

## Mathematics

### Department of Mathematics

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### Overview

Mathematics is a broad discipline with many diverse applications in social, managerial, and life sciences, as well as in the physical sciences and engineering. The Department of Mathematics provides a variety of concentrations leading to a baccalaureate degree.

### About our Degrees

#### Acceptance Criteria - BA

Minimum GPA of 2.5 in [MTH 141](#), [MTH 142](#) and [MTH 241](#) (or transfer equivalents).

#### Acceptance Criteria - BS

Minimum GPA of 2.5 in [MTH 141-MTH 142](#) and [MTH 241](#) (or transfer equivalents).

#### Acceptance Information

Deadlines: Rolling  
Number of applicants/year: Fall - 45; Spring - 40  
Number of accepted majors/year: 85

### About our Courses

#### Suggested Introductory Courses

- [CSE 113](#) Introduction to Computer Science or [CSE 115](#) Introduction to Computer Science for Majors
- [MTH 141-MTH 142](#) College Calculus I-II

#### The typical class size for:

Freshman/introductory courses is: 90  
Sophomore/intermediate courses is: 60  
Upper level/advanced courses is: 30

#### In the Department of Mathematics, what do teaching assistants (TAs) do?

TAs teach in recitation sections (not lectures), and assist in grading.

For course descriptions, please see [Courses](#).

### About our Faculty

The Department of Mathematics is proud of its excellent teaching and active research programs. Three of our faculty members have received the Chancellor's Award for Excellence in Teaching. Faculty members are currently involved in research in areas such as cryptography, differential equations, fluid mechanics, representation theory, number theory, population dynamics and many more. Each year approximately one third of the faculty hold external research grants, from agencies such as the National Science Foundation, National Security Agency and the Department of Defense. Research opportunities for undergraduates include writing senior honors theses or applying for the NSF-funded URGE to Compute program.

The Director of Undergraduate Studies, Professor David Hemmer, is available to talk one-on-one with any student interested in finding out about our mathematics program. For appointments call 645-8785.

## Mathematics

See a list of our [Undergraduate Faculty](#).

### Acceptance Information

Applicants to the mathematics program should schedule an appointment with the undergraduate director by calling 716.645.8785. Formal application to the major can be made at any time after they have completed the three-course calculus sequence [MTH 141-MTH 142-MTH 241](#) or the equivalent at a transfer institution, with a 2.5 GPA. Regular advisement is available and recommended to all students intending or contemplating a mathematics major.

The department's requirement for admission is a minimum GPA of 2.5 in the three calculus courses. Students who have taken more than these three courses usually need a minimum grade of C in any additional required courses they have completed.

*Note: Admittance to the department guarantees admittance to the General Curriculum Program only-all other concentrations or programs require specific approval from the director of undergraduate studies. Students who expect difficulty in being admitted to the department should follow the requirements for the General Curriculum Program or see the director of undergraduate studies for advice on which concentration to follow, pending admittance.*

### Transfer Policy

Transfer students who intend to major in mathematics are urged to consult the director of undergraduate studies before or very early in their first semester at the University at Buffalo to determine equivalency of transferred mathematics courses. Transfer students are required to complete at least four upper-division courses in the Department of Mathematics at the University at Buffalo.

### Academic Requirements

**Departmental Probation.** Students whose math GPA drops below 2.0 are placed on departmental probation for one semester. If their GPA remains below 2.0 at the end of the probationary semester, they are dropped from the department. They may reapply after one semester.

**Departmental Requirements for Graduation.** After a student has been accepted as a major, progress toward fulfillment of the degree requirements is monitored by the department. A student is recommended for a baccalaureate degree in mathematics only if:

- (1) the program has been approved by the director of undergraduate studies,
- (2) all required/approved courses have been completed, and
- (3) a minimum departmental GPA of 2.0 has been attained in the specific program except in the General Curriculum Program where the minimum is 2.5.

### Extracurricular Activities

#### **Undergraduate Mathematics Club**

This is an entirely student-run club that plans a variety of academic and community involvement activities such as field trips, a commencement ceremony, volunteer work for organizations such as Habitat for Humanity, tutoring for area high schools, and so forth. For more information, call 716-645-6284.

See the [UB Student Association](#).

### Practical Experience and Special Academic Opportunities

#### **Honors, Awards, and Scholarships**

##### *Honors Program*

The honors program in mathematics requires the completion of all requirements for a BA or BS degree in the Preparation for Graduate Study in Mathematics or the Preparation for Graduate Study in Applied Mathematics program. Students must maintain a minimum GPA of 3.5 GPA in mathematics, and write an honors thesis under the direction of a faculty member.

##### *Math Tutoring*

Math majors in good academic standing are encouraged to tutor freshmen/sophomore level math in the Math Place Tutoring Lab run by the Learning Center. This is particularly attractive to students preparing for careers in teaching.

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### *Harriet F. Montague Award*

This is presented to an undergraduate math major after the completion of his or her junior year, and is awarded on the basis of intellectual and creative promise in mathematics.

### *Harry Merrill Gehman Endowment Award*

This is presented to an undergraduate math major whose goal is to teach mathematics, and is awarded after the completion of the junior year for outstanding achievement.

### *Hazel and John Wilson Undergraduate Mathematics Scholarship*

This is presented to one or more outstanding mathematics majors annually, and is awarded on the basis of outstanding academic achievement and demonstrated financial need.

## Career Information and Further Study

Mathematics is the most fundamental of all sciences, having applications in almost every area of human endeavor including biology, biomedical sciences, chemistry, computer science, economics, engineering, finance, geography, geology, operations research, and physics. Those whose job title is mathematician fall mainly into two categories. One is the theoretical mathematicians, who advance mathematical knowledge by developing new principles and recognizing previously unknown relationships between existing principles of mathematics. Most have Ph.D.s and work as professors at universities. The other major category is the applied mathematicians, who use theories and techniques such as mathematical modeling and computational methods to formulate and solve practical problems in business, government, and engineering, and in the physical, life and social sciences. It is common for applied mathematicians to have masters or Ph.D. degrees, and many work for federal or state governments as well as for manufacturing and consulting businesses. In addition to the above, mathematics graduates work in jobs with titles other than mathematician, such as actuary, statistician, systems engineer, and secondary school teacher.

### **Skills gained in this program include:**

**Critical Thinking:** Reasoning, analyzing, ability to think conceptually, and understanding components of complex problems.

**Research and development:** Research methods, research theory, statistics, evaluating evidence, examining electronic data sources, and developing systems for processing data.

**Communication:** Writing, teaching, speaking to groups, presenting research findings, reading critically, expressing ideas and relationships in numbers and words, and translating mathematical formulations and electronic data into generally understood language.

**Additional Transferable Skills:** Managing, interpreting, editing, advising, organizing, developing original solutions to problems, recognizing essential details in problems, and advising on program design.

### **Career Choices**

- Actuary
- Budget officer
- Bursar/educator
- Computer analyst
- Computer programmer
- Computer systems engineer
- Econometrician
- Efficiency expert
- Engineering analyst
- Environmental planner
- Financial analyst
- Fundraiser
- Information scientist
- Internal Revenue Service worker
- Mathematician
- Numerical analyst
- Purchasing agent
- Quality control supervisor
- Statistician
- Teacher

### **Alumni in Mathematics have found employment in the following additional fields:**

- Accountancy

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- Appraising
- Banking
- College teaching
- Data processing
- Estimation
- Hydrography
- Market research analysis
- Meteorology
- Scientific programming
- Urban planning

### What percentage of graduates goes on to find related employment?

75%

Of those recent graduates who accepted employment, some entered the teaching profession, but most took jobs in business and industry.

### Work settings include:

- Accounting firms
- Banks
- Colleges/universities
- Computer firms
- Corporations/businesses
- Engineering firms
- Health agencies
- Insurance companies
- Investment houses
- K-12 Schools
- Libraries
- Manufacturers such as aerospace companies
- U.S. and state governments

### Salary Information

Salaries range greatly from one occupation, position, and work setting to another. According to the NACE (National Assoc of Colleges and Employers)salary survey, Summer 2009, the average starting salary for a holder of a bachelors degree working as a mathematician or statistician was \$48,408 [www.naceweb.org](http://www.naceweb.org).

### Post-undergraduate Opportunities

Many graduates further their careers by continuing on to graduate school. This is the case both for those wishing to become teachers and for those who want employment as mathematicians or in a wide variety of other careers: for example, a major in mathematics is an excellent background for graduate study in business administration, or for research in any of the sciences when combined with an appropriate minor.

