# MATHEMATICS (MATH)

**MATH 6001. Introduction to Graduate Studies in Mathematics. 2 Credit Hours.**
This course covers practical information helping students start their careers as a professional mathematician. It also satisfies the Georgia Tech RCR requirements for "in-person" training.

**MATH 6014. Graph Theory and Combinatorial Structures. 3 Credit Hours.**
Fundamentals, connectivity, matchings, colorings, extremal problems, Ramsey theory, planar graphs, perfect graphs. Applications to operations research and the design of efficient algorithms.

**MATH 6021. Algebra and Topology in Finite-dimensional Spaces. 3 Credit Hours.**
Metric spaces, normed linear spaces, convexity, and separation; polyhedra and simplicial complexes; surfaces; Brouwer fixed point theorem.

**MATH 6112. Advanced Linear Algebra. 3 Credit Hours.**
An advanced course in Linear Algebra and applications.

**MATH 6121. Modern Abstract Algebra I. 3 Credit Hours.**
Graduate-level linear and abstract algebra including groups, finite fields, classical matrix groups and bilinear forms, multilinear algebra, and matroids. First of two courses.

**MATH 6122. Modern Abstract Algebra II. 3 Credit Hours.**
Graduate-level linear and abstract algebra including rings, fields, modules, some algebraic number theory and Galois theory. Second of two courses.

**MATH 6221. Advanced Classical Probability Theory. 3 Credit Hours.**
Classical introduction to probability theory including expectation, notions of convergence, laws of large numbers, independence, large deviations, conditional expectation, martingales, and Markov chains.

**MATH 6235. Stochastic Processes in Finance II. 3 Credit Hours.**
Advanced mathematical modeling of financial markets, derivative securities pricing, and portfolio optimization. Concepts from advanced probability and mathematics are introduced as needed.

**MATH 6241. Probability I. 3 Credit Hours.**
Develops the probability basis requisite in modern statistical theories and stochastic processes. Topics of this course include measure and integration foundations of probability, distribution functions, convergence concepts, laws of large numbers, and central limit theory. First of two courses.

**MATH 6242. Probability II. 3 Credit Hours.**
Develops the probability basis requisite in modern statistical theories and stochastic processes. Topics of this course include results for sums of independent random variables, Markov processes, martingales, Poisson processes, Brownian motion, conditional probability and conditional expectation, and topics from ergodic theory. Second of two classes.

**MATH 6262. Advanced Statistical Inference I. 3 Credit Hours.**
Basic theories of statistical estimation, including optimal estimation in finite samples and asymptotically optimal estimation. A careful mathematical treatment of the primary techniques of estimation utilized by statisticians.

**MATH 6263. Advanced Statistical Inference II. 3 Credit Hours.**
Basic theories of testing statistical hypotheses, including a thorough treatment of testing in exponential class families. A careful mathematical treatment of the primary techniques of hypothesis testing utilized by statisticians.

**MATH 6266. Linear Statistical Models. 3 Credit Hours.**
Basic unifying theory underlying techniques of regression, analysis of variance and covariance, from a geometric point of view. Modern computational capabilities are exploited fully. Students apply the theory to real data through canned and coded programs.

**MATH 6267. Multivariate Statistical Analysis. 3 Credit Hours.**
Multivariate normal distribution theory, correlation and dependence analysis, regression and prediction, dimension-reduction methods, sampling distributions and related inference problems, selected applications in classification theory, multivariate process control, and pattern recognition.

**MATH 6300. Fractal Geometry. 3 Credit Hours.**
Hausdorff dimension, box-counting dimension, iterated function systems, continued fractions, number theory, Julia sets.

**MATH 6307. Ordinary Differential Equations I. 3 Credit Hours.**
This sequence develops the qualitative theory for systems of ordinary differential equations. Topics include stability, Lyapunov functions, Floquet theory, attractors, invariant manifolds, bifurcation theory, normal forms. First of two courses.

**MATH 6308. Ordinary Differential Equations II. 3 Credit Hours.**
This sequence develops the qualitative theory for systems of differential equations. Topics include stability, Lyapunov functions, Floquet theory, attractors, invariant manifolds, bifurcation theory, and normal forms. Second of two courses.

**MATH 6321. Functions of a Complex Variable I. 3 Credit Hours.**
Complex integration, including Goursat's theorem; classification of singularities, the argument principle, the maximum principle; Riemann Mapping theorem; analytic continuation and Riemann surfaces; range of an analytic function, including Picard's theorem.

