COMS W3157</td>
<td>Advanced Programming</td>
</tr>
<tr>
<td>COMS W3203</td>
<td>Discrete Mathematics: Introduction to Combinatorics and Graph Theory</td>
</tr>
<tr>
<td>COMS W3261</td>
<td>Computer Science Theory</td>
</tr>
<tr>
<td>CSEE W3827</td>
<td>Fundamentals of Computer Systems</td>
</tr>
</tbody>
</table>

**Mathematics**

Select one of the following sequences:

<table>
<thead>
<tr>
<th>Sequence</th>
<th>Calculus I</th>
<th>and Calculus II</th>
<th>and Calculus III</th>
<th>and Calculus IV</th>
<th>and Linear Algebra</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH UN1101</td>
<td>MATH UN1102</td>
<td>MATH UN1201</td>
<td>MATH UN2010</td>
<td>MATH UN2010</td>
<td></td>
</tr>
<tr>
<td>MATH UN1101</td>
<td>MATH UN1102</td>
<td>MATH UN1205</td>
<td>MATH UN2010</td>
<td>MATH UN2010</td>
<td></td>
</tr>
<tr>
<td>MATH UN1101</td>
<td>MATH UN1102</td>
<td>MATH UN1207</td>
<td>MATH UN2010</td>
<td>MATH UN2010</td>
<td></td>
</tr>
<tr>
<td>MATH UN1101</td>
<td>MATH UN1102</td>
<td>MATH UN1208</td>
<td>MATH UN2010</td>
<td>MATH UN2010</td>
<td></td>
</tr>
</tbody>
</table>

MATH UN3951 | Undergraduate Seminars in Mathematics I

or MATH UN3952 | Undergraduate Seminars in Mathematics II

MATH GU4041 | INTRO MODERN ALGEBRA I

**Electives**

Select two of the following courses:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSOR W4231</td>
<td>Analysis of Algorithms I</td>
</tr>
<tr>
<td>COMS W4241</td>
<td>Numerical Algorithms and Complexity</td>
</tr>
<tr>
<td>MATH BC2006</td>
<td>Combinatorics</td>
</tr>
<tr>
<td>MATH UN2500</td>
<td>Analysis and Optimization</td>
</tr>
<tr>
<td>MATH UN3007</td>
<td>Complex Variables</td>
</tr>
<tr>
<td>MATH UN3020</td>
<td>Number Theory and Cryptography</td>
</tr>
<tr>
<td>MATH UN3386</td>
<td>Differential Geometry</td>
</tr>
<tr>
<td>MATH GU4051</td>
<td>Topology</td>
</tr>
<tr>
<td>MATH GU4061</td>
<td>INTRO MODERN ANALYSIS I</td>
</tr>
</tbody>
</table>

**Major in Economics-Mathematics**

**Major in Mathematics-Statistics**

The program is designed to prepare the student for: (1) a career in industries such as finance and insurance that require a high level of mathematical sophistication and a substantial knowledge of probability and statistics, and (2) graduate study in quantitative disciplines. Students choose electives in finance, actuarial science, operations research, or other quantitative fields to complement requirements in mathematics, statistics, and computer science.

**Mathematics**

Select one of the following sequences:

<table>
<thead>
<tr>
<th>Sequence</th>
<th>Calculus I</th>
<th>and Calculus II</th>
<th>and Calculus III</th>
<th>and Calculus IV</th>
<th>and Linear Algebra</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH UN1101</td>
<td>MATH UN1102</td>
<td>MATH UN1201</td>
<td>MATH UN2010</td>
<td>MATH UN2010</td>
<td></td>
</tr>
<tr>
<td>MATH UN1101</td>
<td>MATH UN1102</td>
<td>MATH UN1205</td>
<td>MATH UN2010</td>
<td>MATH UN2010</td>
<td></td>
</tr>
<tr>
<td>MATH UN1101</td>
<td>MATH UN1102</td>
<td>MATH UN1207</td>
<td>MATH UN2010</td>
<td>MATH UN2010</td>
<td></td>
</tr>
<tr>
<td>MATH UN1101</td>
<td>MATH UN1102</td>
<td>MATH UN1208</td>
<td>MATH UN2010</td>
<td>MATH UN2010</td>
<td></td>
</tr>
</tbody>
</table>

