

# Mathematics (MATH)

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## Courses

### **MATH 5013. Abstract Algebra with Connections to School Mathematics. 3 Hours.**

Basic structures of abstract algebra (rings, fields, groups, modules and vector spaces) with emphasis on rings and fields as generalizations of the ring of integers and field of rational numbers. Graduate degree credit will not be awarded for both MATH 4113 (or MATH 5123) and MATH 5013. Prerequisite: Graduate standing or departmental consent. (Typically offered: Irregular)

### **MATH 5023. Geometry with Connections to School Mathematics. 3 Hours.**

School geometry from an advanced perspective including conformity to the Common Core State Standards for Mathematics. Study will include historical developments and geometry based on transformations of two- and three-dimensional space. Prerequisite: Graduate standing. (Typically offered: Fall Odd Years)

### **MATH 5033. Advanced Calculus with Connections to School Mathematics Teaching. 3 Hours.**

Rigorous development of the real numbers, continuity, differentiation, and integration. Graduate degree credit will not be awarded for both MATH 4513 (or MATH 5503) and MATH 5033. Prerequisite: Departmental consent. (Typically offered: Irregular)

### **MATH 504V. Special Topics for Teachers. 1-6 Hour.**

Current topics in mathematics of interest to secondary school teachers. Prerequisite: Graduate standing or departmental consent. (Typically offered: Irregular) May be repeated for degree credit.

### **MATH 5053. Probability & Statistics with Connections to School Mathematics. 3 Hours.**

An advanced perspective of probability and statistics as contained in the high school mathematics curriculum with connections to other components of school mathematics. The content is guided by the content of the high school probability and statistics of the Common Core State Standards for Mathematics. Prerequisite: Graduate standing. (Typically offered: Spring)

### **MATH 507V. Professional Development for Secondary Mathematics Teaching. 1-6 Hour.**

Validated participation in professional development mathematics workshops or institutes sanctioned by national or international educational organizations such as the College Board, International Baccalaureate Program, and the National Board for Professional Teaching Standards. Prerequisite: Enrollment in Secondary Mathematics Teaching, MA degree program or departmental consent. (Typically offered: Irregular) May be repeated for up to 6 hours of degree credit.

### **MATH 510V. Mathematical Seminar. 1-3 Hour.**

Members of the faculty and advanced students meet for presentation and discussion of topics. Prerequisite: Graduate standing in mathematics or statistics, or departmental consent. (Typically offered: Fall and Spring) May be repeated for up to 3 hours of degree credit.

### **MATH 5113. Introduction to Abstract Algebra II. 3 Hours.**

Topics in abstract algebra including finite abelian groups, linear groups, factorization in commutative rings and Galois theory. Graduate degree credit will not be given for both MATH 4113 and MATH 5113. Prerequisite: MATH 3113. (Typically offered: Spring)

### **MATH 5123. Algebra I. 3 Hours.**

What the beginning graduate student should know about algebra: groups, rings, fields, modules, algebras, categories, homological algebra, and Galois Theory. Prerequisite: MATH 3113, and graduate standing in mathematics or statistics, or departmental consent. (Typically offered: Fall)

### **MATH 5133. Algebra II. 3 Hours.**

Continuation of MATH 5123. Prerequisite: MATH 5123, and graduate standing in mathematics or statistics. (Typically offered: Spring)

### **MATH 5153. Advanced Linear Algebra. 3 Hours.**

Linear functionals, matrix representation of linear transformations, scalar product, and spectral representation of linear transformations. Graduate degree credit will not be given for both MATH 4103 and MATH 5153. Prerequisite: Graduate standing. (Typically offered: Fall)

### **MATH 5163. Dynamic Models in Biology. 3 Hours.**

Mathematical and computational techniques for developing, executing, and analyzing dynamic models arising in the biological sciences. Both discrete and continuous time models are studied. Applications include population dynamics, cellular dynamics, and the spread of infectious diseases. Graduate degree credit will not be given for both MATH 4163 and MATH 5163. Prerequisite: MATH 2554. (Typically offered: Irregular)

### **MATH 5213. Advanced Calculus I. 3 Hours.**

The real and complex number systems, basic set theory and topology, sequences and series, continuity, differentiation, and Taylor's theorem. Emphasis is placed on careful mathematical reasoning. Graduate degree credit will not be given for both MATH 4513 and MATH 5213. Prerequisite: Graduate standing. (Typically offered: Fall)

### **MATH 5223. Advanced Calculus II. 3 Hours.**

The Riemann-Stieltjes integral, uniform convergence of functions, Fourier series, implicit function theorem, Jacobians, and derivatives of higher order. Graduate degree credit will not be given for both MATH 4523 and MATH 5223. Prerequisite: MATH 4513 or MATH 5213 (formerly MATH 4513). (Typically offered: Spring)

### **MATH 525V. Internship in Professional Practice. 1-3 Hour.**

Professional work experience involving significant use of mathematics or statistics in business, industry or government. Graduate degree credit will not be given for both MATH 405V and MATH 525V. (Typically offered: Fall, Spring and Summer) May be repeated for up to 3 hours of degree credit.

