**MATHEMATICS**

332G Milbank Hall  
212-854-3577  
Department Assistant: Marsha Peruo

**General Information**

Students who have special placement problems, or are unclear about their level, should make an appointment with a faculty member or the Chair.

Two help rooms, one in 404 Mathematics and one in 502 Milstein Center, are available. Hours will be posted on the door and on [https://math.barnard.edu/math-tutoring-schedules](https://math.barnard.edu/math-tutoring-schedules) for students seeking individual help and counseling from Barnard tutors and Columbia teaching assistants. No appointments are necessary. Both Barnard and Columbia students are welcome. NOTE: Changes to tutoring schedules and remote tutoring can occur in response to COVID-19.

**Courses for First-Year Students**

The systematic study of Mathematics begins with one of the following alternative sequences:

<table>
<thead>
<tr>
<th>Calculus I, II, III, IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH UN1101</td>
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<tr>
<td>MATH UN1102</td>
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<td>MATH UN1201</td>
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<tr>
<td>MATH UN1202</td>
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<tr>
<td>Honors Math A-B</td>
</tr>
<tr>
<td>MATH UN1207</td>
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<tr>
<td>MATH UN1208</td>
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</tbody>
</table>

Credit is allowed for only one of the calculus sequences. The calculus sequence is a standard course in differential and integral calculus. **Honors Mathematics A-B** is for exceptionally well-qualified students who have strong advanced placement scores. It covers second-year Calculus (MATH UN1201 Calculus III–MATH UN1202 CALCULUS IV) and MATH UN2010 LINEAR ALGEBRA, with an emphasis on theory.

**Calculation II** is NOT a prerequisite for **Calculation III**, so students who plan to take only one year of calculus may choose between I and II or I and III. The latter requires a B or better in Calculus I and is a recommended option for some majors.

MATH UN2000 INTRO TO HIGHER MATHEMATICS is a course that can be taken in their first or second year by students with an aptitude for mathematics who would like to practice writing and understanding mathematical proofs.

**Placement in the Calculus Sequence**

**College Algebra and Analytical Geometry** is a refresher course for students who intend to take Calculus but do not have adequate background for it.

**Advanced Placement**: Students who have passed the advanced placement test for Calculus AB with a grade of 4 or 5 or BC with a grade of 4 receive 3 points of credit. Those who passed Calculus BC with a grade of 5 will receive 4 points of credit or 6 points on placing into Calculus III or Honors Math A and completing with a grade of C or better.

**Calculus I, II, III**: Students who have not previously studied calculus should begin with Calculus I. Students with 4 or higher on the Calculus AB or BC advanced placement test may start with Calculus II. Students with 5 on the Calculus BC test should start with Calculus III.

**Honors Mathematics A**: Students who have passed the Calculus BC advanced placement test with a grade of 5, and who have strong mathematical talent and motivation, should start with Honors Mathematics A. This is the most attractive course available to well-prepared, mathematically talented first-year students, whether or not they intend to be mathematics majors. Students who contemplate taking this course should consult with the instructor. If this is not possible ahead of time, they should register and attend the first class.

**Chair**: Daniela De Silva (Professor)  
**Professors**: Dave Bayer, Daniela De Silva, Dusa McDuff (Helen Lyttle Kimmel Chair)  
**Term Assistant Professor**: Lindsay Piechnik  
**Professors Emeriti**: Joan Birman, Walter Neumann

Links to other faculty of Columbia University offering courses in Mathematics:

Faculty by Rank: [http://www.math.columbia.edu/people/faculty-by-rank/](http://www.math.columbia.edu/people/faculty-by-rank/)


**Requirements for the Major**

The major programs in both Mathematics and Applied Mathematics are appropriate for students who plan to continue their training in graduate school. The major in Mathematical Sciences combines the elements of Mathematics, Computer Science and Statistics. It is designed to prepare students for employment in business, administration, and finance, and also give excellent background for someone planning graduate study in a social science field. Students who plan to obtain a teaching qualification in mathematics should plan their course of study carefully with an advisor, since courses that are too far from mathematics do not count towards certification.

