Mathematics Courses (MATH)

This is a list of all mathematics courses. For more information, see Mathematics.

**MATH:0100 Basic Algebra I**  3 s.h.
Percents, ratio and proportion, algebraic expressions and operations, simple products, linear and quadratic equations, simultaneous equations, exponents and radicals; emphasis on verbal problems. GE: Algebra I - Developmental.

**MATH:0300 Basic Geometry**  3 s.h.
Angles, triangles, polygons, areas, Pythagorean theorem, similar triangles, circles, loci, related topics. Offered spring semesters. Recommendations: it is strongly recommended that students whose math placement score is older than one year retake the math placement test for accurate placement and success in the course. GE: Geometry - Developmental.

**MATH:1000 First-Year Seminar**  1 s.h.
Small discussion class taught by a faculty member; topics chosen by instructor; may include outside activities (e.g., films, lectures, performances, readings, visits to research facilities). Requirements: first- or second-semester standing.

**MATH:1005 College Algebra**  4 s.h.
Algebraic techniques, equations and inequalities, functions and graphs, exponential and logarithmic functions, systems of equations and inequalities. Prerequisites: MATH:0100 with a minimum grade of C- or ALEKS score of 30 or higher. Recommendations: it is strongly recommended that students whose math placement score is older than one year retake the math placement test for accurate placement and success in the course.

**MATH:1010 Trigonometry**  3 s.h.
Trigonometric functions, solutions of right and oblique triangles, complex numbers. Prerequisites: MATH:1340 with a minimum grade of C- or MPT Level 3 score of 9 or higher or MATH:1005 with a minimum grade of C- or MATH:1380 with a minimum grade of C- or ALEKS score of 55 or higher. Recommendations: it is strongly recommended that students whose math placement score is older than one year retake the math placement test for accurate placement and success in the course.

**MATH:1020 Elementary Functions**  4 s.h.
Functions, relations, coordinate systems; properties and graphs of algebraic, trigonometric, logarithmic, exponential functions; inverse trigonometric functions; properties of lines, conic sections. Prerequisites: MATH:1010 with a minimum grade of C- or MATH:1005 with a minimum grade of C- or MPT Level 3 score of 9 or higher or ALEKS score of 60 or higher or MATH:1340 with a minimum grade of C-. Recommendations: it is strongly recommended that students whose math placement score is older than one year retake the math placement test for accurate placement and success in the course. GE: Quantitative or Formal Reasoning.

**MATH:1120 Logic of Arithmetic**  4 s.h.
Mathematical and conceptual foundations of the natural numbers used in elementary school arithmetic teaching; multiple algorithmic approaches to arithmetic and its mathematical and contextual relationships, extensions to integers, rational and irrational numbers, multiple representations. Prerequisites: ALEKS score of 30 or higher or MATH:1460 with a minimum grade of C- or MATH:1010 with a minimum grade of C- or MATH:1550 with a minimum grade of C- or MATH:1340 with a minimum grade of C- or MATH:1860 with a minimum grade of C- or MATH:1005 with a minimum grade of C- or MATH:1020 with a minimum grade of C- or MPT Level 3 score of 9 or higher or MATH:1850 with a minimum grade of C- or MATH:1380 with a minimum grade of C- or MATH:1440 with a minimum grade of C- or MATH:0100 with a minimum grade of C-. Recommendations: it is strongly recommended that students whose math placement score is older than one year retake the math placement test for accurate placement and success in the course. GE: Quantitative or Formal Reasoning.

**MATH:1140 Mathematical Basis of Elementary Geometry**  3 s.h.
Points, lines, planes; measurement, two- and three-dimensional coordinate geometry, transformational geometry and vectors; applications of geometry to solve real-world problems. Prerequisites: MPT Level 3 score of 9 or higher or MATH:1850 with a minimum grade of C- or ALEKS score of 30 or higher or MATH:1010 with a minimum grade of C- or MATH:1005 with a minimum grade of C- or MATH:1380 with a minimum grade of C- or MATH:1020 with a minimum grade of C- or MATH:1460 with a minimum grade of C- or MATH:1340 with a minimum grade of C- or MATH:1860 with a minimum grade of C- or MATH:1020 with a minimum grade of C- or MATH:1550 with a minimum grade of C-. Requirements: elementary teacher certificate candidacy or certification. Recommendations: it is strongly recommended that students whose math placement score is older than one year retake the math placement test for accurate placement and success in the course.