### **MATH 5263. Symbolic Logic I. 3 Hours.**

Rigorous analyses of the concepts of proof, consistency, equivalence, validity, implication, and truth. Full coverage of truth-functional logic and quantification theory (predicate calculus). Discussion of the nature and limits of mechanical procedures (algorithms) for proving theorems in logic and mathematics. Informal accounts of the basic facts about infinite sets. Graduate degree credit will not be given for both MATH 4253 and MATH 5263. Prerequisite: MATH 2603, MATH 2803, or PHIL 2203. (Typically offered: Fall)

This course is cross-listed with PHIL 5253.

### **MATH 5313. Partial Differential Equations. 3 Hours.**

Laplace's equation, Heat equation, Wave Equation, Method of Characteristics. Prerequisite: MATH 4423, MATH 4513, and graduate standing in mathematics or statistics, or departmental consent. (Typically offered: Fall)

### **MATH 5323. Partial Differential Equations II. 3 Hours.**

Fourier Transforms, Sobolev Spaces, Elliptic Regularity. Prerequisite: MATH 5313 and graduate standing in mathematics or statistics, or departmental consent. (Typically offered: Spring)

### **MATH 5353. Mathematical Modeling. 3 Hours.**

Mathematical techniques for formulating, analyzing, and criticizing deterministic models taken from the biological, social, and physical sciences. Techniques include graphical methods, stability, optimization, and phase plane analysis. Graduate degree credit will not be given for both MATH 4153 and MATH 5353. Prerequisite: MATH 2584. (Typically offered: Irregular)

**MATH 5363. Scientific Computation and Numerical Methods. 3 Hours.**

An introduction to numerical methods used in solving various problems in engineering and the sciences. May not earn credit for this course and MATH 4353 or MATH 4363. Prerequisite: Graduate standing in mathematics or statistics, or departmental consent. (Typically offered: Fall)  
This course is cross-listed with PHYS 5363.

**MATH 5373. Finite Element Methods and Solution of Sparse Linear. 3 Hours.**

Provides an in-depth understanding of numerical methods for the solution of partial differential equations using Finite Element Methods, Direct and Iterative Methods for the Sparse Linear Systems. Prerequisite: MATH 5393. (Typically offered: Spring)

**MATH 5383. Numerical Analysis. 3 Hours.**

General iterative techniques, error analysis, root finding, interpolation, approximation, numerical integration, and numerical solution of differential equations. Graduate degree credit will not be given for both MATH 4363 and MATH 5383. Prerequisite: Graduate standing. (Typically offered: Fall)

**MATH 5393. Numerical Linear Algebra. 3 Hours.**

Numerical methods for problems of linear algebra, including the solution of very large systems, eigenvalues, and eigenvectors. Graduate degree credit will not be given for both MATH 4353 and MATH 5393. Prerequisite: Graduate standing. (Typically offered: Spring)  
This course is equivalent to MATH 4353.

**MATH 5403. Numerical Linear Algebra II. 3 Hours.**

Provides an in-depth understanding of numerical methods for the solution of large scale eigenvalue problems arising in science and engineering applications including theory, implementation and applications. Prerequisite: MATH 5393. (Typically offered: Fall)

**MATH 5423. Introduction to Partial Differential Equations. 3 Hours.**

Separation of variables, Fourier transform, and Laplace transform methods for the solution of partial differential equations. Topics include Fourier series, Fourier-Bessel series, orthogonal expansions, and the error function. Does not count towards degree credit in MATH. Prerequisite: Graduate standing. (Typically offered: Fall, Spring and Summer)

**MATH 5443. Complex Variables. 3 Hours.**

Complex analysis, series, and conformal mapping. Graduate degree credit will not be given for both MATH 4443 and MATH 5443. Prerequisite: MATH 2603 or MATH 2803, and MATH 2584 or MATH 2584C. (Typically offered: Fall)

**MATH 5453. Functional Analysis I. 3 Hours.**

Banach Spaces, Hilbert Spaces, operator theory, compact operators, dual spaces and adjoints, spectral theory, Hahn-Banach, open mapping and closed graph theorems, uniform boundedness principle, weak topologies. Prerequisite: MATH 5513, and graduate standing in mathematics or statistics, or departmental consent. (Typically offered: Spring Odd Years)

**MATH 5503. Theory of Functions of a Real Variable I. 3 Hours.**

Real number system, Lebesgue measure, Lebesgue integral, convergence theorems, differentiation of monotone functions, absolute continuity and the fundamental theorem of calculus  $L^p$  spaces, Holder and Minkowski inequalities, and bounded linear functionals on the  $L^p$  spaces. Prerequisite: MATH 4523 or MATH 5223 (formerly MATH 4523), and graduate standing in mathematics or statistics, or departmental consent. (Typically offered: Fall)

**MATH 5513. Theory of Functions of a Real Variable II. 3 Hours.**

Measure and integration on abstract measure spaces, signed measures, Hahn decomposition, Radon-Nikodym theorem, Lebesgue decomposition, measures on algebras and their extensions, product measures, and Fubini's theorem. Prerequisite: MATH 5503, and graduate standing in mathematics or statistics, or departmental consent. (Typically offered: Spring)

