The major in mathematics is an introduction to some of the highlights of the development of theoretical mathematics over the past four hundred years from a modern perspective. This study is also applied to many problems, both internal to mathematics and arising in other disciplines such as physics, cryptography, and finance.

Majors begin by taking either Honors mathematics or the calculus sequence. Students who do not take MATH UN1207 Honors Mathematics A and MATH UN1208 Honors Mathematics B normally take MATH UN2010 LINEAR ALGEBRA in the second year. Following this, majors begin to learn some aspects of the main branches of modern mathematics: algebra, analysis, and geometry; as well as some of their subdivisions and hybrids (e.g., number theory, differential geometry, and complex analysis). As the courses become more advanced, they also become more theoretical and proof-oriented and less computational.

Aside from the courses offered by the Mathematics Department, cognate courses in areas such as astronomy, chemistry, physics, probability, logic, economics, and computer science can be used toward the major. A cognate course must be a 2000-level (or higher) course and must be approved by the director of undergraduate studies. In general, 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, 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, in the Computer Science Department.

Another requirement for majors is participation in an undergraduate seminar, usually in the junior or senior year. Applied math majors must take the undergraduate seminar in both the junior and 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:

<table>
<thead>
<tr>
<th>Sequence 1</th>
<th>Sequence 2</th>
<th>Sequence 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH UN1101</td>
<td>MATH UN1102</td>
<td>MATH UN1201</td>
</tr>
<tr>
<td>- MATH UN1102</td>
<td>and MATH UN1201</td>
<td>and MATH UN1202</td>
</tr>
<tr>
<td>- MATH UN1201</td>
<td>- and MATH UN1202</td>
<td>and MATH III</td>
</tr>
<tr>
<td>- MATH UN1202</td>
<td>and MATH IV</td>
<td>and MATH UN2010</td>
</tr>
<tr>
<td>- MATH UN2010</td>
<td>- and LINEAR ALGEBRA</td>
<td>and LINEAR ALGEBRA</td>
</tr>
</tbody>
</table>

OR

<table>
<thead>
<tr>
<th>Sequence 1</th>
<th>Sequence 2</th>
<th>Sequence 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH UN1101</td>
<td>MATH UN1102</td>
<td>MATH UN1205</td>
</tr>
<tr>
<td>- MATH UN1102</td>
<td>and MATH UN1205</td>
<td>and Accelerated Multivariable Calculus</td>
</tr>
<tr>
<td>- MATH UN1205</td>
<td>and MATH IV</td>
<td>and MATH UN2010</td>
</tr>
<tr>
<td>- MATH UN2010</td>
<td>and LINEAR ALGEBRA</td>
<td>and LINEAR ALGEBRA</td>
</tr>
</tbody>
</table>

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.

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)
- Andrew Blumberg
- Simon Brendle
- Ivan Corwin
- Panagiota Daskalopoulos
- Aise Johan de Jong
- Daniela De Silva (Barnard Chair)
- Julien Dubedat
- Robert Friedman (Department Chair)
- Dorian Goldfeld
- Brian Greene
- Richard Hamilton
- Michael Harris
- Ioannis Karatzas
- Mikhail Khovanov
- Igor Krichever
- Chiu-Chu Liu
- Dusa McDuff (Barnard)
- Andrei Okounkov
- D. H. Phong
- Henry Pinkham
- Ovidiu Savin
- Michael Thaddeus
- Eric Urban
- Mu-Tao Wang

**Associate Professors**

- Amol Aggarwal
- Chao Li

**Assistant Professors**

- Elena Giorgi
- Francesco Lin
- Lindsay Piechnik (Barnard)
- Giulia Sacca
- Will Sawin

**J.F. Ritt Assistant Professors**

- Konstantin Aleshkin
- Amadou Bah
- Marco Castronovo
- Evgeni Dimitrov
- Kyle Hayden
- Milind Hegde
- Yash Jhaveri
- Florian Johne
- Inbar Klang
- Konstantin Matetski
- S. Michael Miller Eismeier
- Tudor Padurariu
- Akash Sengupta
- Xi Sisi Shen
- Evan Warner
Senior Lecturers in Discipline

