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: Introduction to Combinatorics and Graph Theory, in the Computer Science Department.

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.
**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
- 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 (Department Chair)
- Eric Urban
- Mu-Tao Wang

**Associate Professors**

- Daniela De Silva (Barnard)
- Julien Dubedat

**Assistant Professors**

- Chao Li
- Giulia Sacca
- Will Sawin

**J.F. Ritt Assistant Professors**

- Akram Alishahi
- Evgeni Dimitrov
- Teng Fei
- Alexandra Florea
- Bin Guo
- Shotaro Makisumi
- Konstantin Matetski
- Henri Roesch
- Nicholas Salter
- Gus Schrader
- Lihn Truong
- Evan Warner
- Hui Yu
- Yihang Zhu

**Senior Lecturers in Discipline**

- Lars Nielsen
- Mikhail Smirnov
- Peter Woit

**Lecturers in Discipline**

- Michael Woodbury
**On Leave**

- Profs. Corwin, Krichever, Neumann, Pinkham, Sawin (Fall 2018)
- Profs. Neumann, Phong, Pinkham, Sacca, Sawin, Urban (Spring 2019)

**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>Course Code</th>
<th>Course Title</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 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>

15 points in the following required courses:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</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 UN1207</td>
<td>and Honors Math A</td>
</tr>
<tr>
<td>MATH UN1208</td>
<td>and Honors Math B</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>Course Code</th>
<th>Course Title</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 UN1202</td>
<td>and Calculus IV</td>
</tr>
<tr>
<td>MATH UN2010</td>
<td>and Linear Algebra</td>
</tr>
</tbody>
</table>

Select one of the following three courses:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH UN2500</td>
<td>Analysis and Optimization</td>
</tr>
<tr>
<td>MATH GU4032</td>
<td>Fourier Analysis</td>
</tr>
<tr>
<td>MATH GU4061</td>
<td>Introduction to Modern Analysis I</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 Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH UN2500</td>
<td>Analysis and Optimization</td>
</tr>
<tr>
<td>MATH UN3007</td>
<td>Complex Variables</td>
</tr>
<tr>
<td>MATH UN3027</td>
<td>Ordinary Differential Equations</td>
</tr>
<tr>
<td>MATH UN3028</td>
<td>Partial Differential Equations</td>
</tr>
<tr>
<td>APMA E4204</td>
<td>Functions of a Complex Variable</td>
</tr>
<tr>
<td>APMA E4032</td>
<td>Fourier Analysis</td>
</tr>
<tr>
<td>APMA E4000</td>
<td>Computational Math: Introduction to Numerical Methods</td>
</tr>
<tr>
<td>APMA E4101</td>
<td>Introduction to Dynamical Systems</td>
</tr>
<tr>
<td>APMA E4150</td>
<td>Applied Functional Analysis</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 Code</th>
<th>Course 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>
</tbody>
</table>
or COMS W3137 Honors Data Structures and Algorithms
COMS W3157 Advanced Programming
COMS W3203 Discrete Mathematics: Introduction to Combinatorics and Graph Theory
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 Calculus I
- MATH UN1102 and Calculus II
- MATH UN1201 and Calculus III
- 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

MATH UN3951 Undergraduate Seminars in Mathematics I
or MATH UN3952 Undergraduate Seminars in Mathematics II
MATH GU4041 Introduction to 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 Introduction to Modern Analysis I

Major in Economics-Mathematics

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:

MATH UN1101 Calculus I
- MATH UN1102 and Calculus II
- MATH UN1201 and Calculus III
- MATH UN2010 and Linear Algebra
- MATH UN2500 and Analysis and Optimization

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:

MATH UN1101 Calculus I
- MATH UN1102 and Calculus II
- MATH UN1201 and Calculus III
- MATH UN2010 and Linear Algebra
- MATH UN2500 and Analysis and Optimization

Statistics

Introductory Course

STAT UN1201 Calculus-Based Introduction to Statistics

Required Courses

STAT GU4203 PROBABILITY THEORY
STAT GU4204 Statistical Inference
STAT GU4205 Linear Regression Models

Select one of the following courses:

STAT GU4207 Elementary Stochastic Processes
STAT GU4262 Stochastic Processes for Finance
STAT GU4264 STOCHASTIC PROCESSES-APPLIC
STAT GU4265 Stochastic Methods in Finance

Computer Science

Select one of the following courses:

COMS W1004 Introduction to Computer Science and Programming in Java
COMS W1005 Introduction to Computer Science and Programming in MATLAB
ENGI E1006 Introduction to Computing for Engineers and Applied Scientists
COMS W1007 Honors Introduction to Computer Science
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 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 Introduction To Modern Analysis I and MATH GU4062 Introduction To 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:

MATH UN1201 Calculus III
- MATH UN1202 and Calculus IV
- MATH UN2010 and Linear Algebra

MATH UN1205 Accelerated Multivariable Calculus
- MATH UN2010 and Linear Algebra

MATH UN1207 Honors Mathematics A
- MATH UN1208 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.