**For a major in Mathematics: 14 courses (a minimum of 35 credits) as follows:**

Four courses in calculus or Honors Mathematics A-B, including Advanced Placement Credit. Six courses in mathematics numbered at or above 2000, and four courses in any combination of mathematics and cognate courses. The courses in mathematics must include:

| MATH UN2010 | LINEAR ALGEBRA (also satisfied by Honors Math A-B) |
| MATH GU4041 | INTRO MODERN ALGEBRA I (I) |
| MATH GU4042 | INTRO MODERN ALGEBRA II (II) |
| MATH GU4061 | INTRO MODERN ANALYSIS I (I) |
| MATH GU4062 | INTRO MODERN ANALYSIS II (II) |
| MATH UN3951 | Undergraduate Seminars in Mathematics I (at least one term) or MATH UN3952 |
| Undergraduate Seminars in Mathematics II |
* Note: It is strongly recommended that the sequences MATH GU4041 INTRO MODERN ALGEBRA I - MATH GU4062 INTRO MODERN ANALYSIS II and MATH GU4061 INTRO MODERN ANALYSIS I - MATH GU4062 INTRO MODERN ANALYSIS II be taken in separate years.

However, students who are not contemplating graduate study in mathematics may replace one or both of the two terms of MATH GU4061 INTRO MODERN ANALYSIS I - MATH GU4062 INTRO MODERN ANALYSIS II by one or two of the following courses: MATH UN2500 ANALYSIS AND OPTIMIZATION, MATH UN3007 Complex Variables, or MATH GU4032 Fourier Analysis and may replace MATH GU4042 INTRO MODERN ALGEBRA II by one of MATH UN3020 Number Theory and Cryptography or MATH UN3025 Making, Breaking Codes. In exceptional cases, the chair will approve the substitution of certain more advanced courses for those mentioned above.

For a major in Applied Mathematics: 14 courses (a minimum of 35 credits)

Four courses in calculus or Honors Mathematics A-B, including Advanced Placement Credit.

- MATH UN2010 LINEAR ALGEBRA (also satisfied by Honors Math A-B)
- MATH GU4061 INTRO MODERN ANALYSIS I
- APMA E4901 Seminar Problem in Applied Mathematics
- APMA E4903 Seminar: Problems in Applied Mathematics
- APMA E3900 Undergraduate Research in Applied Mathematics (APMA E3900 may be replaced, with approval, by another technical elective for seniors that involves an undergraduate thesis or creative research report)

Additional electives, to be approved by the Applied Math Committee, e.g.:

- MATH UN2500 ANALYSIS AND OPTIMIZATION
- MATH UN3007 Complex Variables or MATH GU4065 or APMA E4204 FUNCNTS OF A COMPLEX VARIABLE
- MATH UN3027 ORDINARY DIFFERENTIAL EQUATIONS or MATH UN2030
- MATH UN3028 PARTIAL DIFFERENTIAL EQUATIONS or APMA E4200
- MATH GU4032 Fourier Analysis
- APMA E4300 Computational Math: Introduction to Numerical Methods
- APMA E4101 Introduction to Dynamical Systems
- APMA E4150 Applied Functional Analysis

Possible further courses selected from the following:

- MATH UN1202 CALCULUS IV
- MATH UN2500 ANALYSIS AND OPTIMIZATION
- MATH UN3020 Number Theory and Cryptography
- MATH UN3025 Making, Breaking Codes

Any 3 credit MATH course numbered 2000 or above

Statistics

Select at least one of the following:

- STAT UN1101 Introduction to Statistics
- STAT UN1201 Calculus-Based Introduction to Statistics or equivalent

Other courses from the Statistics list (eg. STAT UN2102, STAT UN2103, STAT UN2104, STAT UN3105, STAT UN3106)

Computer Science

Select at least one of the following programming courses:

- COMS W1002 Computing in Context
- COMS W1004 Introduction to Computer Science and Programming in Java (preferred)
- COMS W1005 Introduction to Computer Science and Programming in MATLAB
- COMS W1007 Honors Introduction to Computer Science

Possible further courses selected from the following:

- Other classes from the Computer Science Core
- COMS W3203 DISCRETE MATHEMATICS
- COMS W3210 Scientific Computation
- ENGI E1006 Introduction to Computing for Engineers and Applied Scientists

More generally, electives may be any course with a prerequisite of at least one semester of Calculus, Statistics or Computer Science with the prior approval of the Mathematics Chair.

The Capstone Experience can be fulfilled by a significant thesis written under the supervision of faculty of any one of the three departments or by the Undergraduate Seminar in Mathematics.

