NYU | COURANT

CAS UNDERGRADUATE MATHEMATICS PROGRAM

ACADEMIC YEAR 2021 – 2022
(Revised September 2021)

New York University
College of Arts & Science
Mathematics Department
Warren Weaver Hall
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This guide is meant to provide majors with a comprehensive picture of the offerings of the Mathematics Department. It contains information on courses, degree requirements, special programs, activities, prizes and awards. It supplements and repeats the information contained in the New York University Bulletin for the College of Arts and Sciences.

Table of Contents

I. Welcome to The Mathematics Department

The undergraduate division of the Department of Mathematics offers a wide variety of courses in pure and applied mathematics. The faculty are members of the University's Courant Institute of Mathematical Sciences, noted for its advanced training and research programs, which emphasize the applications of mathematics to technology and other branches of science.

Joint programs are available in mathematics and (1) computer science, (2) economics, (3) data science, and (4) engineering. They lead to the B.A. in four years, with the exception of the engineering option, which leads to a joint B.S./B.S. degree from NYU and NYU Tandon School of Engineering. Additionally, an accelerated B.A. and M.S. degree in Mathematics or Mathematics of Finance, as well as a M.A. in Math Education with Steinhardt, from New York University in five years is offered. The department also provides an honors program in (1) mathematics, (2) mathematics and computer science, and (3) mathematics and economics for outstanding students. Additionally, independent study and internship courses are available for students with special interests.

Required courses for all mathematics majors include MATH-UA 121 Calculus I, MATH-UA 122 Calculus II, MATH-UA 123 Calculus III, MATH-UA 140 Linear Algebra, MATH-UA 325 Analysis, and MATH-UA 343 Algebra (except joint mathematics and economics major who have the option to take MATH-UA 131–133 Math for Economics I–III in place of Calculus I–III).

Mathematics majors are encouraged to spend a semester studying abroad at one of the many centers run by NYU Global Programs. Currently, mathematics can be studied at NYU Abu Dhabi, NYU London, NYU Paris, and NYU Shanghai.

II. Advising

Students intending to major in mathematics are urged to declare their major as early as possible and no later than the beginning of their junior year. Students can declare their major by completing a major declaration form which is found on the [Declaring a Major or Minor](#) website.

The Undergraduate Advisement office for the Department is located in room 625 and 626 of Warren Weaver Hall. All matters concerning mathematics courses, majors, and minors can be addressed here. When necessary, math advisors will arrange appointments with the Director of Undergraduate Studies or Vice Chair of Undergraduate Affairs for advisement or academic counseling. Each mathematics major is assigned to a faculty advisor in the mathematics department. All declared mathematics majors must have their proposed course schedules approved each term by their faculty advisors. The approved schedule must be signed by the faculty advisor and delivered to the mathematics department administrative staff in room 606, 625, or 627 for final clearance.

Students who believe that they are prepared to start their work in mathematics at an advanced level, or who feel qualified to enter a course without the formal prerequisites, should submit a documentation of prior college level coursework along with syllabuses to the Vice Chair of Undergraduate Affairs. Calculus placement exams are offered each semester.

III. Degree Programs

Any changes to a degree program's requirements apply only to students matriculating after those changes are adopted, and not to students currently enrolled. Each student should follow the requirements in place at the time they entered the university.

A. Major in Mathematics

REQUIREMENTS FOR STUDENTS WHO ENROLLED IN CAS FALL 2019 OR LATER

The requirements for the mathematics major are thirteen courses numbered MATH-UA 120 or higher. The only exceptions are MATH-UA 131–133 Math for Economics I–III, which are not open to anyone who has taken Calculus and are for Economics majors. The courses must include:

a. Introductory Course Requirement
- MATH-UA 120 Discrete Mathematics
- MATH-UA 121 Calculus I
- MATH-UA 122 Calculus II
- MATH-UA 123 Calculus III
- MATH-UA 140 Linear Algebra

Calculus III and Linear Algebra can each be substituted by their more intensive counterparts:

- MATH-UA 129 Honors Calculus III
- MATH-UA 148 Honors Linear Algebra

b. Analysis and Algebra Requirement
- MATH-UA 325 Analysis

- MATH-UA 343 Algebra

Either of these courses can be substituted by its more intensive counterpart:

- MATH-UA 328 Honors Analysis I

- MATH-UA 348 Honors Algebra I

We strongly suggest students take analysis prior to algebra. Both courses are fully proof-based.

c. **Advanced Electives Requirement**

   The rest of the 13 required courses must include at least three of the following:

   - MATH-UA 233 Theory of Probability or MATH-UA 238 Honors Theory of Probability

   - MATH-UA 234 Mathematical Statistics

   - MATH-UA 240 Combinatorics

   - MATH-UA 248 Theory of Numbers

   - MATH-UA 252 Numerical Analysis

   - MATH-UA 253 Linear and Nonlinear Optimization

   - MATH-UA 262 Ordinary Differential Equations or MATH-UA 268 Honors Ordinary Differential Equations

   - MATH-UA 263 Partial Differential Equations

   - MATH-UA 264 Chaos & Dynamical Systems

   - MATH-UA 282 Functions of a Complex Variable

   - MATH-UA 329 Honors Analysis II

   - MATH-UA 349 Honors Algebra II

   - MATH-UA 375 Topology

   - MATH-UA 377 Differential Geometry

- MATH-UA 393 Honors I

- MATH-UA 394 Honors II

- MATH-UA 397 Honors III

- MATH-UA 398 Honors IV

Additional Guidelines

In addition to the above requirements, the following guidelines must be observed:

- Any two computer science courses (numbered CSCI-UA 101 or higher, except CSCI-UA 380) or graduate data science DS-GA courses may be credited toward the 13-course requirement.

- Students enrolled in and who complete the Premedical or Predental Program and who wish to major in mathematics may substitute at most two math classes by any two of the following: PHYS-UA 11–12 General Physics I and II, or PHYS-UA 91–93 Physics I and II toward their 13-course requirement. However, if these physics courses are used towards the mathematics major, the computer science or data science courses will not apply towards the major.

- Students may double-count no more than two courses towards both the Mathematics Major and the requirements of another major or minor.

- Students may petition to enroll in graduate mathematics courses and apply them to the undergraduate major. Permission to enroll is not granted until the student has completed MATH-UA 325 Analysis and the available undergraduate courses on the same topic. Please see the Enrollment in Graduate Courses webpage for more detailed information.

- Courses taken under the pass/fail option are not counted toward the major.

- A grade of C or better is required in all courses used to fulfill the major requirement.

- Students must maintain a 2.0 mathematics GPA.

- At least half of all courses in the major must be taken at CAS.

REQUIREMENTS FOR STUDENTS WHO ENROLLED IN CAS FALL 2014 - SUMMER 2019

The requirements for the mathematics major are thirteen courses numbered MATH-UA 120 or higher. The only exceptions are MATH-UA 131, 132, and 133 Math for Economics I, II and III which are not open to anyone who has taken Calculus and are for Economics Majors. The courses must include:

a.   **Introductory Course Requirement**

- MATH-UA 121 Calculus I

- MATH-UA 122 Calculus II

- MATH-UA 123 Calculus III

- MATH-UA 140 Linear Algebra

Calculus III and Linear Algebra can each be substituted by their more intensive counterparts:

- MATH-UA 129 Honors Calculus III

- MATH-UA 148 Honors Linear Algebra

b.   **Analysis and Algebra Requirement**

- MATH-UA 325 Analysis

- MATH-UA 343 Algebra

Either of these courses can be substituted by its more intensive counterpart:

- MATH-UA 328 Honors Analysis I

- MATH-UA 348 Honors Algebra I

We strongly suggest students take analysis prior to algebra. Both courses are fully proof-based.

c. Advanced Electives Requirement

The rest of the 13 required courses must include at least three of the following:

- MATH-UA 233 Theory of Probability or MATH-UA 238 Honors Theory of Probability

- MATH-UA 234 Mathematical Statistics

- MATH-UA 240 Combinatorics

- MATH-UA 248 Theory of Numbers

- MATH-UA 252 Numerical Analysis

- MATH-UA 253 Linear and Nonlinear Optimization

- MATH-UA 262 Ordinary Differential Equations or MATH-UA 268 Honors Differential Equations

- MATH-UA 263 Partial Differential Equations

- MATH-UA 264 Chaos & Dynamical Systems

- MATH-UA 282 Functions of a Complex Variable

- MATH-UA 329 Honors Analysis II

- MATH-UA 349 Honors Algebra II

- MATH-UA 375 Topology

- MATH-UA 377 Differential Geometry

- MATH-UA 393 Honors I

- MATH-UA 394 Honors II

- MATH-UA 397 Honors III

- MATH-UA 398 Honors IV

Additional Guidelines

In addition to the above requirements, the following guidelines must be observed:

- Any two computer science courses (numbered CSCI-UA 101 or higher, except CSCI-UA 380) or graduate data science DS-GA courses may be credited toward the 13-course requirement.

- Students enrolled in and who complete the Premedical or Predental Program and who wish to major in mathematics may substitute at most two math classes by any two of the following: PHYS-UA 11–12 General Physics I and II, or PHYS-UA 91–93 Physics I and II toward their 13-course requirement. However, if these physics courses are used towards the mathematics major, the computer science or data science courses will not apply towards the major.

- Students may double-count no more than two courses towards both the Mathematics Major and the requirements of another major or minor.

- Students may petition to enroll in graduate mathematics courses and apply them to the undergraduate major. Permission to enroll is not granted until the student has completed MATH-UA 325 Analysis and the available undergraduate courses on the same topic. Graduate courses may not be counted as Advanced Electives in requirement (c) above. Please see the [Enrollment in Graduate Level Courses](#) webpage for more detailed information.

- Courses taken under the pass/fail option are not counted toward the major.

- A grade of C or better is required in all courses used to fulfill the major requirement.

- Students must maintain a 2.0 mathematics GPA.

- At least half of all courses in the major must be taken at CAS.

B. **Joint Major in Mathematics and Computer Science**
   An interdisciplinary major offered jointly by the Department of Mathematics and Computer Science, provides the opportunity to study both computer science and relevant mathematics courses such as analysis, algebra, probability, and statistics. Students must complete one CSCI-UA course with a recorded grade of C or better before they can declare this joint major (this policy applies to all NYU students, not just to those matriculated in CAS).

   a. **Mathematics Requirements**
      The requirements are ten courses numbered MATH-UA 120 or higher, except MATH-UA 131, 132, 133 from the Mathematics Department,

which must include:

- MATH-UA 120 Discrete Math

- MATH-UA 121 Calculus I

- MATH-UA 122 Calculus II

- MATH-UA 123 Calculus III or MATH-UA 129 Honors Calculus III

- MATH-UA 140 Linear Algebra or MATH-UA 148 Honors Linear Algebra

- MATH-UA 325 Analysis or MATH-UA 328 Honors Analysis I

- MATH-UA 343 Algebra or MATH-UA 348 Honors Algebra I

The rest of the 10 required courses must include two of the following:

- MATH-UA 233 Theory of Probability or MATH-UA 238 Honors Theory of Probability

- MATH-UA 234 Mathematical Statistics

- MATH-UA 240 Combinatorics

- MATH-UA 248 Theory of Numbers

- MATH-UA 251 Mathematical Modeling

- MATH-UA 252 Numerical Analysis

- MATH-UA 253 Linear and Nonlinear Optimization

- MATH-UA 262 Ordinary Differential Equations or MATH-UA 268 Honors Ordinary Differential Equations

- MATH-UA 263 Partial Differential Equations

- MATH-UA 264 Chaos & Dynamical Systems

- MATH-UA 282 Functions of a Complex Variable

- MATH-UA 329 Honors Analysis II

- MATH-UA 349 Honors Algebra II

- MATH-UA 375 Topology

- MATH-UA 377 Differential Geometry

- MATH-UA 393 Honors I

- MATH-UA 394 Honors II

- MATH-UA 397 Honors III

- MATH-UA 398 Honors IV

b. **Computer Science Requirements**
   Eight computer science courses as required for the major in that department, which must include:

   - CSCI-UA 101 Introduction to Computer Science

   - CSCI-UA 102 Data Structures

   - CSCI-UA 201 Computer Systems Organization

   - CSCI-UA 202 Operating Systems

   - CSCI-UA 310 Basic Algorithms

   - CSCI-UA 421 Numerical Computing

   - CSCI-UA 4xx Advanced CS Elective

   - CSCI-UA 4xx Advanced CS Elective

   Please refer to the [Computer Science Majors](#) website for information on computer science courses.