**MATH:1340 Mathematics for Business**  4 s.h.
Algebraic techniques, functions and functional models, exponential and logarithmic functions and models, applications of geometry to solve real-world problems. Prerequisites: MATH:1005 with a minimum grade of C- or MATH:1380 with a minimum grade of C- or MPT Level 3 score of 9 or higher or ALEKS score of 45 or higher. Recommendations: it is strongly recommended that students whose math placement score is older than one year retake the math placement test for accurate placement and success in the course. GE: Quantitative or Formal Reasoning.

**MATH:1380 Calculus and Matrix Algebra for Business**  4 s.h.
Quantitative methods for treating problems arising in management, economic sciences, related areas; introduction to differential and integral calculus, systems of linear equations and matrix operations. Prerequisites: MATH:1340 with a minimum grade of C- or MPT Level 3 score of 9 or higher or MATH:1020 with a minimum grade of C- or ALEKS score of 65 or higher or MATH:1440 with a minimum grade of C- or MATH:1005 with a minimum grade of C-. Recommendations: it is strongly recommended that students whose math placement score is older than one year retake the math placement test for accurate placement and success in the course. GE: Quantitative or Formal Reasoning.
MATH:1440 Mathematics for the Biological Sciences 4 s.h.
Relations, functions, coordinate systems, graphing, polynomials, trigonometric functions, logarithmic and exponential functions; discrete mathematics, probability; examples and applications from biological sciences. Prerequisites: MATH:1005 with a minimum grade of C- or MATH:1340 with a minimum grade of C- or ALEKS score of 55 or higher or MATH:1010 with a minimum grade of C- or MPT Level 3 score of 9 or higher. Recommendations: it is strongly recommended that students whose math placement score is older than one year retake the math placement test for accurate placement and success in the course. GE: Quantitative or Formal Reasoning.

MATH:1460 Calculus for the Biological Sciences 4 s.h.
One-semester survey of calculus for students in biological or life sciences; nontheoretical treatment of differential and integral calculus; brief introduction to differential equations and probability with calculus, with applications to the life sciences. Prerequisites: MATH:1440 with a minimum grade of C- or MATH:1020 with a minimum grade of C- or (MATH:1005 with a minimum grade of C- and MATH:1010 with a minimum grade of C-) or ALEKS score of 70 or higher or (ALEKS score of 55 or higher and MATH:1010 with a minimum grade of C-) or (MATH:1010 with a minimum grade of C- and MATH:1340 with a minimum grade of C-) or MPT Level 3 score of 9 or higher. Recommendations: it is strongly recommended that students whose math placement score is older than one year retake the math placement test for accurate placement and success in the course. GE: Quantitative or Formal Reasoning.

MATH:1550 Engineering Mathematics I: Single Variable Calculus 4 s.h.
Limits, derivatives, max/min, other applications, mean-value theorem, approximating functions, concavity, curve sketching, exponential models; Riemann sums, fundamental theorem; integration techniques, improper integrals, approximations. Prerequisites: (MATH:1010 with a minimum grade of C- and MATH:1005 with a minimum grade of C-) or MATH:1202 with a minimum grade of C- or ALEKS score of 75 or higher or (ALEKS score of 55 or higher and MATH:1010 with a minimum grade of C-) or (MATH:1010 with a minimum grade of C- and MATH:1340 with a minimum grade of C-) or MPT Level 3 score of 9 or higher. Recommendations: it is strongly recommended that students whose math placement score is older than one year retake the math placement test for accurate placement and success in the course. GE: Quantitative or Formal Reasoning.

