MATHEMATICS

MAA 5104 Advanced Calculus for Engineers and Physical Scientists I 3 Credits
Grading Scheme: Letter Grade
Advanced Calculus for Engineers and Physical Scientists I

MAA 5105 Advanced Calculus for Engineers and Physical Scientists II 3 Credits
Grading Scheme: Letter Grade
Advanced Calculus for Engineers and Physical Scientists II
Prerequisite: MAA 5104.

MAA 5228 Modern Analysis I 3 Credits
Grading Scheme: Letter Grade
Topology of metric spaces, numerical sequences and series, continuity, differentiation, the Riemann-Stieltjes integral, sequences and series of functions, the Stone-Weierstrass theorem, and the Lebesgue theory.
Prerequisite: advanced calculus.

MAA 5229 Modern Analysis II 3 Credits
Grading Scheme: Letter Grade
Modern Analysis II
Prerequisite: MAA 5228.

MAA 5404 Introduction to Complex Variables for Engineers and Physical Scientists 3 Credits
Grading Scheme: Letter Grade
Introduction to Complex Variables for Engineers and Physical Scientists

MAA 6406 Complex Analysis I 3 Credits
Grading Scheme: Letter Grade
Rapid survey of properties of complex numbers, linear transformations, geometric forms and necessary concepts from topology. Complex integration. Cauchy's theorem and its corollaries. Taylor series and the implicit function theorem in complex form. Conformality and the Riemann-Caratheodory mapping theorem. Theorems of Bloch, Schottky, and the big and little theorems of Picard. Harmonicity and Dirichlet's problems.
Prerequisite: MAA 5229.

MAA 6407 Complex Analysis II 3 Credits
Grading Scheme: Letter Grade
Complex Analysis II
Prerequisite: MAA 6406.

MAA 6616 Analysis I 3 Credits
Grading Scheme: Letter Grade
Fundamentals of measure and integration theory, including Lp spaces and the Radon-Nikodym theorem. Introduction to functional analysis: Banach spaces, Hilbert spaces, and the theory of linear operators.
Prerequisite: MAA 5229.

MAA 6617 Analysis II 3 Credits
Grading Scheme: Letter Grade
Continuation of MAA 6616 Analysis I.
Prerequisite: MAA 6616.

MAA 7526 Advanced Topics in Functional Analysis I 3 Credits, Max 6 Credits
Grading Scheme: Letter Grade
Algebraic and topological approach to current material and methods in analysis.
Prerequisite: MAA 6617

MAA 7527 Advanced Topics in Functional Analysis II 3 Credits, Max 6 Credits
Grading Scheme: Letter Grade
Advanced Topics in Functional Analysis II
Prerequisite: MAA 7526.

MAD 6206 Combinatorial Theory I 3 Credits
Grading Scheme: Letter Grade
Matching theory, Ramsey's theorem, lattice theory, Mobius inversion, generating functions. Polya's theorem, matroids, applications, block designs, graph theory.

MAD 6207 Combinatorial Theory II 3 Credits
Grading Scheme: Letter Grade
Combinatorial Theory II
Prerequisite: MAD 6206.

MAD 6406 Numerical Linear Algebra 3 Credits
Grading Scheme: Letter Grade
Topics most useful in applications with emphasis on numerical techniques: systems of linear equations, positive definite and toeplitz systems, least squares problems, singular value decomposition, and eigenvalues. Numerical stability and efficiency of algorithms as well as effect of perturbations on the problem. Companion to MAD 6407.
Prerequisite: MAS 3114, 4105, or 4124; and programming language.

MAD 6407 Numerical Analysis 3 Credits
Grading Scheme: Letter Grade
Numerical techniques to solve systems of nonlinear equations to approximate functions, to compute derivatives, to evaluate integrals, and to integrate systems of differential equations. Introduction to numerical techniques for partial differential equations. Companion to MAD 6406.
Prerequisite: MAA 4212, MAA 5105, or MAA 5229; and programming language.

MAD 7396 Topics in Combinatorial Theory I 3 Credits, Max 6 Credits
Grading Scheme: Letter Grade
Topics chosen from among graph theory, coding theory, matroid theory, finite geometries, projective geometry, difference methods, and Latin squares.
Prerequisite: MAS 5312.

MAD 7397 Topics in Combinatorial Theory II 3 Credits
Grading Scheme: Letter Grade
Topics in Combinatorial Theory II
Prerequisite: MAD 7396.