### What percentage of graduates goes on to graduate school?

15%

### Additional Resources

- [Mathematical Association of America](#)
- [Mathematical Sciences Career Information](#)
- [Sloan Foundation](#)
- [Society for Industrial and Applied Mathematics](#)
- [U.S. Department of Labor, Bureau of Labor Statistics](#)

## Degree Options

### BA in Mathematics

#### *General Curriculum in Mathematics*

Basic liberal arts major program in mathematics; not tied to a specific career direction, but rather provides a general background for students interested in a variety of careers that require mathematical expertise. Well suited to students pursuing multiple majors.

## Mathematics

### *Concentration C*

Mathematics major with a concentration in computing and applied mathematics; designed for students interested in careers in applying mathematics or doing scientific programming.

### *Concentration GS/ED*

For the student whose career goal is to attain a master's degree for professional certification in adolescent mathematics education; may be coupled with a minor in teacher education.

### *Concentration GS*

Basic theoretical course of study for mathematics majors intending graduate study in mathematics, or intending careers in such fields as actuarial science, financial analysis or cryptography.

### *Concentration GS/AM*

Mathematics major for intended graduate study in applied mathematics; a basic theoretical course of study for students planning a career and/or graduate study in applied mathematics.

## **BS in Mathematics**

### *Concentration A*

Provides a course of study for mathematics majors intending to pursue a career as an actuary. Admission to this concentration is by departmental approval only. See the director of undergraduate studies for information.

### *Concentration BSc*

Same as Program GS with four additional electives.

### *Concentration BSc/AM*

Same as Program GS/AM with four additional electives.

## **BA in Mathematics/Economics**

### *Program M/E*

Joint major with economics, for students intending graduate study in economics.

## **BS in Mathematical Physics**

### *Program M/P*

Joint major with physics, for students intending graduate study in mathematical physics.

## **BS in Bioinformatics and Computational Biology**

### *Concentration in Mathematics*

The university offers a bachelor of science degree in bioinformatics and computational biology, with options for a concentration in biology, biophysics, computer science and engineering, or mathematics. Please refer to the Bioinformatics and Computational Biology program for further details.

## **BA/MA in Mathematics**

Five-year, 138-credit combined degree program. Admission requires a minimum GPA of 3.0 in courses through differential equations and linear algebra, as well as letters of recommendation. For program details, contact the director of undergraduate studies.

## **Degrees Offered**

**Undergraduate:** BA, BS, Minor

**Concentrations:** Actuarial Sciences (BS), General Curriculum (BA), Computing and Applied Mathematics (BA), Preparation for Graduate Study in Mathematics (BA and BS), Preparation for Graduate Study in Applied Mathematics (BA and BS), and General Study in Mathematics and Education (BA)

**Combined:** BA/MA

**Graduate:** MA, PhD

**Other programs:** Joint programs with other departments including Economics (BA), Physics (BS), and Bioinformatics and Computational Biology (BS)

## **Links to Further Information About this Program**

- [Undergraduate Catalog](#)
- [Undergraduate Admissions](#)
- [Graduate Admissions](#)
- [Department of Mathematics](#)
- [College of Arts and Sciences](#)

## Mathematics

### Mathematics - B.S.

#### About the Concentration

This concentration provides a basic theoretical course of study for mathematics majors intending graduate study in mathematics. Admission to this concentration is by departmental approval only. See the director of undergraduate studies regarding approval.

#### Acceptance Criteria

Minimum GPA of 2.5 in the prerequisite courses.

#### Prerequisite Courses

[MTH 141](#) College Calculus I  
[MTH 142](#) College Calculus II  
[MTH 241](#) College Calculus III

#### Required Courses

[MTH 311](#) Introduction to Higher Mathematics  
[MTH 306](#) Introduction to Differential Equations  
[MTH 309](#) Introductory Linear Algebra  
[MTH 419](#) Introduction to Abstract Algebra  
[MTH 420](#) Advanced Linear Algebra  
[MTH 431](#) Introduction to Real Variables I  
[MTH 432](#) Introduction to Real Variables II  
 Three 300/400-level mathematics courses  
 Four 300/400-level courses in mathematics or computer science

#### Summary

Total required credit hours for the major (concentration BSc): 64-68

See [Baccalaureate Degree Requirements](#) for general education and remaining university requirements.

#### Recommended Sequence of Program Requirements

##### FIRST - THIRD YEARS

Follow first three years of concentration GS

##### FOURTH YEAR

Three 300/400 level mathematics courses  
 Four 300/400 level courses in mathematics or computer science

*Note: Not all seven electives need to be taken in the senior year.*

### Mathematics - B.S.

#### About the Concentration

This concentration provides a course of study for mathematics majors intending to pursue graduate study in applied mathematics. Admission to this concentration is by departmental approval only. See the director of undergraduate studies regarding approval.

#### Acceptance Criteria

Minimum GPA of 2.5 in the prerequisite courses.

#### Prerequisite Courses

[MTH 141](#) College Calculus I  
[MTH 142](#) College Calculus II  
[MTH 241](#) College Calculus III

#### Required Courses

[CSE 115](#) Introduction to Computer Science for Majors I

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[MTH 306](#) Introduction to Differential Equations  
[MTH 309](#) Introductory Linear Algebra  
[MTH 311](#) Introduction to Higher Mathematics  
[MTH 337](#) Introduction to Scientific and Mathematical Computing  
[MTH 417](#) Survey of Multivariable Calculus  
[MTH 418](#) Survey of Partial Differential Equations  
[MTH 419](#) Introduction to Abstract Algebra or [MTH 420](#) Advanced Linear Algebra  
[MTH 431](#) Introduction to Real Variables I  
[MTH 443](#) Fundamentals of Applied Mathematics I  
Three 300/400-level mathematics courses  
Three 300/400-level courses in mathematics or computer science  
[PHY 107](#) General Physics I  
[PHY 108](#) General Physics II

### Summary

Total required credit hours for the major (concentration BSc/AM): 77-83

See [Baccalaureate Degree Requirements](#) for general education and remaining university requirements.

### Recommended Sequence of Program Requirements

#### FIRST YEAR

Fall [CSE 115](#), [MTH 141](#), [PHY 107](#)  
Spring [MTH 142](#), [PHY 108](#)

#### SECOND YEAR

Fall [MTH 241](#), [MTH 309](#)  
Spring [MTH 306](#), [MTH 337](#)

#### THIRD YEAR

Fall [MTH 417](#); [MTH 311](#); One 300/400 level courses in mathematics  
Spring [MTH 418](#); [MTH 419](#) or [MTH 420](#); One 300/400 level courses in mathematics or computer science

#### FOURTH YEAR

Fall [MTH 443](#); Two 300/400 level mathematics courses or computer science  
Spring [MTH 431](#); Two 300/400 level courses in mathematics

## Mathematics - B.S.

### About the Concentration

The Actuarial Science concentration provides a curriculum for mathematics majors intending to pursue a career as an actuary. Please see the Director of Undergraduate Studies for more information on this course of study.

### Acceptance Criteria

A minimum GPA of 2.5 in the prerequisite courses.

### Prerequisites

[STA 119](#) Statistical Methods  
[MTH 141](#) College Calculus I  
[MTH 142](#) College Calculus II  
[MTH 241](#) College Calculus III

### Required Courses

[CSE 113](#) or [CSE 115](#) Introduction to Computer Science  
[ECO 405](#) Microeconomic Theory  
[ECO 407](#) Macroeconomic Theory  
[ECO 461](#) Economic Fluctuations and Forecasting  
[ECO 480](#) Econometrics I  
[ECO 481](#) Econometrics II  
[MGA 201](#) Accounting I  
[MGA 202](#) Accounting II

## Mathematics

[MGF 301](#) Corporation Finance  
[MTH 306](#) Differential Equations  
[MTH 309](#) Linear Algebra  
[MTH 311](#) Intro to Higher Math  
[MTH 411](#) Probability or [STA 301](#) Probability  
[MTH 412](#) Statistical Inference or [STA 302](#) Statistical Inference  
[MTH 458](#) Mathematical Finance I  
[MTH 459](#) Mathematical Finance II  
[STA 403/STA 503](#) Regression Analysis or [MGQ 301](#) Statistical Decisions in Management  
One STA 400/500 level elective

### Summary

Total required credit hours for the major (concentration A): 79

See [Baccalaureate Degree Requirements](#) for general education and remaining university requirements.

