# COURSES FOR MATHEMATICS

## Mathematics Courses

**MATH501 Pathway to Graduate Studies in Mathematics**
Hours 1

This course is to help students transition into graduate studies in math, and improve their understanding of math topics in introductory real analysis and advanced linear algebra. Credits for this course will not count toward any degree program.

**MATH502 Teaching Workshop**
Hours 2

This course is to prepare graduate students to teach lower-division mathematics courses. Students will explore topics related to preparing for class, methods for engaging students and cultivating a learning-centered classroom environment, and methods for understanding and assessing student thinking. This course does not count towards any degree program.

**MATH503 Algebraic Structures for Secondary Teachers**
Hours 3

Explore the interconnections between the algebraic, analytic, and gemetric areas of mathematics with a focus on properties of various number systems, importance of functions, and the relationship of algebraic structures to solving analytic equations. This exploration will also include the development and sequential nature of each of these branches of mathematics and how it relates to the various levels within the algebra mathematics curriculum.

Prerequisite(s): C- or higher in MATH 237 and C- or higher in MATH 301

**MATH504 Topics Mod Math Teachers**
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Hours 1-3

Diverse mathematical topics designed to enhance skills and broaden knowledge in mathematics for secondary mathematics teachers.

Special Topics Course

**MATH505 Geometry for Secondary Teachers**
Hours 3

This course will give an overview of geometry from a modern point of view. Axiomatic, analytic, transformational, and algebraic approaches to geometry will be used. The relationship between Euclidean geometry, the geometry of complex numbers, and trigonometry will be emphasized.

Prerequisite(s): C- in MATH 403 or C- in MATH 503

**MATH508 Topics In Algebra**
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Hours 3

Content changes from semester to semester to meet the needs of students. Designed for graduate students not majoring in mathematics.

Special Topics Course

**MATH509 Data Analysis for Secondary Teachers**
Hours 3

Concepts and techniques of posing questions and collecting, analyzing, and interpreting data. Topics include: univariate and bivariate statistics, probability, simulation, confidence intervals and hypothesis testing.

Prerequisite(s): C- or higher in MATH 125 and C- or higher in ST 260

**MATH510 Numerical Linear Algebra**
Hours 3

Further study of matrix theory emphasizing computational aspects. Topics include direct solution of linear algebraic systems, analysis of errors in numerical methods for solutions of linear systems, linear least-squares problems, orthogonal and unitary transformations, eigenvalues and eigenvectors, and singular value decomposition.

Prerequisite(s): MATH 371 or MATH 572

**MATH511 Numerical Analysis I**
Hours 3

Mathematical principles of numerical analysis and their application to the study of certain methods. Topics includes numerical methods for solving nonlinear equations; iterative methods for solving linear systems of equations; approximation and interpolation methods; numerical differentiation and integration techniques; and numerical methods for solving initial-value problems for ordinary differential equations.

Prerequisite(s): (MATH 237 and MATH 238 and MATH 537) or permission of instructor

**MATH512 Numerical Analysis II**
Hours 3

This is the second course in the numerical analysis sequence for graduate students in mathematics, science or engineering with an emphasis on numerical methods for solving boundary value problems, ordinary differential equations and partial differential equations, multistep methods for initial value problems, and approximation theory (least-squares problems, fast Fourier Transforms).

Prerequisite(s): MATH 343 and MATH 511

**MATH520 Linear Optimization Theory**
Hours 3

This course is an introduction to theory of linear programming. Topics include: basic theory (fundamental theorem of LP, equivalence of basic feasible solutions and extreme points, duality and sensitivity results), simplex algorithm and its variations, and special applications to transportation and network problems. Non-simplex methods are also briefly introduced.

Prerequisite(s): MATH 572 or permission of instructor

**MATH521 Non-Linear Optimization Theory**
Hours 3

This course is an introduction to nonlinear programming. Topics will include necessary and sufficient conditions for optimality, as well as basic theory and numerical algorithms for several traditional optimization methods, e.g., basic descent methods, conjugate direction methods, quasi-Newton methods, penalty and barrier methods, Lagrange multiplier methods. A brief introduction to selected modern topics may be added if time permits.