For a major in Mathematics-Statistics: 14 courses (a minimum of 38 credits):

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

- MATH UN1207 Honors Mathematics A
- MATH UN1208 and HONORS MATHEMATICS B
- MATH UN2500 and ANALYSIS AND OPTIMIZATION

Statistics

Statistics required courses

- STAT UN1201 Calculus-Based Introduction to Statistics
- STAT GU4203 PROBABILITY THEORY
STAT GU4204  Statistical Inference
STAT GU4205  Linear Regression Models
And select one of the following courses:
STAT GU4207  Elementary Stochastic Processes
STAT GU4262  Stochastic Processes for Finance
STAT GU4264  STOCHASTIC PROCESSES-APLIC
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
COMS W1007  Honors Introduction to Computer Science
ENGI E1006  Introduction to Computing for Engineers and Applied Scientists

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 should plan to include a senior thesis or the Undergraduate Seminar in Mathematics in their program, in consultation with their advisers.

Note: Students must obtain approval from an adviser in each of the two departments before selecting electives. Students should take MATH UN2010 LINEAR ALGEBRA in the second semester of the second year.

For a major in Mathematics-Computer Science 15 courses (a minimum of 38 credits):

Mathematics
Four courses in calculus or Honors Mathematics A-B, including Advanced Placement Credit; and the 3 following courses:
MATH UN2010  LINEAR ALGEBRA (also satisfied by Honors Math A-B)
MATH GU4041  INTRO MODERN ALGEBRA I
MATH UN3951  Undergraduate Seminars in Mathematics I (at least one term)
or MATH UN3952  Undergraduate Seminars in Mathematics II

Computer Science
COMS W1004  Introduction to Computer Science and Programming in Java
COMS W3134  Data Structures in Java
COMS W3157  Advanced Programming
COMS W3203  DISCRETE MATHEMATICS
COMS W3261  Computer Science Theory
CSEE W3827  Fundamentals of Computer Systems

Note A: AP Computer Science with a grade of 4 or 5 or similar experience (e.g., COMS W1004) is a prerequisite for COMS W1007

Electives: 2 of the following:
CSOR W4231  Analysis of Algorithms I
COMS W4241  Numerical Algorithms and Complexity
MATH UN3020  Number Theory and Cryptography

MATH BC2006  Combinatorics
MATH GU4061  INTRO MODERN ANALYSIS I
MATH UN2500  ANALYSIS AND OPTIMIZATION
MATH UN3007  Complex Variables
MATH UN3386  Differential Geometry
MATH GU4051  Topology

Students seeking to pursue a Ph.D. program in either discipline are urged to take additional courses, in consultation with their advisers.

For a major in Economics and Mathematics, see the catalogue.

Requirement for the Minor in Mathematics
For a minor in Mathematics or Applied Mathematics: Six courses from any of the courses offered by the department except MATH UN1003 COLLEGE ALGEBRA-ANLYTC GEOMTRY, MATH UN1101 CALCULUS I / MATH UN1102 CALCULUS II. Some cognate courses are also acceptable with prior approval from the department chair.

Requirements for the Minor in Mathematical Sciences
The minor in Mathematical Sciences comprises 6 courses, at least two from Mathematics and one from each of Statistics and Computer Science. There should be a minimum of three courses in Statistics and Computer Science. Eligible courses are any listed in the Mathematical Sciences Major with the exception of Calculus I and II.

MATH UN1003 COLLEGE ALGEBRA-ANLYTC GEOMTRY. 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.
# Mathematics

## 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)

### Spring 2021: 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>
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<td>13/35</td>
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<td>3.00</td>
<td>31/35</td>
</tr>
<tr>
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<td>003/12306</td>
<td>T Th 10:10am - 11:25am Online Only</td>
<td>Panagiota Daskalopoulos</td>
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<td>61/100</td>
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<tr>
<td>MATH 1101</td>
<td>004/12305</td>
<td>T Th 11:40am - 12:55pm Online Only</td>
<td>George Dragomir</td>
<td>3.00</td>
<td>82/100</td>
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<tr>
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<td>Tobias Schaefer</td>
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<td>Sayan Das</td>
<td>3.00</td>
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### Fall 2021: 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>
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<tbody>
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<td>001/10622</td>
<td>M W 10:10am - 11:25am 203 Mathematics Building</td>
<td>Daniele Alessandri</td>
<td>3.00</td>
<td>68/100</td>
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<tr>
<td>MATH 1101</td>
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<td>Amadou Bah</td>
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<tr>
<td>MATH 1101</td>
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<td>M W 2:40pm - 3:55pm 203 Mathematics Building</td>
<td>Akash Sengupta</td>
<td>3.00</td>
<td>110/110</td>
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<tr>
<td>MATH 1101</td>
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<td>M W 4:10pm - 5:25pm 203 Mathematics Building</td>
<td>Akash Sengupta</td>
<td>3.00</td>
<td>109/110</td>
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<tr>
<td>MATH 1101</td>
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<td>George Dragomir</td>
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<td>100/116</td>
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<td>MATH 1101</td>
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<td>George Dragomir</td>
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<td>M W 6:10pm - 7:25pm 405 Milbank Hall</td>
<td>Lindsay Piekarski</td>
<td>3.00</td>
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<tr>
<td>MATH 1101</td>
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<td>Xi Shen</td>
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<td>Xi Shen</td>
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</table>