### Recommended Sequence of Program Requirements

#### FIRST YEAR

Fall [MTH 141](#), [STA 119](#)

Spring [MTH 142](#), [CSE 113](#) or [CSE 115](#)

#### SECOND YEAR

Fall [MTH 241](#), [MGA 201](#)

Spring [MTH 306](#), [MTH 309](#), [MGA 202](#)

#### THIRD YEAR

Fall [MTH 411](#), [ECO 480](#), [ECO 405](#)

Spring [MTH 412](#), [ECO 481](#), [ECO 407](#)

#### FOURTH YEAR

Fall [ECO 461](#), [MTH 458](#), [MGF 301](#), [STA 503](#) or [MGQ 301](#)

Spring [MTH 311](#), [MTH 459](#), STA 400/500 level elective

## Mathematical Physics - B.S.

### Acceptance Criteria

Minimum GPA of 2.5 in the prerequisite courses.

### Advising Notes

Students should consult with the undergraduate director in the physics and mathematics department regarding approved electives.

This is a joint program. A student who follows this program but does not complete it will have difficulty completing a math major without substantial additional coursework.

### Prerequisite Courses

[MTH 141](#) College Calculus I

[MTH 142](#) College Calculus II

[PHY 107](#) General Physics I or [PHY 117](#) Honors Physics I (preferred)

[PHY 108](#) General Physics II or [PHY 118](#) Honors Physics II (preferred)

[PHY 158](#) General Physics II Lab

### Required Courses

[MTH 241](#) College Calculus III

[MTH 306](#) Introduction to Differential Equations

[MTH 309](#) Introductory Linear Algebra

[MTH 417](#) Survey of Multivariable Calculus

[MTH 418](#) Survey of Partial Differential Equations

[MTH 419](#) Introduction to Abstract Algebra or [MTH 420](#) Advanced Linear Algebra

[MTH 425](#) Introduction to Complex Variables I

[PHY 207](#) General Physics III or [PHY 217](#) Honors Physics III



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[PHY 208](#) General Physics IV  
[PHY 257](#) General Physics III Lab  
[PHY 301](#) Intermediate Mechanics I  
[PHY 307](#) Modern Physics Lab  
[PHY 401](#) Modern Physics I  
[PHY 403](#) Electricity and Magnetism I  
[PHY 405](#) Thermal and Statistical Physics I  
[PHY 407](#) Advanced Laboratory or [PHY 408](#) Advanced Laboratory  
[PHY 431](#) Introduction to Mathematical Physics I (or [MTH 424](#), if offered)  
 One 300/400-level MTH elective  
 One PHY elective (one of the following: [PHY 302](#) Intermediate Mechanics II, [PHY 402](#) Modern Physics II, [PHY 404](#) Electricity and Magnetism II, or [PHY 406](#) Thermal and Statistical Physics II)

### Summary

Total required credit hours for the major: 78

See [Baccalaureate Degree Requirements](#) for general education and remaining university requirements.

### Recommended Sequence of Program Requirements

#### FIRST YEAR

Fall [MTH 141](#), [PHY 107](#) or [PHY 117](#)  
 Spring [MTH 142](#), [PHY 108](#) or [PHY 118](#), [PHY 158](#)

#### SECOND YEAR

Fall [MTH 241](#), [MTH 306](#), [PHY 208](#)  
 Spring [MTH 309](#); [PHY 207](#) or [PHY 217](#); [PHY 257](#)

#### THIRD YEAR

Fall [MTH 417](#), [PHY 301](#), [PHY 401](#)  
 Spring [MTH 418](#), [PHY 307](#), one PHY elective

#### FOURTH YEAR

Fall [MTH 419](#) or [MTH 420](#); [PHY 431](#), [PHY 403](#), [PHY 405](#)  
 Spring [MTH 425](#); [PHY 408](#); one 300/400 level MTH elective

## Mathematics - B.A.

### General Curriculum in Mathematics

This is the basic liberal arts major program in mathematics, and allows for freedom in course choice by the students. A total of nine mathematics (MTH) courses are required: five core courses ([MTH 141](#), [MTH 142](#), [MTH 241](#), [MTH 306](#), [MTH 309](#)) and four electives. An overall GPA of 2.5 in these nine mathematics courses is required to graduate in this program. Several concentrations requiring additional coursework are available for students with specific career goals.

### Acceptance Criteria

Minimum GPA of 2.5 in the prerequisite courses (or transfer equivalents).

### Prerequisite Courses

[MTH 141](#) College Calculus I  
[MTH 142](#) College Calculus II  
[MTH 241](#) College Calculus III

### Required Courses

[MTH 306](#) Introduction to Differential Equations  
[MTH 309](#) Introduction to Linear Algebra  
 One of the following: [MTH 311](#) Introduction to Higher Mathematics, [MTH 313](#) Elements of Set Theory, [MTH 335](#) Elements of Geometry, [MTH 419](#) Introduction to Abstract Algebra, [MTH 420](#) Advanced Linear Algebra, [MTH 431](#) Introduction to Real Variables I, or other proofs course approved by the director of undergraduate studies in mathematics.

Three 300/400-level mathematics courses. For students transferring a non-computer-based differential equations course, one of these three courses must be a computer applications course approved by the director of undergraduate studies.

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### Summary

Total required credit hours for the major (basic curriculum): 33-36

The requirement of an overall GPA of at least 2.5 in the nine mathematics courses will be strictly enforced. Students who fail to meet this requirement with their first nine courses may take additional mathematics courses approved by the director of undergraduate studies to achieve a package of nine in which a 2.5 GPA is earned.

See [Baccalaureate Degree Requirements](#) for general education and remaining university requirements.

### Recommended Sequence of Program Requirements

#### FIRST YEAR

Fall [MTH 141](#)

Spring [MTH 142](#)

#### SECOND YEAR

Fall [MTH 241](#)

Spring [MTH 309](#)

#### THIRD YEAR

Fall [MTH 306](#)

Spring One of the following: [MTH 311](#), [MTH 313](#), [MTH 335](#), [MTH 419](#), [MTH 420](#), [MTH 431](#), or other mathematical proofs course approved by the director of undergraduate studies in mathematics

(Note: selections above must be made in consultation with the director of undergraduate studies in mathematics.)

#### FOURTH YEAR

Fall and Spring Three 300/400 level-mathematics courses

*Each elective must be pre-approved by the director of undergraduate studies in mathematics*

## Mathematics - B.A.

### About the Concentration

This concentration is designed to serve those students interested in careers as applied mathematicians or scientific applications programmers.

The courses in this concentration are like the calculus and computing courses, though more difficult. A student who can handle [MTH 141](#), [MTH 142](#), [MTH 241](#), [CSE 115](#), and [CSE 116](#) should be able to handle concentration C.

### Acceptance Criteria

Minimum GPA of 2.5 in the prerequisite courses.

### Prerequisite Courses

[MTH 141](#) College Calculus I

[MTH 142](#) College Calculus II

[MTH 241](#) College Calculus III

### Required Courses

[CSE 115](#) Introduction to Computer Science for Majors I

[CSE 116](#) Introduction to Computer Science for Majors II

[CSE 241](#) Digital Systems

[CSE 250](#) Algorithms and Data Structures

[MTH 306](#) Introduction to Differential Equations

[MTH 309](#) Introductory Linear Algebra

[MTH 417](#) Survey of Multivariable Calculus and [MTH 418](#) Survey of Partial Differential Equation or [MTH 431](#) Introduction to Real Variables I and [MTH 432](#) Introduction to Real Variables II\*

[MTH 437](#) Introduction to Numerical Analysis I

[MTH 438](#) Introduction to Numerical Analysis II

Two 300/400-level mathematics courses

Two 300/400-level courses in mathematics or computer science

## Mathematics

### Summary

Total required credit hours for the major (concentration C): 64-68

See [Baccalaureate Degree Requirements](#) for general education and remaining university requirements.