Spring 2019: MATH UN1003
<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>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 1003</td>
<td>001/60225</td>
<td>M W 6:10pm - 8:00pm 304 Hamilton Hall</td>
<td>Zhi Li</td>
<td>3</td>
<td>18/30</td>
</tr>
<tr>
<td>MATH 1003</td>
<td>002/28863</td>
<td>T Th 12:10pm - 2:00pm 302 Fayerweather</td>
<td>Anton Osinenko</td>
<td>3</td>
<td>23/30</td>
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</tbody>
</table>

Fall 2019: MATH UN1003
<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>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 1003</td>
<td>001/50641</td>
<td>M W 6:10pm - 7:25pm 407 Mathematics Building</td>
<td>Lindsay Piechok</td>
<td>3</td>
<td>17/30</td>
</tr>
<tr>
<td>MATH 1003</td>
<td>002/50642</td>
<td>T Th 2:40pm - 3:55pm Room TBA</td>
<td>Lindsay Piechok</td>
<td>3</td>
<td>29/30</td>
</tr>
</tbody>
</table>

MATH UN1101 Calculus I. 3 points.
Prerequisites: (see Courses for First-Year Students). Functions, limits, derivatives, introduction to integrals, or an understanding of pre-calculus will be assumed.

The Help Room in 333 Milbank Hall (Barnard College) is open during the day, Monday through Friday, to students seeking individual help from the teaching assistants. (SC)

Spring 2019: MATH UN1101
<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>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 1101</td>
<td>001/75145</td>
<td>M W 10:10am - 11:25am 407 Mathematics Building</td>
<td>Yang An</td>
<td>3</td>
<td>28/30</td>
</tr>
<tr>
<td>MATH 1101</td>
<td>002/62612</td>
<td>M W 4:10pm - 5:25pm 207 Mathematics Building</td>
<td>Jacob Shapiro</td>
<td>3</td>
<td>54/100</td>
</tr>
<tr>
<td>MATH 1101</td>
<td>003/27890</td>
<td>M W 6:10pm - 7:25pm 407 Mathematics Building</td>
<td>Dmitrii Pirozhkov</td>
<td>3</td>
<td>27/30</td>
</tr>
<tr>
<td>MATH 1101</td>
<td>004/73630</td>
<td>T Th 11:40am - 12:55pm Room TBA</td>
<td>Wenhua Yu</td>
<td>3</td>
<td>18/30</td>
</tr>
<tr>
<td>MATH 1101</td>
<td>005/69201</td>
<td>T Th 1:10pm - 2:25pm 407 Mathematics Building</td>
<td>Huaxin Liu</td>
<td>3</td>
<td>31/30</td>
</tr>
<tr>
<td>MATH 1101</td>
<td>006/19056</td>
<td>T Th 2:40pm - 3:55pm 417 Mathematics Building</td>
<td>Alexander Cowan</td>
<td>3</td>
<td>42/50</td>
</tr>
</tbody>
</table>

