

## Mathematics

Make a Gift

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### Program Description

Courses in mathematics build a strong foundation for a career in the field and for an expanding range of other fields that require sophisticated understanding of mathematics. Faculty work closely with you to instill an appreciation of the intrinsic purity and precision of mathematics and its practical value in the social and natural sciences.

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Recognizing the ways computers have contributed to a modern renaissance in mathematics, the department integrates computer technology in problem solving, using a range of sophisticated computer tools and educational programs such as Mathematica and MATLAB.

Many students work one-on-one with faculty on mathematical [research projects](#). Past projects delved into everything from number theory and chaotic dynamics to hurricane evacuation plans and the number of people a room can hold and still make it possible for a safe exit in an emergency.

Mathematics majors have gone on to great success in [graduate programs and careers](#) in mathematics and science, as well as a wide range of other careers including education, law, management, medicine, and engineering.

### Program Requirements

#### Requirements for the Mathematics Major

The Mathematics Major consists of the following courses:

- Mathematics 111 (or 105-106), 112, 211, 212, and 215
- Computer Science 107 or 111; CS 103 may be counted by majors graduating before 2016.
- Four 300-level Mathematics courses, which must include at least one selected from Mathematics 315, 321, or 331
- Math 403, the Mathematics capstone course
- One additional elective at the 200-level or above

Students considering graduate study in mathematics are advised to take both Mathematics 321 and 331.

#### Requirements for the Mathematics Minor

The minor in mathematics consists of six mathematics courses numbered 111 or higher, including at least

one course at the 300 level.

## Grade Requirements

All courses taken to satisfy the requirements for the major or minor must be taken using the A-F grading system. To advance to a course with prerequisites, a minimum grade of C- is required for each prerequisite course.

## Course Listing

Course level:

100 | 200 | 300 | 400

### ***MATH-103 Mathematical Ideas***

Introduction to the power and scope of mathematical ideas by investigating several particular topics. Topics vary among sections. Example of topics include basic mathematical modeling, dynamic geometry, puzzles and recreational mathematics, linear programming, game theory, voting power, legislative representation, and cryptology. Course is intended for first year and sophomore students in the arts, humanities, and social sciences who do not plan to take calculus. Students who have completed a Mathematics course at Gettysburg College may not enroll in Mathematics 103. No prerequisites.

### ***MATH-105 Calculus with Precalculus I***

Study of precalculus and differential and integral calculus. Topics include basic algebraic concepts, equations and inequalities, functions, introduction to limits, continuity, the derivative, and the definite integral. No prerequisites.

### ***MATH-106 Calculus with Precalculus II***

Study of precalculus and differential and integral calculus. Topics include basic algebraic concepts, equations and inequalities, functions, introduction to limits, continuity, the derivative, and the definite integral. Prerequisite: Math 105 with a C- or better.

### ***MATH-107 Applied Statistics***

Introduction to statistical methods with applications from social, biological, and health sciences. Topics include descriptive statistics, fundamentals of probability theory, probability distributions, hypothesis testing, linear regression and correlation, analysis of categorical data, and analysis of variance. Laboratory work is designed to utilize the computational power of a statistical computer package. Credit cannot be received for both this course and Biology 260, Economics 241, and Psychology 205. No prerequisites.

### ***MATH-111 Calculus I (Honors)***

Differential and integral calculus of one real variable. Topics include introduction to limits, continuity, the derivative, the definite integral. Applications are drawn from the natural and social sciences. No prior experience with calculus is assumed. Students who have received credit for Mathematics 105-106 cannot also receive credit for Mathematics 111. No prerequisites.

### ***MATH-111 Calculus I***

Differential and integral calculus of one real variable. Topics include introduction to limits, continuity, the derivative, the definite integral. Applications are drawn from the natural and social sciences. No prior experience with calculus is assumed. Students who have received credit for Mathematics 105-106 cannot also receive credit for Mathematics 111. No prerequisites.

