

MATHEMATICS (MAT)

Mathematics (MAT) Courses

MAT 5003. Modern Mathematics for Teachers. (3-0) 3 Credit Hours.

A practical orientation concerned with the classroom uses of mathematics for teachers of K–12. This course may not be applied toward the Master of Science degree in Mathematics. Differential Tuition: \$150. Course Fees: GS01 \$90; LRS1 \$46.20; STSI \$21.60.

MAT 5023. Problem-Solving Seminar. (3-0) 3 Credit Hours.

Students will have the opportunity to engage in extensive experience and practice in solving mathematical problems. Differential Tuition: \$150. Course Fees: GS01 \$90.

MAT 5033. Foundations and Fundamental Concepts of Mathematics. (3-0) 3 Credit Hours.

Topics include the study of mathematics in antiquity as an empirical science, the shift from inductive reasoning to axiomatic structures, the development of geometry in the plane and 3-space, the discovery of analysis, the emergence of axiomatic systems, and the focus on algebraic structures. This course may not be applied to the Master of Science degree in Mathematics without approval of the Graduate Advisor of Record and the Graduate Review Committee. Differential Tuition: \$150. Course Fees: GS01 \$90.

MAT 5043. Euclidean and Non-Euclidean Geometry. (3-0) 3 Credit Hours.

Topics will be selected from advanced Euclidean and non-Euclidean geometry, solid analytic geometry, and differential geometry. Differential Tuition: \$150. Course Fees: GS01 \$90.

MAT 5103. Introduction to Mathematical Analysis. (3-0) 3 Credit Hours.

Prerequisite: MAT 4213 or consent of instructor. Axiomatic construction of the reals, metric spaces, continuous functions, differentiation and integration, partial derivatives, and multiple integration. This course may not be applied to the Master of Science degree in Mathematics. (Credit cannot be earned for both MAT 5103 and MAT 5203.) Differential Tuition: \$150. Course Fees: GS01 \$90.

MAT 5113. Computing for Mathematics. (3-0) 3 Credit Hours.

Prerequisite: MAT 1313 or an equivalent or consent of the instructor. Project-based modular course allowing individualized learning of computer tools and skills most relevant to each mathematics student. Available modules include: LaTeX typesetting, calculation and visualization in Desmos and GeoGebra, introduction to general-purpose programming in Python, and specialized tools including Sage, Mathematica, Matlab/Octave, R, etc. (Same as MAT 4113. Credit can not be earned for both MAT 5113 and MAT 4113.) Differential Tuition: \$150. Course fee: GS01 \$90.

MAT 5123. Introduction to Cryptography. (3-0) 3 Credit Hours.

Prerequisite: MAT 4213. Congruences and residue class rings, Fermat's Little Theorem, the Euler phi-function, the Chinese Remainder Theorem, complexity, symmetric-key cryptosystems, cyclic groups, primitive roots, discrete logarithms, one-way functions, public-key cryptosystems, digital signatures, finite fields, and elliptic curves. Differential Tuition: \$150. Course Fees: GS01 \$90.

MAT 5133. Mathematical Biology. (3-0) 3 Credit Hours.

Prerequisite: MAT 1193 or equivalent or consent of instructor. A broad introduction to nonlinear dynamics. Topics may include discrete and continuous models, flows on the line, linear stability analysis, matrix operations and eigenvalues, flows on the plane, bifurcations, discrete dynamical systems, higher-dimensional systems, and others. The biological problems studied include: Molecular processes (glycolysis, lactose operon, etc.), physiological processes (single neuron), and ecological processes (predator-prey, competing species, infectious disease modeling). (Same as MAT 4133. Credit can not be earned for both MAT 4133 and MAT 5133.) Differential Tuition: \$150. Course Fee: GS01 \$90.

MAT 5153. Data Analytics. (3-0) 3 Credit Hours.

Prerequisite: MAT 1214, MAT 2233, and MAT 4113 or CS 1063 or CS 1083, or equivalent, or consent of instructor. This course is intended to develop practical marketable skills in data analytics using rigorous mathematical methodologies via SQL, Python, and Git. The mathematical topics covered involve: Singular value decomposition, single and multiple discriminant analysis, integral transforms with orthogonal and non-orthogonal functions/data and their connection with regression techniques, and nonlinear discriminants through dimensionality augmentation (artificial neural networks). The course covers techniques to characterize the context of a data problem, and addresses issues related to reproducibility of computational results. (Same as MAT 4153. Credit can not be earned for both MAT 4153 and MAT 5153.) Differential tuition: \$150. Course Fee: GS01 \$90.