**MATH 6337. Real Analysis I. 3 Credit Hours.**
Measure and integration theory. Topics include measures, measurable functions, integration and differentiation of measures.

**MATH 6338. Real Analysis II. 3 Credit Hours.**
Topics include Lp spaces, Banach and Hilbert spaces, basic functional analysis.

**MATH 6341. Partial Differential Equations I. 3 Credit Hours.**
Introduction to the mathematical theory of partial differential equations covering the basic linear models of science and exact solution techniques.

**MATH 6342. Partial Differential Equations II. 3 Credit Hours.**
This course covers the general mathematical theory of linear stationary and evolution problems plus selected topics chosen from the instructor's interests.

**MATH 6421. Algebraic Geometry I. 3 Credit Hours.**
The study of zero sets of polynomials: algebraic varieties, regular and rational mappings, the Zariski topology.

**MATH 6422. Algebraic Geometry II. 3 Credit Hours.**
A continuation of Algebraic Geometry I.

**MATH 6441. Algebraic Topology I. 3 Credit Hours.**
Simplicial homology. Chain complexes and acyclic carriers. Simplicial approximation. The exact homology sequence. Maps of spheres. Mayer-Vietoris sequence.

**MATH 6442. Algebraic Topology II. 3 Credit Hours.**
Continuation of MATH 6441. Singular homology. Local homology and manifolds. CW complexes. Cohomology. Duality in manifolds.

**MATH 6451. General Topology. 3 Credit Hours.**
Introduction to topological and metric spaces. Continuity, compactness, convergence, completion. Product and quotient spaces. Elementary homotopy.

**MATH 6452. Differential Topology. 3 Credit Hours.**
Manifolds. Differentiable structures. Tangent bundles. Embeddings and immersions. Maps on manifolds. Transversality. Morse-Sard Theorem. Vector bundles.

**MATH 6453. Geometric Topology. 3 Credit Hours.**
Characteristic classes, Morse theory, three-manifolds, four-manifolds, symplectic and contact manifolds, knot theory.

**MATH 6455. Differential Geometry I. 3 Credit Hours.**
Core topics in differential, including: Lie groups, curvature, and relations with topology.

**MATH 6456. Differential Geometry II. 3 Credit Hours.**
Introduces students to topics of current interest in geometry.

**MATH 6457. Geometry and Topology I. 3 Credit Hours.**
The course is an introduction to the fundamental group, covering spaces and techniques used to describe and study differentiable Manifolds and smooth functions.

**MATH 6458. Introduction to Geometry and Topology II. 3 Credit Hours.**
Introduction to differential geometry and (co) homology.

**MATH 6514. Industrial Mathematics I. 3 Credit Hours.**
Applied mathematics techniques to solve real-world problems. Topics include mathematical modeling, asymptotic analysis, differential equations and scientific computation. Prepares the student for MATH 6515.

**MATH 6515. Industrial Mathematics II. 3 Credit Hours.**
Applications of mathematical techniques from MATH 6514 to solve real-world problems. Group projects to solve industrial problems in topics chosen by the instructor.

**MATH 6580. Introduction to Hilbert Spaces. 3 Credit Hours.**
Geometry, convergence, and structure of linear operators in infinite dimensional spaces. Applications to science and engineering, including integral equations and ordinary partial differential equations.

**MATH 6583. Integral Equations and Transforms. 3 Credit Hours.**
Volterra and Fredholm linear integral equations; relation to differential equations; solution methods; Fourier, Laplace, and Mellin transforms; applications to boundary value problems and integral equations.

**MATH 6584. Special Functions of Higher Mathematics. 3 Credit Hours.**
Gamma function; exponential function; orthogonal polynomials; Bessel, Legendre, and hypergeometric functions; application to singular ordinary differential equations; and separation of variables for partial differential equations.

**MATH 6635. Numerical Methods in Finance. 3 Credit Hours.**
Basic numerical and simulation techniques used in the pricing of derivative securities and in related problems in finance. Some programming experience required.

**MATH 6640. Applied Computational Methods for Partial Differential Equations. 3 Credit Hours.**
Introduction to the implementation and analysis of numerical algorithms for the numerical solution of the classic partial differential equations of science and engineering. Must have knowledge of a computer programming language, familiarity with partial differential equations and elements of scientific computing.

**MATH 6641. Advanced Numerical Methods for Partial Differential Equations. 3 Credit Hours.**
Analysis and implementation of numerical methods for nonlinear partial differential equations including elliptic, hyperbolic, and/or parabolic problems. Must have knowledge of classic linear partial differential equations and exposure to numerical methods for partial differential equations at the level of MATH 6640 or numerical linear algebra at the level of MATH 6643.