MATH UN3951 | Undergraduate Seminars in Mathematics I

or MATH UN3952 | Undergraduate Seminars in Mathematics II

MATH GU4041 | INTRO MODERN ALGEBRA I

**Statistics**

**Introductory Course**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>STAT UN1201</td>
<td>Calculus-Based Introduction to Statistics</td>
</tr>
</tbody>
</table>

**Required Courses**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>STAT GU4203</td>
<td>PROBABILITY THEORY</td>
</tr>
<tr>
<td>STAT GU4204</td>
<td>Statistical Inference</td>
</tr>
<tr>
<td>STAT GU4205</td>
<td>Linear Regression Models</td>
</tr>
</tbody>
</table>

Select one of the following courses:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>STAT GU4207</td>
<td>Elementary Stochastic Processes</td>
</tr>
<tr>
<td>STAT GU4262</td>
<td>Stochastic Processes for Finance</td>
</tr>
<tr>
<td>STAT GU4264</td>
<td>STOCHASTIC PROCESSES-APPLIC</td>
</tr>
<tr>
<td>STAT GU4265</td>
<td>Stochastic Methods in Finance</td>
</tr>
</tbody>
</table>

**Computer Science**

Select one of the following courses:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>COMS W1004</td>
<td>Introduction to Computer Science and Programming in Java</td>
</tr>
<tr>
<td>COMS W1005</td>
<td>Introduction to Computer Science and Programming in MATLAB</td>
</tr>
<tr>
<td>ENGI E1006</td>
<td>Introduction to Computing for Engineers and Applied Scientists</td>
</tr>
<tr>
<td>COMS W1007</td>
<td>Honors Introduction to Computer Science</td>
</tr>
</tbody>
</table>

or an advanced computer science offering in programming

**Electives**

An approved selection of three advanced courses in mathematics, statistics, applied mathematics, industrial engineering and operations research, computer science, or approved mathematical methods courses in a quantitative discipline. At least one elective must be a Mathematics Department course numbered 3000 or above.
Students interested in modeling applications are recommended to take MATH UN3027 Ordinary Differential Equations and MATH UN3028 Partial Differential Equations.

Students interested in finance are recommended to take MATH GR5010 Introduction to the Mathematics of Finance, STAT GU4611 Statistical Methods in Finance, and STAT GU4221 Time Series Analysis.

Students interested in graduate study in mathematics or in statistics are recommended to take MATH GU4061 INTRO MODERN ANALYSIS I and MATH GU4062 INTRO MODERN ANALYSIS II.

Students preparing for a career in actuarial science are encouraged to take STAT GU4205 Linear Regression Models and STAT GU4206 Statistical Methods in Finance.

Students interested in finance are recommended to take MATH UN3027 Ordinary Differential Equations and MATH UN3028 Partial Differential Equations.

MATH 1003
Number: 11290
Fall 2020: MATH UN1003
Course Number: 1003
Times/Location: M W 6:10pm - 7:25pm
Instructor: Alexander Pieloch
Points: 3
Enrollment: 26/30

MATH 1003
Number: 11291
Fall 2020: MATH UN1003
Course Number: 1003
Times/Location: T Th 2:40pm - 3:55pm
Instructor: M Rudul Thate
Points: 3
Enrollment: 18/30

Concentration in Mathematics

The concentration requires the following:

Mathematics

Select one of the following three multivariable calculus and linear algebra sequences:

- MATH UN1201 - MATH UN1202 - MATH UN2010 Calculus III and Honors Mathematics A
- MATH UN1205 - MATH UN2010 Accelerated Multivariable Calculus and Honors Mathematics B

Additional Courses

Select at least 12 additional points from any of the courses offered by the department numbered 2000 or higher.