MAT 5163. Probability Theory and Comput. (3-0) 3 Credit Hours.

Prerequisite: CS 3333 or MAT 2313 or equivalent or permission of instructor. Topics may include: expectation and moments of random variables, Gaussian distribution, moment generating functions, the Central Limit Theorem, basic concentration inequalities (Chernoff's and Hoeffding's), discrete probabilistic structures and computing, bucket sort algorithm, Poisson approximation, Johnson-Lindenstrauss dimensionality reduction lemma, etc. Differential Tuition: \$150. Course Fee: GS01 \$90.

MAT 5173. Algebra I. (3-0) 3 Credit Hours.

Prerequisite: MAT 4233 or consent of instructor. The opportunity for development of basic theory of algebraic structures. Areas of study may include monoids, semigroups, groups, isomorphism theorems, free groups, group extensions and group actions, Sylow theorems, group chains and composition series, nilpotent and solvable groups, cohomology of groups. Differential Tuition: \$150. Course Fees: GS01 \$90.

MAT 5183. Algebra II. (3-0) 3 Credit Hours.

Prerequisite: MAT 5173. Areas of study may include: Theory of rings, ideals, chain conditions, Artin and Nother rings, Ore conditions and ring of fractions, Jacobson radicals, group rings, modules, module homomorphisms, free modules, tensor products, modules over principal ideal domains, algebras, Galois theory. Formerly MAT 5313. Credit cannot be earned for both MAT 5313 and MAT 5183. Differential Tuition: \$150. Course Fees: GS01 \$90.

MAT 5203. Theory of Functions of a Real Variable I. (3-0) 3 Credit Hours.

Prerequisite: MAT 4213 or consent of instructor. Measure and integration theory. (Credit cannot be earned for both MAT 5203 and MAT 5103.) Differential Tuition: \$150. Course Fees: GS01 \$90.

MAT 5213. Theory of Functions of a Real Variable II. (3-0) 3 Credit Hours.

Prerequisite: MAT 5203. Further development of measure and integration theory, metric space topology, and elementary Banach space theory. Differential Tuition: \$150. Course Fees: GS01 \$90; LRS1 \$46.20; STSI \$21.60.

MAT 5223. Theory of Functions of a Complex Variable I. (3-0) 3 Credit Hours.

Prerequisite: MAT 3213 or MAT 4213. Complex integration, Cauchy's theorem, calculus of residues, and power series. Differential Tuition: \$150. Course Fees: GS01 \$90.

MAT 5233. Theory of Functions of a Complex Variable II. (3-0) 3 Credit Hours.

Prerequisite: MAT 5223. Infinite products, entire functions, Picard's theorem, Riemann mapping theorem, and functions of several complex variables. Differential Tuition: \$150. Course Fees: GS01 \$90.

MAT 5243. General Topology I. (3-0) 3 Credit Hours.

Prerequisite: MAT 4273 or consent of instructor. Topological spaces, metric spaces, continua, and plane topology. Differential Tuition: \$150. Course Fees: GS01 \$90.

MAT 5253. General Topology II. (3-0) 3 Credit Hours.

Prerequisite: MAT 5243. Topics may include: Metrizable topological spaces, function spaces, covering spaces, homotopy theory and fundamental groups, classification of surfaces, and others. Differential Tuition: \$150. Course Fees: GS01 \$90.

MAT 5263. Algebraic Topology. (3-0) 3 Credit Hours.

Prerequisite: MAT 4273 or MAT 5243. Fundamental ideas of algebraic topology, homotopy and simplicial complexes, fundamental group, covering spaces, and duality theorems. Differential Tuition: \$150. Course Fees: GS01 \$90.

MAT 5283. Linear Algebra. (3-0) 3 Credit Hours.

Prerequisite: MAT 2233 or an equivalent. A study of linear algebraic structures that may include linear transformations, inner product spaces, eigenvalues, Cayley-Hamilton theorem, similarity, the Jordan canonical form, spectral theorem for normal transformation and applications. Differential Tuition: \$150. Course Fees: GS01 \$90.

MAT 5293. Numerical Linear Algebra. (3-0) 3 Credit Hours.

Prerequisite: MAT 2233 or an equivalent. Direct and iterative methods for solving general linear systems, the algebraic eigenvalue problem, least squares problems, and solutions of sparse systems arising from partial differential equations. (Same as CS 5293. Credit cannot be earned for both MAT 5293 and CS 5293.) Differential Tuition: \$150. Course Fees: GS01 \$90.

MAT 5323. Mathematical Modeling. (3-0) 3 Credit Hours.