**MATH 6643. Numerical Linear Algebra. 3 Credit Hours.**
Introduction to the numerical solution of the classic problems of linear algebra including linear systems, least squares, Singular value decomposition, eigenvalue problems. Crosslisted with CSE 6643.

**MATH 6644. Iterative Methods for Systems of Equations. 3 Credit Hours.**
Iterative methods for linear and nonlinear systems of equations including Jacobi, G-S, SOR, CG, multigrid, Newton quasi-Newton, updating, and gradient-based methods. Crosslisted with CSE 6644.

**MATH 6645. Numerical Approximation Theory. 3 Credit Hours.**
Theoretical and computational aspects of polynomial, rational, trigonometric, spline, and wavelet approximation.

**MATH 6646. Numerical Methods for Ordinary Differential Equations. 3 Credit Hours.**
Analysis and implementation of numerical methods for initial and two-point boundary value problems for ordinary differential equations.

**MATH 6647. Numerical Methods for Dynamical Systems. 3 Credit Hours.**
Approximation of the dynamical structure of a differential equation and preservation of dynamical structure under discretization. Must be familiar with dynamical systems and numerical methods for initial and boundary value problems in ordinary differential equations.

**MATH 6701. Math Methods of Applied Sciences I. 3 Credit Hours.**
Review of linear algebra and ordinary differential equations, brief introduction to functions of a complex variable.

**MATH 6702. Math Methods of Applied Sciences II. 3 Credit Hours.**
Review of vector calculus and its applications to partial differential equations.

**MATH 6705. Modeling and Dynamics. 3 Credit Hours.**
Mathematical methods for solving problems in the life sciences. Models-based course on basic facts from the theory of ordinary differential equations and numerical methods of their solution. Introduction to the control theory, diffusion theory, maximization, minimization and curve fitting. Math majors may not use this course toward any degree in the School of Mathematics.

**MATH 6710. Numerical Methods in Computational Science and Engineering I. 3 Credit Hours.**
Introduction to numerical algorithms widely used in computational science and engineering. Numerical linear algebra, linear programming, and applications. Crosslisted with CSE 6710.

**MATH 6711. Numerical Methods in Computational Science and Engineering II. 3 Credit Hours.**
Efficient numerical techniques for solving partial differential equations and large-scale systems of equations arising from discretization of partial differential equations or variational problems in applications in science and engineering. Crosslisted with CSE 6711.

**MATH 6759. Stochastic Processes in Finance I. 3 Credit Hours.**
Mathematical modeling of financial markets, derivative securities pricing, and portfolio optimization. Concepts from probability and mathematics are introduced as needed. Crosslisted with ISYE 6759.

**MATH 6761. Stochastic Processes I. 3 Credit Hours.**
Discrete time Markov chains, Poisson processes, and renewal processes. Transient and limiting behavior. Average cost and utility measures of systems. Algorithms for computing performance measures. Modeling of inventories, and flows in manufacturing and computer networks. Crosslisted with ISYE 6761.

**MATH 6762. Stochastic Processes II. 3 Credit Hours.**
Continuous time Markov chains. Uniformization, transient and limiting behavior. Brownian motion and martingales. Optional sampling and convergence. Modeling of inventories, finance, flows in manufacturing and computer networks. Crosslisted with ISYE 6762.

**MATH 6767. Design and Implementation of Systems to Support. 3 Credit Hours.**
Computational Finance Introduction to large scale system design to support computational finance for options, stocks, or other financial instruments. Some programming experience, and previous exposure to stocks, bonds, and options required. Crosslisted with ISYE 6767.

**MATH 6769. Fixed Income Securities. 3 Credit Hours.**
Description, institutional features, and mathematical modeling of fixed income securities. Use of both deterministic and stochastic models. Crosslisted with ISYE 6769.

**MATH 6781. Reliability Theory. 3 Credit Hours.**
Reliability systems and related distributions, failure rate functions and nonparametric classes, accelerated life testing, dependent failure analysis, statistical inference of reliability data. Crosslisted with ISYE 6781.

**MATH 6783. Statistical Techniques of Financial Data Analysis. 3 Credit Hours.**
Fundamentals of statistical inference for models used in the modern analysis of financial data. Crosslisted with ISYE 6783.