- Lars Nielsen
- Mikhail Smirnov
- Peter Woit

Lecturers in Discipline

- George Dragomir

On Leave

- Prof. Abouzaid, Aggarwal, Corwin, Daskalopoulos, Harris, Khovanov, Krichever, Liu, Okounkov, Thaddeus (Fall 2021)
- Prof. Abouzaid, Aggarwal, Castronovo, Corwin, Dubedat, Liu, Okounkov, Sawin, Thaddeus (Spring 2022)

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>MATH UN1101</th>
<th>CALCULUS I</th>
</tr>
</thead>
<tbody>
<tr>
<td>- MATH UN1102</td>
<td>and CALCULUS II</td>
</tr>
<tr>
<td>- MATH UN1201</td>
<td>and Calculus III</td>
</tr>
<tr>
<td>- MATH UN1202</td>
<td>and CALCULUS IV</td>
</tr>
<tr>
<td>- MATH UN2010</td>
<td>and LINEAR ALGEBRA</td>
</tr>
</tbody>
</table>

OR

<table>
<thead>
<tr>
<th>MATH UN1101</th>
<th>CALCULUS I</th>
</tr>
</thead>
<tbody>
<tr>
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<tr>
<td>- MATH UN1201</td>
<td>and Calculus III</td>
</tr>
<tr>
<td>- MATH UN2010</td>
<td>and LINEAR ALGEBRA</td>
</tr>
</tbody>
</table>

OR

<table>
<thead>
<tr>
<th>MATH UN1101</th>
<th>CALCULUS I</th>
</tr>
</thead>
<tbody>
<tr>
<td>- MATH UN1102</td>
<td>and CALCULUS II</td>
</tr>
<tr>
<td>- MATH UN1201</td>
<td>and Accelerated Multivariable Calculus</td>
</tr>
<tr>
<td>- MATH UN1208</td>
<td>and HONORS MATHEMATICS A</td>
</tr>
<tr>
<td>- MATH UN2010</td>
<td>and LINEAR ALGEBRA</td>
</tr>
</tbody>
</table>

15 points in the following required courses:

<table>
<thead>
<tr>
<th>MATH UN3951</th>
<th>Undergraduate Seminars in Mathematics</th>
</tr>
</thead>
<tbody>
<tr>
<td>- MATH UN3952</td>
<td>and Undergraduate Seminars in Mathematics II (at least one term)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MATH GU4041</th>
<th>INTRO MODERN ALGEBRA I</th>
</tr>
</thead>
<tbody>
<tr>
<td>- MATH GU4042</td>
<td>and INTRO MODERN ALGEBRA II</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MATH GU4061</th>
<th>INTRO MODERN ANALYSIS I</th>
</tr>
</thead>
<tbody>
<tr>
<td>- MATH GU4062</td>
<td>and INTRO MODERN ANALYSIS II</td>
</tr>
</tbody>
</table>

12 points from the following:

1) Courses offered by the department numbered 2000 or higher

2) Courses from the list of approved cognate courses below. A maximum of 6 credits may be taken from courses outside the department. **

* 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.

** Additional courses may be selected only with prior written approval from the Director of Undergraduate Studies.

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.

Approved Cognate Courses 1

<table>
<thead>
<tr>
<th>Approved Cognate Courses 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>COMSC W4261 INTRO</td>
</tr>
<tr>
<td>ECON GU4015 Game</td>
</tr>
</tbody>
</table>

Approved Cognate Courses 3

<table>
<thead>
<tr>
<th>Approved Cognate Courses 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>COMSC W4261 INTRO</td>
</tr>
<tr>
<td>ECON GU4015 Game</td>
</tr>
</tbody>
</table>
Major in Applied Mathematics

The major requires 37-41 points as follows:

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

- MATH UN1101 - MATH UN1102 - MATH UN1201 - MATH UN1202 - MATH UN2010
  - CALCULUS I
  - CALCULUS II
  - Calculus III
  - CALCULUS IV
  - LINEAR ALGEBRA

OR

- MATH UN1101 - MATH UN1102 - MATH UN1205 - MATH UN2010
  - CALCULUS I
  - CALCULUS II
  - Accelerated Multivariable Calculus
  - LINEAR ALGEBRA

OR

- MATH UN1101 - MATH UN1102 - MATH UN1207 - MATH UN1208
  - CALCULUS I
  - CALCULUS II
  - Honors Mathematics A
  - HONORS MATHEMATICS B

Select one of the following three courses. The selected course may not count as an elective.