## 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)

### Spring 2021: MATH UN1102

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<tr>
<th>Course Number</th>
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<th>Times/Location</th>
<th>Instructor</th>
<th>Points</th>
<th>Enrollment</th>
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<td>MATH 1102</td>
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<td>Evgeni Dimitrov</td>
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### Fall 2021: MATH UN1102

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<th>Course Number</th>
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<th>Enrollment</th>
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<td>Gerhardt Hinkley</td>
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<td>Yash Uday Deshmukh</td>
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<td>MATH 1102</td>
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<td>Francesco Lin</td>
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<td>Yu-sheng Lee</td>
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<td>T Th 6:10pm - 7:25pm 520 Mathematics Building</td>
<td>Elliott Stein</td>
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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 1201
Course Number
Fall 2021: MATH UN1201
Course Number
Spring 2021: MATH UN1201
Course Number

<table>
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<th>Course Number</th>
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<th>Instructor</th>
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<th>Enrollment</th>
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<td>Evgeni Smirnov 3</td>
<td>26/100</td>
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<td>Mikhail Mu-Tao Wang 3</td>
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MATH UN1202 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 1202
Course Number
Spring 2021: MATH UN1202
Course Number

<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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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)

MATH 1207
Course Number
Fall 2021: MATH UN1207
Course Number

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<td>001/00656</td>
<td>T Th 1:10pm - 2:25pm 207 Mathematics Building</td>
<td>Evan Warner 4</td>
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MATH UN1208 Honors Mathematics B. 4.00 points.
Prerequisites: (see Courses for First-Year Students).
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)

MATH 1208
Course Number
Spring 2021: MATH UN1208
Course Number

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MATH UN2000 INTRO TO HIGHER MATHEMATICS. 3.00 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)

Spring 2021: MATH UN2000
Course Number Section/Call Number Times/Location Instructor Points Enrollment
MATH 2000 001/12293 M W 10:10am - 11:25am Online Only Gus Schrader 3.00 28/100

Fall 2021: MATH UN2000
Course Number Section/Call Number Times/Location Instructor Points Enrollment
MATH 2000 001/000172 M W 10:10am - 11:25am 302 Milbank Hall Dusa McDuff 3.00 36/55

MATH BC2001 Perspectives in Mathematics. 1 point.
Prerequisites: some calculus or the instructor’s permission. Intended as an enrichment to the mathematics curriculum of the first years, this course introduces a variety of mathematical topics (such as three dimensional geometry, probability, number theory) that are often not discussed until later, and explains some current applications of mathematics in the sciences, technology and economics.

MATH BC2006 Combinatorics. 3 points.
Corequisites: MATH V2010 is helpful as a corequisite, but not required. Honors-level introductory course in enumerative combinatorics. Pigeonhole principle, binomial coefficients, permutations and combinations. Polya enumeration, inclusion-exclusion principle, generating functions and recurrence relations.

Spring 2021: MATH BC2006
Course Number Section/Call Number Times/Location Instructor Points Enrollment
MATH 2006 001/000086 T Th 10:10am - 11:25am Room TBA David Bayer 3 38/40

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

Spring 2021: MATH UN2010
Course Number Section/Call Number Times/Location Instructor Points Enrollment
MATH 2010 001/12292 M W 10:10am - 11:25am Online Only Konstantin Alekshin 3.00 21/100
MATH 2010 002/12291 M W 1:10pm - 2:25pm Online Only Gus Schrader 3.00 83/120
MATH 2010 003/12290 T Th 11:40am - 12:55pm Online Only Stephen Miller 3.00 73/100
MATH 2010 004/12289 T Th 1:10pm - 2:25pm Online Only Andrew Ahn 3.00 19/100
MATH 2010 005/12288 T Th 6:10pm - 7:25pm Online Only Elliott Stein 3.00 28/46
MATH 2010 006/19231 Online Only Andrew Ahn 3.00 1/5