### Recommended Sequence of Program Requirements

#### FIRST YEAR

Fall [CSE 115](#), [MTH 141](#)

Spring [CSE 116](#), [MTH 142](#)

#### SECOND YEAR

Fall [CSE 241](#), [MTH 241](#)

Spring [CSE 250](#), [MTH 306](#)

#### THIRD YEAR

Fall [MTH 309](#); [MTH 417](#) or [MTH 431](#)\*

Spring [MTH 418](#) or [MTH 432](#)\*

#### FOURTH YEAR

Fall [MTH 437](#)

Spring [MTH 438](#)

Fall or Spring Two 300/400-level mathematics courses, two 300/400-level courses in mathematics or computer science

*\*MTH 311 is a prerequisite for MTH 431. Students must take one complete sequence MTH 417-MTH 418 or MTH 431-MTH 432. Students intending to go to graduate school in applied mathematics should take MTH 311-MTH 431-MTH 432 instead of MTH 417-MTH 418. MTH 311 would then count as a technical elective.*

### Approved Technical Electives

Any 300/400-level MTH course is acceptable. Note that [MTH 431-MTH 432](#) and [MTH 419-MTH 420](#) are designed for students who want intensive preparation in analysis and modern algebra, and are not good choices to just fill out a schedule. [MTH 431-MTH 432](#) may be taken as electives (in addition to [MTH 417](#) or [MTH 418](#)) or as requirements (in place of [MTH 417](#) and [MTH 418](#)).

Approved technical electives outside the Mathematics department: any 300 or 400 level CSE course.

## Mathematics - B.A.

### About the Concentration

This concentration describes a basic theoretical course of study for mathematics majors intending to pursue graduate study in mathematics, or intending careers in such fields as actuarial science, financial analysis, or cryptography.

Admission to this concentration is by departmental approval only. See the director of undergraduate studies regarding approval.

### Acceptance Criteria

Minimum GPA of 2.5 in the prerequisite courses.

### Advising Notes

Concentration GS has the fewest courses of any of the math concentrations except General Curriculum, but many courses are quite difficult; [MTH 311](#), [MTH 431-MTH 432](#), and [MTH 419-MTH 420](#) are abstract theoretical courses emphasizing proofs. A student must do well in [MTH 311](#) to enter this program.

Students planning to go to graduate school should meet with the director of undergraduate studies in mathematics in the fall semester of their junior year. They should plan to take the GREs in either spring of the junior year or fall of the senior year.

### Prerequisite Courses

[MTH 141](#) College Calculus I

[MTH 142](#) College Calculus II

[MTH 241](#) College Calculus III

### Required Courses

## Mathematics

[MTH 306](#) Introduction to Differential Equations  
[MTH 309](#) Introductory Linear Algebra  
[MTH 311](#) Introduction to Higher Mathematics  
[MTH 419](#) Introduction to Abstract Algebra  
[MTH 420](#) Advanced Linear Algebra  
[MTH 431](#) Introduction to Real Variables I  
[MTH 432](#) Introduction to Real Variables II  
 One 300/400-level mathematics course  
 Two 300/400-level courses in mathematics or computer science

### Summary

Total required credit hours for the major (concentration GS): 49-52  
*(thirteen courses in math and related areas)*

See [Baccalaureate Degree Requirements](#) for general education and remaining university requirements.

### Recommended Sequence of Program Requirements

#### FIRST YEAR

Fall [MTH 141](#)  
 Spring [MTH 142](#)

#### SECOND YEAR

Fall [MTH 241](#), [MTH 309](#)  
 Spring [MTH 306](#), [MTH 311](#)

#### THIRD YEAR

Fall [MTH 419](#), [MTH 431](#)  
 Spring [MTH 420](#), [MTH 432](#)

#### FOURTH YEAR

Fall or Spring One 300/400-level mathematics course (not [MTH 417](#)), two 300/400-level courses in mathematics or computer science (not [MTH 417](#))

## Mathematics - B.A.

### About the Concentration

This concentration describes a course of study for mathematics majors intending to pursue graduate study in applied mathematics. Admission to this concentration is by departmental approval only. See the director of undergraduate studies regarding approval.

### Acceptance Criteria

A minimum GPA of 2.5 in the prerequisite courses.

### Advising Notes

[MTH 311](#), [MTH 431](#), [MTH 419](#) and [MTH 420](#) are abstract theoretical courses emphasizing proofs. A student must do well in [MTH 311](#) to enter this program.

Students planning to go to graduate school should meet with the director of undergraduate studies in mathematics in the fall semester of their junior year. They should plan to take the GREs in either spring of the junior year or fall of the senior year.

### Prerequisite Courses

[MTH 141](#) College Calculus I  
[MTH 142](#) College Calculus II  
[MTH 241](#) College Calculus III

### Required Courses

[CSE 115](#) Introduction to Computer Science for Majors I  
[MTH 306](#) Introduction to Differential Equations  
[MTH 309](#) Introductory Linear Algebra

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[MTH 311](#) Introduction to Higher Mathematics  
[MTH 337](#) Introduction to Scientific and Mathematical Computing  
[MTH 417](#) Survey of Multivariable Calculus  
[MTH 418](#) Survey of Partial Differential Equations  
[MTH 419](#) Introduction to Abstract Algebra or [MTH 420](#) Advanced Linear Algebra  
[MTH 431](#) Introduction to Real Variables I  
[MTH 443](#) Fundamentals of Applied Mathematics I  
 Two 300/400-level courses in mathematics or computer science  
[PHY 107](#) General Physics I  
[PHY 108](#) General Physics II

### Summary

Total required credit hours for the major (concentration GS/AM): 65-67  
*(seventeen courses in math and related areas)*

See [Baccalaureate Degree Requirements](#) for general education and remaining university requirements.

### Recommended Sequence of Program Requirements

#### FIRST YEAR

Fall [CSE 115](#), [MTH 141](#), [PHY 107](#)  
 Spring [MTH 142](#), [PHY 108](#)

#### SECOND YEAR

Fall [MTH 241](#), [MTH 309](#)  
 Spring [MTH 306](#), [MTH 337](#)

#### THIRD YEAR

Fall [MTH 311](#); [MTH 417](#)  
 Spring [MTH 418](#); [MTH 419](#) or [MTH 420](#)

#### FOURTH YEAR

Fall [MTH 431](#); [MTH 443](#)  
 Spring Two 300/400-level course in mathematics or computer science

## Mathematics - Economics - B.A.

### About the Concentration

This is a program for students intending graduate study in economics. Acceptance into this program requires a minimum GPA of 2.5 in both the mathematics and economics courses during the first year. Separate applications must be submitted to both the Department of Mathematics and the Department of Economics. Admission to this program is by departmental approval only. See the director of undergraduate studies regarding approval.

### Acceptance Criteria

A minimum GPA of 2.5 in the prerequisite courses.

### Advising Notes

A student must be able to handle [MTH 311](#) to enter this program. Students should consult the advisor in each department concerning senior-level courses. Exceptions in the curriculum may be allowed through consultation with the appropriate department. Interested students should contact the departments upon application for up-to-date information on possible changes.

### Prerequisite Courses

[MTH 141](#) College Calculus I  
[MTH 142](#) College Calculus II  
[MTH 241](#) College Calculus III

### Required Courses

[ECO 405](#) Microeconomic Theory  
[ECO 407](#) Macroeconomic Theory or [ECO 337](#) Honors Macroeconomic Theory  
[MTH 306](#) Introduction to Differential Equations

## Mathematics

[MTH 309](#) Introductory Linear Algebra  
[MTH 311](#) Introduction to Higher Mathematics  
[MTH 411](#) Probability Theory  
[MTH 412](#) Introduction to Statistical Inference  
[MTH 419](#) Introduction to Abstract Algebra or [MTH 420](#) Advanced Linear Algebra  
[MTH 431](#) Introduction to Real Variables I  
 One 300/400-level mathematics course  
 Two 300/400-level courses in economics (not [ECO 480](#) or [ECO 481](#))

### Summary

Total required credit hours for the major (program M/E): 58-61  
*(fifteen courses in math and economics)*

See [Baccalaureate Degree Requirements](#) for general education and remaining university requirements.

### Recommended Sequence of Program Requirements

#### FIRST YEAR

Fall [MTH 141](#)  
 Spring [MTH 142](#)

#### SECOND YEAR

Fall [ECO 407](#) or [ECO 337](#); [MTH 241](#)  
 Spring [ECO 405](#), [MTH 306](#), [MTH 309](#), [MTH 311](#)

#### THIRD YEAR

Fall [MTH 411](#), [MTH 431](#)  
 Spring [MTH 419](#) or [MTH 420](#), one 300/400-level mathematics course (not [MTH 417](#))

#### FOURTH YEAR

Fall One 300/400-level courses in economics (not [ECO 480](#) or [ECO 481](#))  
 Spring [MTH 412](#); one 300/400-level course in economics (not [ECO 480](#) or [ECO 481](#))

## Mathematics - B.A.

### About the Concentration

This concentration is designed for the student whose career goal is to attain a master's degree for professional certification in adolescent mathematics education. Students interested in this concentration should obtain advisement from the director of undergraduate studies in mathematics, 233 Mathematics Building, and, for questions related to the education courses, from the Teacher Education Institute (TEI), 375 Baldy Hall.