For mathematics courses taken in other departments, consult with the director of undergraduate studies.

Any course given by the Mathematics department fulfills the General Studies quantitative reasoning requirement when passed with a satisfactory letter grade.

MATH UN1003 College Algebra and Analytic Geometry. 3 points.
Prerequisites: score of 550 on the mathematics portion of the SAT completed within the last year or the appropriate grade on the General Studies Mathematics Placement Examination.

Columbia College students do not receive any credit for this course and must see their CSA advising dean. For students who wish to study calculus but do not know analytic geometry. Algebra review, graphs and functions, polynomial functions, rational functions, conic sections, systems of equations in two variables, exponential and logarithmic functions, trigonometric functions and trigonometric identities, applications of trigonometry, sequences, series, and limits.

MATH UN1101 CALCULUS I. 3.00 points.
Prerequisites: (see Courses for First-Year Students). Functions, limits, derivatives, introduction to integrals, or an understanding of pre-calculus will be assumed. (SC)

Fall 2020: MATH UN1101
Course Number: 1101
Times/Location: M W 10:10am - 11:25am
Instructor: Daniele Alessandri
Points: 3.00
Enrollment: 16/116

MATH UN1101
Number: 1102
Fall 2020: MATH UN1101
Course Number: 1102
Times/Location: M W 11:40am - 12:55pm
Instructor: Daniele Alessandri
Points: 3.00
Enrollment: 21/116

MATH UN1101
Number: 1103
Fall 2020: MATH UN1101
Course Number: 1103
Times/Location: M W 1:10pm - 2:25pm
Instructor: Akash Sengupta
Points: 3.00
Enrollment: 78/110

MATH UN1101
Number: 1104
Fall 2020: MATH UN1101
Course Number: 1104
Times/Location: M W 2:40pm - 3:55pm
Instructor: Akash Sengupta
Points: 62/110

MATH UN1101
Number: 1105
Fall 2020: MATH UN1101
Course Number: 1105
Times/Location: M W 4:10pm - 5:25pm
Instructor: Chun Hsiang Kwan
Points: 22/30

MATH UN1101
Number: 1106
Fall 2020: MATH UN1101
Course Number: 1106
Times/Location: T Th 10:10am - 11:25am
Instructor: George Dragomir
Points: 50/100

MATH UN1101
Number: 1107
Fall 2020: MATH UN1101
Course Number: 1107
Times/Location: T Th 2:40pm - 3:55pm
Instructor: Robin Zhang
Points: 30/30

MATH UN1101
Number: 1108
Fall 2020: MATH UN1101
Course Number: 1108
Times/Location: T Th 1:10pm - 2:25pm
Instructor: George Dragomir
Points: 46/100

MATH UN1101
Number: 1109
Fall 2020: MATH UN1101
Course Number: 1109
Times/Location: T Th 11:40am - 12:55pm
Instructor: Panagiotis Daskalopoulos
Points: 28/100

MATH UN1102 Calculus II. 3 points.
Prerequisites: MATH UN1101 or the equivalent.
Methods of integration, applications of the integral, Taylor's theorem, infinite series. (SC)

Fall 2020: MATH UN1102
Course Number: 1102
Times/Location: M W 11:40am - 12:55pm
Instructor: Maithrey Sengupta
Points: 3
Enrollment: 23/30

MATH UN1102
Number: 1103
Fall 2020: MATH UN1102
Course Number: 1103
Times/Location: M W 2:40pm - 3:55pm
Instructor: Zachary Sengupta
Points: 20/100