MAE 6940 Supervised Teaching 1-5 Credits, Max 5 Credits
Grading Scheme: S/U
Supervised Teaching
Prerequisite: consent of graduate adviser.

MAE 6943 Internship in College Teaching 3 Credits, Max 6 Credits
Grading Scheme: Letter Grade
Internship in College Teaching
Prerequisite: consent of graduate adviser.

MAP 5304 Intermediate Differential Equations for Engineers and Physical Scientists 3 Credits
Grading Scheme: Letter Grade
Intermediate Differential Equations for Engineers and Physical Scientists

MAP 5345 Introduction to Partial Differential Equations 3 Credits
Grading Scheme: Letter Grade
Introduction to Partial Differential Equations

MAP 5489 Modeling in Mathematical Biology 3 Credits
Grading Scheme: Letter Grade
Mathematical models of biological systems. Models of growth, predator-prey populations, competition, chemostat, epidemics, excitable systems, and analytical tools such as linearization, phase-plane analysis, Poincare-Bendixson theory, Lyapunov functions, and bifurcation analysis.
Prerequisite: undergraduate course in ordinary differential equations.

MAP 6208 Numerical Optimization 3 Credits
Grading Scheme: Letter Grade
Unconstrained and constrained optimization, linear and nonlinear programming, gradient, multiplier, and quasi-Newton methods. Penalty, multiplier, and projection methods for constrained problems.
Prerequisite: MAD 6406 and MAD 6407 or consent of instructor.

MAP 6213 Variational Analysis 3 Credits
Grading Scheme: Letter Grade
Develops smooth analysis through problems that arise in the calculus of variations and explores nonsmooth analysis through problems that arise in optimal control. Develops first and second-order optimality conditions, discrete approximations to continuous problems, and mathematical tools to analyze discretization errors.
Prerequisite: (MAA 5104 & MAA 5105) or MAD 6406.

MAP 6327 Applied Differential Equations I 3 Credits
Grading Scheme: Letter Grade
Theory and methods for solving linear and nonlinear systems of differential equations and partial differential equations. Applications and computer techniques included.
Prerequisite: MAA 5229.

MAP 6356 Partial Differential Equations I 3 Credits
Grading Scheme: Letter Grade
Cauchy-Kowalewski theorem, first order equations, classification of equations, hyperbolic equations, elliptic equations, parabolic equations, hyperbolic systems, nonlinear hyperbolic systems, existence theory based on functional analysis. Applications to physical sciences.
Prerequisite: MAA 5229, MAP 5345 or MAP 6506.

MAP 6357 Partial Differential Equations II 3 Credits
Grading Scheme: Letter Grade
Partial Differential Equations II
Prerequisite: MAP 6356.

MAP 6375 Numerical Partial Differential Equations 3 Credits
Grading Scheme: Letter Grade
Introduction to partial differential equations and fundamental concepts. Parabolic equations: finite differences, consistency, convergence and stability, 2- and 3-dimensional problems. Elliptic equations: finite differences, solution to linear equations, boundary integral equation methods. Hyperbolic equations: finite differences and method of characteristics. Introduction to finite elements. Methods of lines.
Prerequisite: MAD 6406 and MAD 6407 or consent of instructor.

MAP 6376 Finite Element Method 3 Credits
Grading Scheme: Letter Grade
Variational formulations of partial differential equations, finite element approximations; addresses theoretical framework and numerical issues. Finite element spaces in one, two, and three dimensions. Error analysis. Nonconforming finite element spaces. Isoparametric approximations to boundary conditions.
Prerequisite: MAD 6406 and MAD 6407 or consent of instructor.

MAP 6467 Stochastic Differential Equations and Filtering Theory I 3 Credits
Grading Scheme: Letter Grade
Introduction to random functions; Brownian motion process. Ito's stochastic integral; Ito's stochastic calculus; stochastic differential equations. Linear filtering; Kalman filtering; nonlinear filtering theory.

MAP 6468 Stochastic Differential Equations and Filtering Theory II 3 Credits
Grading Scheme: Letter Grade
Stochastic Differential Equations and Filtering Theory II
Prerequisite: MAP 6467.

MAP 6472 Probability and Potential Theory I 3 Credits
Grading Scheme: Letter Grade
Random variables, independence and conditioning. Laws of large numbers and the Central Limit Theorem. Stochastic processes, martingales, Gaussian processes, Markov processes, potentials and excessive functions.
Prerequisite: MAA 5229 or STA 6326.