Additional Guidelines

In addition to the above requirements, the following guidelines must be observed:

- Students may double-count no more than two courses towards both the Joint Major in Mathematics and Computer Science and the requirements of another major or minor.
- Courses taken under the pass/fail option are not counted toward the major.
- A grade of C or better is required in all these courses to fulfill the major requirement.
- Students must maintain a 2.0 mathematics GPA.

- At least 4 of the math courses and a total of 9 courses for the entire joint major must be taken at CAS.

C. Joint Major in Mathematics and Data Science

An interdisciplinary major offered jointly by the Departments of Mathematics and Data Science trains students to use data science methods, and enables them to understand the mathematical theories that go into the analysis of large data sets. It will allow students to apply mathematical theories to real-world challenges that need data science and computational solutions.

a. **Mathematics Requirements**

The requirements are nine courses numbered MATH-UA 120 or higher from the Mathematics Department, which must include:
- MATH-UA 120 Discrete Math
- MATH-UA 121 Calculus I
- MATH-UA 122 Calculus II
- MATH-UA 123 Calculus III or MATH-UA 129 Honors Calculus III
- MATH-UA 140 Linear Algebra or MATH-UA 148 Honors Linear Algebra
- MATH-UA 233 Theory of Probability or MATH-UA 238 Honors Theory of Probability
- MATH-UA 234 Mathematical Statistics
- MATH-UA 252 Numerical Analysis
- MATH-UA 325 Analysis or MATH-UA 328 Honors Analysis I

b. **Data Science Requirements**

Five data science courses as required for the major in that department, which must include:
- DS-UA 111 Data Science for Everyone
- DS-UA 112 Introduction to Data Science
- DS-UA 201 Causal Inference
- DS-UA 202 Responsible Data Science
- DS-UA 300 Advanced Topics in Data Science

c. **Computer Science Requirements**

Four computer science courses as required for the major in that department, which must include:
- CSCI-UA 101 Introduction to Computer Science
- CSCI-UA 102 Data Structures
- CSCI-UA 473 Machine Learning
- CSCI-UA 479 Data Management and Analysis

Please refer to the [Data Science Undergraduate Program](#) website for

information on data science courses and the [Computer Science Majors](#) website for information on computer science courses.

Additional Guidelines

In addition to the above requirements, the following guidelines must be observed:

- Students may double-count no more than two courses towards both the Joint Major in Mathematics and Data Science and the requirements of another major or minor.
- Courses taken under the pass/fail option are not counted toward the major.
- A grade of C or better is required in all these courses to fulfill the major requirement.
- At least 3 of the math courses and a total of 9 courses for the entire joint major must be taken at CAS.

D. **Joint Major in Mathematics and Economics**
An interdisciplinary major offered jointly by the Departments of Mathematics and Economics, providing the opportunity to study economics, and in mathematics, analysis, statistics, and operations research. Please note: Students in the joint mathematics/economics major may only take the theory sequence in Economics.

a. **Mathematics Requirements**
The requirements are nine courses numbered MATH-UA 120 or higher from the Mathematics Department, which must include:
- **EITHER,** the following three courses (preferred):
  - MATH-UA 131 Math for Economics I
  - MATH-UA 132 Math for Economics II
  - MATH-UA 133 Math for Economics III
- **OR,** the following three courses:
  - MATH-UA 121 Calculus I
  - MATH-UA 122 Calculus II
  - MATH-UA 123 Calculus III or MATH-UA 129 Honors Calculus III

  AND

- MATH-UA 140 Linear Algebra or MATH-UA 148 Honors Linear Algebra

- MATH-UA 325 Analysis or MATH-UA 328 Honors Analysis I

The Math for Economics sequence is the preferred sequence for this major. Students must complete *one* of the sequences and courses from the other sequence may not be applied to the same degree program. *Students may not register simultaneously for separate courses within the two sequences.*

Plus, four chosen from:

- MATH-UA 233 Theory of Probability or MATH-UA 238 Honors Theory of Probability

- MATH-UA 234 Mathematical Statistics

- MATH-UA 235 Probability & Statistics

- MATH-UA 240 Combinatorics

- MATH-UA 248 Theory of Numbers

- MATH-UA 250 Mathematics of Finance

- MATH-UA 251 Mathematical Modeling

- MATH-UA 252 Numerical Analysis

- MATH-UA 253 Linear and Nonlinear Optimization

- MATH-UA 262 Ordinary Differential Equations or MATH-UA 268 Honors Ordinary Differential Equations

- MATH-UA 263 Partial Differential Equations

- MATH-UA 264 Chaos & Dynamical Systems

- MATH-UA 282 Functions of a Complex Variable

- MATH-UA 329 Honors Analysis II

- MATH-UA 343 Algebra or MATH-UA 348 Honors Algebra I

- MATH-UA 349 Honors Algebra II

- MATH-UA 375 Topology

- MATH-UA 377 Differential Geometry

- MATH-UA 393 Honors I

- MATH-UA 394 Honors II

- MATH-UA 397 Honors III

- MATH-UA 398 Honors IV

b. **Economics Requirements**

Nine economics courses as required for the major in that department, which must include:

- ECON-UA 1 Introduction to Macroeconomics

- ECON-UA 2 Introduction to Microeconomics

- ECON-UA 11 Microeconomic Analysis

- ECON-UA 13 Macroeconomic Analysis

- ECON-UA 20 Analytical Statistics *(if not taking MATH-UA 234 Mathematical Statistics)*

- ECON-UA 266 Introduction to Econometrics

- Plus, any three economics elective courses, at least two of which must be theory electives numbered ECON-UA 300-399. *Note that students who take MATH-UA 234 instead of ECON-UA 20 for the statistics requirement must take a total of four ECON-UA electives.*

Please refer to the [Department of Economics](#) website for information on economics courses.

Additional Guidelines

In addition to the above requirements, the following guidelines must be observed:

- Students may double-count no more than two courses towards both the Joint Major in Mathematics and Economics and the requirements of another major or minor.
- Courses taken under the pass/fail option are not counted toward the major.

- A grade of C or better is required in all these courses to fulfill the major requirement.
- Students must maintain a 2.0 mathematics GPA.
- At least 3 of the math courses and a total of 9 courses for the entire joint major must be taken at CAS.

E. Mathematics Minor

The requirements for a mathematics minor are four courses in the department numbered MATH-UA 120 or higher. Courses from the sequences MATH-UA 121-123 Calculus I-III and MATH-UA 131-133 Math for Economics I-III may not both be applied to the mathematics minor. Although courses transferred from other colleges may count towards the minor, at least two courses for the minor must be taken at NYU. Students pursuing majors that require mathematics courses may follow this minor, as long as two of the four courses do not apply simultaneously to the requirements for their major.

Additional Guidelines

In addition to the above requirements, the following guidelines must be observed:
- Courses taken under the pass/fail option are not counted toward the minor.
- A grade of C or better is required in all courses to count toward the minor.

F. Joint Mathematics and Computer Science Minor

The requirements for the Joint Mathematics and Computer Science Minor are the four courses:
- MATH-UA 121 Calculus I
- MATH-UA 122 Calculus II
- CSCI-UA 101 Introduction to Computer Science
- CSCI-UA 102 Data Structures

Economics majors may substitute MATH-UA 131 Math for Economics I and 132 Math for Economics II for MATH-UA 121 and 122.

Additional Guidelines

In addition to the above requirements, the following guidelines must be observed:

- Students must complete one CSCI-UA course with a recorded grade of C or better before they can declare this joint minor (this policy applies to all NYU students, not just to those matriculated in CAS).

- At most one mathematics course in the joint minor may be transferred from another college.
- Students who wish to double-count courses for the math portion of the minor and another requirement may count at most two such courses toward the minor.
- Courses taken under the pass/fail option are not counted toward the minor.
- A grade of C or better is required in all courses to count toward the minor.

G. **Advanced Mathematical Methods Minor (for Stern undergraduates only)**
The Advanced Mathematical Methods Minor provides students with mathematical tools to handle complex business problems. The requirements are:

- MATH-UA 140 Linear Algebra or MATH-UA 148 Honors Linear Algebra
- STAT-UB 14 Introduction to the Theory of Probability
- MATH-UA 252 Numerical Analysis or MATH-GA 2010 Numerical Methods I
- **ONE** course from the advanced course list below:
    - MATH-UA 262 Ordinary Differential Equations or MATH-UA 268 Honors Ordinary Differential Equations
    - MATH-UA 263 Partial Differential Equations
    - MATH-UA 325 Analysis or MATH-UA 328 Honors Analysis I
    - STAT-UB 15 Statistical Inference and Regression Analysis
    - STAT-UB 21 Introduction to Stochastic Processes

All students must take at least one Stern course in order to meet the minor requirements. Students who have completed MATH-UA 233 Theory of Probability or equivalent should not take STAT-UB 14, and should substitute one of the advanced courses in its place.

H. **Mathematics Education Minor for Mathematics Majors**
The Mathematics Education Minor (for Mathematics Majors) enables students to complete coursework as an undergraduate in CAS that will reduce the number of credits required of a Steinhardt School of Education M.A. degree in Teachers of Mathematics, Grades 7-12 for Initial teacher certification. The master's degree will require 30 credits including student teaching internships beyond the bachelor's degree.

We recommend students declare the minor and begin taking these courses during the first semester of their junior year. Most of these courses require a fieldwork component consisting of classroom observation and participation. For course descriptions, please view the [Steinhardt School of Education's Teacher Education](#) website.

I. **B.S. /B.S. Program in Engineering**
The College of Arts and Science, in cooperation with the NYU Tandon School of Engineering, offers a joint B.S./B.S. program in engineering. Students in the program

receive the B.S. degree in mathematics and the B.S. degree in either civil, computer, electrical or mechanical engineering. The joint mathematics/engineering students must complete the 13-course mathematics requirement. Students are allowed to substitute CSCI-UA 101, 102 Computer Science I, II, or PHYS-UA 91, 93 Physics I, II for a maximum of two mathematics classes. Further information is available from Mr. Tyrell Davis, advisor for the B.S./B.S. program, in the College Advising Center, Silver Center, 100 Washington Square East, Room 905; 212-998-8133**.**

J. **B.A./M.S. Program in Mathematics or Mathematics in Finance**
The NYU GSAS Bachelor's-Master's track allows students to earn both a Mathematics Bachelor's and Master's degree in five years. The program is suited to students who have decided not to enter a Ph.D. program at this time but who would like to increase their skills before entering the job market. Qualifying students are accepted into a program toward the end of the sophomore year or during their junior year before they reach 96 credits. Students must earn a minimum of a 3.50 GPA in order to qualify for acceptance into the Bachelor's-Master's track. During the last few undergraduate semesters, students should accelerate by taking one quarter of their graduate courses during regular terms and/or during the summer. In the graduate portion of the program, they can qualify for a scholarship covering up to 50 percent of the tuition for the master's degree.