MATH UN1102
Number: 1104
Fall 2020: MATH UN1102
Course Number: 1104
Times/Location: M W 4:10pm - 5:25pm
Instructor: Zachary Sengupta
Points: 8/110

MATH UN1102
Number: 1105
Fall 2020: MATH UN1102
Course Number: 1105
Times/Location: T Th 2:40pm - 3:55pm
Instructor: Lindsay Dieckmann
Points: 43/100

MATH UN1102
Number: 1106
Fall 2020: MATH UN1102
Course Number: 1106
Times/Location: T Th 6:10pm - 7:25pm
Instructor: Elliott Stein
Points: 21/45

MATH UN1102
Number: 1107
Fall 2020: MATH UN1102
Course Number: 1107
Times/Location: T Th 11:40am - 12:55pm
Instructor: Renata Picciotto
Points: 9/30

MATH 1100
Number: 1100
Fall 2020: MATH UN1100
Course Number: 1100
Times/Location: M W 6:10pm - 7:25pm
Instructor: Alexander Pieloch
Points: 3
Enrollment: 26/30

MATH 1100
Number: 1101
Fall 2020: MATH UN1100
Course Number: 1101
Times/Location: M W 6:10pm - 7:25pm
Instructor: M Rudul Thate
Points: 3
Enrollment: 18/30

MATH 1100
Number: 1102
Fall 2020: MATH UN1100
Course Number: 1102
Times/Location: T Th 2:40pm - 3:55pm
Instructor: M Rudul Thate
Points: 3
Enrollment: 18/30

MATH 1100
Number: 1103
Fall 2020: MATH UN1100
Course Number: 1103
Times/Location: T Th 2:40pm - 3:55pm
Instructor: M Rudul Thate
Points: 3
Enrollment: 18/30
MATH UN1201 Calculus III. 3 points.
Prerequisites: MATH UN1101 or the equivalent
Vectors in dimensions 2 and 3, complex numbers and the complex exponential function with applications to differential equations, Cramer's rule, vector-valued functions of one variable, scalar-valued functions of several variables, partial derivatives, gradients, surfaces, optimization, the method of Lagrange multipliers. (SC)

MATH UN1202 Calculus IV. 3 points.
Prerequisites: MATH UN1102 and MATH UN1201 or the equivalent
Multiple integrals, Taylor's formula in several variables, line and surface integrals, calculus of vector fields, Fourier series. (SC)

MATH UN2010 Linear Algebra. 3 points.
Prerequisites: MATH UN1101 or the equivalent.
Matrices, vector spaces, linear transformations, eigenvalues and eigenvectors, canonical forms, applications. (SC)

MATH UN2030 Ordinary Differential Equations. 3 points.
Prerequisites: MATH UN1102 and MATH UN1201 or the equivalent.
MATH UN2500 Analysis and Optimization. 3 points.
Prerequisites: MATH UN1102 and MATH UN1201 or the equivalent and MATH UN2010.

Fall 2020: MATH UN2500
<table>
<thead>
<tr>
<th>Course</th>
<th>Section/Call Number</th>
<th>Times/Location</th>
<th>Instructor</th>
<th>Points</th>
<th>Enrollment</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 2500</td>
<td>001/11464</td>
<td>T Th 1:10pm - 2:25pm Online Only</td>
<td>Kanstantin Matetski</td>
<td>3</td>
<td>50/64</td>
</tr>
<tr>
<td>MATH 2500</td>
<td>002/11466</td>
<td>T Th 2:40pm - 3:55pm Online Only</td>
<td>Kanstantin Matetski</td>
<td>3</td>
<td>47/64</td>
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</table>

MATH UN3007 Complex Variables. 3 points.
Prerequisites: MATH UN2012 An elementary course in functions of a complex variable.
Fundamental properties of the complex numbers, differentiability, Cauchy-Riemann equations. Cauchy integral theorem. Taylor and Laurent series, poles, and essential singularities. Residue theorem and conformal mapping. (SC)