Prerequisite(s): MATH 572 or permission of instructor

**MATH530 Mathematical Foundations of Data Science and Programming**
Hours 3

An introduction to the mathematical foundations of data science, machine learning, and programming. The fundamental roles of linear algebra and probability theory in data science will be explored. Heuristics for a variety of learning tasks, such as methods for clustering, classification, regression, or deep learning will be discussed in tandem with mathematical justifications for their use and effectiveness, as well as exercises illustrating their practical use in data analysis. Theoretical models for the feasibility of machine learning and for different types of learning problems will be introduced. Python programming will also be introduced.

Prerequisite(s): (MATH 355 and MATH 572) or permission of instructor

**MATH538 Topics in Mathematics**
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Hours 3

This is a general topics course in mathematics. The contents will vary depending on department needs.

Special Topics Course

**MATH541 Boundary Value Problems**
Hours 3

Emphasis on boundary value problems for classical partial differential equations of physical sciences and engineering. Other topics include Fourier series, Fourier transforms, asymptotic analysis of integrals and boundary-value problems for ordinary differential equations.

Prerequisite(s): MATH 343 and MATH 486 or MATH 586.

**MATH551 Math Stats W/Applictn I**
Hours 3

Introduction to mathematical statistics. Topics include bivariate and multivariate probability distributions, functions of random variables, sampling distributions and the central limit theorem, concepts and properties of point estimators, various methods of point estimation, interval estimation, tests of hypotheses and Neyman-Pearson lemma with some applications.

Prerequisite(s): MATH 355

**MATH552 Math Stats W/Applictn II**
Hours 3

This course considers further applications of the Neyman-Pearson lemma, likelihood ratio tests, Chi-square test for goodness of fit, estimation and test of hypotheses for linear statistical models, analysis of variance, analysis of enumerative data, and some topics in nonparametric statistics.

Prerequisite(s): MATH 551

**MATH554 Advanced Math Statistics I**
Hours 3

Distributions of random variables, moments of random variables, probability distributions, joint distributions, and change of variable techniques.

Prerequisite(s): MATH 237 and MATH 355 and (MATH 486 or MATH 586) or permission of instructor

**MATH555 Advanced Math Statistics II**
Hours 3

Order statistics, asymptotic distributions, point estimation, interval estimation, and hypothesis testing.

Prerequisite(s): MATH 554 or equivalent

**MATH557 Stochastic Processes I**
Hours 3

Introduction to the basic concepts and applications of stochastic processes. Markov chains, continuous-time Markov processes, Poisson and renewal processes, and Brownian motion. Applications of stochastic processes including queueing theory and probabilistic analysis of computational algorithms.

Prerequisite(s): MATH 355

**MATH559 Stochastic Processes II**
Hours 3

Continuation of MATH 557. Advanced topics of stochastic processes including Martingales, Brownian motion and diffusion processes, advanced queueing theory, stochastic simulation, and probabilistic search algorithms such as simulated annealing.

Prerequisite(s): MATH 457 or MATH 557

**MATH560 Intro Differential Geom**
Hours 3

Introduction to basic classical notions in differential geometry: curvature, torsion, geodesic curves, geodesic parallelism, differential manifold, tangent space, vector field, Lie derivative, Lie algebra, Lie group, exponential map, and representation of a Lie group.

Prerequisite(s): MATH 586 or equivalent

**MATH565 Intro General Topology**
Hours 3

Basic notions in topology that can be used in other disciplines in mathematics. Topics include topological spaces, open sets, closed sets, basis for a topology, continuous functions, separation axioms, compactness, connectedness, product spaces, quotient spaces, and metric spaces.

Prerequisite(s): MATH 586 or equivalent

**MATH566 Intro Algebraic Topology**
Hours 3

Homotopy, fundamental groups, covering spaces, covering maps, and basic homology theory, including the Eilenberg Steenrod axioms.

Prerequisite(s): MATH 565 or equivalent

**MATH570 Prin Modern Algebra I**
Hours 3

This is a first course in abstract algebra. Topics include groups, permutations groups, Cayley's theorem, finite Abelian groups, isomorphism theorems and Lagrange's theorem. Usually offered in the spring semester. Credit for this course will not be counted toward a Ph. D. in Mathematics.

Prerequisite(s): (MATH 237 and MATH 301) or MATH 371 or MATH 572

**MATH571 Prin Modern Algebra II**
Hours 3

An introduction to ring theory. Topics include rings, polynomial rings, matrix rings, modules, fields and semi-simple rings. Usually offered in the fall semester.