MAP 6473 Probability and Potential Theory II 3 Credits
Grading Scheme: Letter Grade
Probability and Potential Theory II
Prerequisite: MAP 6472

MAP 6487 Biomathematics Seminar I 3 Credits
Grading Scheme: Letter Grade
Stochastic processes, differential equations, and reaction-diffusion equations used to model various biological processes. Among the applications covered are the following: population dynamics, epidemiology, genetics, enzyme kinetics, cell differentiation and morphogenesis, nerve impulse generation, and aggregation of slime mold. The course is designed to benefit graduate students in biological sciences, as well as mathematics.
Prerequisite: MAC 2312, MAP 2302, STA 6326 or MAP 4102.

MAP 6488 Biomathematics Seminar II 3 Credits
Grading Scheme: Letter Grade
Continuation of MAP 6487.
Prerequisite: MAP 6487.

MAP 6505 Mathematical Methods of Physics and Engineering 3 Credits
Grading Scheme: Letter Grade
Orthogonal functions; theory of distributions; integral equations; eigenfunctions and Green's functions; special functions; boundary and initial value problems, with emphasis on potential theory (Laplace and Poisson equations); the wave equation; and the diffusion equation.
Prerequisite: MAA 5404, MAP 5304, MAP 5345, MAS 5157 or equivalent.

MAP 6506 Mathematical Methods of Physics and Engineering II 3 Credits
Grading Scheme: Letter Grade
Mathematical Methods of Physics and Engineering II
Prerequisite: MAP 6505.

MAP 6941 Internship in Applied Mathematics 1-5 Credits, Max 9 Credits
Grading Scheme: Letter Grade
Mathematical research on projects sponsored by a university laboratory or an off-campus industrial internship program.
Prerequisite: consent of supervisory committee chair.

MAP 7436 Seminar in Applied Mathematics I 3 Credits, Max 6 Credits
Grading Scheme: Letter Grade
Various topics in applications of mathematics both classical and in areas of current research.

MAP 7437 Seminar in Applied Mathematics II 3 Credits, Max 6 Credits
Grading Scheme: Letter Grade
Seminar in Applied Mathematics II

MAS 5311 Introductory Algebra I 3 Credits
Grading Scheme: Letter Grade
The basic algebraic systems: groups, rings, vector spaces, and modules. Linear transformations, matrices, and determinants.
Prerequisite: MAS 4105 and 4302.

MAS 5312 Introductory Algebra II 3 Credits
Grading Scheme: Letter Grade
Introductory Algebra II
Prerequisite: MAS 5311.

MAS 6331 Algebra I 3 Credits
Grading Scheme: Letter Grade
Solvable and nilpotent groups, Jordan-Holder theorem, abelian groups, Galois theory, Noetherian rings, Dedekind domains, Jacobson radical, Jacobson density theorem, Wedderburn-Artin theorem.
Prerequisite: MAS 5312.

MAS 6332 Algebra II 3 Credits
Grading Scheme: Letter Grade
Algebra II
Prerequisite: MAS 6331.

MAS 7215 Theory of Numbers I 3 Credits
Grading Scheme: Letter Grade
Introduction to theory of numbers; theorems on divisibility; congruence, number-theoretic functions; primitive roots and indices; quadratic reciprocity law; Diophantine equations and continued functions.
Prerequisite: 2 of MAA 6407, MAA 6617, MAS 6332.

MAS 7216 Theory of Numbers II 3 Credits, Max 6 Credits
Grading Scheme: Letter Grade
Theory of Numbers II
Prerequisite: MAS 7215.

MAS 7396 Advanced Topics in Algebra I 3 Credits, Max 6 Credits
Grading Scheme: Letter Grade
Current topics in algebra.
Prerequisite: MAA 6407, MAA 6617, MAS 6332 or MTG 6347.

MAS 7397 Topics in Algebra II 3 Credits
Grading Scheme: Letter Grade
Topics in Algebra II

MAT 6905 Individual Work 3 Credits, Max 9 Credits
Grading Scheme: Letter Grade
Individual Work

MAT 6910 Supervised Research 1-5 Credits, Max 5 Credits
Grading Scheme: S/U
Supervised Research

MAT 6932 Special Topics in Mathematics 3 Credits, Max 18 Credits
Grading Scheme: Letter Grade
Special Topics in Mathematics
Prerequisite: consent of graduate adviser, who should be consulted well in advance of registration.