### ***MATH-112 Calculus II (Honors)***

Differential and integral calculus of one real variable. Topics include the definite integral, integration techniques, improper integrals, differential equations and sequences and series. Applications are drawn from the natural and social sciences. Prerequisite: Math 105 and 106 or Math 111 with a C- or better or First Year Standing with no credit for any other mathematics course at Gettysburg.

### ***MATH-112 Calculus II***

Differential and integral calculus of one real variable. Topics include the definite integral, integration techniques, improper integrals, differential equations and sequences and series. Applications are drawn from the natural and social sciences. Prerequisite: Math 105 and 106 or Math 111 with a C- or better or First Year Standing with no credit for any other mathematics course at Gettysburg.

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### ***MATH-201 Introduction to Research in Mathematics***

Introduction to the methodology and procedures of research in mathematics. After selecting one or more of the open-ended research projects discussed in class, students will individually or in small groups carry out an investigation, culminating in a written report and its public presentation. No prerequisites.

### ***MATH-211 Multivariable Calculus***

Vectors, vector functions, functions of several variables, partial differentiation, optimization, multiple integration, transformation of coordinates, line and surface integrals, and Green's and Stokes' theorems.

Prerequisite: Math 112 with a C- or better.

### ***MATH-212 Linear Algebra***

Systems of linear equations, algebra of matrices, determinants, abstract vector spaces, linear transformations, eigenvalues, and quadratic forms. Prerequisite: Math 112 with a C- or better.

### ***MATH-215 Abstract Mathematics I***

Introduction to abstract mathematical thinking, emphasizing mathematical reasoning and exposition. Students examine the concepts and methods of abstract mathematics, such as primitives and definitions, axioms and theorems, conjectures and proofs; study the topics of higher-level mathematics, such as logic, sets, quantifiers, and mathematical structures; learn the skills of reading, understanding, writing, and presenting rigorous mathematics; and gain an appreciation for the history and culture of mathematics. No prerequisites.

### ***MATH-225 Differential Equations***

Analysis of one and two-dimensional differential equations, with an emphasis on the qualitative behavior of solutions. Topics include graphical exploration, numerical approximation, separable and linear equations, phase line and phase plane analysis, conservative and dissipative systems, linearization, and applications to biology, chemistry, and physics. Prerequisite: Math 112 with a C- or better.

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### ***MATH-301 Intermediate Research in Mathematics***

Development of intermediate level research in mathematics. After selecting one or more of the open-ended research projects discussed in class, students will individually or in small groups carry out an investigation which provides a careful and complete proof of their results. The research will culminate in a written report and its public presentation. Prerequisite: Math 212 or Math 215 with a C- or better.

### ***MATH-308 Introduction to Combinatorics***

Topics selected from partition and permutation theory, enumeration, recursion, partially ordered sets, Markov chains, generating functions, algebraic combinatorics, combinatorial geometry, and design and coding theory. Applications are chosen from computer science, optimization, and the social and life sciences. Prerequisite: Math 212 or Math 215 with a C- or better.

### ***MATH-309 Introduction to Graph Theory***

Topics are selected from extremal graph theory, network flow and design, coloring, Ramsey theory, matching and transversal theory, random graphs, and algebraic and topological graph theory. Applications are chosen from computer science, optimization, and the social and life sciences.

### ***MATH-314 From Zero to Infinity: Philosophical Revolutions in Mathematics***

Study of the philosophical foundations of mathematics starting with the concept of number and culminating the Godel's groundbreaking incompleteness result. Specific topics include the historical developments and mathematical and philosophical ramifications of zero, rational, irrational, imaginary, and transfinite numbers as well as an examination of the completeness of arithmetic.

### ***MATH-315 Abstract Mathematics II***

Further development of the skills of abstract mathematical reasoning and writing proofs, as well as the rigorous development of the elements of advanced mathematics. Topics include a variety of advanced proof techniques, relations, functions, order, limits, finite enumeration, infinite cardinalities, and number systems. Prerequisite: Math 215 with a C- or better.

### ***MATH-321 Real Analysis***

Rigorous treatment of concepts studied in elementary calculus and an introduction to more advanced topics in analysis. Topics include elements of logic and set theory, properties of real numbers, elements of metric space topology, continuity, the derivative, the Riemann integral, sequences and series, and uniform convergence. Prerequisite: Math 215 with a C- or better.