Fall 2021: MATH UN2010
Course Number Section/Call Number Times/Location Instructor Points Enrollment
MATH 2010 001/000173 T Th 8:40am - 9:55am 328 Milbank Hall David Bayer 3.00 32/50
MATH 2010 002/000174 T Th 10:10am - 11:25am 328 Milbank Hall David Bayer 3.00 45/50
MATH 2010 003/10679 M W 10:10am - 11:25am 207 Mathematics Building Marco Castronovo 3.00 38/100
MATH 2010 004/10693 M W 11:40am - 12:55pm 312 Mathematics Building Marco Castronovo 3.00 48/100
MATH 2010 005/10698 T Th 4:10pm - 5:25pm 520 Mathematics Building Henry Pinkham 3.00 15/49

MATH UN2020 Honors Linear Algebra. 3 points.
Not offered during 2021-22 academic year.

Prerequisites: MATH UN201. 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 EQUATION. 3.00 points.
Prerequisites: MATH UN1102 and MATH UN1201 or the equivalent. Prerequisites: MATH UN102 and MATH UN101 or the equivalent. Special differential equations of order one. Linear differential equations with constant and variable coefficients. Systems of such equations. Transform and series solution techniques. Emphasis on applications.

Spring 2021: MATH UN2030
Course Number Section/Call Number Times/Location Instructor Points Enrollment
MATH 2030 001/12287 M W 2:40pm - 3:55pm Online Only Igor Krichever 3.00 63/100
MATH 2030 002/12286 T Th 10:10am - 11:25am Online Only Aleksander Doan 3.00 47/100

Fall 2021: MATH UN2030
Course Number Section/Call Number Times/Location Instructor Points Enrollment
MATH 2030 001/10718 M W 1:10pm - 2:25pm 312 Mathematics Building Florian Johne 3.00 39/100
MATH 2030 002/10719 T Th 2:40pm - 3:55pm 312 Mathematics Building Evgeni Dimitrov 3.00 69/100
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)

Fall 2021: MATH UN2500
Course Number Section/Call Number Times/Location Instructor Points Enrollment
MATH 2500 001/10723 T Th 1:10pm - 2:25pm 312 Mathematics Building Dorian Goldfeld 3 99/100

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

Fall 2021: MATH UN3025
Course Number Section/Call Number Times/Location Instructor Points Enrollment
MATH 3025 001/10723 T Th 1:10pm - 2:25pm 312 Mathematics Building Dorian Goldfeld 3 99/100

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

Fall 2021: MATH UN3027
Course Number Section/Call Number Times/Location Instructor Points Enrollment
MATH 3027 001/10735 T Th 11:40am - 12:55pm 312 Mathematics Building Elena Giorgi 3 42/100

MATH UN3038 Partial Differential Equations. 3.00 points.
Prerequisites: MATH UN3027 and MATH UN2010 or the equivalent
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 2021: MATH UN3038
Course Number Section/Call Number Times/Location Instructor Points Enrollment
MATH 3038 001/12282 M W 1:10pm - 2:25pm Online Only Florian Johne 3.00 45/100

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 2021: MATH UN3050
Course Number Section/Call Number Times/Location Instructor Points Enrollment
MATH 3050 001/13870 M W 6:10pm - 7:25pm 312 Mathematics Building Mikhail Smirnov 3 55/60

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 2021: MATH UN3386
Course Number Section/Call Number Times/Location Instructor Points Enrollment
MATH 3386 001/10751 T Th 11:40am - 12:55pm 520 Mathematics Building Richard Hamilton 3 9/49

MATH UN3901 Supervised Readings in Mathematics I. 2-3 points.
Prerequisites: The written permission of the staff member who agrees to act as sponsor (sponsorship limited to full-time instructors on the staff list), as well as the permission of the Director of Undergraduate Studies. The written permission must be deposited with the Director of Undergraduate Studies before registration is completed. Guided reading and study in mathematics. A student who wishes to undertake individual study under this program must present a specific project to a member of the staff and secure his or her willingness to act as sponsor. Written reports and periodic conferences with the instructor.
MATH UN3952 Supervised Readings in Mathematics II. 2-3 points.
Prerequisites: The written permission of the staff member who agrees to act as a supervisor, and the permission of the Director of Undergraduate Studies. 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.