Admission to the major must be sought from the Department of Mathematics, usually in the student's second year. For advice on prerequisites for required courses in education and selection of general education courses fulfilling the State Education Department (SED) requirement for prospective teachers, students should consult with TEI as early as their freshman year.

Completion of the major concentration (including the required education courses) provides advanced status toward initial New York State teacher certification, accomplished through one year of subsequent coursework at the graduate level through the Graduate School of Education. It is then possible to complete, within the state-mandated three years, the master's degree required for a professional teaching certificate, provided that all NYS requirements have been successfully completed.

### Acceptance Criteria

A minimum GPA of 2.5 in the prerequisite courses.

### Advising Notes

The courses in this concentration are more theoretical than those in concentration C; [MTH 311](#), [MTH 419](#), and [MTH 431](#) are difficult. A student must be able to handle [MTH 311](#) in order to enter this concentration. *Warning: In order to graduate with a degree in mathematics in concentration GS/ED, a student must complete all the required education courses, as well as the required mathematics courses. Students who complete concentration GS/ED math requirements but do not complete the education requirements must change to the basic curriculum or to another concentration in order to graduate.* It is recommended that students interested in this concentration contact the department upon application for up-to-date information on possible changes in requirements.

### Prerequisite Courses

## Mathematics

[MTH 141](#) College Calculus I  
[MTH 142](#) College Calculus II  
[MTH 241](#) College Calculus III

### Required Courses

[CEP 400](#) Educational Psychology  
[CSE 113](#) Introduction to Computer Science I or [CSE 115](#) Introduction to Computer Science for Majors I  
[MTH 337](#) Introduction to Scientific and Mathematical Computing or [CSE 114](#) Introduction to Computer Science II or [CSE 116](#) Introduction to Computer Science for Majors II  
[ELP 405](#) Sociology of Education  
[LAI 350](#) Introduction to Education  
[LAI 414](#) Language, Cognition & Writing  
[MTH 191](#) Introduction to Discrete Mathematics or [CSE 191](#) Discrete Structures  
[MTH 306](#) Introduction to Differential Equations  
[MTH 309](#) Introductory Linear Algebra  
[MTH 311](#) Introduction to Higher Mathematics  
[MTH 335](#) Elements of Geometry  
[MTH 411](#) Probability Theory  
[MTH 419](#) Introduction to Abstract Algebra  
[MTH 431](#) Introduction to Real Variables I  
 One 300/400-level mathematics elective  
 Two 300/400-level electives from the Educational Leadership and Policy department or the Counseling, School, and Educational Psychology department, or one education-related College of Arts and Sciences course

### Summary

Total required credit hours for the major: 74-75  
*(fourteen courses in math and related areas)*

See [Baccalaureate Degree Requirements](#) for general education and remaining university requirements.

### Recommended Sequence of Program Requirements

#### FIRST YEAR

Fall [MTH 141](#), [CSE 113](#) or [CSE 115](#)  
 Spring [MTH 142](#), [CSE 113](#) or [MTH 337](#)

#### SECOND YEAR

Fall [MTH 241](#), [MTH 191](#) or [CSE 191](#)  
 Spring [LAI 350](#), [MTH 306](#), [MTH 311](#)

#### THIRD YEAR

Fall [MTH 309](#), [MTH 431](#)  
 Spring [CEP 400](#), [ELP 405](#), [MTH 335](#)

#### FOURTH YEAR

Fall [MTH 411](#), [MTH 419](#) or [MTH 420](#), [LAI 414](#), one 300/400-level course chosen from the list of approved electives for the Undergraduate Minor in Education  
 Spring One 300/400-level mathematics elective; one 300/400-level course chosen from the list of approved electives for the Undergraduate Minor in Education

## Mathematics - B.A./M.A.

### About the Program

This program is designed for students who demonstrate, in their first two years of mathematical study, a high level of competence and motivation. Upon admission to the BA/MA program, students follow an integrated course of study leading to a combined degree. Admission to this program is by departmental approval only and requires a minimum GPA of 3.0 in mathematics courses (calculus, differential equations, linear algebra) as well as letters of recommendation.

### Acceptance Criteria

A minimum GPA of 2.5 in the prerequisite courses.

## Mathematics

### Prerequisite Courses

[MTH 141](#) College Calculus I  
[MTH 142](#) College Calculus II  
[MTH 241](#) College Calculus III

### Required Courses

[MTH 306](#) Introduction to Differential Equations  
[MTH 309](#) Introductory Linear Algebra  
[MTH 311](#) Introduction to Higher Mathematics  
[MTH 519](#) Introduction to Abstract Algebra  
[MTH 520](#) Advanced Linear Algebra  
[MTH 531](#) Introduction to Real Variables I  
[MTH 532](#) Introduction to Real Variables II

Three 300/400-level courses in mathematics or computer science. At least one of these must be a mathematics course (excluding [MTH 498](#), [499](#)). Electives require approval by the director of undergraduate studies.

Six graduate-level courses, including at least 12 credits in mathematics. Included must be at least one year-long sequence in mathematics at the 500 level or above (other than 519-520 or 531-532). Electives require approval by the director of graduate studies.

### Summary

Total required credit hours for the undergraduate portion: 33-36  
 Total required credit hours for the B.A./M.A.: 63-66

See [Baccalaureate Degree Requirements](#) for general education and remaining university requirements.

Refer to the Graduate School's Policies and Procedures Manual for Master's Candidate Requirements.

### Recommended Sequence of Program Requirements

#### FIRST YEAR

Fall [MTH 141](#)  
 Spring [MTH 142](#)

#### SECOND YEAR

Fall [MTH 241](#), [MTH 309](#)  
 Spring [MTH 306](#), [MTH 311](#)

#### THIRD YEAR

Fall and Spring Three 300/400-level courses in mathematics or computer science. At least one of these must be a mathematics course other than [MTH 417](#). Electives require approval by the director of undergraduate studies in mathematics.

#### FOURTH YEAR

Fall [MTH 519](#), [MTH 531](#)  
 Spring [MTH 520](#), [MTH 532](#)

#### FIFTH YEAR

Fall and Spring Six graduate-level math electives, including at least 12 credits in mathematics. Included must be at least one year-long sequence in mathematics at the 500 level or above (other than [MTH 519-MTH 520](#) or [MTH 531-MTH 532](#)). Electives require approval by the director of graduate studies.

Project or thesis (up to 6 credits of the 18 credits of graduate level electives may be used for [MTH 800](#) Thesis Guidance.)

## Mathematics - Minor

### Acceptance Criteria

Minimum GPA of 2.5 in the prerequisite courses (or approved transfer equivalent).

### Prerequisite Courses

[MTH 141](#) College Calculus I  
[MTH 142](#) College Calculus II  
[MTH 241](#) College Calculus III



## Mathematics

### Required Courses

[MTH 306](#) Introduction to Differential Equations

[MTH 309](#) Introductory Linear Algebra

Two additional 300/400-level mathematics electives from within the Department of Mathematics

*Note: A minimum GPA of 2.0 is required in these courses for departmental recommendation for a minor in mathematics.*

### Summary

Total required credit hours for the minor: 26-28

(7 courses from within the Mathematics department)

### MTH 115: SURVEY of ALGEBRA & TRIG

**Credits:** 1

**Semester(s):** Fall, Spring

**Type:**

**MTH 120: Selected Topics in Calculus**

**Credits:** 1-3

**Semester(s):** Fall, Spring, Summer

**Type:** TUT

Allows transfer students to efficiently learn specific topics from UB calculus courses that were not covered in calculus courses they took at other institutions.

### MTH 121: Survey of Calculus and Its Applications I

**Credits:** 4

**Semester(s):** Fall, Spring, Summer

**Pre-requisites:** [MTH 115](#) or Regents Course III Required for Registration

**Type:** LEC/LAB

*This course is a limited enrollment (impacted) course. Students who have previously attempted the course and received a grade other than W may not register for this course during the fall or spring semester.*

For students in social, biological, and management sciences. Limits, continuity, differentiation of algebraic and exponential functions; applications; introduces integration. This course is a controlled enrollment (impacted) course. Students who have previously attempted the course and received a grade other than W may repeat the course in the summer or only in the fall or spring semester with a petition to the College of Arts and Sciences Deans' Office.