### ***MATH-331 Abstract Algebra***

Study of basic structures of modern abstract algebra, including groups, rings, fields, and vector spaces. Prerequisite: Math 215 with a C- or better.

### ***MATH-337 Number Theory***

Study of topics in elementary number theory. Topics include factorization and the prime numbers, Diophantine equations, quadratic reciprocity, and the Fundamental Theorem of Arithmetic. Applications of these ideas to cryptography are explored. Prerequisite: Math 215 with a C- or better.

### ***MATH-342 Applied Linear Algebra***

Rigorous continuation of first-semester linear algebra, with applications both within mathematics and to the social and natural sciences. Topics, chosen by the instructor, may include matrix powers and exponentials, nonnegative matrices and Markov chains, coding theory, design theory, graph theory, the Perron-Frobenius theorem, ranking theory, data clustering, and max-plus algebra. Prerequisite: Math 212 with a C- or better.

### ***MATH-343 Topics in Geometry***

Study of both synthetic and analytic approaches to geometry. Topics include axiomatic systems, Euclidean geometry, non-Euclidean geometries, projective geometry, and subgeometries of projective geometry. Prerequisite: Math 215 with a C- or better.

### ***MATH-351 Mathematical Probability***

Combinatorics, discrete and continuous random variables and their distributions, expected value and variance, functions of random variables, the Law of Large Numbers, the Central Limit Theorem, generating functions, and applications such as Markov chains, random walks, and games of chance.

### ***MATH-352 Mathematical Statistics***

Expectation, special probability distributions and densities, bivariate and multivariate distributions, sampling distributions, theory and applications of estimation, hypothesis testing, regression, correlation, analysis of variance, and nonparametric methods

### ***MATH-353 Probability and Statistics***

Study of topics in probability and statistics. Topics include discrete and continuous random variables and their distributions, expected value and variance, the Law of Large Numbers, the Central Limit Theorem, sampling distributions, theory and application of estimation, hypothesis testing, regression, correlation, and analysis of variance. Applications to problems in the social and natural sciences will also be considered. Prerequisites: Math 211 and Math 212 with a C- or better.

### ***MATH-361 Chaos and Dynamical Systems***

Dynamical systems and chaos theory. Topics include linear and nonlinear systems, mappings and orbits, bifurcations, stability theory and applications of dynamical systems. Prerequisite: Math 225 with a C- or better.

### ***MATH-362 Operations Research***

Study of techniques and tools used in mathematical models applied to the biological and social sciences. Topics are selected from optimization, linear and nonlinear programming, transportation problems, network analysis, dynamic programming, and game theory.

### ***MATH-363 Wavelets and Their Applications***

Introduction to discrete wavelet transformations and their applications in digital image processing and other areas. Topics may include basic complex analysis, Fourier series, convolution and filters, and the Haar and Daubechies Wavelet Transformations. Mathematica (or similar software) is used as a tool to explore and to manipulate images stored as large matrices. Prerequisite: Math 212 with a C- or better.

### ***MATH-364 Complex Analysis***

Complex numbers, analytic functions, complex integration, Cauchy's Theorem, Taylor and Laurent series, contour integrals, the residue theorem, and conformal mapping. Prerequisite: Math 211 and Math 215 with a C- or better.

### ***MATH-366 Numerical Analysis***

Numerical techniques for solving mathematical problems. Topics include solutions of equations, solutions of simultaneous linear equations, interpolation and approximation, numerical differentiation and integration, the eigenvalue problem, numerical solutions of ordinary differential equations, and error analysis.

### ***MATH-381 Selected Topics***

Study of an advanced phase of mathematics not otherwise in the curriculum. Subject matter and frequency of offering depend on student interest. Possible areas for study are point set topology, combinatorics, graph theory, partial differential equations, differential geometry, and number theory. Prerequisite: Depends on the topic

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### ***MATH-401 Advanced Research in Mathematics***

Development of advanced level research in mathematics. Students work on open-ended research projects that they have previously worked on in Math 301 (Intermediate Research in Mathematics). The emphasis in this course is on developing professional writing and presentation skills. The goal of the course is for students to complete a formal paper on their research, including an abstract, an overview of the history of

the project, a statement of new results, an explanation of methods, a description of possible questions for future research, and a complete bibliography. Students are also expected to present their research off campus. Prerequisite: Math 301 with a C- or better.