Fall 2019: MATH UN1101
<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>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 1101</td>
<td>001/29218</td>
<td>M W 10:10am - 11:25am Room TBA</td>
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<tr>
<td>MATH 1101</td>
<td>002/50794</td>
<td>M W 2:40pm - 3:55pm 203 Mathematics Building</td>
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<td></td>
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<tr>
<td>MATH 1101</td>
<td>003/50795</td>
<td>M W 4:10pm - 5:25pm 207 Mathematics Building</td>
<td>3</td>
<td>8/30</td>
<td></td>
</tr>
<tr>
<td>MATH 1101</td>
<td>004/50796</td>
<td>M W 6:10pm - 7:25pm 312 Mathematics Building</td>
<td>Chao Li</td>
<td>3</td>
<td>87/100</td>
</tr>
<tr>
<td>MATH 1101</td>
<td>005/50797</td>
<td>T Th 8:40am - 9:55am 312 Mathematics Building</td>
<td>Zachary Sylvan</td>
<td>3</td>
<td>6/100</td>
</tr>
<tr>
<td>MATH 1101</td>
<td>006/50798</td>
<td>T Th 10:10am - 11:25am 312 Mathematics Building</td>
<td>Michael Woodbury</td>
<td>3</td>
<td>20/100</td>
</tr>
<tr>
<td>MATH 1101</td>
<td>007/50799</td>
<td>T Th 11:40am - 12:55pm 203 Mathematics Building</td>
<td>Michael Woodbury</td>
<td>3</td>
<td>12/100</td>
</tr>
<tr>
<td>MATH 1101</td>
<td>008/50800</td>
<td>T Th 2:40pm - 3:55pm 207 Mathematics Building</td>
<td>Alisa Knizel</td>
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</tr>
<tr>
<td>MATH 1101</td>
<td>009/50801</td>
<td>M W 1:10pm - 2:25pm 407 Mathematics Building</td>
<td>Oleksandr Kravets</td>
<td>3</td>
<td>12/30</td>
</tr>
<tr>
<td>MATH 1101</td>
<td>010/50802</td>
<td>T Th 1:10pm - 2:25pm 407 Mathematics Building</td>
<td>Zhi Li</td>
<td>3</td>
<td>11/30</td>
</tr>
</tbody>
</table>
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)

Spring 2019: MATH UN1102

<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>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 1102</td>
<td>001/17885</td>
<td>M W 4:10pm - 5:25pm 203 Mathematics Building</td>
<td>Henri Roesch</td>
<td>3</td>
<td>47/100</td>
</tr>
<tr>
<td>MATH 1102</td>
<td>002/72870</td>
<td>M W 6:10pm - 7:25pm 203 Mathematics Building</td>
<td>Henri Roesch</td>
<td>3</td>
<td>8/100</td>
</tr>
<tr>
<td>MATH 1102</td>
<td>003/62450</td>
<td>T Th 11:40am - 12:55pm 417 Mathematics Building</td>
<td>Pak Hin Lee</td>
<td>3</td>
<td>33/36</td>
</tr>
<tr>
<td>MATH 1102</td>
<td>004/16563</td>
<td>T Th 2:40pm - 3:55pm 407 Mathematics Building</td>
<td>Raymond Cheng</td>
<td>3</td>
<td>27/36</td>
</tr>
<tr>
<td>MATH 1102</td>
<td>005/17398</td>
<td>T Th 4:10pm - 5:25pm Room TBA</td>
<td>Beomjun Choi</td>
<td>3</td>
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Fall 2019: MATH UN1102

<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>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 1102</td>
<td>001/29219</td>
<td>M W 1:10pm - 2:25pm 417 Mathematics Building</td>
<td>Yi Sun</td>
<td>3</td>
<td>7/64</td>
</tr>
<tr>
<td>MATH 1102</td>
<td>002/50788</td>
<td>T Th 10:10am - 11:25am 417 Mathematics Building</td>
<td>Peter Wort</td>
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<td>6/64</td>
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<td>MATH 1102</td>
<td>003/50789</td>
<td>T Th 4:10pm - 5:25pm 203 Mathematics Building</td>
<td>Nathan Dowlin</td>
<td>3</td>
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<tr>
<td>MATH 1102</td>
<td>004/50790</td>
<td>T Th 6:10am - 7:25pm 203 Mathematics Building</td>
<td>Nathan Dowlin</td>
<td>3</td>
<td>8/100</td>
</tr>
<tr>
<td>MATH 1102</td>
<td>005/50791</td>
<td>M W 4:10pm - 5:25pm 407 Mathematics Building</td>
<td>Xuan Wu</td>
<td>3</td>
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<tr>
<td>MATH 1102</td>
<td>006/50792</td>
<td>T Th 11:40am - 12:55pm 407 Mathematics Building</td>
<td>Donghan Kim</td>
<td>3</td>
<td>9/30</td>
</tr>
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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)

Spring 2019: MATH UN1201

<table>
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<tr>
<th>Course Number</th>
<th>Section/Call Number</th>
<th>Times/Location</th>
<th>Instructor</th>
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<td>001/29129</td>
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<td>Igor Krichever</td>
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<td>MATH 1201</td>
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<td>M W 2:40pm - 3:55pm 203 Mathematics Building</td>
<td>Linh Truong</td>
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<td>Giulia Sacca</td>
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<td>Teng Fei</td>
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<td>Yoel Groman</td>
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Fall 2019: MATH UN1201