### MTH 122: Survey of Calculus and Its Applications II

**Credits:** 4

**Semester(s):** Fall, Spring, Summer

**Pre-requisites:** [MTH 121](#) or [MTH 131](#)

**Type:** LEC/LAB

Continuation of [MTH 121](#). Maximization of functions of several variables using both calculus and elementary linear programming techniques. Elementary integration, simple differential equations, matrix algebra.

### MTH 131: Mathematical Analysis for Management

**Credits:** 4

**Semester(s):** Fall, Spring, Summer

**Pre-requisites:** [MTH 115](#) or Regents Course III Required for Registration

**Type:** LEC/LAB

*This course is a limited enrollment (impacted) course. Students who have previously attempted the course and received a grade other than W may not register for this course during the fall or spring semester.*

For students in Management. Limits, continuity, differentiation of algebraic and exponential functions. Applications, partial derivatives and applications. Introduces integration. This course is a controlled enrollment (impacted) course. Students who have previously attempted the course and received a grade other than W may repeat the course in the summer or only in the fall or spring semester with a petition to the College of Arts and Sciences Deans' Office.

### MTH 141: College Calculus I

**Credits:** 4

**Semester(s):** Fall, Spring, Summer

**Pre-requisites:** [MTH 115](#) or Trigonometry or Regents Course III Required for Registration

**Type:** LEC/LAB

*This course is a limited enrollment (impacted) course. Students who have previously attempted the course and received a grade other than W may not register for this course during the fall or spring semester.*

Beginning of a three-semester sequence in calculus for students of mathematics, natural sciences, and engineering. Covers differentiation and integration with applications. This course is a controlled enrollment (impacted) course. Students who have previously attempted the course and received a grade other than W may repeat the course in the summer or only in the fall or spring semester with a petition to the College of Arts and Sciences Deans' Office.

### MTH 142: College Calculus 2

**Credits:** 4

## Mathematics

**Semester(s):** Fall, Spring, Summer  
**Type:** LEC/LAB

[MTH 121](#) is usually not adequate preparation for [MTH 142](#).

*This course is a limited enrollment (impacted) course. Students who have previously attempted the course and received a grade other than W may not register for this course during the fall or spring semester.*

Differentiation and integration of transcendental functions; infinite sequences; series and power series; integration methods; additional topics in analytic geometry. This course is a controlled enrollment (impacted) course. Students who have previously attempted the course and received a grade other than W may repeat the course in the summer or only in the fall or spring semester with a petition to the College of Arts and Sciences Deans' Office.

### MTH 153: Honors Calculus I

**Credits:** 4  
**Semester(s):** Fall  
**Pre-requisites:** Permission of Instructor or 4/5 on AP Calculus Required for Registration  
**Type:** LEC/LAB

First course in the honors sequence for intended math majors or for others with suitable preparation. Emphasizes proofs and concepts of calculus.

### MTH 154: Honors Calculus 2

**Credits:** 4  
**Semester(s):** Spring  
**Type:** LEC/LAB

Differentiation and integration of transcendental functions; infinite sequences; series and power series; integration methods. Topics enhance those of [MTH 142](#) and concepts are studied in detail. May be taken in addition to advanced placement credit already earned.

### MTH 191: Introduction to Discrete Mathematics I

**Credits:** 4  
**Pre-requisites:** Working Knowledge of a Programming Language Required for Registration  
**Type:** LEC/LAB

First part of a two-semester sequence. Provides the mathematical foundations for the study of computer science. Also approved for mathematics majors in Concentration GS/ED. Topics include sets, relations, functions, mathematical induction, fundamental counting methods, difference equations, and sequences and series.

### MTH 192: Introduction to Discrete Mathematics II

**Credits:** 4  
**Semester(s):** Spring  
**Pre-requisites:** [MTH 191](#) or [CSE 191](#)  
**Type:** LEC/LAB

Second part of a two-semester sequence. Provides the mathematical foundations for the study of computer science. Topics include discrete probability, mathematical logic, linear algebra, and

graph theory. Same as [CSE 192](#).

### MTH 241: College Calculus 3

**Credits:** 4  
**Semester(s):** Fall, Spring, Summer  
**Pre-requisites:** [MTH 142](#)  
**Type:** LEC/LAB

[MTH 121-MTH 122](#) is usually not adequate preparation for [MTH 241](#).

*This course is a limited enrollment (impacted) course. Students who have previously attempted the course and received a grade other than W may not register for this course during the fall or spring semester.*

Geometry and vectors of n-dimensional space; Green's theorem, Gauss theorem, Stokes theorem; multidimensional differentiation and integration; application to 2- and 3-D space. This course is a controlled enrollment (impacted) course. Students who have previously attempted the course and received a grade other than W may repeat the course in the summer or only in the fall or spring semester with a petition to the College of Arts and Sciences Deans' Office.

### MTH 251: Honors Calculus 3

**Credits:** 4  
**Semester(s):** Fall  
**Pre-requisites:** Permission of Instructor Required for Registration  
**Type:** LEC/LAB

Third-semester calculus course for honors students and students with an excellent record in previous calculus courses. Emphasizes proofs and concepts of calculus.

### MTH 306: Introduction to Differential Equations

**Credits:** 4  
**Semester(s):** Fall, Spring, Summer  
**Pre-requisites:** [MTH 142](#)  
**Type:** LEC/LAB

Analytic solutions, qualitative behavior of solutions to differential equations. First-order and higher-order ordinary differential equations, including nonlinear equations. Covers analytic, geometric, and numerical perspectives as well as an interplay between methods and model problems. Discusses necessary matrix theory and explores differential equation models of phenomena from various disciplines. Uses a mathematical software system designed to aid in the numerical and qualitative study of solutions, and in the geometric interpretation of solutions.

### MTH 309: Introductory Linear Algebra

**Credits:** 4  
**Semester(s):** Fall, Spring, Summer  
**Pre-requisites:** [MTH 142](#)  
**Type:** LEC/LAB

Linear equations, matrices, determinants, vector spaces, linear mappings, inner products, eigenvalues, eigenvectors.

## Mathematics

### MTH 311: Introduction to Higher Mathematics

**Credits:** 4  
**Semester(s):** Fall, Spring  
**Pre-requisites:** [MTH 241](#)  
**Type:** LEC/LAB

Develops the student's ability to read, comprehend and construct rigorous proofs. Topics may include the following: the number systems  $N$ ,  $Z$ ,  $Q$ ,  $R$  and the existence of irrational numbers; sets and functions; size of sets (finite/infinite, countable/uncountable); the countability of the rationals and the uncountability of the real numbers; boundedness; upper and lower bounds; lub's and glb's; lub and glb property; density of the rationals in the reals; Archimedean property of the reals; mathematical induction, including strong induction and the well-ordering of the natural numbers; sequences of real numbers, including the Monotone Convergence Theorem, Cauchy sequences, and the Bolzano-Weierstrass Theorem.

### MTH 313: Elements of Set Theory

**Credits:** 4  
**Pre-requisites:** [MTH 241](#)  
**Type:** LEC/LAB

Cardinals, ordinals, order-types, and operations on them. Axiom of choice. Sets.

### MTH 335: Elements of Geometry

**Credits:** 4  
**Semester(s):** Spring  
**Pre-requisites:** [MTH 309](#)  
**Type:** LEC/LAB

Euclidean and non-Euclidean geometries. Studies the Hilbert postulates and various models, emphasizing Euclidean and Lobachevskian geometries.

### MTH 337: Introduction to Scientific and Mathematical Computing

**Credits:** 4  
**Pre-requisites:** [MTH 141](#) & [MTH 142](#)  
**Type:** LEC/LAB

Computing now plays an essential and ever-expanding role in science and mathematics. This course provides a broad introduction to computing in the sciences and in both abstract and applied mathematics. It is accessible to students early in their undergraduate program, thereby opening the door to the profitable use of computation throughout the junior and senior years.

### MTH 353: Introduction to Combinatorics I

**Credits:** 3  
**Semester(s):** Fall  
**Pre-requisites:** [MTH 241](#)  
**Type:** LEC

Permutations, combinations, and other problems of selecting and arranging objects subject to various restrictions; generating functions; recurrence relations; inclusion-exclusion theorem.