The application requirements are as follows:

Mathematics

Application Prerequisites: Minimum 3.7 GPA in Mathematics coursework, and completion of 2 of the following courses:

- MATH-UA 233 Theory of Probability or MATH-UA 238 Honors Theory of Probability
- MATH-UA 262 Ordinary Differential Equations or MATH-UA 268 Honors Ordinary Differential Equations
- MATH-UA 282 Functions of a Complex Variable
- MATH-UA 325 Analysis or MATH-UA 328 Honors Analysis I
- MATH-UA 343 Algebra or MATH-UA 348 Honors Algebra I

Minimum MS Credits Before Bachelor's: 9 (three 3-credit courses)

Mathematics in Finance

Application Prerequisites:

1. Minimum 3.7 GPA in Mathematics coursework

2. Completion of the following courses **before** the semester of application:

   - MATH-UA 140 Linear Algebra or MATH-UA 148 Honors Linear Algebra
   - MATH-UA 233 Theory of Probability or MATH-UA 238 Honors Theory of Probability or MATH-UA 234 Mathematical Statistics
   - MATH-UA 325 Analysis or MATH-UA 328 Honors Analysis I
   - CSCI-UA 101 Introduction to Computer Science
   - CSCI-UA 102 Data Structures (or equivalent)

   The department also recommends students complete the following courses (although these are not required for admission): MATH-UA 262, MATH-UA 263, MATH-UA 252, MATH-UA 253, CSCI-UA 310, CSCI-UA 470.

3. At least one letter of recommendation from a professor in an advanced math or computer science course (ideally one of the courses listed above)

Minimum MS Credits Before Bachelor's: 12 (four 3-credit courses)

For more information, please contact Associate Director, Juniors and Inter-School Programs, Brendan Sullivan at brendan.m.sullivan@nyu.edu or (212) 998-3748.

K. **B.A./M.A. Program in Mathematics/Teacher Education**
   Students in Mathematics can complete both their Bachelor's degree and a Master's degree in Teaching (grades 7 - 12) in just 5 years. In addition to saving money by completing the MA at an accelerated pace, students in this dual degree program receive a generous scholarship toward the MA degree. The scholarship typically covers 30% of graduate tuition and may cover more depending on the program of study and availability of external funds. For more information, please contact Associate Director, Juniors and Inter-School Programs, Brendan Sullivan at brendan.m.sullivan@nyu.edu or (212) 998-3748.

IV. Honors Program

A. **Mathematics Honors Major**
   The Honors Program is designed for students with a strong commitment to mathematics. It is recommended for students who intend to pursue graduate study in mathematics.

REQUIREMENTS FOR STUDENTS WHO ENROLLED IN CAS FALL 2019 OR LATER

The requirements for the Honors Mathematics major are thirteen courses numbered MATH-UA 120 or higher, including the Honors electives. The only exceptions are MATH-UA 131, 132, and 133 Math for Economics I, II and III which are not open to anyone who has taken Calculus and are for Economics Majors. The courses must include:

a. **Introductory Course Requirement**
   - MATH-UA 120 Discrete Mathematics
   - MATH-UA 121 Calculus I
   - MATH-UA 122 Calculus II
   - MATH-UA 123 Calculus III
   - MATH-UA 140 Linear Algebra

   Calculus III and Linear Algebra can each be substituted by their more intensive counterparts:
   - MATH-UA 129 Honors Calculus III
   - MATH-UA 148 Honors Linear Algebra

b. **Analysis and Algebra Requirement**
   - MATH-UA 325 Analysis
   - MATH-UA 343 Algebra

   Either of these courses can be substituted by its more intensive counterpart:
   - *MATH-UA 328 Honors Analysis I*
   - *MATH-UA 348 Honors Algebra I*

   We strongly suggest students take analysis prior to algebra. Both courses are fully proof-based.

c. **Advanced Electives Requirement**

   The rest of the 13 required courses must include at least three of the following:

- MATH-UA 233 Theory of Probability or *MATH-UA 238 Honors Theory of Probability*

- MATH-UA 234 Mathematical Statistics

- MATH-UA 240 Combinatorics

- MATH-UA 248 Theory of Numbers

- MATH-UA 252 Numerical Analysis

- MATH-UA 253 Linear and Nonlinear Optimization

- MATH-UA 262 Ordinary Differential Equations or *MATH-UA 268 Honors Differential Equations*

- MATH-UA 263 Partial Differential Equations

- MATH-UA 264 Chaos & Dynamical Systems

- MATH-UA 282 Functions of a Complex Variable

- *MATH-UA 329 Honors Analysis II*

- *MATH-UA 349 Honors Algebra II*

- MATH-UA 375 Topology

- MATH-UA 377 Differential Geometry

- *MATH-UA 393 Honors I*

- *MATH-UA 394 Honors II*

- *MATH-UA 397 Honors III*

- *MATH-UA 398 Honors IV*

While working through the above requirements, students must complete at least **four** of the *Honors Electives.* Where applicable, the same course counts both towards the general restricted electives as well as towards the honors electives. For example, students who have taken MATH-UA 325 Analysis or MATH-UA 343 Algebra may not take the corresponding MATH-UA 328 Honors Analysis I or MATH-UA 348 Honors Algebra I to fulfill this requirement.

Honors Project

This may be satisfied by participation in the mathematics Summer Undergraduate Research Experience (SURE) program under individual faculty supervision. Students who participate in this program are required to present their research at Courant's undergraduate research forum in the fall semester of their senior year. Students who participate in SURE receive financial support for the summer.

OR

Students may also satisfy this research component by participating in the AM-SURE program. This program is for students interested in applied mathematics and will pay a competitive salary. For more information please go to the AM-SURE website.

OR

Alternatively, students must complete up to two semesters of independent study (MATH-UA 997, 998) under faculty supervision and present their research at the Dean's Undergraduate Research Forum (DURF) in the spring. Students should seek approval of their honors project from the Honors Faculty Advisor, Antoine Cerfon.

* The math department reserves the right to nominate strong academic records for admittance into the departmental honors program.

Admission into the Mathematics Honors Program

A grade point average of 3.65 or higher

Students who have completed at least 64 points of graded work in the College will be awarded degrees with departmental honors by successfully completing the designated honors sequence, or the equivalent approved by the department, and by maintaining a general average of 3.65 and an average of 3.65 in the major.

If you have questions about the honors program, please contact the Assistant Director of Academic Affairs, Beth Markowitz at beth@cims.nyu.edu or the Honors Faculty Advisor, Antoine Cerfon at cerfon@cims.nyu.edu.

If you are a mathematics major who is interested in joining the honors program,

please complete the online major declaration form and select the option "Current Math Major interested in the Math Honors Program." (Please note: you must be logged into your NYU e-mail account in order to access this form).

To be graduated with Latin honors, a student must have completed at least 64 points in courses in the College with passing grades. All graded courses taken while enrolled in the College, or in other divisions of the University, will be used to compute the honors average. Pass grades are not counted, nor are grades received in courses at other institutions. The student must have a good record of conduct and maintain a minimum general average as follows: cum laude, 3.686; magna cum laude, 3.805; summa cum laude, 3.9.

Additional Guidelines

In addition to the above requirements, the following guidelines must be observed:

- Any two computer science courses (numbered CSCI-UA 101 or higher, except CSCI-UA 380) or graduate data science DS-GA courses may be credited toward the 13-course requirement.

- Students enrolled in and who complete the Premedical or Predental Program and who wish to major in mathematics may substitute at most two math classes by any two of the following: PHYS-UA 11–12 General Physics I and II, or PHYS-UA 91–93 Physics I and II toward their 13-course requirement. However, if these physics courses are used towards the mathematics major, the computer science or data science courses will not apply towards the major.

- Students may double-count no more than two courses towards both the Mathematics Major and the requirements of another major or minor.

- Students may petition to enroll in graduate mathematics courses and apply them to the undergraduate major. Permission to enroll is not granted until the student has completed MATH-UA 325 Analysis and the available undergraduate courses on the same topic. Please see the Enrollment in Graduate Courses webpage for more detailed information.

- Courses taken under the pass/fail option are not counted toward the major.

- A grade of C or better is required in all courses used to fulfill the major requirement.

- At least half of all courses in the major must be taken at CAS.

REQUIREMENTS FOR STUDENTS WHO ENROLLED IN CAS FALL 2014 - SUMMER 2019

The requirements for the mathematics major are thirteen courses numbered MATH-UA 120 or higher, including the Honors electives. The only exceptions are MATH-UA 131, 132, and 133 Math for Economics I, II and III which are not open to anyone who has taken Calculus and are for Economics Majors. The courses must include:

d. Introductory Course Requirement

- MATH-UA 121 Calculus I

- MATH-UA 122 Calculus II

- MATH-UA 123 Calculus III

- MATH-UA 140 Linear Algebra

Calculus III and Linear Algebra can each be substituted by their more intensive counterparts:

- MATH-UA 129 Honors Calculus III

- MATH-UA 148 Honors Linear Algebra

e. Analysis and Algebra Requirement

- MATH-UA 325 Analysis

- MATH-UA 343 Algebra

Either of these courses can be substituted by its more intensive counterpart:

- *MATH-UA 328 Honors Analysis I*

- *MATH-UA 348 Honors Algebra I*

f. Advanced Electives Requirement

The rest of the 13 required courses must include at least three of the following:

- MATH-UA 233 Theory of Probability or *MATH-UA 238 Honors Theory of Probability*

- MATH-UA 234 Mathematical Statistics

- MATH-UA 240 Combinatorics

- MATH-UA 248 Theory of Numbers

- MATH-UA 252 Numerical Analysis

- MATH-UA 253 Linear and Nonlinear Optimization

- MATH-UA 262 Ordinary Differential Equations or *MATH-UA 268 Honors Ordinary Differential Equations*

- MATH-UA 263 Partial Differential Equations

- MATH-UA 264 Chaos & Dynamical Systems

- MATH-UA 282 Functions of a Complex Variable

- *MATH-UA 329 Honors Analysis II*

- *MATH-UA 349 Honors Algebra II*

- MATH-UA 375 Topology

- MATH-UA 377 Differential Geometry

- *MATH-UA 393 Honors I*

- *MATH-UA 394 Honors II*

- *MATH-UA 397 Honors III*

- *MATH-UA 398 Honors IV*

While working through the above requirements, Honors students must complete at least **four** of the *Honors Electives.* Where applicable, the same course counts both towards the general restricted electives as well as towards the honors electives. For example, students who have taken MATH-UA 325 Analysis or MATH-UA 343 Algebra may not take the corresponding MATH-UA 328 Honors Analysis I or MATH-UA 348 Honors Algebra I to fulfill this requirement.

Honors Project

This may be satisfied by participation in the mathematics Summer Undergraduate Research Experience (SURE) program under individual faculty supervision. Students who participate in this program are required to present their research at Courant's undergraduate research forum in the fall semester of

their senior year. Students who participate in SURE receive financial support for the summer.

OR

Students may also satisfy this research component by participating in the AM-SURE program. This program is for students interested in applied mathematics and will pay a competitive salary. For more information please go to the [AM-SURE](#) website.

OR

Alternatively, students must complete up to two semesters of independent study (MATH-UA 0997, 0998) under faculty supervision and present their research at the Dean's Undergraduate Research Forum (DURF) in the spring. Students should seek approval of their honors project from the Honors Faculty Advisor, Antoine Cerfon.

* The math department reserves the right to nominate strong academic records for admittance into the departmental honors program.

<u>Admission into the Mathematics Honors Program</u>

- A grade point average of 3.65 or higher

Students who have completed at least 64 points of graded work in the College will be awarded degrees with departmental honors by successfully completing the designated honors sequence, or the equivalent approved by the department, and by maintaining a general average of 3.65 and an average of 3.65 in the major.