MATH:1560 Engineering Mathematics II: Multivariable Calculus 4 s.h.
Vector geometry; functions of several variables; polar coordinates; partial derivatives, gradients, directional derivatives; tangent lines and planes; max/min/parametric curves, curvilinear motion; multiple integrals; vector fields, flows; integration on curves, work; divergence, flux, Green's theorem. Prerequisites: MATH:1550 with a minimum grade of C- or MATH:1850 with a minimum grade of C- or MPT Level 3 score of 15 or higher. Requirements: score of 4 or higher on AP Calc (AB) exam, or score of 4 or higher on AP Calc (BC) exam.
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
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<tbody>
<tr>
<td>MATH:2850</td>
<td>Calculus III</td>
<td>4 s.h.</td>
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<td>Multivariable calculus; vector functions, total differentials, gradient, implicit functions, coordinate systems, Taylor’s expansion, extrema, multiple integrals, vector fields, line integrals, surface integrals, and Green’s, Stokes’, and divergence theorems. Prerequisites: MATH:1860 with a minimum grade of C- or MATH:1560 with a minimum grade of C-.</td>
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<tr>
<td>MATH:2995</td>
<td>Introduction to Research Opportunities</td>
<td>1 s.h.</td>
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<td>Modern mathematics research areas and activities; seminar. Prerequisites: (MATH:2700 or MATH:2550) and (MATH:1560 or MATH:1860).</td>
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<tr>
<td>MATH:3550</td>
<td>Engineering Mathematics V: Vector Calculus</td>
<td>3 s.h.</td>
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<td>Partial derivatives, max-min problems, integrals along curves, surfaces and solids, vector fields and conservation of energy; curl, divergence, Stokes’ theorem and the divergence theorem; the classical partial differential equations and qualitative behavior of their solutions. Prerequisites: MATH:1560 and (MATH:2550 or MATH:2700). Corequisites: MATH:2560.</td>
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<tr>
<td>MATH:3600</td>
<td>Introduction to Ordinary Differential Equations</td>
<td>2-3 s.h.</td>
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<td>First-order ordinary differential equations; second-order linear differential equations; series solutions; higher-order linear and matrix differential equations; existence and uniqueness theorems. Prerequisites: (MATH:1560 or MATH:1860) and (MATH:2550 or MATH:2700). Corequisites: MATH:2850 (if not taken as a prerequisite). Requirements: prior or concurrent enrollment in MATH:2850.</td>
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<td>MATH:3700</td>
<td>Introduction to Matrix Theory</td>
<td>3 s.h.</td>
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<td>Vector algebra and geometry of three-dimensional Euclidean space and extensions to n-space and vector spaces; lines and planes, matrices, linear transformations, systems of linear equations, reduction to row-echelon form, dimension, rank, determinants, eigenvalues and eigenvectors, diagonalization, Principal Axis Theorem. Requirements: graduate standing.</td>
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<td>MATH:3720</td>
<td>Introduction to Abstract Algebra I</td>
<td>4 s.h.</td>
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<td>Basic logic, proof methods, sets, functions, relations, mathematical induction; gradual transition from familiar number systems to abstract structures—division algorithm, unique factorization theorems; groups, subgroups, quotient groups, homomorphisms. Prerequisites: MATH:2700 or MATH:2560.</td>
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<td>MATH:3750</td>
<td>Classical Analysis</td>
<td>3 s.h.</td>
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<td>Multivariable calculus; vector functions, total differentials, gradient, implicit functions, coordinate systems, Taylor’s expansion, extrema, multiple integrals, vector fields, line integrals, surface integrals, and Green’s, Stokes’, and divergence theorems. Requirements: graduate standing and one year of calculus.</td>
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<tr>
<td>MATH:3770</td>
<td>Fundamental Properties of Spaces and Functions I</td>
<td>4 s.h.</td>
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<td>Elementary topological and analytic properties of real numbers; emphasis on ability to handle definitions, theorems, proofs. Prerequisites: MATH:1560 or MATH:1860. Corequisites: MATH:2700. Requirements: second-semester calculus.</td>
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<td>MATH:3800</td>
<td>Elementary Numerical Analysis</td>
<td>3 s.h.</td>
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<td>Computer arithmetic, root finding, polynomial approximation, numerical integration, numerical linear algebra, numerical solution of differential equations; use of a higher-level computer language such as Matlab, Python, or Julia. Prerequisites: (MATH:2550 or MATH:2700) and (MATH:1560 or MATH:1860). Same as CS:3700.</td>
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<tr>
<td>MATH:3900</td>
<td>Introduction to Mathematics Research</td>
<td>3 s.h.</td>
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<td>Research experience; students study an elementary topic of active research, then work in groups under faculty supervision. Prerequisites: (MATH:2700 or MATH:2550) and (MATH:1860 or MATH:1560).</td>
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<td>MATH:3995</td>
<td>Topics in Mathematics</td>
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<td>Varied topics. Recommendations: junior, senior, or graduate standing in mathematics, classics, or related fields.</td>
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<tr>
<td>MATH:3996</td>
<td>Individual Study and Honors in Mathematics</td>
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<tr>
<td>MATH:3997</td>
<td>Readings in Mathematics</td>
<td>arr.</td>
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<tr>
<td>MATH:4010</td>
<td>Basic Analysis</td>
<td>3 s.h.</td>
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<td>Elementary topological and analytical properties of real numbers; emphasis on ability to handle definitions, theorems, proofs; same material as MATH:3770 for non-mathematics graduate students. Requirements: graduate standing, one year of calculus, and one semester of linear algebra.</td>
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<tr>
<td>MATH:4020</td>
<td>Basic Abstract Algebra</td>
<td>3 s.h.</td>
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<td>Basic logic, proof methods, sets, functions, relations, mathematical induction; gradual transition from familiar number systems to abstract structures (division algorithm, unique factorization theorems); groups, subgroups, quotient groups, homomorphisms; same material as MATH:3720; for non-mathematics graduate students. Requirements: graduate standing, one year of calculus, and one semester of linear algebra.</td>
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<td>MATH:4040</td>
<td>Matrix Theory</td>
<td>3 s.h.</td>
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<td>Vector spaces, linear transformations, matrices, equivalence of matrices, eigenvalues and eigenvectors, canonical forms, similarity, orthogonal transformations, bilinear and quadratic forms. Prerequisites: MATH:2700 or MATH:3700.</td>
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<tr>
<td>MATH:4050</td>
<td>Introduction to Discrete Mathematics</td>
<td>3 s.h.</td>
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<td>Basic methods of enumerative combinatorics, inclusion-exclusion and generating functions, applications of group theory (Polya-Burnside theorem). Offered fall semesters. Prerequisites: (MATH:1860 or MATH:1560) and (MATH:2550 or MATH:2700).</td>
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<td>MATH:4060</td>
<td>Discrete Mathematical Models</td>
<td>3 s.h.</td>
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<td>Basic combinatorics and graph theory, their applications (which may include scheduling, matching, optimization); Eulerian and Hamiltonian paths, spanning trees. Offered spring semesters. Prerequisites: MATH:2700 or MATH:2550.</td>
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<td>MATH:4080</td>
<td>Elementary Theory of Numbers</td>
<td>3 s.h.</td>
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<td>Factorization, congruence, Diophantine equations, law of quadratic reciprocity. Prerequisites: MATH:1860 and MATH:2700.</td>
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<td>MATH:4090</td>
<td>A Rigorous Introduction to Abstract Algebra</td>
<td>4 s.h.</td>
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<td>Rigorous review of groups including homomorphisms and quotient groups; group actions; Sylow’s theorems; rigorous review of rings; ideals, ring homomorphisms, quotient rings; polynomial rings; vector spaces and linear transformations; basic field theory; serves as a bridge between MATH:3720 and MATH:5000. Prerequisites: MATH:3720. Requirements: MATH:3720 or graduate standing.</td>
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MATH:4120 History of Mathematics 3 s.h.
May include numerical systems; Babylonian, Egyptian, and Greek mathematics; mathematics of other cultures; calculus; 19th- and 20th-century mathematics. Prerequisites: (MATH:2700 or MATH:2550) and (MATH:1560 or MATH:1860). Requirements: two semesters of calculus and one semester of linear algebra.