### MTH 354: Introduction to Combinatorics II

**Credits:** 3  
**Semester(s):** Spring  
**Pre-requisites:** [MTH 241](#)  
**Type:** LEC

Theory of graphs: Eulerian and Hamiltonian circuits; trees; planarity; colorability; directed graphs and tournaments; isomorphism; adjacency matrix; applications to problems in communication, scheduling, and traffic flow.

### MTH 399: Junior Seminar

**Credits:** 1-3  
**Pre-requisites:** [MTH 241](#) and Permission of Instructor Required for Registration  
**Type:** SEM

*The content of this course is variable and therefore it is repeatable for credit. The [University Grade Repeat Policy](#) does not apply.*

Seminar based around a specific topic or area of mathematics appropriate to juniors in mathematics and the mathematical sciences. The format is determined by the instructor or team of instructors. Sessions include lectures by UB faculty in Mathematics and other departments around the university, talks by outside experts presentations by the students registered in the seminar on readings and/or research work they have done in relation to the subject matter of the seminar, and occasional field trips. Open discussion during the sessions is a key feature.

### MTH 411: Probability Theory

**Credits:** 4  
**Semester(s):** Fall, Spring  
**Pre-requisites:** [MTH 141](#) and [MTH 142](#)  
**Type:** LEC/LAB

A first course in probability. Introduces the basic concepts of probability theory and addresses many concrete problems. A list of basic concepts includes axioms of probability, conditional probability, independence, random variables (continuous and discrete), distribution functions, expectation, variance, joint distribution functions, limit theorems.

### MTH 412: Introduction to Statistical Inference

**Credits:** 4  
**Semester(s):** Fall  
**Pre-requisites:** [MTH 411](#)  
**Type:** LEC/LAB

Topics include: review of probability, conditional probability, Bayes' Theorem; random variables and distributions; expectation and properties; covariance, correlation, and conditional expectation; special distributions; Central Limit Theorem and applications; estimations, including Bayes; estimators, maximum likelihood estimators, and their properties. Includes use of sufficient statistics to improve estimators, distribution of estimators, unbiasedness, hypothesis testing, linear statistical models, and statistical inference from the Bayesian point of view.

### MTH 413: Introduction to Mathematical Logic I

## Mathematics

**Credits:** 3

**Semester(s):** Fall

**Pre-requisites:** [MTH 313](#)

**Type:** LEC/LAB

Informal and formal development of propositional calculus; predicate calculus and predicate calculus with equality; completeness theorem and some consequences.

### MTH 417: Survey of Multivariable Calculus

**Credits:** 4

**Semester(s):** Fall, Spring

**Pre-requisites:** [MTH 241](#)

**Type:** LEC/LAB

For math majors in Concentration C, and majors of science and engineering. Surveys functions of several variables; differentiation, composite, and implicit functions; critical points; line integrals; Green's theorem. Vector field theory; gradient, divergence, and curl; integral theorems. Introduces functions of a complex variable; curves and regions in the complex plane; analytic functions, Cauchy-Riemann equations, Cauchy integral formula. Applications.

### MTH 418: Survey of Partial Differential Equations

**Credits:** 4

**Semester(s):** Fall, Spring

**Pre-requisites:** [MTH 241](#) and [MTH 306](#)

**Type:** LEC/LAB

Surveys elementary differential equations of physics; separation of variables and superposition of solutions; orthogonal functions and Fourier series. Introduces boundary value problems, Fourier and Laplace transforms.

### MTH 419: Introduction to Abstract Algebra

**Credits:** 4

**Semester(s):** Fall, Spring

**Pre-requisites:** [MTH 309](#), also [MTH 311](#) Recommended

**Type:** LEC/LAB

Topics in finite rings and algebraic number theory.

### MTH 420: Advanced Linear Algebra

**Credits:** 4

**Semester(s):** Spring

**Pre-requisites:** [MTH 309](#), also [MTH 311](#) recommended

**Type:** LEC/LAB

Topics in advanced linear algebra.

### MTH 425: Introduction to Complex Variables I

**Credits:** 3

**Semester(s):** Spring

**Pre-requisites:** [MTH 241](#)

**Type:** LEC

For students of physics, electrical and other areas of engineering, and mathematics. Analyticity; calculus over the complex numbers. Cauchy theorems, residues, singularities, conformal mapping.

Weierstrass convergence theorem; analytic continuation.

### MTH 426: Introduction to Complex Variables II

**Credits:** 3

**Pre-requisites:** [MTH 425](#)

**Type:** LEC

Continuation of [MTH 425](#). Weierstrass and Mittag-Leffler theorems, harmonic functions, conformal mapping and Green's function, analytic equivalence, and Riemann's mapping theorem. Montel's theorem, external mappings.

### MTH 427: Introduction to Topology I

**Credits:** 3

**Semester(s):** Fall

**Pre-requisites:** [MTH 311](#) recommended

**Type:** LEC

Abstract topological spaces, bases, convergence, filters, and nets; separation axioms, continuity, and homeomorphisms; connectedness, separability, compactness.

### MTH 428: Introduction to Topology II

**Credits:** 3

**Semester(s):** Spring

**Pre-requisites:** [MTH 427](#)

**Type:** LEC

Continuation of [MTH 427](#). Product and quotient topologies; compactification; complete semi-metric spaces; metrization; topological algebra. Applies results to such fields as differential equations, numerical analysis, probability theory.

### MTH 429: Introduction to the Theory of Numbers I

**Credits:** 3

**Semester(s):** Fall

**Pre-requisites:** [MTH 311](#) Recommended

**Type:** LEC

The Euclidean algorithm and unique factorization; arithmetical functions; congruences, reduced residue systems; primitive roots; certain diophantine equations.

### MTH 430: Introduction to the Theory of Numbers II

**Credits:** 3

**Semester(s):** Spring

**Pre-requisites:** [MTH 429](#)

**Type:** LEC

Continuation of [MTH 429](#). Irrational numbers; continued fractions from a geometric viewpoint; best rational approximations to real numbers; the Fermat-Pell equation; quadratic fields and integers. Applications to diophantine equations.

### MTH 431: Introduction to Real Variables I

**Credits:** 4

**Semester(s):** Fall, Spring

## Mathematics

**Pre-requisites:** [MTH 311](#)

**Type:**

Comprehensive and rigorous course in the study of real valued functions of one real variable. Topics include sequences of numbers, limits and the Cauchy criterion, continuous functions, differentiation, inverse function theorem, Riemann integration, sequences and series, uniform convergence. A prerequisite for most advanced courses in analysis.

### MTH 432: Introduction to Real Variables II

**Credits:** 4

**Semester(s):** Spring

**Pre-requisites:** [MTH 431](#)

**Type:** LEC/LAB

Rigorous course in analyzing dimensions greater than one. Includes details of three basic theorems: the inverse function theorem, the implicit function theorem, and the change of variables theorem in multiple integrals. Topics include continuously differentiable functions, the chain rule, inverse and implicit function theorems, Riemann integration, partitions of unity, change of variables theorem.

### MTH 435: Introduction to Cryptography

**Credits:** 3

**Semester(s):** Fall

**Pre-requisites:** [MTH 419](#) or [MTH 429](#)

**Type:** LEC

Explains the basics of cryptography, which is the systematic study of methods of concealing messages from people who are not authorized to read them. Topics include the following: cryptosystem definitions and basic types of attack; substitution ciphers. Hill ciphers; congruences and modular exponentiation; digital encryption standard; public key and RSA cryptosystems; pseudoprimes and primality testing; Pollard rho method; basic finite field theory; discrete log; and digital signatures.

### MTH 437: Introduction to Numerical Analysis I

**Credits:** 4

**Semester(s):** Fall

**Pre-requisites:** [CSE 113](#) or [CSE 115](#) or [MTH 337](#) and [MTH 241](#) and [MTH 306](#) and [MTH 309](#)

**Type:** LEC/LAB

First part of a 2-semester sequence which explores the design and implementation of numerical methods to solve the most common types of problem arising in science and engineering. Most such problems cannot be solved in terms of a closed analytical formula, but many can be handled with numerical methods learned in this course. Topics for the two semesters include: how a computer does arithmetic, solving systems of simultaneous linear or nonlinear equations, finding eigenvalues and eigenvectors of (large) matrices, minimizing a function of many variables, fitting smooth functions to data points (interpolation and regression), computing integrals, solving ordinary differential equations (initial and boundary value problems), and solving partial differential equations of elliptic, parabolic, and hyperbolic types. We study how and why numerical methods work, and also their errors and limitations. Students gain practical experience through course projects that entail writing computer programs.