- MATH UN2500: ANALYSIS AND OPTIMIZATION
- MATH GU4032: Fourier Analysis
- MATH GU4061: INTRO MODERN ANALYSIS I
- APMA E4901: SEM-PROBLEMS IN APPLIED MATH (junior year)
- APMA E4903: SEM-PROBLEMS IN APPLIED MATH (senior year)

18 points in electives, with at least 9 points from the following courses. A maximum of 9 points may be selected from courses outside this list, with prior written approval from the Director of Undergraduate Studies.

- MATH UN2500: ANALYSIS AND OPTIMIZATION
- MATH UN2030: ORDINARY DIFFERENTIAL EQUATIONS
- MATH UN3007: Complex Variables
- MATH GU4065: Honors Complex Variables
- or APMA E4204: FUNCTNS OF A COMPLEX VARIABLE
- MATH UN3028: PARTIAL DIFFERENTIAL EQUATIONS
- or APMA E4200: PARTIAL DIFFERENTIAL EQUATIONS
- or APMA E6301: ANALYTIC METHODS FOR PDE’S
- MATH GU4032: Fourier Analysis
- APMA E4301: APPL MATH III: DYNAMICAL SYSTMS
- APMA E4150: APPLIED FUNCTIONAL ANALYSIS
- APMA E4400: INTRO TO BIOPHYSICAL MODELING

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

- COMS W1004: Introduction to Computer Science and Programming in Java
  or COMS W1007: Honors Introduction to Computer Science
- COMS W3134: Data Structures in Java
  or COMS W3137: Honors Data Structures and Algorithms
- COMS W3157: Advanced Programming
- COMS W3203: DISCRETE MATHEMATICS
- COMS W3261: Computer Science Theory
- CSEE W3827: Fundamentals of Computer Systems

Mathematics

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

- MATH UN1101 - MATH UN1102 - MATH UN1201 - MATH UN1202 - MATH UN2010
  - CALCULUS I
  - CALCULUS II
  - Calculus III
  - CALCULUS IV
  - LINEAR ALGEBRA

OR

- MATH UN1101 - MATH UN1102 - MATH UN1205 - MATH UN2010
  - CALCULUS I
  - CALCULUS II
  - Accelerated Multivariable Calculus
  - LINEAR ALGEBRA

OR

- MATH UN1101 - MATH UN1102 - MATH UN1207 - MATH UN1208
  - CALCULUS I
  - CALCULUS II
  - Honors Mathematics A
  - HONORS MATHEMATICS B

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:

- CSOR W4231: Analysis of Algorithms I
- COMS W4241: Numerical Algorithms and Complexity
- MATH BC2006: Combinatorics
- MATH UN2500: ANALYSIS AND OPTIMIZATION
- MATH UN3007: Complex Variables
- MATH UN3020: Number Theory and Cryptography
- MATH UN3386: Differential Geometry
- MATH GU4051: Topology
- MATH GU4061: INTRO MODERN ANALYSIS I

Major in Economics-Mathematics

For a description of the joint major in economics-mathematics, see the Economics section of this bulletin.

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>Course</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH UN1101</td>
<td>Calculus I</td>
</tr>
<tr>
<td>- MATH UN1102</td>
<td>and Calculus II</td>
</tr>
<tr>
<td>- MATH UN1201</td>
<td>and Accelerated Multivariable Calculus</td>
</tr>
<tr>
<td>- MATH UN2010</td>
<td>and LINEAR ALGEBRA</td>
</tr>
<tr>
<td>- MATH UN2500</td>
<td>and ANALYSIS AND OPTIMIZATION</td>
</tr>
</tbody>
</table>

OR

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH UN1207</td>
<td>Honors Mathematics A</td>
</tr>
<tr>
<td>- MATH UN1208</td>
<td>and HONORS MATHEMATICS B</td>
</tr>
<tr>
<td>- MATH UN2500</td>
<td>and ANALYSIS AND OPTIMIZATION (with approval from the adviser)</td>
</tr>
</tbody>
</table>

Statistics

Introductory Course

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</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>Description</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>Description</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>Description</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>INTRO TO COMP FOR ENG/APP SCI</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 UN2030 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 GU4261 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 replace STAT GU4205 Linear Regression Models with STAT GU4282 Linear Regression and Time Series Methods, and to take among their electives STAT GU4281 Theory of Interest.