If you have questions about the honors program, please contact the Assistant Director of Academic Affairs, Beth Markowitz at beth@cims.nyu.edu or the Honors Faculty Advisor, Antoine Cerfon at cerfon@cims.nyu.edu.

If you are a mathematics major who is interested in joining the honors program, please complete the online major declaration form and select the option "Current Math Major interested in the Math Honors Program." *(Please note: you must be logged into your NYU e-mail account in order to access this form).*

To be graduated with Latin honors, a student must have completed at least 64 points in courses in the College with passing grades. All graded courses taken

while enrolled in the College, or in other divisions of the University, will be used to compute the honors average. Pass grades are not counted, nor are grades received in courses at other institutions. The student must have a good record of conduct and maintain a minimum general average as follows: cum laude, 3.686; magna cum laude, 3.805; summa cum laude, 3.9.

Additional Guidelines

In addition to the above requirements, the following guidelines must be observed:

- Any two computer science courses (numbered CSCI-UA 101 or higher, except CSCI-UA 380) or graduate data science DS-GA courses may be credited toward the 13-course requirement.

- Students enrolled in and who complete the Premedical or Predental Program and who wish to major in mathematics may substitute at most two math classes by any two of the following: PHYS-UA 11–12 General Physics I and II, or PHYS-UA 91–93 Physics I and II toward their 13-course requirement. However, if these physics courses are used towards the mathematics major, the computer science or data science courses will not apply towards the major.

- Students may double-count no more than two courses towards both the Mathematics Major and the requirements of another major or minor.

- Students may petition to enroll in graduate mathematics courses and apply them to the undergraduate major. Permission to enroll is not granted until the student has completed MATH-UA 325 Analysis and the available undergraduate courses on the same topic. Please see the Enrollment in Graduate Courses webpage for more detailed information.

- Courses taken under the pass/fail option are not counted toward the major.

- A grade of C or better is required in all courses used to fulfill the major requirement.

- At least half of all courses in the major must be taken at CAS.

B. **Joint Honors in Mathematics and Computer Science**
   This is an interdisciplinary major offered by the Department of Mathematics and the Department of Computer Science.

1. **Mathematics Requirements**

    - MATH-UA 121 Calculus I
    - MATH-UA 122 Calculus II
    - MATH-UA 123 Calculus III (MATH-UA 129 Honors Calculus III is recommended, but not required)
    - MATH-UA 140 Linear Algebra (MATH-UA 148 Honors Linear Algebra is recommended, but not required)
    - MATH-UA 325 Analysis or 328 Honors Analysis I
    - MATH-UA 329 Honors Analysis II
    - MATH-UA 343 Algebra or 348 Honors Algebra I
    - MATH-UA 349 Honors Algebra II
    - Two of the following:
        - MATH-UA 238 Honors Theory of Probability
        - MATH-UA 268 Honors Ordinary Differential Equations
        - MATH-UA 393 Honors I
        - MATH-UA 394 Honors II
        - MATH-UA 397 Honors III
        - MATH-UA 398 Honors IV

2. **Computer Science Requirements**

    - CSCI-UA 101 Introduction to Computer Science
    - CSCI-UA 102 Data Structures
    - CSCI-UA 201 Computer Systems Organization
    - CSCI-UA 202 Operating Systems
    - CSCI-UA 310 Basic Algorithms
    - CSCI-UA 421 Numerical Computing
    - CSCI-UA 453 Theory of Computation

- Three computer science courses listed at the CSCI-UA 400 level.

Students should complete a guided research project, sponsored by either department and presented at the Dean's Undergraduate Research Fund (DURF) which takes places in late April. Students are expected to dedicate 10-20 hours per week toward their research.

If completing research sponsored by the Math Department, this requirement can also be fulfilled through the mathematics Summer Undergraduate Research Experience (SURE) program under individual faculty supervision. Students who participate in this program are required to present their research at Courant's undergraduate research forum in the fall semester of their senior year. Students who participate in SURE receive financial support for the summer. Honors students are given special consideration for admission into the program.

OR

Students may also satisfy this research component by participating in the AM-SURE program. This program is for students interested in applied mathematics and will pay a competitive salary. For more information please go to the AM-SURE website.

OR

Alternatively, students must complete up to two semesters of independent study (MATH-UA 0997, 0998) under faculty supervision and present their research at the Dean's Undergraduate Research Forum (DURF) in the spring. Students should seek approval of their honors project from the Honors Faculty Advisor, Antoine Cerfon.

Students who have completed at least 64 points of graded work in the College will be awarded degrees with departmental honors by successfully completing the designated honors sequence, or the equivalent approved by the department, and by maintaining a general average of 3.65 and an average of 3.65 in the major.

If you have questions about the honors program, please contact the Assistant Director of Academic Affairs, Beth Markowitz at beth@cims.nyu.edu or the Honors Faculty Advisor, Antoine Cerfon at cerfon@cims.nyu.edu.

If you are a mathematics major who is interested in joining the honors program, please complete the online major declaration form and select the option "Current Math Major interested in the Math Honors Program." (Please note: you

must be logged into your NYU e-mail account in order to access this form).

To be graduated with Latin honors, a student must have completed at least 64 points in courses in the College with passing grades. All graded courses taken while enrolled in the College, or in other divisions of the University, will be used to compute the honors average. Pass grades are not counted, nor are grades received in courses at other institutions. The student must have a good record of conduct and maintain a minimum general average as follows: cum laude, 3.686; magna cum laude, 3.805; summa cum laude, 3.9.

C. Joint Honors in Mathematics and Economics

This is an interdisciplinary major offered by the Department of Mathematics and the Department of Economics.

1. Mathematics Requirements

Introductory Course Requirement
- MATH-UA 121 Calculus I OR MATH-UA 131 Math for Economics I
- MATH-UA 122 Calculus II OR MATH-UA 132 Math for Economics II
- MATH-UA 123 Calculus III *(MATH-UA 129 Honors Calculus III is recommended, but not required)* OR MATH-UA 133 Math for Economics III
- MATH-UA 140 Linear Algebra *(MATH-UA 148 Honors Linear Algebra is recommended, but not required)*
- MATH-UA 328 Honors Analysis I

Two required electives from the following:
- MATH-UA 238 Honors Theory of Probability
- MATH-UA 268 Honors Ordinary Differential Equations
- MATH-UA 329 Honors Analysis II
- MATH-UA 348 Honors Algebra I
- MATH-UA 349 Honors Algebra II
- MATH-UA 393 Honors I
- MATH-UA 394 Honors II
- MATH-UA 397 Honors III
- MATH-UA 398 Honors IV

Two more math electives from the following:
- MATH-UA 233 Theory of Probability or MATH-UA 238 Honors Theory of Probability (if not fulfilling the two required courses above)
- MATH-UA 234 Mathematical Statistics
- MATH-UA 235 Probability & Statistics*

- MATH-UA 240 Combinatorics
- MATH-UA 248 Theory of Numbers
- MATH-UA 250 Mathematics of Finance
- MATH-UA 251 Mathematical Modeling
- MATH-UA 252 Numerical Analysis
- MATH-UA 253 Linear and Nonlinear Optimization
- MATH-UA 262 Ordinary Differential Equations or MATH-UA 268 Honors Ordinary Differential Equations (if not fulfilling the two required courses above)
- MATH-UA 263 Partial Differential Equations
- MATH-UA 264 Chaos & Dynamical Systems
- MATH-UA 282 Functions of a Complex Variable
- MATH-UA 375 Topology
- MATH-UA 377 Differential Geometry

* Students who take MATH-UA 235 cannot also count MATH-UA 233, MATH-UA 238 or MATH-UA 234 towards the major requirements. Students who take MATH-UA 233, MATH-UA 238 or MATH-UA 234 cannot also count MATH-UA 235.

2. **Economics Requirements**

- ECON-UA 1 Introduction to Macroeconomics
- ECON-UA 2 Introduction to Microeconomics
- ECON-UA 11 Microeconomic Analysis
- ECON-UA 13 Macroeconomic Analysis
- ECON-UA 20 Analytical Statistics, if not taking MATH-UA 234 Mathematical Statistics*
- ECON-UA 266 Introduction to Econometrics
- any three economics elective courses, at least two of which must be theory electives numbered ECON-UA 300-399.

*Students who take MATH-UA 234 instead of ECON-UA 20 for the statistics requirement must take a total of four ECON-UA electives.

Research Requirements

Students should complete a guided research project, sponsored by either department, and present it at the Dean's Undergraduate Research Forum (DURF), which takes place in late April of each year. Students are expected to dedicate 10–20 hours per week toward their research. Students may satisfy their research requirement either through the economic honors sequence ECON-UA 410 and 450, or if completing research sponsored by the Math Department through MATH-UA 997 or 998 under faculty supervision and present their research at the Dean's Undergraduate Research Forum (DURF) in the spring. Students should seek approval of their

honors project from the Honors Faculty Advisor, Antoine Cerfon.

This requirement can also be fulfilled through the mathematics Summer Undergraduate Research Experience (SURE) program under individual faculty supervision. Students who participate in this program are required to present their research at Courant's undergraduate research forum in the fall semester of their senior year. Students who participate in SURE receive financial support for the summer. Honors students are given special consideration for admission into the program.

OR

Students may also satisfy this research component by participating in the AM-SURE program. This program is for students interested in applied mathematics and will pay a competitive salary. For more information, please go to the AM-SURE website.

Students who have completed at least 64 points of graded work in the College will be awarded degrees with departmental honors by successfully completing the designated honors sequence, or the equivalent approved by the department, and by maintaining a general average of 3.65 and an average of 3.65 in the major.

For additional information about the honors program, students should contact the Assistant Director of Academic Affairs, Beth Markowitz at beth@cims.nyu.edu.

Mathematics majors who are interested in joining the joint honors program should complete the online major declaration form and select the option "Current Math Major interested in the Math/Economics Joint Honors Program." (Please note: you must be logged into your NYU e-mail account in order to access this form).

To be graduated with Latin honors, a student must have completed at least 64 points in courses in the College with passing grades. All graded courses taken while enrolled in the College, or in other divisions of the University, will be used to compute the honors average. Pass grades are not counted, nor are grades received in courses at other institutions. The student must have a good record of conduct and maintain a minimum general average as follows: cum laude, 3.686; magna cum laude, 3.805; summa cum laude, 3.9.

V. Transfer Students

Transfer students who have taken mathematics courses at other colleges should refer to the Math Major Transfer Student website for complete instructions on how to complete the transfer course equivalency process. In order to check transfer course equivalencies, transfer students should contact one of our advisement team and attach a copy of your unofficial transcript(s) with all previous math course grades:

Students whose last (family) name begins with letters A–M should contact Dana Jaggi, Program Administrator, at djaggi@cims.nyu.edu

Students whose last (family) name begins with letters N–Z should contact Beth Markowitz, Assistant Director, Academic Affairs, at beth@cims.nyu.edu

Our advisors will check to see if we have already reviewed your course(s) before, and will be able to let you know if they are equivalent. For any course not previously reviewed, the advisor will ask for a copy of the course syllabus, which must show a list of textbooks used and a weekly breakdown of topics covered. They will then have math faculty review each syllabus for equivalency, and will advise on the MATH-UA course credit(s) to be received.

Transfer courses that are to be counted toward major or optional minor requirements must be judged equivalent to courses currently offered by the mathematics department. With the exception of courses taught online due to the COVID-19 pandemic, credit cannot be transferred for courses in which a majority of the assessment is conducted in a distance-learning environment.

The mathematics department can only evaluate mathematics courses for equivalency and transfer credit. Transfer students should contact the corresponding departments for each non-math course to be evaluated.