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<td>Mohammed Abouzaid</td>
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<td>Ilya Kofman</td>
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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)

Fall 2019: MATH UN1202

<table>
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<tr>
<th>Course Number</th>
<th>Section/Call Number</th>
<th>Times/Location</th>
<th>Instructor</th>
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<td>Mu-Tao Wang</td>
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<td>MATH 1202</td>
<td>002/50786</td>
<td>M W 6:10pm - 7:25pm 207 Mathematics Building</td>
<td>Mikhail Smirnov</td>
<td>3</td>
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</table>
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.

Fall 2019: MATH UN1205
Course Number  | Section/Call Number | Times/Location | Instructor | Points | Enrollment
--- | --- | --- | --- | --- | ---
MATH 1205 | 001/50701 | M W 2:40pm - 3:55pm 520 Mathematics Building | Robert Friedman | 4 | 11/49

MATH UN1207 Honors Mathematics A. 4 points.
Prerequisites: (see Courses for First-Year Students). The second term of this course may not be taken without the first. Multivariable calculus and linear algebra from a rigorous point of view. Recommended for mathematics majors. Fulfills the linear algebra requirement for the major. (SC)

Fall 2019: MATH UN1207
Course Number  | Section/Call Number | Times/Location | Instructor | Points | Enrollment
--- | --- | --- | --- | --- | ---
MATH 1207 | 001/50643 | M W 4:10pm - 5:25pm 312 Mathematics Building | Evan Warner | 4 | 8/100

MATH UN1208 Honors Mathematics B. 4 points.
Prerequisites: (see Courses for First-Year Students). The second term of this course may not be taken without the first. Multivariable calculus and linear algebra from a rigorous point of view. Recommended for mathematics majors. Fulfills the linear algebra requirement for the major. (SC)

Spring 2019: MATH UN1208
Course Number  | Section/Call Number | Times/Location | Instructor | Points | Enrollment
--- | --- | --- | --- | --- | ---
MATH 1208 | 001/61919 | M W 1:10pm - 2:25pm 203 Mathematics Building | Evan Warner | 4 | 52/100

MATH UN2000 An Introduction to Higher Mathematics. 3 points.
Introduction to understanding and writing mathematical proofs. Emphasis on precise thinking and the presentation of mathematical results, both in oral and in written form. Intended for students who are considering majoring in mathematics but wish additional training. CC/ GS: Partial Fulfillment of Science Requirement. BC: Fulfillment of General Education Requirement: Quantitative and Deductive Reasoning (QUA).

Fall 2019: MATH UN2000
Course Number  | Section/Call Number | Times/Location | Instructor | Points | Enrollment
--- | --- | --- | --- | --- | ---
MATH 2000 | 001/50754 | M W 10:10am - 11:25am 520 Mathematics Building | Gus Schrader | 3 | 23/49

MATH UN2010 Linear Algebra. 3 points.
Prerequisites: MATH UN1201 or the equivalent. Matrices, vector spaces, linear transformations, eigenvalues and eigenvectors, canonical forms, applications. (SC)

Spring 2019: MATH UN2010
Course Number  | Section/Call Number | Times/Location | Instructor | Points | Enrollment
--- | --- | --- | --- | --- | ---
MATH 2010 | 001/61743 | M W 11:40am - 12:55pm 312 Mathematics Building | Bianca Santoro | 3 | 89/116

Fall 2019: MATH UN2010
Course Number  | Section/Call Number | Times/Location | Instructor | Points | Enrollment
--- | --- | --- | --- | --- | ---
MATH 2010 | 002/18837 | M W 1:10pm - 2:25pm 312 Mathematics Building | Joshua Sussan | 3 | 93/100

MATH 2010 | 003/12804 | T Th 10:10am - 11:25am 312 Mathematics Building | Nicholas Salter | 3 | 62/100

MATH 2010 | 004/23515 | T Th 11:40am - 12:55pm 312 Mathematics Building | Nicholas Salter | 3 | 81/100

MATH 2010 | 005/68757 | T Th 6:10pm - 7:25pm Room TBA | Elliott Stein | 3 | 50/100

MATH UN2010 Honors Linear Algebra. 3 points.
Not offered during 2019-20 academic year.