Concentration in Mathematics

The concentration requires the following:

Mathematics

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

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH UN1201</td>
<td>Calculus III</td>
</tr>
<tr>
<td>- MATH UN1202</td>
<td>and Calculus IV</td>
</tr>
<tr>
<td>- MATH UN2010</td>
<td>and LINEAR ALGEBRA</td>
</tr>
<tr>
<td>- MATH UN2500</td>
<td>and ANALYSIS AND OPTIMIZATION</td>
</tr>
</tbody>
</table>

OR

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH UN1205</td>
<td>Accelerated Multivariable Calculus</td>
</tr>
<tr>
<td>- MATH UN2010</td>
<td>and LINEAR ALGEBRA</td>
</tr>
<tr>
<td>OR</td>
<td></td>
</tr>
<tr>
<td>MATH UN1207</td>
<td>Honors Mathematics A</td>
</tr>
<tr>
<td>- MATH UN1208</td>
<td>and HONORS MATHEMATICS B</td>
</tr>
</tbody>
</table>

**Additional Courses**

Select at least 12 additional points from any of the courses offered by the department numbered 2000 or higher. A maximum of 3 credits may be taken from courses outside the department.

* 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-ANLYTC GEOMETRY. 3.00 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. 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. 

### Course Listing

**Spring 2022: MATH UN1003**

<table>
<thead>
<tr>
<th>Course</th>
<th>Section</th>
<th>Instructor</th>
<th>Points</th>
<th>Enrollment</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 1003</td>
<td>001/11810</td>
<td>Kevin Smith</td>
<td>3.00</td>
<td>16/30</td>
</tr>
<tr>
<td>MATH 1003</td>
<td>002/11814</td>
<td>David Marcil</td>
<td>3.00</td>
<td>19/30</td>
</tr>
</tbody>
</table>

**Fall 2022: MATH UN1003**

<table>
<thead>
<tr>
<th>Course</th>
<th>Section</th>
<th>Instructor</th>
<th>Points</th>
<th>Enrollment</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 1003</td>
<td>001/00055</td>
<td>Lindsay Piechnik</td>
<td>3.00</td>
<td>5/24</td>
</tr>
<tr>
<td>MATH 1003</td>
<td>002/00056</td>
<td>Lindsay Piechnik</td>
<td>3.00</td>
<td>4/24</td>
</tr>
</tbody>
</table>
### 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)

<table>
<thead>
<tr>
<th>Course Number</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 1101</td>
<td>001/00005</td>
<td>M W 6:10pm - 7:25pm Ll002 Milstein Center</td>
<td>Lindsay Piechnik</td>
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<tr>
<td>MATH 1101</td>
<td>003/11815</td>
<td>T Th 11:40am - 12:55pm 203 Mathematics Building</td>
<td>Xi Shen</td>
<td>3.00</td>
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<tr>
<td>MATH 1101</td>
<td>004/11818</td>
<td>M W 10:10am - 11:25am 407 Mathematics Building</td>
<td>Hung Chiang</td>
<td>3.00</td>
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<tr>
<td>MATH 1101</td>
<td>005/11822</td>
<td>T Th 4:10pm - 5:25pm 407 Mathematics Building</td>
<td>Jingze Zhu</td>
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### Fall 2022: MATH UN1101

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<td>Michael Thaddeus</td>
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<tr>
<td>MATH 1101</td>
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<td>Akash Sengupta</td>
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<tr>
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<td>T Th 1:10pm - 2:25pm 202 Altschul Hall Room TBA</td>
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### MATH UN1102 CALCULUS II. 3.00 points.
Prerequisites: MATH UN1101 or the equivalent. Methods of integration, applications of the integral, Taylor's theorem, infinite series. (SC)

<table>
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<tr>
<th>Course Number</th>
<th>Section/Call Number</th>
<th>Times/Location</th>
<th>Instructor</th>
<th>Points</th>
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<tr>
<td>MATH 1102</td>
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<td>M W 1:10pm - 2:25pm 517 Hamilton Hall</td>
<td>Panagiota Daskalogioudis</td>
<td>3.00</td>
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<tr>
<td>MATH 1102</td>
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<td>M W 2:40pm - 3:55pm 203 Mathematics Building</td>
<td>Tudor Paduraru</td>
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<td>MATH 1102</td>
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<td>Chaim Avram Zeff</td>
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<tr>
<td>MATH 1102</td>
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<td>Gerhardt Hinke</td>
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<td>George Dragomir</td>
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<td>Evan Warner</td>
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### Fall 2022: MATH UN1102