Official transcripts must also be sent to the University registrar's office.

No more than half of a major can be completed with transfer course credits; the remainder of the courses must be taken at NYU. For the Math Major which requires 13 courses, only 6 math courses can be completed with transfer credit. For the Joint Math and Economics Major which requires 9 math courses, only 6 math courses and a total of 9 courses for the entire joint major can be completed with transfer credit. For the Joint Math and Data Science Major which requires 9 math courses, only 6 math courses and a total of 9 courses for the entire joint major can be completed with transfer credit. For the Joint Math and Computer Science Major which requires 10 math courses, only 6 math courses and a total of 9 courses for the entire joint major can be completed with transfer credit.

If a student happens to have more than half of the major credits equivalent from transfer courses, they will still be able to use them for placement/prerequisite purposes and possibly towards their 128 graduation credits, but they will not be able to count towards their major requirements.

VI. Courses Offered in Academic Year 2021 – 2022

FALL		SPRING	
Algebra,Trigonometry,&Functions	MATH-UA 9	Algebra,Trigonometry,&Functions	MATH-UA 9
Discrete Mathematics	MATH-UA 120	Discrete Mathematics	MATH-UA 120
Calculus I	MATH-UA 121	Calculus I	MATH-UA 121
Calculus II	MATH-UA 122	Calculus II	MATH-UA 122
Calculus III	MATH-UA 123	Calculus III	MATH-UA 123
Honors Calculus III	MATH-UA 129	Honors Calculus III	MATH-UA 129
Linear Algebra	MATH-UA 140	Linear Algebra	MATH-UA 140
Honors Linear Algebra	MATH-UA 148	Intro to Computer Simulation	MATH-UA 144
Math for Economics I	MATH-UA 131	Honors Linear Algebra	MATH-UA 148
Math for Economics II	MATH-UA 132	Math for Economics I	MATH-UA 131
Math for Economics III	MATH-UA 133	Math for Economics II	MATH-UA 132
Theory of Probability	MATH-UA 233	Math for Economics III	MATH-UA 133
Mathematical Statistics	MATH-UA 234	Earth's Atmosphere and Ocean: Fluid Dynamics and Climate	MATH-UA 228
Probability and Statistics	MATH-UA 235	Introduction to Fluid Dynamics	MATH-UA 230
Combinatorics	MATH-UA 240	Theory of Probability	MATH-UA 233
Theory of Numbers	MATH-UA 248	Mathematical Statistics	MATH-UA 234
Mathematics of Finance	MATH-UA 250	Probability and Statistics	MATH-UA 235
Intro to Math Modeling	MATH-UA 251	Honors Theory of Probability	MATH-UA 238
Numerical Analysis	MATH-UA 252	Combinatorics	MATH-UA 240
Linear and Nonlinear Optimization	MATH-UA 253	Theory of Numbers	MATH-UA 248
		Mathematics of Finance	MATH-UA 250
Ordinary Differential Equations	MATH-UA 262	Intro to Math Modeling	MATH-UA 251
Partial Differential Equations	MATH-UA 263	Numerical Analysis	MATH-UA 252
Honors Ordinary Differential Equations	MATH-UA 268	Linear and Nonlinear Optimization	MATH-UA 253
Analysis	MATH-UA 325	Computers in Medicine and Biology	MATH-UA 256
Honors Analysis I	MATH-UA 328	Ordinary Differential Equations	MATH-UA 262
Algebra	MATH-UA 343	Partial Differential Equations	MATH-UA 263
Honors Algebra I	MATH-UA 348	Chaos and Dynamical Systems	MATH-UA 264
Honors III	MATH-UA 397	Functions of Complex Variable	MATH-UA 282
Special Topics	MATH-UA 395	Analysis	MATH-UA 325
Internship	MATH-UA 897	Honors Analysis I	MATH-UA 328
Independent Study	MATH-UA 997	Honors Analysis II	MATH-UA 329
		Algebra	MATH-UA 343
		Honors Algebra II	MATH-UA 349
		Differential Geometry	MATH-UA 377
		Honors IV	MATH-UA 398
		Internship	MATH-UA 898
		Independent Study	MATH-UA 998

• *MATH-UA 397-398 Honors topics and MATH-UA 395 Special Topics are announced and posted in advance.*

• *MATH-UA 131, 132, and 133 do not count towards the Math Major degree.*

• *MATH-UA 131, 132, and 133 are for Economics Majors (if they are double majoring in Math they may use these instead of Calculus I – III)*

VII. Suggested Course Programs

The programs shown below are suggestions only. Many students will take more mathematics electives than are listed in these programs.

A. Possible program for mathematics majors:

YEAR	FALL	SPRING
First Year	MATH-UA 121 Calculus I	MATH-UA 122 Calculus II
	MATH-UA 120 Discrete Math	
Second Year	MATH-UA 123 Calculus III	
	MATH-UA 140 Linear Algebra	MATH-UA 325 Analysis
Third Year	Mathematics Elective	MATH-UA 343 Algebra or Advanced Elective
	Advanced Elective or MATH-UA 343 Algebra	
Fourth Year	Mathematics Elective	Mathematics Elective
	Advanced Elective	Advanced Elective

By the end of the seventh semester students should complete Analysis, Algebra, and one or more advanced electives.

B. Possible program for mathematics majors who intend to go into secondary school education:

YEAR	FALL	SPRING
First Year	MATH-UA 121 Calculus I	MATH-UA 122 Calculus II
	MATH-UA 120 Discrete Math	
Second Year	MATH-UA 123 Calculus III	MATH-UA 325 Analysis
	MATH-UA 140 Linear Algebra	
Third Year	MATH-UA 233 Theory of Probability	MATH-UA 343 Algebra
	Mathematics Elective	
Fourth Year	Mathematics Elective	Mathematics Elective
	Advanced Elective	Advanced Elective

Recommended electives are MATH-UA 120 Discrete Mathematics, MATH-UA 255 Mathematics in Medicine and Biology, MATH-UA 248 Theory of Numbers, MATH-UA 264 Chaos & Dynamical Systems, MATH-UA 262 Ordinary Differential Equations, and MATH-UA 282 Function of Complex Variables.

C. Possible Honors Program. (Especially recommended for students who intend to go to graduate school for advanced work in mathematics).

YEAR	FALL	SPRING
First Year	MATH-UA 122 Calculus II	MATH-UA 129 Honors Calculus III
	MATH-UA 120 Discrete Math	MATH-UA 148 Honors Linear Algebra
Second Year	MATH-UA 328 Honors Analysis I	MATH-UA 329 Honors Analysis II
		MATH-UA 262 Ordinary Diff. Equations

Third Year	MATH-UA 348 Honors Algebra I	MATH-UA 349 Honors Algebra II
	Mathematics Elective	Mathematics Elective
Fourth Year	MATH-UA 393 Honors I or III	MATH-UA 394 Honors II or IV

Students with advanced standing should begin their freshman year at the appropriate level. Highly qualified students are encouraged to take graduate mathematics courses provided they satisfy the prerequisites and obtain permission from the Vice Chair, Matthew Leingang. If approved these courses cannot replace Advanced Electives. Please see our Enrollment in Graduate Level Courses website for more information.

VIII. Activities

A. **Mathematics Society**
   There is an active mathematics society open to all students interested in the study of mathematics. An organizational meeting is held shortly after classes begin in the fall to plan for the coming academic year. Activities include talks by faculty and guest speakers on a variety of topics including mathematics and career opportunities as well as attending conferences. The club is under the supervision of Trushant Majmudar and Charmaine Sia.

B. **Association for Women in Mathematics**
   The mission and purpose of AWM – NYU Chapter is to increase interest in the mathematical sciences and their applications in various industries. More specifically, it focuses on mentoring, encouraging and bringing together women undergraduates in mathematics to increase visibility of women and their contributions in the discipline. The club is under the supervision of Corrin Clarkson.

C. **NYU Society for Industrial and Applied Mathematics**
   NYU SIAM creates a space for students to come together and discuss topics significant to the learning of mathematics by engaging them with a diverse range of topics and opportunities in math and its related fields; and providing opportunities for mentorship, workshops, and cross-school collaboration. The club is under the supervision of Mutiara Sondjaja and Miranda Holmes-Cerfon.

D. **William Lowell Putnam Competition**
   The mathematics department participates in the annual William Lowell Putnam Competition, a mathematics competition open to all undergraduate mathematics students in the USA and Canada. Interested students should contact the department as early as possible in the school year since the contest takes place in early December. A series of preparation sessions is held under the supervision of Selin Kalaycioglu.

E. **Mathematical Contest in Modeling**

MCM is a contest where teams of undergraduates use mathematical modeling to present their solutions to real world problems. Interested students should contact the department as early as possible in the school year. This club is under the supervision of Mutiara Sondjaja.

F. **Interdisciplinary Contest in Modeling**

The Interdisciplinary Contest in Modeling (ICM) is an international contest for high school students and college undergraduates. ICM is an extension of the Mathematical Contest in Modeling (MCM). It is designed to develop and advance interdisciplinary problem-solving skills as well as competence in written communication. Registration for ICM is via MCM.

G. **Peer Mentor Program**

The mathematics department has an active peer mentor program for mathematics majors. The program is designed to assist new mathematics majors in making the transition to the mathematics major and life at NYU. Students interested in becoming a mentor or mentee should send an email to djaggi@cims.nyu.edu.

H. **Study Abroad**

NYU undergraduates can spend a semester studying abroad at one of the many centers run by NYU Global Programs. Currently, mathematics can be studied at NYU Berlin, NYU London, NYU Abu Dhabi, NYU Paris, and NYU Shanghai. Students interested in participating in any of these programs should contact the study abroad office.

I. **SURE Program**

Since the spring 2000 semester the Mathematics Department has sponsored a number of summer research experiences (SURE) for a selected number of undergraduate math majors. The Summer Undergraduate Research Experience is aimed at advanced undergraduate math students in their junior year. The project ends with a written report and an oral presentation in the beginning of the fall semester. Funds to support this activity are limited and student participants are chosen by a faculty committee based on grades, coursework, and fit between their research interests and those of the supervising faculty. Applications are considered more highly if students have found a faculty mentor and research topic. Students with questions regarding this program should send an e-mail to beth@cims.nyu.edu.

J. **AM-SURE Program**

The Applied Math Summer Undergraduate Research Experience is a summer research program for undergraduate students interested in *applied* mathematics, both *modeling* and *simulation*. The main goal is for each student to complete a research project under the joint guidance of graduate students, postdocs, and faculty in the mathematics

department at NYU. Some projects will involve theoretical modeling and computer simulation, and others may involve Courant's Applied Math Lab, where students will help conduct experiments to validate models and simulations. The program will include a set of coherent activities such as frequent group academic meetings and social gatherings. Students will be given office space and computational resources to complete their projects. Students can apply during the Spring semester using the [online application form.](#)

IX. Awards

A. Prizes
Every spring the mathematics department presents awards to exceptional students in the department.

- The Mathematics Award is presented to a graduating senior for excellence in mathematics and service to the department and fellow students, and to members of the junior class for meritorious service, or for excellence in mathematics
- The Hollis Cooley Memorial Prize is awarded for excellence and exceptional promise in mathematics.
- Mathematics Awards for Academic Achievement are presented to graduating seniors for academic excellence in mathematics.

B. Scholarships and Grants
New York University sponsors and administers a wide variety of financial aid programs, including its own scholarship and grant funds and some New York State and Federal funds. For additional information, students should refer to the College of Arts and Science Bulletin.