Fall 2020: MATH UN3007
<table>
<thead>
<tr>
<th>Course</th>
<th>Section/Call Number</th>
<th>Times/Location</th>
<th>Instructor</th>
<th>Points</th>
<th>Enrollment</th>
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<tr>
<td>MATH 3007</td>
<td>001/11470</td>
<td>M W 2:40pm - 3:55pm Online Only</td>
<td>Nicholas Salter</td>
<td>3</td>
<td>64/64</td>
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</table>

MATH UN3020 Number Theory and Cryptography. 3 points.
Prerequisites: one year of calculus.
Prerequisite: One year of Calculus. Congruences. Primitive roots. Quadratic residues. Contemporary applications.

MATH UN3025 Making, Breaking Codes. 3 points.
Prerequisites: (MATH UN1101 and MATH UN1102 and MATH UN1201) and MATH UN2010.
A concrete introduction to abstract algebra. Topics in abstract algebra used in cryptography and coding theory.

Fall 2020: MATH UN3025
<table>
<thead>
<tr>
<th>Course</th>
<th>Section/Call Number</th>
<th>Times/Location</th>
<th>Instructor</th>
<th>Points</th>
<th>Enrollment</th>
</tr>
</thead>
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<tr>
<td>MATH 3025</td>
<td>001/11471</td>
<td>T Th 1:10pm - 2:25pm Online Only</td>
<td>Dorian Goldfeld</td>
<td>3</td>
<td>98/116</td>
</tr>
</tbody>
</table>

MATH UN3027 Ordinary Differential Equations. 3 points.
Prerequisites: MATH UN1102 and MATH UN1201 or the equivalent.
Corequisites: MATH UN2010

Fall 2020: MATH UN3027
<table>
<thead>
<tr>
<th>Course</th>
<th>Section/Call Number</th>
<th>Times/Location</th>
<th>Instructor</th>
<th>Points</th>
<th>Enrollment</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 3027</td>
<td>001/11478</td>
<td>T Th 11:40am - 12:55pm Online Only</td>
<td>Simon Brendle</td>
<td>3</td>
<td>68/116</td>
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</table>

MATH UN3028 Partial Differential Equations. 3 points.
Prerequisites: MATH UN3027 and MATH UN2010 or the equivalent

MATH UN3050 Discrete Time Models in Finance. 3 points.
Prerequisites: (MATH UN1102 and MATH UN1201) or (MATH UN1101 and MATH UN1102 and MATH UN1201) and MATH UN2010
Recommeded: MATH UN3027 (or MATH UN2030 and SIEO W3600).
Elementary discrete time methods for pricing financial instruments, such as options. Notions of arbitrage, risk-neutral valuation, hedging, term-structure of interest rates.

MATH UN3386 Differential Geometry. 3 points.
Prerequisites: MATH UN1202 or the equivalent.
Local and global differential geometry of submanifolds of Euclidean 3-space. Frenet formulas for curves. Various types of curvatures for curves and surfaces and their relations. The Gauss-Bonnet theorem.

Fall 2020: MATH UN3386
<table>
<thead>
<tr>
<th>Course</th>
<th>Section/Call Number</th>
<th>Times/Location</th>
<th>Instructor</th>
<th>Points</th>
<th>Enrollment</th>
</tr>
</thead>
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<tr>
<td>MATH 3386</td>
<td>001/11484</td>
<td>T Th 11:40am - 12:55pm Online Only</td>
<td>Richard Hamilton</td>
<td>3</td>
<td>36/49</td>
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</tbody>
</table>

MATH UN3951 Undergraduate Seminars in Mathematics I. 3 points.
Prerequisites: Two years of calculus, at least one year of additional mathematics courses, and the director of undergraduate studies' permission.
The subject matter is announced at the start of registration and is different in each section. Each student prepares talks to be given to the seminar, under the supervision of a faculty member or senior teaching fellow.