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<th>Course Number</th>
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</table>
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 1202 Calculus IV. 3.00 points.
Prerequisites: MATH UN1102 and MATH UN1201 or the equivalent
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 UN1205 Accelerated Multivariable Calculus. 4 points.
Prerequisites: (MATH UN1101 and MATH UN1102)
Vectors in dimensions 2 and 3, vector-valued functions of one variable, scalar-valued functions of several variables, partial derivatives, gradients, optimization, Lagrange multipliers, double and triple integrals, line and surface integrals, vector calculus. This course is an accelerated version of MATH UN1201 - MATH UN1202. Students taking this course may not receive credit for MATH UN1201 and MATH UN1202.
MATHEMATICS

MATH UN2010 LINEAR ALGEBRA. 3.00 points.
Prerequisites: MATH UN1201 or the equivalent.
Matrices, vector spaces, linear transformations, eigenvalues and eigenvectors, canonical forms, applications. (SC)

Spring 2022: MATH UN2010

<table>
<thead>
<tr>
<th>Course Number</th>
<th>Section/Call Number</th>
<th>Times/Location</th>
<th>Instructor</th>
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<td>Henry Pinkham</td>
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Fall 2022: MATH UN2010

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<th>Instructor</th>
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<td>David Bayer</td>
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MATHEMATICS

MATH UN2015 Linear Algebra and Probability. 3.00 points.
MATH UN2015 features linear algebra with a focus on probability and statistics. The course covers the standard linear algebra topics: systems of linear equations, matrices, determinants, vector spaces, bases, dimension, eigenvalues and eigenvectors. It also teaches applications of linear algebra to probability, statistics and dynamical systems giving a background sufficient for higher level courses in probability and statistics. The topics covered in the probability theory part include conditional probability, discrete and continuous random variables, probability distributions and the limit theorems, as well as Markov chains, curve fitting, regression, and pattern analysis. The course contains applications to life sciences, chemistry, and environmental life sciences. No a prior i background in the life sciences is assumed. This course is best suited for students who wish to focus on applications and practical approach to problem solving, rather than abstract mathematics and mathematical proofs. It is recommended to students majoring in engineering, technology, life sciences, social sciences, and economics. Students majoring in mathematics should take MATH UN2010 - Linear Algebra, which focuses on linear algebra concepts, and provides an introduction to writing mathematical proofs

Fall 2022: MATH UN2015

<table>
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<th>Course Number</th>
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<td>Yash Jhaveri</td>
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Spring 2022: MATH UN2500

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<td>MATH 2030</td>
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<td>Evgeni Dimitrov</td>
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Fall 2022: MATH UN2030

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MATHEMATICS

MATH UN2500 ANALYSIS AND OPTIMIZATION. 3.00 points.
Prerequisites: MATH UN1102 and MATH UN1201 or the equivalent and MATH UN2010.
Prerequisites: MATH UN1102 and MATH UN1201 or the equivalent and MATH UN2010. Mathematical methods for economics. Quadratic forms, Hessian, implicit functions. Convex sets, convex functions. Optimization, constrained optimization, Kuhn-Tucker conditions. Elements of the calculus of variations and optimal control. (SC)

Spring 2022: MATH UN2500

<table>
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<th>Course Number</th>
<th>Section/Call Number</th>
<th>Times/Location</th>
<th>Instructor</th>
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<td>Chen-Chih Lai</td>
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MATHEMATICS

MATH UN3007 Complex Variables. 3 points.
Prerequisites: MATH UN1202 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 2022: MATH UN3007

<table>
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<th>Section/Call Number</th>
<th>Times/Location</th>
<th>Instructor</th>
<th>Points</th>
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<tr>
<td>MATH 3007</td>
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<td>M W 2:40pm - 3:55pm</td>
<td>Ovidiu Savin</td>
<td>3</td>
<td>42/100</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.