Prerequisite(s): MATH 570

**MATH572 Advanced Linear Algebra**
Hours 3

A proof-oriented classes covering the theory of vector spaces; bases and coordinates; linear transformations and matrices; determinants; eigenvalues, eigenvectors and diagonalization; inner product spaces; adjoint operators; the spectral theorem; and Jordan Canonical Form.

Prerequisite(s): (MATH 237 and MATH 301) pr permission of instructor

**MATH573 Abstract Algebra I**
Hours 3

Fundamental aspects of group theory are covered. Topics include Sylow theorems, semi-direct products, free groups, composition series, nilpotent and solvable groups, and infinite groups.

Prerequisite(s): MATH 570

**MATH585 Intro Complex Variables**
Hours 3

Some basic notions in complex analysis. Topics include analytic functions, complex integration, infinite series, contour integration, and conformal mappings. Credit for this course will not be counted if it is taken after MATH 583.

Prerequisite(s): MATH 227 or MATH 247

**MATH586 Introduction to Real Analysis I**
Hours 3

Rigorous development of the calculus of real variables. Topics include the topology of the real line, sequences and series, limits, limit suprema and infima, continuity, and differentiation, Taylor polynomials.

Prerequisite(s): MATH 301

**MATH587 Introduction to Real Analysis II**
Hours 3

A continuation of Math 586. Topics include Riemann integration, sequences and series of functions, uniform convergence, power series, topology of metric spaces, the Weierstrass approximation theorem, the Arzela-Ascoli theorem, derivatives of multivariable functions, implicit function theorem, inverse function theorem.

Prerequisite(s): MATH 586

**MATH588 Theory Diff Equations I**
Hours 3

Topics covered include existence and uniqueness of solutions, Picard theorem, homogenous linear equations, Floquet theory, properties of autonomous systems, Poincare-Bendixson theory, stability, and bifurcations.

Prerequisite(s): MATH 238 and MATH 586

**MATH591 Teaching College Math**
Hours 3

Preparation for future mathematics faculty for the teaching component of a faculty position at community colleges, four-year colleges or universities, comprehensive universities, or research universities. Topics include active learning strategies and course development, including syllabi, textbook selection, and assessment strategies.

**MATH593 Collegiate Math Education Rsrc**
Hours 3

This course is designed to enable students to understand and synthesize current research in college mathematics education involving subjects usually taught during the first two years of college. This will include a survey of a range of educational research models and will discuss qualitative, quantitative, and mixed methods research design in mathematics education research.

**MATH597 Directed Individual Studies**
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Hours 3

This is a course on directed individual studies in mathematics. The contents will vary depending on department needs.

Prerequisite(s): permission of instructor

Special Topics Course

**MATH598 Non-Thesis Research**
Hours 1-3

Research not related to thesis. Students are required to write a project report that summarizes their research activities and findings.

Prerequisite(s): Instructor Permission

**MATH599 Thesis Research**
Hours 1-6

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**MATH610 Iteratve Meth Linear Sys**
Hours 3

Describes some of the best iterative techniques for solving large sparse linear systems.

**MATH611 Numerical Methods for Partial Differential Equations**
Hours 3

Finite difference methods for hyperbolic, parabolic, and elliptical partial differential equations; consistency, convergence, and order of accuracy of finite difference schemes; stability analysis and the Courant-Friedrichs-Lewy (CFL) condition; numerical dispersion and dissipation; finite difference schemes in higher dimensions; implicit methods and alternating direction implicit (ADI) schemes; a brief introduction to additional topics, such as spectral methods, pseudo-spectral methods, finite volume methods, and finite element methods, may be offered at the discretion of instructor.

Prerequisite(s): MATH 512 or equivalent, and ability to program in a high-level programming language (MATLAB, C++, or FORTRAN).

**MATH638 Advanced Topics in Mathematics**
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Hours 3

This is an advanced topics course in mathematics. The contents will vary depending on department needs.

Prerequisite(s): permission of instructor

Special Topics Course

**MATH642 Partial Differential Equations I**
Hours 3

This is an introductory course in partial differential equations. It covers the theory, methods of solution, and applications related to the three second order equations of mathematical physics (the Laplace's equation, the heat equation, and the wave equation), and the nonlinear first order equations.