### MTH 438: Introduction to Numerical Analysis II

**Credits:** 4

**Semester(s):** Spring

**Pre-requisites:** [MTH 437](#) or [CSE 437](#)

**Type:** LEC/LAB

Second part of the 2-semester sequence described under [MTH 437](#).

### MTH 443: Fundamentals of Applied Mathematics I

**Credits:** 3

**Pre-requisites:** [MTH 241](#), [MTH 306](#), and [MTH 309](#)

**Type:** LEC

Mathematical formulation and analysis of models for phenomena in the natural sciences. Includes derivation of relevant differential equations from conservation laws and constitutive relations. Potential topics include diffusion, stationary solutions, traveling waves, linear stability analysis, scaling and dimensional analysis, perturbation methods, variational and phase-space methods, kinematics, and laws of motion for continuous media. Examples from areas might include, but are not confined to, biology, fluid dynamics, elasticity, chemistry, astrophysics, geophysics.

### MTH 444: Fundamentals of Applied Mathematics II

**Credits:** 3

**Pre-requisites:** [MTH 241](#), [MTH 306](#), and [MTH 309](#)

**Type:** LEC

Explores other topics described in [MTH 443](#).

### MTH 455: Mathematical Modeling

**Credits:** 3

**Pre-requisites:** [MTH 306](#) and [MTH 309](#)

**Type:** LEC

Introduces the use of mathematical modeling in applied mathematics using a case study approach. Population ecology; chemical kinetics; traffic dynamics.

### MTH 458: Mathematical Finance

**Credits:** 3

**Pre-requisites:** [MTH 241](#)

**Co-requisites:** [MTH 306](#)

**Type:** LEC

Introduces the mathematical theory and computation of modern financial products used in the banking and corporate world. Derives and analyzes mathematical models for the valuation of derivative products.

### MTH 459: Mathematical Finance 2

**Credits:** 3

**Pre-requisites:** [MTH 458](#)

**Type:** LEC

Describes the mathematical development of both the theoretical and the computational techniques used to analyze financial

## Mathematics

instruments. Specific topics include utility functions; forwards, futures, and swaps; and modeling of derivatives and rigorous mathematical analysis of the models, both theoretically and computationally. Develops, as needed, the required ideas from partial differential equations and numerical analysis.

### MTH 460: Theory of Games

**Credits:** 4

**Pre-requisites:** [MTH 241](#) and [MTH 309](#)

**Type:** LEC/LAB

Introduces the mathematical theory of games--a systematic approach to modeling conflict, competition, cooperation, and negotiation--with applications to mathematics, economics, politics and evolutionary biology. A game, in mathematical terms, consists of a starting point and various choices made by 'players.' Each choice might lead to new choices or to an outcome that ends the game. Some choices might be random; some might be made without full information about what has transpired. The players are each trying to maximize their own payoff, but the play of each might influence the results of the others. The approaches Game Theory uses to analyze conflict between two or more people lead to results that can seem paradoxical as well as illuminating. The most important thing a student can take from this course is a useful way of approaching decisions, from the trivial-- how does a couple decide which movie to see--to the critical--how should countries pursue their goals in cooperation or conflict with their allies and enemies. Partial list of topics: Prisoner's Dilemma, game trees, pure and mixed strategies, backward induction, normal form, Nash equilibrium, chance moves, utility functions, domination, convexity, payoff regions, strictly competitive games, separating hyperplanes, repeating games, and cooperative bargaining theory.

### MTH 461: Topics in Algebra

**Credits:** 3

**Type:** LEC

*The content of this course is variable and therefore it is repeatable for credit. The [University Grade Repeat Policy](#) does not apply.*

Treats problems, methods, and recent developments pertaining to a specific area of algebra. Topics courses can be taken more than once for credit.

### MTH 462: Topics in Analysis

**Credits:** 3

**Type:** LEC

*The content of this course is variable and therefore it is repeatable for credit. The [University Grade Repeat Policy](#) does not apply.*

Treats problems, methods, and recent developments pertaining to analysis. Topics courses can be taken more than once for credit.

### MTH 463: Topics in Applied Mathematics

**Credits:** 3

**Type:** LEC

*The content of this course is variable and therefore it is repeatable for credit. The [University Grade Repeat Policy](#) does not apply.*

Treats problems, methods, and recent developments pertaining applied mathematics. Topics courses can be taken more than once for credit.

### MTH 464: Topics in Combinatorial Analysis

**Credits:** 3

**Type:** LEC

*The content of this course is variable and therefore it is repeatable for credit. The [University Grade Repeat Policy](#) does not apply.*

Treats problems, methods, and recent developments pertaining combinatorial analysis. Topics courses can be taken more than once for credit.

### MTH 465: Lectures in Geometry

**Credits:** 3

**Type:** LEC

*The content of this course is variable and therefore it is repeatable for credit. The [University Grade Repeat Policy](#) does not apply.*

Provides a broader understanding of differential geometry. Comprehensively introduces the theory of curves and surfaces in space. Moves toward the goal of viewing surfaces as special concrete examples of differentiable manifolds, reached by studying surfaces using tools that are basic to studying manifolds. Topics include curves in 3-D space, differential forms, Frenet formulae, patch computations, curvature, isometries, intrinsic geometry of surfaces. Serves as an introduction to more advanced courses involving differentiable manifolds.

### MTH 466: Topics in Logic and Set Theory

**Credits:** 3

**Type:** LEC

*The content of this course is variable and therefore it is repeatable for credit. The [University Grade Repeat Policy](#) does not apply.*

Treats problems, methods, and recent developments pertaining logic and set theory. Topics courses can be taken more than once for credit.

### MTH 467: Topics in Number Theory

**Credits:** 3

**Type:** LEC

*The content of this course is variable and therefore it is repeatable for credit. The [University Grade Repeat Policy](#) does not apply.*

Treats problems, methods, and recent developments pertaining number theory. Topics courses can be taken more than once for credit.

### MTH 468: Topics in Numerical Analysis

**Credits:** 3

**Type:** LEC

*The content of this course is variable and therefore it is repeatable*

## Mathematics

for credit. The [University Grade Repeat Policy](#) does not apply.

Treats problems, methods, and recent developments pertaining numerical analysis. Topics courses can be taken more than once for credit.

### MTH 469: Topics in Topology

**Credits:** 3  
**Type:** LEC

*The content of this course is variable and therefore it is repeatable for credit. The [University Grade Repeat Policy](#) does not apply.*

Treats problems, methods, and recent developments pertaining topology. Topics courses can be taken more than once for credit.

### MTH 470: Topics in Mathematics

**Credits:** 3  
**Type:** LEC

Treats problems, methods, and recent developments in any area of mathematics that does not fit nearly or fully under the title of any other "Topics in..." course.

### MTH 495: Undergraduate Supervised Teaching

**Credits:** 3  
**Type:** TUT

*The content of this course is variable and therefore it is repeatable for credit. The [University Grade Repeat Policy](#) does not apply.*

Students who have at least junior status and satisfy the department's pre-requisites may apply to serve as undergraduate teaching assistants in one of the calculus courses ([MTH 121/MTH 122](#), [MTH 131](#), [MTH 141/MTH 142](#), [MTH 241](#)). Under the supervision of the professor, undergraduate teaching assistants will lead two recitation sections each week of approximately 30 students each. Some grading of homework will be expected.

### MTH 496: Internship in Mathematics

**Credits:** 1-4  
**Semester(s):** Fall, Spring  
**Type:** TUT

Students get field experience in mathematical employment, in business, industry or education, working under the joint supervision of an off-campus supervisor and a university faculty member, usually the director of undergraduate studies. May be taken once only.

### MTH 497: Honors Thesis in Mathematics

**Credits:** 4  
**Semester(s):** Fall, Spring  
**Type:** TUT

*The content of this course is variable and therefore it is repeatable for credit. The [University Grade Repeat Policy](#) does not apply.*

Open only to math majors intending to seek an honors degree in

mathematics. For information, consult the director of undergraduate studies in the Department of Mathematics.

### MTH 499: Independent Study

**Credits:** 1-4  
**Semester(s):** Fall, Spring  
**Type:** TUT

*The content of this course is variable and therefore it is repeatable for credit. The [University Grade Repeat Policy](#) does not apply.*

Individual study arranged between student and faculty member in an area of mathematics of particular interest to the student.