MATH:4200 Complex Variables 3 s.h.
Geometry of complex plane, analytic functions; Cauchy-Goursat theorem, applications; Laurent series, residues, elementary conformal mapping. Prerequisites: MATH:2850 or MATH:1560 or MATH:3750.

MATH:4210 Foundations of Analysis 4 s.h.
Introduction to fundamental ideas of analysis; emphasis on understanding and constructing definitions, theorems, and proofs; real and complex numbers, set theory in metric spaces, compactness and connectedness, sequences, Cauchy sequences, series, and continuity; elements of differential and integral calculus; sequences and series of functions; modes of convergence; equicontinuity; serves as a bridge between MATH:3770 and MATH:5200. Prerequisites: MATH:3770. Requirements: MATH:3770 or graduate standing.

MATH:4250 Introduction to Financial Mathematics 3 s.h.
Financial mathematics; option pricing and portfolio optimization, stochastic integration, methods due to Ito and Feynman-Kac, Monte-Carlo simulation. Prerequisites: MATH:2850 or STAT:3120.

MATH:4500 Introduction to Differential Geometry I 3 s.h.
Space curves, Frenet frames, intrinsic and extrinsic geometry of surfaces, first and second fundamental forms, isometries, Gauss map, Gaussian curvature, Theorema Egregium, geodesics, covariant differentiation; may include global theory of curves and Gauss-Bonnet theorem. Prerequisites: (MATH:3550 or MATH:2850) and (MATH:2700 or MATH:2550).