Prerequisites: MATH UN1201. A more extensive treatment of the material in MATH UN2010, with increased emphasis on proof. Not to be taken in addition to MATH UN2010 or MATH UN1207-MATH UN1208.
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.

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)

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.

MATH UN3027 Ordinary Differential Equations. 3 points.
Prerequisites: MATH UN1102 and MATH UN1201 or the equivalent.
Corequisites: MATH UN2010
MATH UN3028 Partial Differential Equations. 3 points.
Prerequisites: MATH UN3027 and MATH UN2010 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 2019: MATH UN3028

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<tr>
<th>Course</th>
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<th>Times/Location</th>
<th>Instructor</th>
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<td>M W 10:10am - 11:25am</td>
<td>Simon Brendle</td>
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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
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 2019: MATH UN3050

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<th>Course</th>
<th>Section/Call Number</th>
<th>Times/Location</th>
<th>Instructor</th>
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<td>MATH 3050</td>
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<td>Mikhail Smirnov</td>
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</table>

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.

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 2019: MATH UN3951

<table>
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<th>Times/Location</th>
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<td>MATH 3951</td>
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<td>Daniela De Silva</td>
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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.

Spring 2019: MATH GU4007

<table>
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<th>Course</th>
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<td>Dorian Goldfeld</td>
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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.

Spring 2019: MATH GU4032

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<td>Peter Woit</td>
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MATH GU4041 Introduction to 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.

Spring 2019: MATH GU4041

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<th>Course</th>
<th>Section/Call Number</th>
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<th>Instructor</th>
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Fall 2019: MATH GU4041

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</table>
MATH GU4042 Introduction to 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.
Groups, homomorphisms, rings, ideals, fields, polynomials, field extensions, Galois theory.

Spring 2019: MATH GU4042
Course Number  Section/Call Number  Times/Location  Instructor  Points  Enrollment
MATH 4042  001/19981  M W 2:40pm - 3:55pm  312 Mathematics Building  Robert Friedman  3  41/100

Fall 2019: MATH GU4042
Course Number  Section/Call Number  Times/Location  Instructor  Points  Enrollment
MATH 4042  001/50644  M W 11:40am - 12:55pm  407 Mathematics Building  Gus Schrader  3  28/35

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.

Fall 2019: MATH GU4043
Course Number  Section/Call Number  Times/Location  Instructor  Points  Enrollment
MATH 4043  001/50710  T Th 10:10am - 11:25am  307 Mathematics Building  Michael Harris  3  13/19

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.

Spring 2019: MATH GU4044
Course Number  Section/Call Number  Times/Location  Instructor  Points  Enrollment
MATH 4044  001/67298  M W 10:10am - 11:25am  417 Mathematics Building  Yihang Zhu  3  10/30

Fall 2019: MATH GU4044
Course Number  Section/Call Number  Times/Location  Instructor  Points  Enrollment
MATH 4044  001/50758  M W 4:10pm - 5:25pm  307 Mathematics Building  Yihang Zhu  3  9/19

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 group theory (e.g., MATH GU4041). MATH UN1208 or MATH GU4061 is recommended, but not required.

Spring 2019: MATH GU4051
Course Number  Section/Call Number  Times/Location  Instructor  Points  Enrollment
MATH 4051  001/50759  T Th 4:10pm - 5:25pm  407 Mathematics Building  Elliott Stein  3  34/35

Fall 2019: MATH GU4051
Course Number  Section/Call Number  Times/Location  Instructor  Points  Enrollment
MATH 4053  001/24645  T Th 2:40pm - 3:55pm  312 Mathematics Building  Akram Alishahi  3  13/80

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 2019: MATH GU4053
Course Number  Section/Call Number  Times/Location  Instructor  Points  Enrollment
MATH 4053  001/50759  T Th 4:10pm - 5:25pm  407 Mathematics Building  Elliott Stein  3  34/35

MATH GU4061 Introduction To 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.

Spring 2019: MATH GU4061
Course Number  Section/Call Number  Times/Location  Instructor  Points  Enrollment
MATH 4061  001/24581  M W 11:40am - 12:55pm  520 Mathematics Building  Hui Yu  3  35/49

Fall 2019: MATH GU4061
Course Number  Section/Call Number  Times/Location  Instructor  Points  Enrollment
MATH 4061  002/61614  M W 2:40pm - 3:55pm  417 Mathematics Building  Hui Yu  3  40/64

MATH GU4065 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 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.