Prerequisite: MAT 3633 or equivalent. Techniques of mathematical modeling for applications, including ordinary and partial differential equations, stochastic models, discrete models and optimization, modeling error and uncertainty quantification. Differential Tuition: \$150. Course Fees: GS01 \$90.

MAT 5343. Differential Geometry. (3-0) 3 Credit Hours.

Prerequisites: MAT 4223 and MAT 4273, or equivalents. Multilinear algebra, differentiable manifolds, exterior differential forms, affine connections, Riemannian geometry, and curvature equations. Differential Tuition: \$150. Course Fees: GS01 \$90.

MAT 5353. Mathematics of Image Processing. (3-0) 3 Credit Hours.

Prerequisite: MAT 5613 or consent of instructor. Topics include image acquisition, denoising and enhancement, transformations, linear and nonlinear filters, image compression, segmentation and edge detection, morphology, and pattern recognition. Differential Tuition: \$150. Course Fees: GS01 \$90; LRS1 \$46.20; STSI \$21.60.

MAT 5403. Functional Analysis I. (3-0) 3 Credit Hours.

Prerequisites: MAT 2233, MAT 4273, and MAT 5203, or their equivalents. Topological vector spaces, inner product spaces, normed spaces, Hilbert spaces and Banach spaces, dual spaces, Hahn-Banach theorem, and bounded linear operators. Differential Tuition: \$150. Course Fees: GS01 \$90.

MAT 5413. Functional Analysis II. (3-0) 3 Credit Hours.

Prerequisite: MAT 5403. Riesz representation theorem, spectral theory, Banach algebras, and C*-algebras. Differential Tuition: \$150. Course Fees: GS01 \$90; LRS1 \$46.20; STSI \$21.60.

MAT 5463. High Dimensional Probability. (3-0) 3 Credit Hours.

Prerequisite: MAT 5163 and MAT 5283 or equivalents. Topics may include: basic inequalities for random variables, Concentration Inequalities: Sub-gaussian and sub-exponential concentration, Chernoff, and Hoeffding. Applications to random networks. High-dimensional vectors: covariance estimation and Principal Component Analysis. Sub-gaussian vectors in high dimensions. Applications to randomized rounding in discrete optimization. Random matrices: net arguments, tail bounds, applications to numerical analysis, community detection, and error correcting codes. Stochastic processes: Gaussian width and basic inequalities for supremum of stochastic processes and applications. Differential Tuition: \$150. Course Fee: GS01 \$90.

MAT 5553. Harmonic Analysis. (3-0) 3 Credit Hours.

Prerequisites: MAT 3223 and MAT 4223, or consent of the instructor. Topics may include properties of Fourier series, convergence and summability, Hardy spaces, boundary behavior and harmonic functions, and other topics at the discretion of the instructor. Differential Tuition: \$150. Course Fees: GS01 \$90.

MAT 5603. Numerical Analysis. (3-0) 3 Credit Hours.

Prerequisite: MAT 3633 or consent of instructor. Emphasis on the mathematical analysis of numerical methods. Areas of study include solution of nonlinear equations and function optimization, approximation theory and numerical quadrature. (Same as CS 5603. Credit cannot be earned for both MAT 5603 and CS 5603.) Differential Tuition: \$150. Course Fees: GS01 \$90.

MAT 5613. Numerical Solutions of Differential Equations. (3-0) 3 Credit Hours.

Prerequisite: MAT 5603 or an equivalent. Emphasis on the mathematical analysis of numerical methods. Areas of study include the analysis of single and multistep methods of ordinary differential equations. Analysis of finite difference and finite element methods for partial differential equations. Differential Tuition: \$150. Course Fees: GS01 \$90; LRS1 \$46.20; STSI \$21.60.

MAT 5653. Differential Equations I. (3-0) 3 Credit Hours.

Prerequisites: MAT 3613 and MAT 4213, or consent of instructor. Solution of initial-value problems, linear systems with constant coefficients, exponentials of operators, canonical forms and generic properties of operators, and contractions. Differential Tuition: \$150. Course Fees: GS01 \$90.

MAT 5663. Differential Equations II. (3-0) 3 Credit Hours.

Prerequisite: MAT 5653. Dynamic systems, the fundamental existence and uniqueness theorem, stability, the Poincare-Bendixon theorem, introduction to perturbation, and bifurcation theory. Differential Tuition: \$150. Course Fees: GS01 \$90; LRS1 \$46.20; STSI \$21.60.

MAT 5673. Partial Differential Equations I. (3-0) 3 Credit Hours.