X. Mathematics Internship Opportunities
MATH-UA 897, INTERNSHIP (OFFERED FALL AND SUMMER SESSION I)

2 or 4 Points. Undergraduate-level. This course is graded Pass/Fail only

Prerequisites: Permission of the department. Students must be a declared Math major, have a math GPA of 3.5 and an overall GPA of 3.0, and have at least 50% of the Math major courses completed.

An internship in mathematics is an excellent complement to formal course work. This is a great opportunity to explore different career options and gain hands-on experience.

MATH-UA 898, INTERNSHIP (OFFERED SPRING AND SUMMER SESSION II)
>   2 or 4 Points. Undergraduate-level. This course is graded Pass/Fail only
>
>   Prerequisites: Permission of the department. Students must be a declared Math major, have a math GPA of 3.5 and an overall GPA of 3.0, and have at least 50% of the Math major courses completed.
>
>   An internship in mathematics is an excellent complement to formal course work. This is a great opportunity to explore different career options and gain hands-on experience.

Internships are an excellent complement to classroom learning, and can be a valuable part of a student's education, especially with all of the exciting opportunities offered through our department and the Wasserman Center for Career Development.

An internship in Mathematics **will not** count towards the Math Major or Minor. The internship credit **will** count towards a student's overall degree.

The College of Arts and Sciences will allow students to take a total of 12 credits between Internships and Independent Studies, **but no more than 8 points may be taken in any one department.**

Note: Not all internships/employers require students to earn academic credit.

REGISTRATION

Each student must fill out the MATH-UA 897/898 Internship Enrollment Request Form found on the Mathematics Internship Opportunities website.

In order to be approved, we expect the internship to have meaningful mathematical content, either directly, or through data analysis, computer science or economics. If the student's internship is approved by faculty, the student will be registered for the internship course by a math advisor.

For F1 International Students: If the students' request for internship credit is approved by the department, students will be notified by their math advisor. At that time, students should submit their CPT request form via the OGS website. **Students should not submit their CPT request before getting approval for their internship from the department.**

SUPERVISOR EVALUATION

Each student's supervisor must complete an evaluation of the student. At the end of the

semester, the supervisor will be instructed to complete an evaluation form to be sent directly back to the department.

ELIGIBILITY

International Students: For more information on policies and procedures, please reach out to the Office of Global Services or email ogs@nyu.edu.

XI. Work Opportunities in the Mathematics Department

A. **Tutoring**
    The department offers paid undergraduate tutoring positions for advanced mathematics majors. Tutors provide free tutoring for undergraduate students taking lower-level mathematics courses. Preferred applicants have completed and received an A in Calculus I, II, III, Linear Algebra, Discrete Mathematics, and Analysis.

B. **Grading**
    Paid grader positions are available for advanced mathematics majors. Students grade homework problems for undergraduate mathematics courses. Preferred applicants have completed and received an A in Calculus I, II, III, Linear Algebra, and Discrete Mathematics

Interested students should complete the Grader and Tutor Application on the Work Opportunities in the Math Department website.

XII. Course Descriptions

Listed below are descriptions of all mathematics courses that satisfy the major and minor requirements. Some of the courses are given only in the fall, others only in the spring, a few are given once every other year, and some only on request. However, any course may be scheduled if there is sufficient demand.

MATH-UA 9 Algebra, Trigonometry, and Functions (offered each term) – 4 points
Prerequisites:
High school mathematics or permission of the department.

This course serves as preparation for MATH-UA 120 Discrete Mathematics, MATH-UA 121 Calculus I, MATH-UA 131 Mathematics for Economics I, and MATH-UA 140 Linear Algebra. Topics include: intermediate algebra and trigonometry; algebraic, exponential, logarithmic, and

trigonometric functions and their graphs.

MATH-UA 120 Discrete Mathematics (offered each term) – 4 points
Prerequisite:
One of the following:
- SAT score of 670 or higher on mathematics portion **March 2016 and later**
- SAT score of 650 or higher on mathematics portion **before March 2016**
- SAT subject test in mathematics (Level 1 or Level 2) score of 650 or greater
- ACT/ACTE Math score of 30 or higher
- AB score of 3 or higher
- BC score of 3 or higher
- A-Level Maths score of C or higher (anyone who took Further Maths should contact the math department as it varies depending on the exam board)
- AS-Level Maths score of B or higher
- Completion of NYU's Algebra, Trigonometry, and Functions (MATH-UA 009) with a grade of C or higher
- Placement Exam

IB Prerequisites for MATH-UA 121 Calculus I 2021 - 2027
- IB Analysis and Approaches HL score of 5
- IB Applications and Interpretations HL score of 5
- IB Analysis and Approaches SL score of 7

IB Prerequisites for MATH-UA 121 Calculus I 2014 - 2020
- IB Mathematics HL score of 5
- IB Mathematics SL score of 6 or higher
- IB Mathematical Studies SL score of 7

A first course in discrete mathematics. Sets, algorithms, induction. Combinatorics. Graphs and trees. Combinatorial circuits. Logic and Boolean algebra.

MATH-UA 121 Calculus I (offered each term) – 4 points
Prerequisite:
Same as for MATH-UA 120 Discrete Mathematics.

Derivatives, antiderivatives, and integrals of functions of one real variable. Trigonometric, inverse trigonometric, logarithmic and exponential functions. Applications, including graphing, maximizing and minimizing functions. Areas and volumes.

MATH-UA 122 Calculus II (offered each term) – 4 points
Prerequisite:
One of the following:
- MATH-UA 121 Calculus I with a C or better
- AB score of 4 or higher

- BC score of 4 or higher
- A-level Maths score of B or higher (anyone who took Further Maths should contact the math department as it varies depending on the exam board)
- Placement Exam

IB Prerequisites for MATH-UA 122 Calculus II 2021 - 2027
- IB Analysis and Approaches HL score of 6
- IB Applications and Interpretations HL score of 6

IB Prerequisites for MATH-UA 122 Calculus II 2014 - 2020
- IB Mathematics HL score of 6 or higher (no Topic 9)

Techniques of integration. Further applications. Plane analytic geometry. Polar coordinates and parametric equations. Infinite series, including power series.

MATH-UA 123 Calculus III (offered each term) – 4 points
Prerequisite:
One of the following:
- MATH-UA 122 Calculus II with a C or higher
- BC score of 5
- SEAB A-Level H-2 score of B or higher
- Certain A-Level Further Maths Exams with score of B or higher (anyone who took Further Maths should contact the math department as it varies depending on the exam board)
- Placement Exam

IB Prerequisites for MATH-UA 123 Calculus III 2021 - 2027
- IB Analysis and Approaches HL score of 7

IB Prerequisites for MATH-UA 123 Calculus III 2014 - 2020
- IB Mathematics HL score of 6 or higher (with Topic 9)
- IB Further Mathematics HL score of 6 or higher

Functions of several optimization and variables. Vectors in the plane and space. Partial derivatives with applications, especially Lagrange multipliers. Double and triple integrals. Spherical and cylindrical coordinates. Surface and line integrals. Divergence, gradient and curl. Theorem of Gauss and Stokes.

MATH-UA 129 Honors Calculus III (offered in the fall and spring terms) – 4 points
Prerequisite:
A- in MATH-UA 122 or equivalent, 5 on the AP Calculus BC, IB Analysis and Approaches HL score of 7 (students entering 2021 - 2027), IB Mathematics HL score of 6 or higher (with Topic 9) (students entering 2014 - 2020), IB Further Mathematics HL score of 6 or higher (students entering 2014 - 2020).

Similar to MATH-UA 123 Calculus III, but at a faster pace and deeper level. Functions of several variables. Vectors in the plane and space. Partial derivatives with applications, especially Lagrange multipliers. Double and triple integrals. Spherical and cylindrical coordinates. Surface and line integrals. Divergence, gradient, and curl. Theorem of Gauss and Stokes. Students interested in an honors mathematics degree are especially encouraged to consider this course.

MATH-UA 140 Linear Algebra (offered each term) – 4 points
Prerequisite:
Same as for MATH-UA 120 Discrete Mathematics.

Systems of linear equations, Gaussian elimination, matrices, determinants, Cramer's rule. Vectors, vector spaces, basis and dimension, linear transformations. Eigenvalues, eigenvectors, and quadratic forms.

MATH-UA 144 Introduction to Computer Simulation (offered spring term) – 4 points *(Identical to CSCI-UA 330)*
Prerequisite:
A grade of C or higher in MATH-UA 121 Calculus I or MATH-UA 132 Math for Economics II (for Economics majors) and PHYS-UA 11 General Physics.

In this course, students will learn how to do computer simulations of such phenomena as orbits (Kepler problem and N-body problem), epidemic and endemic disease (including evolution in response to the selective pressure of a malaria), musical stringed instruments (piano, guitar, and violin), and traffic flow in a city (with lights, breakdowns, and gridlock at corners). The simulations are based on mathematical models, numerical methods, and Matlab programming techniques that will be taught in class. The use of animations (and sound where appropriate) to present the results of simulations will be emphasized.

MATH-UA 148 Honors Linear Algebra (offered in the fall and spring terms) – 4 points
Prerequisite:
A grade of A- or better in MATH-UA 9 Algebra, Trigonometry & Functions or the equivalent. Any additional requirements depend on the professor teaching the course for that semester. Please refer to the most recent course description.

This honors section of Linear Algebra is intended for well-prepared students who have already developed some mathematical maturity. Its scope will include the usual Linear Algebra (MATH-UA 140) syllabus; however, this class will move faster, covering additional topics and going deeper. Vector spaces, linear dependence, basis and dimension, matrices, determinants, solving linear equations, eigenvalues and eigenvectors, quadratic forms, applications such as optimization or linear regression.

MATH-UA 131 Mathematics for Economics I (offered each term) – 4 points
Prerequisite:
The same as for MATH-UA 121 Calculus I.

NOTE: Cannot apply both Calculus courses and Math for Economics courses to your major or minor. Economics majors pursuing a double major in mathematics may substitute these courses for the regular calculus sequence.

Elements of calculus and linear algebra are important to the study of economics. This class is designed to provide the appropriate tools for study in the policy concentration. Examples and motivation are drawn from important topics in economics. Topics covered include derivatives of functions of one and several variables; interpretations of the derivatives; convexity; constrained and unconstrained optimization.

MATH-UA 132 Mathematics for Economics II (offered each term) – 4 points
Prerequisite:
Completion of MATH-UA 131 Math for Economics I with a grade of C or higher, or passing departmental placement exam.

A continuation of Mathematics for Economics I. Matrix algebra; eigenvalues; Ordinary differential equations and stability analysis, multivariable integration and (possibly) dynamic optimization.

MATH-UA 133 Mathematics for Economics III (offered in the fall and spring terms) – 4 points
Prerequisite:
A grade of C or higher in MATH-UA 132 Math for Economics II, or passing departmental placement exam.

Further topics in vector calculus. Vector spaces, matrix analysis. Linear and nonlinear programming with applications to game theory. This course will provide economics students who have taken MATH-UA 131 Mathematics for Economics I and MATH-UA 132 Mathematics for Economics II with the tools to take higher-level mathematics courses.

MATH-UA 228 Earth's Atmosphere and Ocean: Fluid Dynamics and Climate (offered spring term)– 4 points *(Identical to ENVST-UA 360)*
Prerequisite:
A grade of B- or higher in MATH-UA 121 Calculus I or MATH-UA 132 Math for Economics II (for Economics majors) or equivalent and familiarity with introductory physics (at least at the advanced high school level).

Recommended and Preferred: MATH-UA 123 Calculus III

Introduction to dynamical processes that drive the circulation of the atmosphere and ocean, and their interaction. Goal of the lectures is to develop an understanding of the unifying principles of planetary fluid dynamics. Topics include the global energy balance, convection and radiation (the greenhouse effect), effects of planetary rotation (the Coriolis force), structure of the atmospheric circulation (the Hadley cell and wind patterns), structure of the oceanic circulation (wind-driven currents and the thermohaline circulation), and climate and climate variability (including El Niño and anthropogenic warming).