Fall 2020: MATH UN3951
<table>
<thead>
<tr>
<th>Course</th>
<th>Section/Call Number</th>
<th>Times/Location</th>
<th>Instructor</th>
<th>Points</th>
<th>Enrollment</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 3951</td>
<td>001/00120</td>
<td>T Th 11:40am - 12:55pm Online Only</td>
<td>Daniela De Silva</td>
<td>3</td>
<td>35/64</td>
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</tbody>
</table>

MATH UN3952 Undergraduate Seminars in Mathematics II. 3 points.
Prerequisites: Two years of calculus, at least one year of additional mathematics courses, and the director of undergraduate studies' permission.
The subject matter is announced at the start of registration and is different in each section. Each student prepares talks to be given to the seminar, under the supervision of a faculty member or senior teaching fellow. Prerequisite: two years of calculus, at least one year of additional mathematics courses, and the director of undergraduate studies' permission.

MATH GU4007 Analytic Number Theory. 3 points.
Prerequisites: MATH UN3007
A one semester course covering the theory of modular forms, zeta functions, L-functions, and the Riemann hypothesis. Particular topics covered include the Riemann zeta function, the prime number theorem, Dirichlet characters, Dirichlet L-functions, Siegel zeros, prime number theorem for arithmetic progressions, SL (2, Z) and subgroups, quotients of the upper half-plane and cusps, modular forms, Fourier expansions of modular forms, Hecke operators, L-functions of modular forms.
MATH GU4032 Fourier Analysis. 3 points.
Prerequisites: three terms of calculus and linear algebra or four terms of
calculus. Prerequisite: three terms of calculus and linear algebra or four terms of
calculus. Fourier series and integrals, discrete analogues, inversion
and Poisson summation formulae, convolution. Heisenberg uncertainty
principle. Stress on the application of Fourier analysis to a wide range of
disciplines.

MATH GU4041 INTRO MODERN ALGEBRA I. 3 points.
Prerequisites: MATH UN1102 and MATH UN1202 and MATH UN2010 or
the equivalent.
The second term of this course may not be taken without the first.
Groups, homomorphisms, rings, ideals, fields, polynomials, field
extensions, Galois theory.

Fall 2020: MATH GU4041
Course  | Section/Call  | Times/Location | Instructor | Points | Enrollment
--------|---------------|---------------|------------|--------|-------------
MATH 4041 | 001/11487     | M W 2:40pm - 3:55pm | Robert Friedman | 3       | 99/110
          |               | Online Only               |            |        |

MATH GU4042 INTRO MODERN ALGEBRA II. 3 points.
Prerequisites: MATH UN1102 and MATH UN1202 and MATH UN2010 or
the equivalent.
The second term of this course may not be taken without the first. Rings,
homomorphisms, ideals, integral and Euclidean domains, the division
algorithm, principal ideal and unique factorization domains, fields,
algebraic and transcendental extensions, splitting fields, finite fields,
Galois theory.

Fall 2020: MATH GU4042
Course  | Section/Call  | Times/Location | Instructor | Points | Enrollment
--------|---------------|---------------|------------|--------|-------------
MATH 4042 | 001/11488     | M W 1:10pm - 2:25pm | Mikhail Khovanov | 3       | 17/35
          |               | Online Only               |            |        |

MATH GU4043 Algebraic Number Theory. 3 points.
Prerequisites: MATH GU4041 and MATH GU4042 or the equivalent
Algebraic number fields, unique factorization of ideals in the ring of
algebraic integers in the field into prime ideals. Dirichlet unit theorem,
finiteness of the class number, ramification. If time permits, p-adic
numbers and Dedekind zeta function.