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.

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.

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 progressing, SL (2, Z) and subgroups, quotients of the upper half-plane and cusps, modular forms, Fourier expansions of modular forms, Hecke operators, L-functions of modular forms.
MATH GU4032 Fourier Analysis. 3 points.
Prerequisites: three terms of calculus and linear algebra or four terms of
calculus.
Prerequisite: three terms of calculus and linear algebra or four terms of
calculus. Fourier series and integrals, discrete analogues, inversion and
Poisson summation formulae, convolution. Heisenberg uncertainty
principle. Stress on the application of Fourier analysis to a wide range of
disciplines.

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

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 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 W4046 Introduction to Category Theory. 3 points.
CC/GS: Partial Fulfillment of Science Requirement
Not offered during 2021-22 academic year.

MATH GU4051 Topology. 3 points.
Prerequisites: (MATH UN1202 and MATH UN2010) and rudiments of
algebra.

MATH GU4052 Introduction to Knot Theory. 3 points.
CC/GS: Partial Fulfillment of Science Requirement

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

MATH GU4061 INTRO MODERN ANALYSIS I. 3 points.
Prerequisites: MATH 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. Real
numbers, metric spaces, elements of general topology, sequences and
series, continuity, differentiation, integration, uniform convergence,
Ascoli-Arzela theorem, Stone-Weierstrass theorem.

MATH GU4062 INTRO 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.
Prerequisites: MATH UN1202 or the equivalent, and MATH UN2010.
The second term of this course may not be taken without the first. Real
numbers, metric spaces, elements of general topology, sequences and
series, continuity, differentiation, integration, uniform convergence,
Ascoli-Arzela theorem, Stone-Weierstrass theorem.

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.

MATH GU4071 Introduction to the Mathematics of Finance. 3 points.
CC/GS: Partial Fulfillment of Science Requirement
Prerequisites: MATH UN1202 and MATH UN3027 and STAT W4150 and
SEIO W4150, or their equivalents.
The mathematics of finance, principally the problem of pricing of
derivative securities, developed using only calculus and basic probability.
Topics include mathematical models for financial instruments, Brownian
motion, normal and lognormal distributions, the Black-Scholes formula,
and binomial models.

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.
forms and Stokes' theorem.

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.

MATH GU4392 INTRO TO QUANTUM MECHANICS II. 3.00 points.
Not offered during 2021-22 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

Cross-Listed Courses
Computer Science
COMS S3251 Computational Linear Algebra. 3 points.
Not offered during 2021-22 academic year.
Prerequisites: two terms of calculus.
Computational linear algebra, solution of linear systems, sparse linear
systems, least squares, eigenvalue problems, and numerical solution of
other multivariate problems as time permits.
COMS W4203 Graph Theory. 3 points.
Lect: 3.

Prerequisites: (COMS W3203)
General introduction to graph theory. Isomorphism testing, algebraic specification, symmetries, spanning trees, traversability, planarity, drawings on higher-order surfaces, colorings, extremal graphs, random graphs, graphical measurement, directed graphs, Burnside-Polya counting, voltage graph theory.

COMS W3203 DISCRETE MATHEMATICS. 4.00 points.
Lect: 3.

Prerequisites: Any introductory course in computer programming.
Prerequisites: Any introductory course in computer programming. Logic and formal proofs, sequences and summation, mathematical induction, binomial coefficients, elements of finite probability, recurrence relations, equivalence relations and partial orderings, and topics in graph theory (including isomorphism, traversability, planarity, and colorings)

### Spring 2021: COMS W3203

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<td>Ansaf Salleb-Aouissi</td>
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### Fall 2021: COMS W3203

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### Industrial Engineering and Operations Research

CSOR E4010 Graph Theory: A Combinatorial View. 3 points.
Lect: 3. Not offered during 2021-22 academic year.

Prerequisites: Linear Algebra, or instructor’s permission.
Graph Theory is an important part of the theoretical basis of operations research. A good understanding of the basic fundamentals of graph theory is necessary in order to apply the theory successfully in the future. This is an introductory course in graph theory with emphasis on its combinatorial aspects. It covers basic definitions, and some fundamental concepts in graph theory and its applications. Topics include trees and forests graph coloring, connectivity, matching theory and others. This course will provide a solid foundation for students in the IEOR department, on which further courses may build.