Prerequisite(s): MATH 238 and MATH 586 or equivalent or Instructor Permission

**MATH643 Partial Differential Equations II**
Hours 3

Topics include a variety of techniques that are useful for finding explicit solutions for various partial differential equations (similarity solutions, transform methods, asymptotics, power series) and the fundamental theory of second order partial differential equations (Sobolev spaces, weak solutions, energy estimates, regularity, and maximum principles).

Prerequisite(s): MATH 642 and MATH 587 or Instructor Permission

**MATH648 Topics in Partial Differential Equations**
Hours 3

This course concerns the modern theory of partial differential equations (PDE). We will concentrate on modern techniques in the theoretical study of linear and nonlinear PDEs. Topics include Sobolev spaces, weak solutions for second order elliptic, parabolic, and hyperbolic equations, the calculus of variations, nonvariational techniques, systems of conservation laws, fluid dynamics, and other topics decided by instructor.

Prerequisite(s): (MATH 541 or MATH 642) and MATH 580, or permission of instructor.

**MATH661 Algebraic Topology I**
Hours 3

In-depth study of homotopy and homology. The theory of cohomology is also introduced as are characteristic classes.

**MATH674 Abstract Algebra II**
Hours 3

Topics include the theory of fields, including Galois theory, Noetherian and Artinian rings and their modules, polynomial rings, and free and projective modules.

Prerequisite(s): MATH 573

**MATH677 Topics Algebra I**
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Hours 3

Content decided by instructor. Recent topics covered include linear groups, representation theory, commutative algebra and algebraic geometry, algebraic K-theory, and theory of polycyclic groups.

Special Topics Course

**MATH680 Real Analysis I**
Hours 3

Topics covered include measure theory, Lebesgue integration, convergence theorems, Fubini's theorem, and LP spaces.

Prerequisite(s): MATH 587

**MATH681 Real Analysis II**
Hours 3

A continuation of Math 580. Topics covered include basic theory of LP spaces, convolutions, Hahn decomposition, the Radon-Nikodym theorem, Riesz representation theorem, and Banach space theory, including the Hahn-Banach theorem, the open mapping theorem, and the uniform boundedness principle.

Prerequisite(s): MATH 580

**MATH683 Complex Analysis I**
Hours 3

The basic principles of complex variable theory are discussed. Topics include Cauchy-Riemann equations, Cauchy's integral formula, Goursat's theorem, the theory of residues, the maximum principle, and Schwarz's lemma.

Prerequisite(s): MATH 586

**MATH684 Complex Analysis II**
Hours 3

We will cover various topics in Complex Analysis. Some possible topics include: Riemann mapping theorem, conformal mapping, normal families, Zalcman's lemma, Picard's theorem, Bloch's theorem, the monodromy theorem, elliptic functions, ultrahyperbolic metrics, harmonic measure, Hardy spaces, special functions.

Prerequisite(s): MATH 583

**MATH686 Functional Analysis I**
Hours 3

An introduction to functional analysis. Topics include Banach spaces, duality, weak and weak* topologies, Banach-Alaoglu Theorem, Hilbert spaces, Riesz theorem, orthonormal bases, operator theory on Banach and Hilbert spaces, spectral theory, compact operators.

Prerequisite(s): MATH 681 and (MATH 583 or MATH 585)

**MATH688 Topics in Analysis**
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Hours 3

Advanced course in real analysis. Topics may include harmonic analysis (the Fourier transform, Hardy-Littlewood maximal operator, interpolation, singular integral operators, BMO and Hardy spaces, weighted norm inequalities) or analysis and PDEs (Sobolev spaces, weak solutions to PDEs, Lax-Milgram theory, the Fredholm alternative, existence and regularity for elliptic and parabolic equations).

Prerequisite(s): MATH 681

Special Topics Course

**MATH697 Directed Individual Studies of Advanced Topics**
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Hours 3

This is a course on directed individual studies of advanced topics in mathematics. The contents will vary depending on department needs.

Prerequisite(s): permission of instructor

Special Topics Course

**MATH698 Non-Dissertation Research**
Hours 3-9

This course will examine a topic not included in the student's dissertation.

**MATH699 Dissertation Research**
Hours 1-12

*No description available*

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