MATH GU4044 Representations of Finite Groups. 3 points.
Prerequisites: MATH UN2010 and MATH GU4041 or the equivalent.
Finite groups acting on finite sets and finite dimensional vector
spaces. Group characters. Relations with subgroups and factor groups.
Arithmetic properties of character values. Applications to the theory of
finite groups: Frobenius groups, Hall subgroups and solvable groups.
Characters of the symmetric groups. Spherical functions on finite groups.

Fall 2020: MATH GU4044
Course  | Section/Call  | Times/Location | Instructor | Points | Enrollment
--------|---------------|---------------|------------|--------|-------------
MATH 4044 | 001/11490     | T Th 1:10pm - 2:25pm | Chao Li | 3       | 15/19
          |               | Online Only               |            |        |

MATH GU4045 Algebraic Curves. 3 points.
Prerequisites: (MATH GU4041 and MATH GU4042) and MATH UN3007
Plane curves, affine and projective varieties, singularities, normalization,
Riemann surfaces, divisors, linear systems, Riemann-Roch theorem.

MATH GU4051 Topology. 3 points.
Prerequisites: (MATH UN1202 and MATH UN2010) and rudiments of
theory (e.g., MATH GU4041). MATH UN1208 or MATH GU4061 is
recommended, but not required.
Metric spaces, continuity, compactness, quotient spaces. The
fundamental group of topological space. Examples from knot theory and
surfaces. Covering spaces.

Fall 2020: MATH GU4051
Course  | Section/Call  | Times/Location | Instructor | Points | Enrollment
--------|---------------|---------------|------------|--------|-------------
MATH 4051 | 001/11491     | T Th 11:40am - 12:55pm | Stephen Miller | 3       | 40/64
          |               | Online Only               |            |        |

MATH GU4053 Introduction to Algebraic Topology. 3 points.
Prerequisites: MATH UN2010 and MATH GU4041 and MATH GU4051
The study of topological spaces from algebraic properties, including the
essentials of homology and the fundamental group. The Brouwer fixed
point theorem. The homology of surfaces. Covering spaces.

MATH GU4061 INTRO MODERN ANALYSIS I. 3 points.
Prerequisites: MATH UN1102 or the equivalent, and MATH UN2010. The
second term of this course may not be taken without the first.
Prerequisites: MATH UN1202 or the equivalent, and MATH UN2010.
The second term of this course may not be taken without the first. Real
numbers, metric spaces, elements of general topology, sequences and
series, continuity, differentiation, integration, uniform convergence,
Ascoli-Arzelà theorem, Stone-Weierstrass theorem.

Fall 2020: MATH GU4061
Course  | Section/Call  | Times/Location | Instructor | Points | Enrollment
--------|---------------|---------------|------------|--------|-------------
MATH 4061 | 001/11494     | T Th 2:40pm - 3:55pm | Henri Roesch | 3       | 47/100
          |               | Online Only               |            |        |
MATH 4061 | 002/11495     | T Th 4:10pm - 5:25pm | Henri Roesch | 3       | 34/100
          |               | Online Only               |            |        |

MATH GU4052 Introduction to Knot Theory. 3 points.
CC/GS: Partial Fulfillment of Science Requirement
Prerequisites: MATH GU4051 Topology and / or MATH GU4061
Introduction To Modern Analysis I (or equivalents). Recommended (can be
taken concurrently): MATH UN2010 linear algebra, or equivalent.
The study of algebraic and geometric properties of knots in $\mathbb{R}^3$, including
but not limited to knot projections and Reidemeister's theorem, Seifert
surfaces, braids, tangles, knot polynomials, fundamental group of knot
complements. Depending on time and student interest, we will discuss
more advanced topics like knot concordance, relationship to 3-manifold
topology, other algebraic knot invariants.