**MATH 5523. Theory of Functions of a Complex Variable I. 3 Hours.**

Complex numbers, analytic functions, power series, complex integration, Cauchy's Theorem and integral formula, maximum principle, singularities, Laurent series, and Mobius maps. Prerequisite: MATH 4513 or MATH 5213 (formerly MATH 4513). (Typically offered: Fall)

**MATH 5533. Theory of Functions of a Complex Variable II. 3 Hours.**

Riemann Mapping Theorem, analytic continuation, harmonic functions, and entire functions. Prerequisite: MATH 5523, and graduate standing in mathematics or statistics, or departmental consent. (Typically offered: Spring)

**MATH 5603. Differential Geometry. 3 Hours.**

Topics include: classical differential geometry of curves and surfaces in 3-space, differential forms and vector fields. Graduate degree credit will not be given for both MATH 4503 and MATH 5603. Prerequisite: MATH 2574 or MATH 2574C. (Typically offered: Irregular)

**MATH 5703. Topology I. 3 Hours.**

An introduction to topology. Topics include metric spaces, topological spaces and general point-set topology, homotopy and the fundamental group, covering spaces, the classification of surfaces. Prerequisite: MATH 4513 or MATH 5213 (formerly MATH 4513), and graduate standing in mathematics or statistics, or departmental consent. (Typically offered: Fall Even Years)

**MATH 5713. Topology II. 3 Hours.**

The continuation of Topology I. Topics include: advanced homotopy and covering spaces, the Seifert-van Kampen theorem, homology and the Mayer-Vietoris sequence. Prerequisite: MATH 5703, and graduate standing in mathematics or statistics, or departmental consent. (Typically offered: Spring Odd Years)

**MATH 5723. Differential Topology I. 3 Hours.**

An introduction to the topology of smooth manifolds: applications of the inverse function theorem to smooth maps, Sard's theorem, transversality, intersection theory, degrees of maps, vector fields and differential forms on manifolds, integration on manifolds. Prerequisite: MATH 4513 or MATH 5213 (formerly MATH 4513) and graduate standing in mathematics or statistics, or departmental consent. (Typically offered: Fall Odd Years)

**MATH 5733. Differential Topology II. 3 Hours.**

The continuation of Differential Topology I, with additional advanced topics. Possible advanced topics may include: Morse theory, de Rham cohomology theory, Poincaré duality, Riemannian geometry, and Lie groups and Lie algebras. Prerequisite: MATH 5723 and graduate standing in mathematics or statistics, or departmental consent. (Typically offered: Spring Even Years)

**MATH 5803. Introduction to Point-Set Topology. 3 Hours.**

A study of topological spaces including continuous transformations, connectedness and compactness. Graduate degree credit will not be given for both MATH 4703 and MATH 5803. Prerequisite: MATH 4513 or MATH 5213 (formerly MATH 4513). (Typically offered: Irregular)

**MATH 599V. Research Topics in Mathematics. 1-3 Hour.**

Current research interests in mathematics. Graduate degree credit will not be given for both MATH 499V and MATH 599V. Prerequisite: Departmental consent. (Typically offered: Irregular) May be repeated for up to 12 hours of degree credit.

**MATH 610V. Directed Readings. 1-6 Hour.**

Directed readings. Prerequisite: Departmental consent. (Typically offered: Irregular) May be repeated for up to 18 hours of degree credit.

**MATH 619V. Topics in Algebra. 1-6 Hour.**

Current research interests in algebra. Prerequisite: Graduate standing in mathematics or statistics, or departmental consent. (Typically offered: Fall, Spring and Summer) May be repeated for degree credit.

**MATH 6203. Theory of Probability. 3 Hours.**

A rigorous mathematical treatment based on measure theory of the fundamental notions and results of the theory of probability. Topics covered include laws of large numbers, central limit theorems, conditional expectations. Additional topics that may be covered include martingales, Markov chains, Brownian motion and stochastic integration. Prerequisite: MATH 5513. (Typically offered: Fall)

**MATH 6213. Mathematical Statistics. 3 Hours.**

A rigorous mathematical treatment of the fundamental principles and results in the theory of Statistics. Topics include exponential families of distributions, estimation of unknown parameters, the classical theory of hypothesis testing, Large sample approximations, large sample properties of estimators. Prerequisite: MATH 6203. (Typically offered: Spring)

**MATH 659V. Topics in Analysis. 1-6 Hour.**

Current research interests in analysis. Prerequisite: Graduate standing in mathematics or statistics, or departmental consent. (Typically offered: Fall, Spring and Summer) May be repeated for degree credit.

**MATH 679V. Topics in Topology. 1-6 Hour.**

Current research interest in topology. Prerequisite: Graduate standing in mathematics or statistics, or departmental consent. (Typically offered: Fall, Spring and Summer) May be repeated for degree credit.

**MATH 700V. Doctoral Dissertation. 1-18 Hour.**

Doctoral Dissertation. Prerequisite: Doctoral candidacy in mathematics. (Typically offered: Fall, Spring and Summer) May be repeated for degree credit.