Spring 2022: MATH UN3020
Course Number Section/Call Times/Location Instructor Points Enrollment
MATH 3020 001/11887 M W 10:10am - 11:25am 312 Mathematics Building Daniele Alessandrini 3 69/116

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

Fall 2022: MATH UN3025
Course Number Section/Call Times/Location Instructor Points Enrollment
MATH 3025 001/12891 T Th 1:10pm - 2:25pm Room TBA Dorian Goldfeld 3 100/100

MATH UN3027 Ordinary Differential Equations. 3 points.
Prerequisites: MATH UN102 and MATH UN101 or the equivalent.
Corequisites: MATH UN2010

MATH UN3028 PARTIAL DIFFERENTIAL EQUATIONS. 3.00 points.
Prerequisites: MATH UN3027 and MATH UN2010 or the equivalent
Prerequisites: (MATH UN2010 and MATH UN2030) or the equivalent introduction to partial differential equations. First-order equations. Linear second-order equations; separation of variables, solution by series expansions. Boundary value problems

Spring 2022: MATH UN3028
Course Number Section/Call Times/Location Instructor Points Enrollment
MATH 3028 001/11891 M W 10:10am - 11:25am 312 Mathematics Building Florian Johne 3 46/100

MATH UN3050 Discrete Time Models in Finance. 3 points.
Prerequisites: (MATH UN1102 and MATH UN1201) or (MATH UN101 and MATH UN1102 and MATH UN1201) and MATH UN2010
Recommended: 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.

Spring 2022: MATH UN3050
Course Number Section/Call Times/Location Instructor Points Enrollment
MATH 3050 001/11893 M W 6:10pm - 7:25pm 312 Mathematics Building Mikhail Smirnov 3 52/55

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 2022: MATH UN3386
Course Number Section/Call Times/Location Instructor Points Enrollment
MATH 3386 001/12815 T Th 11:40am - 12:55pm Room TBA Richard Hamilton 3 17/100

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 2022: MATH UN3951
Course Number Section/Call Times/Location Instructor Points Enrollment
MATH 3951 001/00059 M W 11:40am - 12:55pm Richard Hamilton 3 64/64

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.

Spring 2022: MATH UN3952
Course Number Section/Call Times/Location Instructor Points Enrollment
MATH 3952 001/00010 M W 2:10pm - 3:25pm 312 Mathematics Building David Bayer 3 79/80

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.

Spring 2022: MATH GU4007
Course Number Section/Call Times/Location Instructor Points Enrollment
MATH 4007 001/11894 T Th 11:40am - 12:55pm 520 Mathematics Building Dorian Goldfeld 3 4/49
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.

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.

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.

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 GU4042) and MATH UN3007
and Poisson summation formulae, convolution. Heisenberg uncertainty principle. Stress on the application of Fourier analysis to a wide range of disciplines.

Fall 2022: MATH GU4032
Course Number: MATH 4032
Section/Call Number: 001/12818
Times/Location: M W 10:10am - 11:25am
Room: TBA
Instructor: Simon Brendle
Points: 3
Enrollment: 53/100

Spring 2022: MATH GU4041
Course Number: MATH 4041
Section/Call Number: 001/11895
Times/Location: T Th 10:10am - 11:25am
Room: 417 Mathematics Building
Instructor: Jorge Pineiro Barcelo
Points: 51/64

Fall 2022: MATH GU4041
Course Number: MATH 4041
Section/Call Number: 001/12819
Times/Location: M W 2:40pm - 3:55pm
Room: TBA
Instructor: William Sawin
Points: 73/100

Spring 2022: MATH GU4042
Course Number: MATH 4042
Section/Call Number: 001/11896
Times/Location: M W 2:40pm - 3:55pm
Room: 312 Mathematics Building
Instructor: Mikhail Khovanov
Points: 31/100

Fall 2022: MATH GU4042
Course Number: MATH 4042
Section/Call Number: 001/12823
Times/Location: T 2:40pm - 3:55pm
Room: TBA
Instructor: Robert Friedman
Points: 18/100

Spring 2022: MATH GU4043
Course Number: MATH 4043
Section/Call Number: 001/11897
Times/Location: M W 10:10am - 11:25am
Room: TBA
Instructor: Simon Brendle
Points: 3
Enrollment: 53/100