MATH GU4062 Introduction To Modern Analysis II. 3 points.
Prerequisites: MATH UN1202 or the equivalent, and MATH UN2010. The
second term of this course may not be taken without the first.
Real numbers, metric spaces, elements of general topology. Continuous
and differential functions. Implicit functions. Integration; change of
variables. Function spaces.
MATH GU4065 Honors Complex Variables. 3 points.
Prerequisites: (MATH UN1207 and MATH UN1208) or MATH GU4061
A theoretical introduction to analytic functions. Holomorphic functions, harmonic functions, power series, Cauchy-Riemann equations, Cauchy's integral formula, poles, Laurent series, residue theorem. Other topics as time permits: elliptic functions, the gamma and zeta function, the Riemann mapping theorem, Riemann surfaces, Nevanlinna theory.

Fall 2020: MATH GU4065

Course Number | Section/Call Number | Times/Location | Instructor | Points | Enrollment
--- | --- | --- | --- | --- | ---
MATH 4065 | 001/11503 | T Th 10:10am - 11:25am | Julien Dubédat | 3 | 30/45

MATH GU4081 Introduction to Differentiable Manifolds. 3 points.
Prerequisites: (MATH GU4051 or MATH GU4061) and MATH UN2010

Fall 2020: MATH GU4081

Course Number | Section/Call Number | Times/Location | Instructor | Points | Enrollment
--- | --- | --- | --- | --- | ---
MATH 4081 | 001/12050 | M W 7:40pm - 8:55pm | Mikhail Smirnov | 3 | 77/140

MATH GU4155 Probability Theory. 3 points.
Prerequisites: MATH GU4061 or MATH UN3007

Fall 2020: MATH GU4155

Course Number | Section/Call Number | Times/Location | Instructor | Points | Enrollment
--- | --- | --- | --- | --- | ---
MATH 4155 | 001/14322 | T Th 4:10pm - 5:25pm | Peter Woit | 3 | 34/40

MATH GU4391 INTRO TO QUANTUM MECHANICS. 3 points.
This course will focus on quantum mechanics, paying attention to both the underlying mathematical structures as well as their physical motivations and consequences. It is meant to be accessible to students with no previous formal training in quantum theory. The role of symmetry, groups and representations will be stressed.

Fall 2020: MATH GU4391

Course Number | Section/Call Number | Times/Location | Instructor | Points | Enrollment
--- | --- | --- | --- | --- | ---
MATH 4391 | 001/14322 | T Th 4:10pm - 5:25pm | Peter Woit | 3 | 34/40

MATH GU4392 INTRO TO QUANTUM MECHANICS II. 3.00 points.
Not offered during 2020-21 academic year.

Continuation of GU4391. This course will focus on quantum mechanics, paying attention to both the underlying mathematical structures as well as their physical motivations and consequences. It is meant to be accessible to students with no previous formal training in quantum theory. The role of symmetry, groups and representations will be stressed.

MATH GR5010 Introduction to the Mathematics of Finance. 3 points.
Prerequisites: MATH UN1102 and MATH UN1201, or their equivalents.
Introduction to mathematical methods in pricing of options, futures and other derivative securities, risk management, portfolio management and investment strategies with an emphasis of both theoretical and practical aspects. Topics include: Arithmetic and Geometric Brownian motion processes, Black-Scholes partial differential equation, Black-Scholes option pricing formula, Ornstein-Uhlenbeck processes, volatility models, risk models, value-at-risk and conditional value-at-risk, portfolio construction and optimization methods.

Fall 2020: MATH GR5010

Course Number | Section/Call Number | Times/Location | Instructor | Points | Enrollment
--- | --- | --- | --- | --- | ---
MATH 5010 | 001/12050 | M W 7:40pm - 8:55pm | Mikhail Smirnov | 3 | 77/140

Of Related Interest

Computer Science

COMS W3203 | Discrete Mathematics: Introduction to Combinatorics and Graph Theory
COMS W3251 | COMPUTATIONAL LINEAR ALGEBRA
COMS W4203 | Graph Theory

Industrial Engineering and Operations Research

CSOR E4010 | Graph Theory: A Combinatorial View