**MATH 6785. The Practice of Quantitative and Computational Finance. 3 Credit Hours.**
Case studies, visiting lecturers from financial institutions, student group projects of an advanced nature, and student reports, all centered around quantitative and computational finance. Crosslisted with ISYE and MGT 6785.

**MATH 6793. Advanced Topics in Quantitative and Computational Finance. 3 Credit Hours.**
Advanced foundational material and analysis techniques in quantitative and computational finance. Crosslisted with ISYE 6793.

**MATH 6XXX. Mathematics Elective. 1-21 Credit Hours.**

**MATH 7000. Master's Thesis. 1-21 Credit Hours.**

**MATH 7012. Enumerative Combinatorics. 3 Credit Hours.**
Fundamental methods of enumeration and asymptotic analysis, including the use of inclusion/exclusion, generating functions, and recurrence relations. Applications to strings over a finite alphabet and graphs.

**MATH 7014. Advanced Graph Theory. 3 Credit Hours.**
Advanced topics in graph theory. Selection of arguments varies every year.

**MATH 7016. Combinatorics. 3 Credit Hours.**
Fundamental combinatorial structures including hypergraphs, transversal sets, colorings, Sperner families, intersecting families, packings and coverings, perfect graphs, and Ramsey theory. Algebraic and topological methods, applications.

**MATH 7018. Probabilistic Methods in Combinatorics. 3 Credit Hours.**
Applications of probabilistic techniques in discrete mathematics, including classical ideas using expectation and variance as well as modern tools, such as martingale and correlation inequalities.

**MATH 7244. Stochastic Processes and Stochastic Calculus I. 3 Credit Hours.**
An introduction to the Ito stochastic calculus and stochastic differential equations through a development of continuous-time martingales and Markov processes. First of two courses.

**MATH 7245. Stochastic Processes and Stochastic Calculus II. 3 Credit Hours.**
An introduction to the Ito stochastic calculus and stochastic differential equations through a development of continuous-time martingales and Markov processes. Continuation of MATH 7244.

**MATH 7334. Operator Theory. 3 Credit Hours.**
Theory of linear operators on Hilbert space. Spectral theory of bounded and unbounded operators. Applications.

**MATH 7337. Harmonic Analysis. 3 Credit Hours.**
Fourier analysis in Euclidean space. Basic topics including L1 and L2 theory; advanced topics such as distribution theory, uncertainty, Littlewood-Paley theory.

**MATH 7338. Functional Analysis. 3 Credit Hours.**
Topics include the Hahn-Banach theorems, the Baire Category theorem and its consequences, duality in Banach spaces, locally convex spaces, and additional topics.

**MATH 7510. Graph Algorithms. 3 Credit Hours.**
Algorithms for graph problems such as maximum flow, covering, matching, coloring, planarity, minimum cuts, shortest paths, and connectivity. Crosslisted with ISYE 7510 and CS 7510.

**MATH 7581. Calculus of Variations. 3 Credit Hours.**
Minimization of functionals, Euler-Lagrange equations, sufficient conditions for a minimum; geodesic, isoperometric, and time of transit problems; variational principles of mechanics; applications to control theory.

**MATH 7586. Tensor Analysis. 3 Credit Hours.**
Review of linear algebra, multilinear algebra, algebra of tensors, co- and contravariant tensors, tensors in Riemann spaces, geometrical interpretation of skew tensors.

**MATH 7999. Preparation for Doctoral Comprehensive Examination. 1-21 Credit Hours.**

**MATH 8305. Aural-Oral English Skills for Math ESL International Teaching Assistants. 2 Credit Hours.**
Enhancement of English listening/speaking skills for SOM international graduate students, post-docs, and new faculty who speak English as their second language (ESL) and who will be teaching undergraduate students.

**MATH 8306. Academic Communication for Intermediate ESL Math International Teaching Assistants. 2 Credit Hours.**
Continued enhancement of English listening/speaking skills for current and future SOM graduate international teaching assistants and international lead instructors who speak English as their second language (ESL).

**MATH 8307. Academic Communication for Advanced ESL Math International Teaching Assistants. 1 Credit Hour.**
Continued enhancement of English listening/speaking skills for current and future SOM graduate international teaching assistants and international lead instructors who speak English as their second language (ESL).

**MATH 8801. Special Topics. 1 Credit Hour.**
This course enables the School of Mathematics to comply with requests for courses in selected topics.

**MATH 8802. Special Topics. 2 Credit Hours.**
This course enables the School of Mathematics to comply with requests for courses in selected topics.