Spring 2019: MATH GU4052
Course Number Section/Call Number Times/Location Instructor Points Enrollment
MATH 4052 001/15003 M W 4:10pm - 5:25pm Room TBA Aliakbar Daemi 3 4/19

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.

Spring 2019: MATH GU4062
Course Number Section/Call Number Times/Location Instructor Points Enrollment
MATH 4062 001/69784 T Th 4:10pm - 5:25pm 203 Mathematics Building Bin Guo 3 14/64

Fall 2019: MATH GU4062
Course Number Section/Call Number Times/Location Instructor Points Enrollment
MATH 4062 001/50645 M W 1:10pm - 2:25pm 520 Mathematics Building Hui Yu 3 28/49

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 2019: MATH GU4065
Course Number Section/Call Number Times/Location Instructor Points Enrollment
MATH 4065 001/50691 T Th 11:40am - 12:55pm 307 Mathematics Building Julien Dubedat 3 15/19

MATH GU4081 Introduction to Differentiable Manifolds. 3 points.
Prerequisites: (MATH GU4051 or MATH GU4061) and MATH UN2010 Concept of a differentiable manifold. Tangent spaces and vector fields. The inverse function theorem. Transversality and Sard’s theorem. Intersection theory. Orientations. Poincare-Hopf theorem. Differential forms and Stokes’ theorem.

Spring 2019: MATH GU4081
Course Number Section/Call Number Times/Location Instructor Points Enrollment
MATH 4081 001/76374 M W 1:10pm - 2:25pm 520 Mathematics Building Mu-Tao Wang 3 12/49

Fall 2019: MATH GU4081
Course Number Section/Call Number Times/Location Instructor Points Enrollment
MATH 4081 001/08792 M W 10:10am - 11:25am Room TBA Dusa McDuff 3 13/40

MATH GU4155 Probability Theory. 3 points.
Prerequisites: MATH GU4061 or MATH UN3007 A rigorous introduction to the concepts and methods of mathematical probability starting with basic notions and making use of combinatorial and analytic techniques. Generating functions. Convergence in probability and in distribution. Discrete probability spaces, recurrence and transience of random walks. Infinite models, proof of the law of large numbers and the central limit theorem. Markov chains.

Spring 2019: MATH GU4155
Course Number Section/Call Number Times/Location Instructor Points Enrollment
MATH 4155 001/24672 T Th 1:10pm - 2:25pm Room TBA Julien Dubedat 3 22/64

MATH GU4391 Intro to Quantum Mechanics: An Introduction for Mathematicians and Physicists I. 3 points.
Not offered during 2019-20 academic year.
Prerequisites: MATH UN1202 or the equivalent and MATH UN2010. 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 for undergraduates with no previous formal training in quantum theory. The measurement problem and issues of non-locality will be stressed.

MATH GU4392 Quantum Mechanics: An Introduction for Mathematicians and Physicists II. 3 points.
Not offered during 2019-20 academic year.
Prerequisites: MATH UN1202 or the equivalent, MATH UN2010 and MATH 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 for undergraduates with no previous formal training in quantum theory. The measurement problem and issues of non-locality 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.

### Of Related Interest

**Computer Science**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
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<tbody>
<tr>
<td>COMS W3203</td>
<td>Discrete Mathematics: Introduction to Combinatorics and Graph Theory</td>
</tr>
<tr>
<td>COMS W3251</td>
<td></td>
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<tr>
<td>COMS W4203</td>
<td>Graph Theory</td>
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**Industrial Engineering and Operations Research**

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<th>Course</th>
<th>Title</th>
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<tbody>
<tr>
<td>CSOR E4010</td>
<td>Graph Theory: A Combinatorial View</td>
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<th>Times/Location</th>
<th>Instructor</th>
<th>Points</th>
<th>Enrollment</th>
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<tr>
<td><strong>Spring 2019: MATH 5010</strong></td>
<td>MATH 5010</td>
<td>001/79979</td>
<td>M W 7:40pm - 8:55pm, 207 Mathematics Building</td>
<td>Mikhail Smirnov</td>
<td>3</td>
<td>122/150</td>
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<tr>
<td><strong>Fall 2019: MATH 5010</strong></td>
<td>MATH 5010</td>
<td>001/50715</td>
<td>M W 7:40pm - 8:55pm, 207 Mathematics Building</td>
<td>Mikhail Smirnov</td>
<td>3</td>
<td>47/140</td>
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