Prerequisites: MAT 3623 and MAT 5663, or consent of instructor. Classical theory of initial value and boundary value problems for partial differential equations, including the heat equation, wave equation, and Laplace equation, et al., and non-linear first and second order partial differential equations and calculus of variation. Differential Tuition: \$150. Course Fees: GS01 \$90.

MAT 5683. Partial Differential Equations II. (3-0) 3 Credit Hours.

Prerequisite: MAT 5673. Modern topics in partial differential equations. Differential Tuition: \$150. Course Fees: GS01 \$90.

MAT 5963. Introduction to Mathematics Education Research. (3-0) 3 Credit Hours.

Prerequisite: Consent of instructor. An introduction to important research and findings in mathematics education. Students will gain experience with interpreting education research and translating it into practice. Students will work on projects designed to help them investigate their own teaching practice. Topics include: mathematical learning theories, philosophical perspectives of mathematics, explorations of mathematical content, and research on student learning. Differential Tuition: \$150. Course Fees: GS01 \$90.

MAT 5973. Directed Research. (0-0) 3 Credit Hours.

Prerequisites: Graduate standing and permission in writing (form available) from the instructor and the student's Graduate Advisor of Record. The directed research course may involve either a laboratory or a theoretical problem. May be repeated for credit, but not more than 6 hours, regardless of discipline, will apply to the Master's degree. Differential Tuition: \$150. Course Fees: GS01 \$90.

MAT 5983. Topics in Applied Mathematics. (3-0) 3 Credit Hours.

Prerequisite: Graduate standing or consent of instructor. In-depth study of current topics in applied mathematics. May be repeated for credit when topics vary. Differential Tuition: \$150. Course Fees: GS01 \$90.

MAT 6603. Optimization Techniques in Operations Research. (3-0) 3 Credit Hours.

Prerequisite: MAT 1224 and MAT 2233 or CS 3333. Topics may include discrete, continuous, linear, and non-linear optimization, optimality conditions, Lagrange multipliers, duality theory, applications of linear programming in computer science and discrete optimization, gradient descent, Newton iteration (i.e., first and second order methods), and applications of first and second order methods to engineering. Differential tuition: \$150. Course Fee: GS01 \$90.

MAT 6953. Independent Study. (0-0) 3 Credit Hours.

Prerequisites: Graduate standing and permission in writing (form available) from the instructor and the student's Graduate Advisor of Record. Independent reading, research, discussion, and/or writing under the direction of a faculty member. For students needing specialized work not normally or not often available as part of the regular course offerings. May be repeated for credit, but not more than 6 hours, regardless of discipline, will apply to the Master's degree. Differential Tuition: \$150. Course Fees: GS01 \$90.

MAT 6961. Comprehensive Examination. (0-0) 1 Credit Hour.

Prerequisite: Approval of the appropriate graduate program committee to take the Comprehensive Examination. Independent study course for the purpose of taking the Comprehensive Examination. May be repeated as many times as approved by the Graduate Program Committee. Enrollment is required each term in which the Comprehensive Examination is taken if no other courses are being taken that term. The grade report for the course is either "CR" (satisfactory performance on the Comprehensive Examination) or "NC" (unsatisfactory performance on the Comprehensive Examination). Differential Tuition: \$50. Course Fees: GS01 \$30.

MAT 6963. Topics in Mathematics Education. (3-0) 3 Credit Hours.

Prerequisite: Consent of instructor. An organized course offering the opportunity for specialized study not normally or not often available as part of the regular course offerings. This course may be repeated for credit when topics vary but not more than 9 hours may be applied toward the Master's degree. This course may not be applied toward the Master of Science degree in Mathematics with a concentration in Mathematics. Differential Tuition: \$150. Course Fees: DL01 \$75, GS01 \$90, MFSM \$35.

MAT 6973. Special Problems. (3-0) 3 Credit Hours.

Prerequisite: Consent of instructor. An organized course offering the opportunity for specialized study not normally or not often available as part of the regular course offerings. Special Problems courses may be repeated for credit when topics vary, but not more than 6 hours, regardless of discipline, will apply to the Master's degree. Differential Tuition: \$150. Course Fees: GS01 \$90.

MAT 6983. Master's Thesis. (0-0) 3 Credit Hours.

Prerequisites: Permission from the Graduate Advisor of Record and thesis director. Thesis research and preparation. May be repeated for credit, but not more than 6 hours will apply to the Master's degree. Credit will be awarded upon completion of the thesis. Enrollment is required each term in which the thesis is in progress. Differential Tuition: \$150. Course Fees: GS01 \$90.