### ***MATH-403 Senior Thesis***

Capstone experience for mathematics majors. Each student explores a topic in significant depth, writes a major paper on the topic, and presents a talk on the topic to mathematics students and faculty. Students meet regularly to discuss course readings, research methods, and their recent individual research findings. Prerequisite: Permission of the Math Department.

### ***MATH-450 Individualized Study-Tutorial***

Individualized tutorial counting toward the minimum requirements in a major or minor, graded A-F

### ***MATH-451 Individualized Study-Tutorial***

Individualized tutorial counting toward the minimum requirements in a major or minor, graded S/U

### ***MATH-451 Individualized Study-Tutorial***

Individualized tutorial counting toward the minimum requirements in a major or minor, graded S/U

### ***MATH-452 Individualized Study-Tutorial***

Individualized tutorial not counting in the minimum requirements in a major or minor, graded A-F

### ***MATH-452 Individualized Study-Tutorial***

Individualized tutorial not counting in the minimum requirements in a major or minor, graded A-F

### ***MATH-453 Individualized Study-Tutorial***

Individualized tutorial not counting in the minimum requirements in a major or minor, graded S/U

### ***MATH-453 Individualized Study-Tutorial***

Individualized tutorial not counting in the minimum requirements in a major or minor, graded S/U

***MATH-460 Individualized Study-Research***

Individualized research counting toward the minimum requirements in a major or minor, graded A-F

***MATH-461 Individualized Study-Research***

Individualized research counting toward the minimum requirements in a major or minor, graded S/U

***MATH-461 Individualized Study-Research***

Individualized research counting toward the minimum requirements in a major or minor, graded S/U

***MATH-462 Individualized Study-Research***

Individualized research not counting in the minimum requirements in a major or minor, graded A-F

***MATH-462 Individualized Study-Research***

Individualized research not counting in the minimum requirements in a major or minor, graded A-F

***MATH-463 Individualized Study-Research***

Individualized research not counting in the minimum requirements in a major or minor graded S/U

***MATH-463 Individualized Study-Research***

Individualized research not counting in the minimum requirements in a major or minor graded S/U

***MATH-470 Individualized Study-Internship***

Internship counting toward the minimum requirements in a major or minor, graded A-F

***MATH-470 Individualized Study-Internship***

Internship counting toward the minimum requirements in a major or minor, graded A-F

***MATH-471 Individualized Study-Internship***

Internship counting toward the minimum requirements in a major or minor, graded S/U

***MATH-471 Individualized Study-Internship***

Internship counting toward the minimum requirements in a major or minor, graded S/U

***MATH-472 Individualized Study-Internship***

Internship not counting in the minimum requirements in a major or minor, graded A-F

***MATH-472 Individualized Study-Internship***

Internship not counting in the minimum requirements in a major or minor, graded A-F

***MATH-473 Individualized Study-Internship***

Internship not counting in the minimum requirements in a major or minor, graded S/U

***MATH-473 Individualized Study-Internship***

Internship not counting in the minimum requirements in a major or minor, graded S/U

***MATH-474 Summer Internship***

Summer Internship graded A-F, counting in the minimum requirements for a major or minor only with written permission filed in the Registrar's Office.

***MATH-474 Summer Internship***

Summer Internship graded A-F, counting in the minimum requirements for a major or minor only with written permission filed in the Registrar's Office.

***MATH-475 Summer Internship***

Summer Internship graded S/U, counting in the minimum requirements for a major or minor only with written permission filed in the Registrar's Office

***MATH-475 Summer Internship***

Summer Internship graded S/U, counting in the minimum requirements for a major or minor only with

written permission filed in the Registrar's Office

### **MATH-477 Half Credit Internship**

Half credit internship, graded S/U.

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