MAT 6971 Research for Master's Thesis 1-15 Credits
Grading Scheme: S/U
Research for Master's Thesis

MAT 7979 Advanced Research 1-12 Credits
Grading Scheme: S/U
Research for doctoral students before admission to candidacy. Designed for students with a master's degree in the field of study or for students who have been accepted for a doctoral program. Not appropriate for students who have been admitted to candidacy.

MAT 7980 Research for Doctoral Dissertation 1-15 Credits
Grading Scheme: S/U
Research for Doctoral Dissertation

MHF 5107 Introduction to Set Theory 3 Credits
Grading Scheme: Letter Grade
Basic axioms and concepts of set theory, axiom of choice, Zorn's lemma, Schroder-Bernstein theorem, cardinal numbers, ordinal numbers, and the continuum hypothesis.

MHF 5207 Foundations of Mathematics 3 Credits
Grading Scheme: Letter Grade
Models and proofs. Foundations of the real and natural number systems. Algorithms. Turing Machines, undecidability and independence. Examples and applications in algebra, analysis, geometry, and topology.

MHF 6306 Mathematical Logic I 3 Credits
Grading Scheme: Letter Grade
Languages, models, and theories; Godel's completeness and incompleteness theorems; formal number theory and axiomatic set theory; applications to other areas of mathematics.

MHF 6307 Mathematical Logic 2 3 Credits
Grading Scheme: Letter Grade
The three sub-areas Model theory, computability theory, and set theory will be covered. Specific topics may include axiomatization of set theory, transfinite recursion and cardinal arithmetic, Goedel's constructible universe, Cohen's method of forcing, Turing degrees, and Post's problem.
Prerequisite: MHF 6306.

MTG 5316 Introduction to Topology I 3 Credits
Grading Scheme: Letter Grade
Basic axioms and concepts of point-set topology, compactness, connectedness, separation axioms, metric spaces, metrization. Tietze extension theorem. Urysohn lemma, Tychonoff theorem, fundamental group.

MTG 5317 Introduction to Topology II 3 Credits
Grading Scheme: Letter Grade
Introduction to Topology II
Prerequisite: MTG 5316.

MTG 6256 Differential Geometry I 3 Credits
Grading Scheme: Letter Grade
Foundations of the theory of smooth manifolds, vector fields, and differential forms. Topics chosen from a list including differential topology, Lie groups, symplectic geometry, Riemannian geometry, and applications to physics.
Prerequisite: consent of instructor.

MTG 6257 Differential Geometry II 3 Credits
Grading Scheme: Letter Grade
Differential Geometry II
Prerequisite: MTG 6256.

MTG 6346 Topology I 3 Credits
Grading Scheme: Letter Grade
A basic introduction to advanced topology. Topics covered include general topology, algebraic topology, homotopy theory and topology of manifolds.
Prerequisite: MTG 5317.

MTG 6347 Topology II 3 Credits
Grading Scheme: Letter Grade
Topology II
Prerequisite: MTG 6346.

MTG 6401 Ergodic Theory and Dynamical Systems I 3 Credits
Grading Scheme: Letter Grade
Periodic points, recurrence, nonwandering and chain recurrent sets, topological conjugacy, minimal sets. Topological entropy, metric entropy. Measure preserving transformations, ergodicity, mixing. Birkhoff's ergodic theorem. Bernouilli shifts. Anosov diffeomorphisms, structural stability, hyperbolic sets. Basic sets, symbolic dynamics, Markov partitions. Lyapunov exponents, KAM (Kolmogorov, Arnold, Moser) theory.
Prerequisite: MTG 5317, MAA 6617, or consent of instructor.

MTG 6402 Ergodic Theory and Dynamical Systems II 3 Credits
Grading Scheme: Letter Grade
Continuation of MTG 6401.
Prerequisite: MTG 6401.

MTG 7396 Advanced Topics in Topology I 3 Credits, Max 6 Credits
Grading Scheme: Letter Grade
Topics change yearly.
Prerequisite: MTG 6347.

MTG 7397 Advanced Topics in Topology II 3 Credits
Grading Scheme: Letter Grade
Discussion of advanced topics in topology and its applications.
Prerequisite: MTG 7396.