MATH-UA 230 Introduction to Fluid Dynamics (offered spring term) – 4 points *(Identical to PHYS-UA 180)*
Prerequisite:
A grade of C or higher in MATH-UA 123 Calculus III or MATH-UA 133 Math for Economics III (for Economics majors)
Suggested:
PHYS-UA 106 Mathematical Physics

Fluid dynamics is the branch of physics that describes motions of fluids as varied as the flow of blood in the human body, the flight of an insect or the motions of weather systems on Earth. The course introduces the key concepts of fluid dynamics: the formalism of continuum mechanics, the conservation of mass, energy and momentum in a fluid, the Euler and Navier-Stokes equations, viscosity and vorticity. These concepts are applied to study classic problems in fluid dynamics, such as potential flow around a cylinder, the Stokes flow, the propagation of sound and gravity waves and the onset of instability in shear flow.

MATH-UA 233 Theory of Probability (offered each term) – 4 points
Prerequisite:
A grade of C or higher in MATH-UA 123 Calculus III or MATH-UA 133 Math for Economics III (for Economics majors) or equivalent, and a grade of C or higher in MATH-UA 140 Linear Algebra or equivalent.

NOTE: Not open to students who have taken MATH-UA 235 Probability and Statistics. This course is intended for math majors and other students with a strong interest in mathematics. It requires fluency in topics such as multi-variable integration and therefore a grade of B or better in MATH-UA 123 or MATH-UA 133 (or the equivalent) is strongly recommended.

An introduction to the mathematical treatment of random phenomena occurring in the natural, physical, and social sciences. Axioms of mathematical probability, combinatorial analysis, binomial distribution, Poisson and normal approximation, random variables and probability distributions, generating functions, Markov chains, applications.

MATH-UA 234 Mathematical Statistics (offered each term) – 4 points
Prerequisite:

A grade of C or higher in MATH-UA 233 Theory of Probability or equivalent.

NOTE: Not open to students who have taken MATH-UA 235 Probability and Statistics.

An introduction to the mathematical foundations and techniques of modern statistical analysis for the interpretation of data in the quantitative sciences. Mathematical theory of sampling; normal populations and distributions; chi-square, t, and F distributions; hypothesis testing; estimation; confidence intervals; sequential analysis; correlation, regression; analysis of variance. Applications to the sciences.

MATH-UA 235 Probability and Statistics (offered spring term) – 4 points
Prerequisite:
A grade of C or higher in MATH-UA 122 Calculus II or MATH-UA 132 Math for Economics II (for Economics majors) or equivalent.

NOTE: Not open to students who have taken MATH-UA 233 Theory of Probability or MATH-UA 234 Mathematical Statistics

A combination of MATH-UA 233 and MATH-UA 234 at a more elementary level, so as to afford the student some acquaintance with both probability and statistics in a single term. In probability: mathematical treatment of chance; combinatorics; binomial, Poisson, and Gaussian distributions; law of large numbers and the normal approximation; application to coin-tossing, radioactive decay, etc. In statistics: sampling; normal and other useful distributions; testing of hypotheses; confidence intervals; correlation and regression; applications to scientific, industrial, and financial data.

MATH-UA 238 Honors Theory of Probability (offered spring term) – 4 points
Prerequisite:
MATH-UA 123 Calculus III or MATH-UA 129 Honors Calculus III or MATH-UA 133 Math for Economics III (for Economics majors) with a grade of B+ or better and/or the equivalent, and MATH-UA 140 Linear Algebra or MATH-UA 148 Honors Linear Algebra with a grade of B+ or better and/or the equivalent, and MATH-UA 120 Discrete Math with a grade of B+ or better and/or the equivalent. Not open to students who have taken MATH-UA 235 Probability and Statistics. While B+ or higher is the standard requirement for this course, the department will consider petitions if you are on the borderline of that requirement.

NOTE: Not open to students who have taken MATH-UA 235 Probability and Statistics. This course is intended for math majors and other students with a strong interest in mathematics.

The aim of this class is to introduce students to probability theory, with a greater emphasis on rigor, more material, and a faster pace than the Theory of Probability class. The material will include discrete and continuous probability, and the most fundamental limit theorems (law of

large numbers and Central Limit Theorem). Students will be made familiar with the classical models, computations on densities, and convergence to universal distributions. They will also be expected to understand the proofs of all the results seen in class, and be able to argue with mathematical rigor.

MATH-UA 240 Combinatorics (offered spring term) – 4 points
Prerequisite:
A grade of C or higher in MATH-UA 122 Calculus II or MATH-UA 132 Math for Economics II (for Economics majors) or equivalent.

Techniques for counting and enumeration including generating functions, the principle of inclusion and exclusion, and Polyacounting. Graph theory. Modern algorithms and data structures for graph-theoretic problems.

MATH-UA 248 Theory of Numbers (offered fall term) – 4 points
Prerequisite:
A grade of C or higher in MATH-UA 122 Calculus II or MATH-UA 132 Math for Economics II (for Economics majors) or equivalent.

Divisibility theory and prime numbers. Linear and quadratic congruences. The classical number-theoretic functions. Continued fractions. Diophantine equations.

MATH-UA 250 Mathematics of Finance (offered in the fall and spring terms) – 4 points
Prerequisite:
A grade of C or higher in MATH-UA 123 Calculus III and one of the following: MATH-UA 233 Theory of Probability, MATH-UA 235 Probability and Statistics, ECON-UA 18 Statistics, or ECON-UA 20 Analytical Statistics and/or permission of the instructor.

Introduction to the mathematics of finance. Topics include: Linear programming with application to pricing. Interest rates and present value. Basic probability, random walks, central limit theorem, Brownian motion, log-normal model of stock prices. Black-Scholes theory of options. Dynamic programming with application to portfolio optimization.

MATH-UA 251 Introduction to Mathematical Modeling (offered in the fall and spring terms) – 4 points
Prerequisite:
A grade of C or higher in MATH-UA 123 Calculus III or MATH-UA 133 Math for Economics III (for Economics majors).

Formulation and analysis of mathematical models. Mathematical tools include dimensional analysis, optimization, simulation, probability, and elementary differential equations. Applications to biology, economics, and other areas of science. The necessary mathematical

and scientific background is developed as needed. Students participate in formulating models as well as in analyzing them.

MATH-UA 252 Numerical Analysis (offered fall and spring terms) – 4 points
Prerequisite:
MATH-UA 123 Calculus III or MATH-UA 129 Honors Calculus III or MATH-UA 133 Mathematics for Economics III (for economics majors) with a grade of C or higher and MATH-UA 140 Linear Algebra with a grade of B- or higher or MATH-UA 148 Honors Linear Algebra with a grade of C or higher, or equivalents.

In numerical analysis, one explores how mathematical problems can be analyzed and solved with a computer. As such, numerical analysis has very broad applications in mathematics, physics, engineering, finance, and the life sciences. This course introduces the subject for mathematics majors. Theory and practical examples using Matlab are combined to explore topics ranging from simple root-finding procedures to differential equations and the finite element method.

MATH-UA 253 Linear and Nonlinear Optimization (offered fall and spring terms) – 4 points
Prerequisite:
MATH-UA 123 Calculus III OR MATH-UA 129 Honors Calculus III OR MATH-UA 133 Math for Economics III (for Economics majors) with a grade of C or better and/or the equivalent, AND MATH-UA 140 Linear Algebra OR MATH-UA 148 Honors Linear Algebra with a grade of C or better and/or the equivalent.

Optimization is a major part of the toolbox of the applied mathematician, and more broadly, of researchers in quantitative sciences including economics, data science, machine learning, and quantitative social sciences. The course provides an introduction to linear programming and convex optimization. It will cover some theory (duality, minimax problems, convexity) and algorithms (descent algorithms in the nonlinear case, simplex and interior point methods in the linear case). The course will put emphasis on numerical implementation (using Python/Numpy and Gurobi), as well on applications to economics (matching models, dynamic programming, resource allocation problems), and operations research (shortest path problems, and more general network flow problems).

MATH-UA 255 Mathematics in Medicine and Biology (offered fall term of even years) – 4 points *(Identical to BIOL-UA 255)*
Prerequisite:
MATH-UA 121 Calculus I or MATH-UA 132 Math for Economics II (for Economics majors) and BIOL-UA 11 Principles of Biology I.

Intended primarily for premedical students with interest and ability in mathematics. Topics of medical importance using mathematics as a tool, including control of the heart, optimal principles in the lung, cell membranes, electrophysiology, countercurrent exchange in the kidney, acid-base balance, muscle, cardiac catheterization, computer diagnosis. Material from the physical sciences and mathematics is introduced as needed and developed within the course.

MATH-UA 256 Computers in Medicine and Biology (offered spring term of even years) - 4 points *(Identical to BIOL-UA 256)*
Prerequisite:
A grade of C or higher in MATH-UA 255 Mathematics in Medicine and Biology
Recommendation:
Familiarity with a programming language. The language used in the course will be MATLAB, but prior experience with MATLAB is not required.

Introduces students to the use of computer simulation as a tool for investigating biological phenomena. The course requirement is to construct three computer models during the semester, to report on results to the class, and to hand in a writeup describing each project. These projects can be done individually, or as part of a team. Topics discussed in class are the circulation of the blood, gas exchange in the lung, electrophysiology of neurons and neural networks, the renal countercurrent mechanism, cross-bridge dynamics in muscle, and the dynamics of epidemic and endemic diseases. Projects are normally chosen from this list, but may be chosen otherwise by students with other interests.

MATH-UA 262 Ordinary Differential Equations (offered in fall and spring terms) – 4 points
Prerequisite:
A grade of C or higher in both MATH-UA 123 Calculus III or MATH-UA 133 Math for Economics III (for Economics majors) and MATH-UA 140 Linear Algebra or equivalent.

A first course in ordinary differential equations, including analytical solution methods, elementary numerical methods, and modeling. Topics to be covered include: first-order equations including integrating factors; second-order equations including variation of parameters; series solutions; elementary numerical methods including Euler's methods, Runge-Kutta methods, and error analysis; Laplace transforms; systems of linear equations; boundary-value problems. Some optional topics to be chosen at the instructor's discretion include: nonlinear dynamics including phase-plane description; elementary partial differential equations and Fourier series.

MATH-UA 263 Partial Differential Equations (offered in the fall and spring terms) – 4 points
Prerequisite:
A grade of C or higher in MATH-UA 262 Ordinary Differential Equations or equivalent.

Many laws of physics are formulated as partial differential equations. This course discusses the simplest examples, such as waves, diffusion, gravity, and static electricity. Non-linear conservation laws and the theory of shock waves are discussed. Further applications to physics, chemistry, biology, and population dynamics.

MATH-UA 264 Chaos and Dynamical Systems (offered spring term) – 4 points
Prerequisite:
A grade of C or higher in both MATH-UA 122 Calculus II or MATH-UA 132 Math for Economics II (for Economics majors) and MATH-UA 140 Linear Algebra or equivalent.

Topics include dynamics of maps and of first-order and second-order differential equations: stability, bifurcations, limit cycles, and dissection of systems with fast and slow timescales. Geometric viewpoint, including phase planes, is stressed. Chaotic behavior is introduced in the context of one-variable maps (the logistic), fractal sets, etc. Applications are drawn from physics and biology. Homework and projects are assigned, as well as a few computer lab sessions. (Programming experience is not a prerequisite.)