**MATH 8803. Special Topics. 3 Credit Hours.**
This course enables the School of Mathematics to comply with requests for courses in selected topics.

**MATH 8804. Special Topics. 4 Credit Hours.**
This course enables the School of Mathematics to comply with requests for courses in selected topics.

**MATH 8805. Special Topics. 5 Credit Hours.**
This course enables the school of Mathematics to comply with requests for courses in selected topics.

**MATH 8811. Special Topics. 1 Credit Hour.**
This course enables the School of Mathematics to comply with requests for courses in selected topics.

**MATH 8812. Special Topics. 2 Credit Hours.**
This course enables the School of Mathematics to comply with requests for courses in selected topics.

**MATH 8813. Special Topics. 3 Credit Hours.**
This course enables the School of Mathematics to comply with requests for courses in selected topics.

**MATH 8814. Special Topics. 4 Credit Hours.**
This course enables the School of Mathematics to comply with requests for courses in selected topics.

**MATH 8815. Special Topics. 5 Credit Hours.**
This course enables the School of Mathematics to comply with requests for courses in selected topics.

**MATH 8821. Special Topics. 1 Credit Hour.**
This course enables the School of Mathematics to comply with requests for courses in selected topics.

**MATH 8822. Special Topics. 2 Credit Hours.**
This course enables the School of Mathematics to comply with requests for courses in selected topics.

**MATH 8823. Special Topics. 3 Credit Hours.**
This course enables the School of Mathematics to comply with requests for courses in selected topics.

**MATH 8824. Special Topics. 4 Credit Hours.**
This course enables the School of Mathematics to comply with requests for courses in selected topics.

**MATH 8825. Special Topics. 5 Credit Hours.**
This course enables the School of Mathematics to comply with requests for courses in selected topics.

**MATH 8831. Special Topics. 1 Credit Hour.**
This course enables the School of Mathematics to comply with requests for courses in selected topics.

**MATH 8832. Special Topics. 2 Credit Hours.**
This course enables the School of Mathematics to comply with requests for courses in selected topics.

**MATH 8833. Special Topics. 3 Credit Hours.**
This course enables the School of Mathematics to comply with requests for courses in selected topics.

**MATH 8834. Special Topics. 4 Credit Hours.**
This course enables the School of Mathematics to comply with requests for courses in selected topics.

**MATH 8835. Special Topics. 5 Credit Hours.**
This course enables the School of Mathematics to comply with requests for courses in selected topics.

**MATH 8841. Special Topics. 1 Credit Hour.**
This course enables the School of Mathematics to comply with requests for courses in selected topics.

**MATH 8842. Special Topics. 2 Credit Hours.**
This course enables the School of Mathematics to comply with requests for courses in selected topics.

**MATH 8843. Special Topics. 3 Credit Hours.**
This course enables the School of Mathematics to comply with requests for courses in selected topics.

**MATH 8844. Special Topics. 4 Credit Hours.**
This course enables the School of Mathematics to comply with requests for courses in selected topics.

**MATH 8845. Special Topics. 5 Credit Hours.**
This course enables the School of Mathematics to comply with requests for courses in selected topics.

**MATH 8851. Special Topics. 1 Credit Hour.**
This course enables the School of Mathematics to comply with requests for courses in selected topics.

**MATH 8852. Special Topics. 2 Credit Hours.**
This course enables the School of Mathematics to comply with requests for courses in selected topics.

**MATH 8853. Special Topics. 3 Credit Hours.**
This course enables the school of Mathematics to comply with requests for courses in selected topics.

**MATH 8854. Special Topics. 4 Credit Hours.**
This course enables the School of Mathematics to comply with requests for courses in selected topics.

**MATH 8855. Special Topics. 5 Credit Hours.**
This course enables the School of Mathematics to comply with requests for courses in selected topics.

**MATH 8863. Advanced Topics in Graph Theory. 3 Credit Hours.**
Selection of topics vary with each offering.

**MATH 8900. Special Problems. 1-21 Credit Hours.**

**MATH 8901. Special Problems. 1-21 Credit Hours.**

**MATH 8902. Special Problems. 1-21 Credit Hours.**

**MATH 8903. Special Problems. 1-21 Credit Hours.**

**MATH 8997. Teaching Assistantship. 1-9 Credit Hours.**
For students holding graduate teaching assistantships.

**MATH 8998. Research Assistantship. 1-9 Credit Hours.**
For students holding graduate research assistantships.

**MATH 9000. Doctoral Thesis. 1-21 Credit Hours.**