Spring 2022: MATH GU4044
Course Number: MATH 4044
Section/Call Number: 001/12825
Times/Location: M W 10:10am - 11:25am
Room: TBA
Instructor: Michael Harris
Points: 3
Enrollment: 13/100

Spring 2022: MATH GU4045
Course Number: MATH 4045
Section/Call Number: 001/11899
Times/Location: M W 4:10pm - 5:25pm
Room: 307 Mathematics Building
Instructor: Akash Sengupta
Points: 3
Enrollment: 4/19

Fall 2022: MATH GU4051
Course Number: MATH 4051
Section/Call Number: 001/12826
Times/Location: T Th 2:40pm - 3:55pm
Room: TBA
Instructor: Mikhail Khovanov
Points: 3
Enrollment: 33/100
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 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.

Fall 2022: MATH GU4052

Course Number    Section/Call Number    Times/Location    Instructor    Points    Enrollment
MATH 4052 001/12828    M W 1:10pm - 2:25pm Room TBA 3 4/100

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.

Spring 2022: MATH GU4053

Course Number    Section/Call Number    Times/Location    Instructor    Points    Enrollment
MATH 4053 001/11901    T Th 2:40pm - 3:55pm 417 Mathematics Building Inbar Klang 3 19/30

MATH GU4061 INTRO MODERN ANALYSIS I. 3 points.
Prerequisites: MATH UN1202 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. Power series, analytic functions, Implicit function theorem, Fubini theorem, change of variables formula, Lebesgue measure and integration, function spaces

Fall 2022: MATH GU4061

Course Number    Section/Call Number    Times/Location    Instructor    Points    Enrollment
MATH 4061 001/11902    M W 2:40pm - 3:55pm 417 Mathematics Building Florian Johne 3 42/50
MATH 4061 002/11903    M W 4:10pm - 5:25pm 520 Mathematics Building Joshua Pfeffer 3 19/49

Spring 2022: MATH GU4061

Course Number    Section/Call Number    Times/Location    Instructor    Points    Enrollment
MATH 4061 001/12829    T Th 2:40pm - 3:55pm Room TBA Florian Johne 3 77/100
MATH 4061 002/12830    T Th 4:10pm - 5:25pm Room TBA Florian Johne 3 19/100

MATH GU4062 INTRO MODERN ANALYSIS II. 3.00 points.
Prerequisites: MATH UN1202 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. Power series, analytic functions, Implicit function theorem, Fubini theorem, change of variables formula, Lebesgue measure and integration, function spaces

Spring 2022: MATH GU4062

Course Number    Section/Call Number    Times/Location    Instructor    Points    Enrollment
MATH 4062 001/11904    T Th 4:10pm - 5:25pm 417 Mathematics Building Abhijit Champanerkar 3.00 31/64
MATH 4062 001/12832    M W 4:10pm - 5:25pm Room TBA Milind Hegde 3.00 21/100

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 2022: MATH GU4065

Course Number    Section/Call Number    Times/Location    Instructor    Points    Enrollment
MATH 4065 001/12833    T Th 11:40am - 12:55pm Room TBA Francesco Lin 3 26/100

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

Spring 2022: MATH GU4081

Course Number    Section/Call Number    Times/Location    Instructor    Points    Enrollment
MATH 4081 001/00011    M W 10:10am - 11:25am 325 Milbank Hall Dusa McDuff 3 15/40

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

Spring 2022: MATH GU4155

Course Number    Section/Call Number    Times/Location    Instructor    Points    Enrollment
MATH 4155 001/11906    T Th 1:10pm - 2:25pm 407 Mathematics Building Milind Hegde 3 13/35
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.

Spring 2022: MATH GU4391

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407 Mathematics Building

MATH GU4392 INTRO TO QUANTUM MECHANICS II. 3.00 points.
Not offered during 2022-23 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.

Of Related Interest

Computer Science
- COMS W3203 DISCRETE MATHEMATICS
- COMS W3251 COMPUTATIONAL LINEAR ALGEBRA
- COMS W4203 Graph Theory

Industrial Engineering and Operations Research
- CSOR E4010 GRAPH THEORY: COMBINATL VIEW

Applied Mathematics
- APMA E2101 INTRO TO APPLIED MATHEMATICS
- APMA E4150 APPLIED FUNCTIONAL ANALYSIS