MATH-UA 268 Honors Ordinary Differential Equations (offered fall term) – 4 points
Prerequisite:
A grade of A- or higher in MATH-UA 325 Analysis or a grade of B+ or higher in MATH-UA 328 Honors Analysis I

This class will develop rigorously the basic theory of Ordinary Differential Equations (ODEs). Existence and uniqueness of solutions to ODEs are first investigated, for linear and nonlinear problems, set on the real line or the complex plane. More qualitative questions are then considered, about the behavior of the solutions, with possible prolongations to various topics in Dynamical Systems theory. Applications to Physics and Biology will appear naturally when discussing examples.

MATH-UA 282 Functions of a Complex Variable (offered spring term) – 4 points
Prerequisite:
A grade of C or higher in both MATH-UA 123 Calculus III or MATH-UA 133 Math for Economics III (for Economics majors) and MATH-UA 140 Linear Algebra or equivalent.

Complex numbers and complex functions. Differentiation and the Cauchy-Riemann equations. Cauchy's theorem and the Cauchy integral formula. Singularities, residues, Taylor and Laurent series. Fractional Linear transformations and conformal mapping. Analytic continuation. Applications to fluid flow etc.

MATH-UA 325 Analysis (offered in fall and spring terms) – 4 points

Prerequisite:
A grade of C or higher in MATH-UA 123 Calculus III or MATH-UA 133 Math for Economics III (for Economics majors) and MATH-UA 140 Linear Algebra or equivalent.

This course is an introduction to rigorous analysis on the real line. Topics include: the real number system, sequences and series of numbers, functions of a real variable (continuity and differentiability), the Riemann integral, basic topological notions in a metric space, sequences and series of functions including Taylor and Fourier series.

MATH-UA 328 Honors Analysis I (offered fall and spring terms) – 4 points
Prerequisite:
A grade of A- or higher in MATH-UA 123 Calculus III (or MATH-UA 133 Math for Economics III *(for Economics majors)*) or a grade of B+ or higher in MATH-UA 129 Honors Calculus III AND a grade of A- or higher MATH-UA 140 Linear Algebra or a grade of B+ or higher in MATH-UA 148 Honors Linear Algebra.

This is an introduction to the rigorous treatment of the foundations of real analysis in one variable. It is based entirely on proofs. Students are expected to know what a mathematical proof is and are also expected to be able to read a proof before taking this class. Topics include: properties of the real number system, sequences, continuous functions, topology of the real line, compactness, derivatives, the Riemann integral, sequences of functions, uniform convergence, infinite series and Fourier series. Additional topics may include: Lebesgue measure and integral on the real line, metric spaces, and analysis on metric spaces.

MATH-UA 329 Honors Analysis II (offered spring term) – 4 points
Prerequisite:
A grade of C or higher in MATH-UA 328 Honors Analysis I or grade of A in MATH-UA 325 Analysis in conjunction with permission by instructor and MATH-UA 140 Linear Algebra with a grade of C or better or the equivalent.

This is a continuation of MATH-UA 328 Honors Analysis I. Topics include: metric spaces, differentiation of functions of several real variables, the implicit and inverse function theorems, Riemann integral on R^n, Lebesgue measure on R^n, the Lebesgue integral.

MATH-UA 343 Algebra (offered fall and spring terms) – 4 points
Prerequisite:
A grade of C or higher in both MATH-UA 123 Calculus III or MATH-UA 133 Math for Economics III (for Economics majors) and MATH-UA 140 Linear Algebra or equivalent.
Strongly recommended:
MATH-UA 325 Analysis

Introduction to abstract algebraic structures, including groups, rings, and fields. Sets and

relations. Congruences and unique factorization of integers. Groups, permutation groups, homomorphisms and quotient groups. Rings and quotient rings, Euclidean rings, polynomial rings. Fields, finite extensions.

MATH-UA 348 Honors Algebra I (offered fall term) – 4 points
Prerequisite:
A grade of A- or higher in MATH-UA 123 Calculus III (or MATH-UA 133 Math for Economics III *(for Economics majors)*) or a grade of B+ or higher in MATH-UA 129 Honors Calculus III AND a grade of A- or higher MATH-UA 140 Linear Algebra or a grade of B+ or higher in MATH-UA 148 Honors Linear Algebra.

Introduction to abstract algebraic structures, including groups, rings, and fields. Sets and relations. Congruences and unique factorization of integers. Groups, permutation groups, group actions, homomorphisms and quotient groups, direct products, classification of finitely generated abelian groups, Sylow theorems. Rings, ideals and quotient rings, Euclidean rings, polynomial rings, unique factorization.

MATH-UA 349 Honors Algebra II (offered spring term) – 4 points
Prerequisite:
A grade of C or higher in MATH-UA 348 Honors Algebra I, or grade of A in MATH-UA 343 Algebra in conjunction with permission by instructor.

Principle ideal domains, polynomial rings in several variables, unique factorization domains. Fields, finite extensions, constructions with ruler and compass, Galois theory, solvability by radicals.

MATH-UA 375 Topology (offered spring term) – 4 points
Prerequisite:
A grade of C or higher in MATH-UA 325 Analysis.

Set-theoretic preliminaries. Metric spaces, topological spaces, compactness, connectedness, covering spaces, and homotopy groups.

MATH-UA 377 Differential Geometry (offered spring term) – 4 points
Prerequisite:
MATH-UA 123 Calculus III and MATH-UA 140 Linear algebra or MATH-UA 148 Honors Linear Algebra. Recommended: MATH-UA 325 Analysis or MATH-UA 328 Honors Analysis I.

The geometry of curves and surfaces in Euclidean space. Frenet formulas, the isoperimetric inequality, local theory of surfaces in Euclidean space, first and second fundamental forms. Gaussian and mean curvature, isometries, geodesics, parallelism, the Gauss-Bonnet Theorem.

MATH-UA 393 Honors I (offered fall term of even years) – 4 points
Prerequisite:
Honors standing or approval of the director of the honors program.

A lecture/seminar course on advanced topics. Topics vary yearly and are updated from time to time. Detailed course descriptions are available during preregistration.

MATH-UA 394 Honors II (offered spring term of odd year) – 4 points
Prerequisite:
Honors standing or approval of the director of the honors program.

A lecture/seminar course on advanced topics. Topics vary yearly and are updated from time to time. Detailed course descriptions are available during preregistration.

MATH-UA 395 Special Topics I (offered on request in the Fall)
Prerequisite:
Prerequisite varies according to topic.

Topics vary.

MATH-UA 396 Special Topics II (offered on request in the Spring)
Prerequisite:
Prerequisite varies according to topic.

Topics vary.

MATH-UA 397 Honors III (offered fall term of odd years) – 4 points
Prerequisite:
Honors standing or approval of the director of the honors program.

A lecture/seminar course on advanced topics. Topics vary yearly and are updated from time to time. Detailed course descriptions are available during preregistration.

MATH-UA 398 Honors IV (offered spring term of even year) – 4 points
Prerequisite:
Honors standing or approval of the director of the honors program.

A lecture/seminar course on advanced topics. Topics vary yearly and are updated from time to time. Detailed course descriptions are available during preregistration.

MATH-UA 897, 898 Internship – 2 or 4 points per term
Prerequisite:

Permission of the department. Student must be a declared Math major, have a math GPA of 3.5 and an overall GPA of 3.0, and have at least 50% of the Math major courses completed.

To register for this course a student must complete the [Enrollment Request Form](#) and have the approval of the Director of Undergraduate Studies.

MATH-UA 997, 998 Independent Study – 2 or 4 points per term
Prerequisite:
Permission of the department.

To register for this course, a student must seek out a faculty sponsor and draft a brief research proposal to be approved by the Director of Undergraduate Studies or the Vice Chair of Undergraduate Affairs.

XIII. Graduate Courses Open to Undergraduates

We encourage undergraduates with demonstrated excellence in rigorous math courses, and a passion for further study in a specific subject, to apply for permission to enroll in graduate courses. The policies and procedures for doing so are outlined here.

Students accepted into the Bachelor's-Master's track for mathematics should contact the graduate math program (grad_math@nyu.edu) with their graduate course requests. All other undergraduates should complete the Graduate Math Course Registration Request Form, linked below, after carefully reading the following information.

Eligibility to request enrollment in graduate courses

In order to qualify for enrollment in any graduate level math course, students must meet the following requirements:

- Enrolled at NYU New York, or NYU Shanghai or NYU Abu Dhabi visiting New York at the time the course is offered
- Pursuing a major degree program in or jointly in mathematics
- Completion of MATH-UA 325 Analysis or equivalent with a grade of A, or MATH-UA 328 Honors Analysis I or equivalent with a grade of A- or higher
- Maintaining a math major GPA of 3.65 or higher
- Junior standing or above at the time the course is offered

(Students can find their major GPA in the Academic Requirements Report in their Albert Student Center drop down menu. The major GPA will be located at the bottom of the Math Major Requirements section.)

Students who do not meet the requirements on this page and would like to petition to enroll in a graduate course should still complete the Graduate Math Course Registration Request Form, and must complete the "Special Permission Request" box at the end of the form.

<u>Procedures for requesting permission and enrollment</u>

- Students should submit the request form once for each course requested. Students should not submit the request form twice for the same course.
- While waiting for their request(s) to be evaluated, students are advised to enroll in undergraduate course selection(s) first, which can later be swapped for any approved graduate courses.
- Requests will be evaluated by the Vice Chair for Undergraduate Affairs.
- Students should receive a follow-up email within ten (10) university business days (normally two weeks) of completing the form. Students may follow up by email if they have not heard about their request by then.

<u>General course enrollment policies</u>

- Students are normally granted permission to enroll in one graduate course in their first semester of receiving permission, and a maximum of two in subsequent semesters.
- MATH-GA courses do not count towards the Restricted/Advanced Electives portion of the Math Major
- MATH-GA courses do not count towards the four required honors level courses of the honors math program. The four honors level courses must be MATH-UA Honors courses.
- DS-GA courses do not count towards the Joint Mathematics & Computer Science and the Joint Mathematics & Economics majors.
- This process should not be seen as a "back door" to a master's program. Students interested in completing a large number of graduate courses should apply for the bachelor's-master's track.
- All math graduate courses carry 3 credits, while undergraduate courses carry 4. Undergraduates taking graduate courses should take care to earn 128 credits prior to their anticipated graduation date.

<u>Specific course policies and prerequisites</u>

- "Core" master's courses such as MATH-GA 1410–20 Introduction to Mathematical Analysis I–II, MATH-GA 2110 Linear Algebra I, MATH-GA 2050 Elements of Discrete

Mathematics, etc., are generally off limits to undergraduates
- Advanced Ph.D. courses designated as "Advanced Topics" are generally off limits to undergraduates
- The number of seats available to undergraduates in a specific graduate course may be limited. Permissions are granted on a first-come, first-served basis.
- Certain courses require additional permission from faculty instructors or overseers.
- Students should not seek permission from faculty instructors to override an unfavorable decision from the department.

A complete list of graduate math courses available to undergraduate students and their prerequisites is available on the [Enrollment in Graduate Level Courses](#) website.

Prerequisites listed are in addition to the general eligibility requirements, and are satisfied by course work or experience, not by undirected self-study. Students who would like to petition to enroll in a course that is not listed can do so by choosing the "Other" course option on the request form.

Descriptions of graduate math courses and current graduate course offerings are available online:
- [Graduate Course Descriptions](#)
- [Graduate Course Schedule](#)

<u>Additional Information</u>

Any questions regarding the Graduate Math Course Registration Request Form, or the process of requesting graduate math course enrollment, should be directed to the Program Administrator, Dana Jaggi, at djaggi@cims.nyu.edu or the Assistant Director of Academic Affairs, Beth Markowitz, at beth@cims.nyu.edu.

XIV. Departmental Faculty

A complete listing of the [Department of Mathematics Faculty](#) can be found on our website.