MATH:4510 Introduction to Differential Geometry II 3 s.h.
Continuation of MATH:4500; geometry of surfaces in Euclidean space, Gauss-Bonnet theorem and its applications, minimal surfaces, abstract surfaces; may include Riemannian manifolds, connections, elementary Lie groups, applications of differential geometry to other disciplines (physics, engineering). Prerequisites: MATH:4500.

MATH:4610 Continuous Mathematical Models 3 s.h.
Building and analyzing mathematical models involving differential equations for specific problems from engineering and the sciences; modeling project. Prerequisites: MATH:2560 or MATH:3600.

MATH:4740 Large Data Analysis 3 s.h.
Current areas that deal with problem of Big Data; techniques from computer science, mathematics, statistics; high performance and parallel computing, matrix techniques, cluster analysis, visualization; variety of applications including Google PageRank, seismology, Netflix-type problems, weather forecasting; fusion of data with simulation; projects. Prerequisites: (CS:1210 with a minimum grade of C- or ENGR:2730 with a minimum grade of C-) and (MATH:3800 or CS:3700) and (STAT:3200 or ISE:3760 or IGPI:3200). Same as CS:4740, IGPI:4740, STAT:4740.

MATH:4820 Optimization Techniques 3 s.h.
Basic theory of optimization, use of numerical algorithms in solution of optimization problems; linear and nonlinear programming, sensitivity analysis, convexity, optimal control theory, dynamic programming, calculus of variations. Prerequisites: (MATH:2700 or MATH:2550) and (ME:4111 or MATH:3800 or CS:3700) and (MATH:1560 or MATH:2850). Same as CS:4720.

MATH:4860 High Performance and Parallel Computing 3 s.h.
Parallel algorithms presented and implemented with different approaches and libraries (e.g., OpenMP, MPI); various platforms including Message Passing Clusters, Multicore and GPUs, MapReduce (Hadoop), and related current topics; scientific computing and large data analysis projects. Prerequisites: (CS:2210 with a minimum grade of C- or MATH:4050) and CS:2230 with a minimum grade of C-. Same as CS:4700.

MATH:5000 Abstract Algebra I 4 s.h.
Groups and homomorphisms, Sylow Theorems, rings, finitely generated modules over a PID, Galois theory, vector spaces, linear transformations and matrices, canonical forms. Prerequisites: MATH:3720 or MATH:4090.

MATH:5010 Abstract Algebra II 4 s.h.
Continuation of MATH:5000. Prerequisites: MATH:5000.

MATH:5200 Introduction to Analysis I 4 s.h.
Real numbers, fundamentals of limits and continuity in the context of metric spaces; Lebesque theory of functions of one real variable. Prerequisites: MATH:3770 or MATH:4210. Requirements: MATH:3770 or graduate standing.

MATH:5210 Introduction to Analysis II 4 s.h.
Local theory of analytic functions of one complex variable, power series, classical transcendental functions; spaces of functions. Prerequisites: MATH:5200.

MATH:5400 General Topology 4 s.h.
Basic concepts of general topological spaces and continuous functions: countability of sets, topological space, comparing topologies; subspace, order, and product topologies; closed sets and limit points, continuous functions, metric topology, quotient topology (including projective spaces and gluing cells), connectedness in the real line and in general spaces, components and local connectedness, compactness in Euclidean and general spaces, limit point compactness, local compactness, countability axioms, separation axioms, normal spaces and Urysohn's Lemma, complete metric spaces, convergence in function spaces. Prerequisites: MATH:3770 or MATH:4210.

MATH:5410 Introduction to Smooth Manifolds 4 s.h.
Calculus on smooth manifolds; smooth functions, mean value theorem, chain rule, smooth manifolds, tangent vectors, tangent spaces, inverse and implicit functions theorems, submersions and immersions, vector fields, flows, multilinear algebra, differential forms, Stokes theorem. Prerequisites: MATH:2700 and MATH:2850 and MATH:5400.

MATH:5600 Nonlinear Dynamics with Numerical Methods 4 s.h.
Nonlinear differential equations, one- and two-dimensional flows, stability, phase plane analysis, limit cycles, bifurcations, chaos, fractals; Euler's, multistep, and Runge-Kutta numerical methods. Prerequisites: MATH:3600 and (MATH:3770 or MATH:4210).
MATH:5700 Partial Differential Equations with Numerical Methods 4 s.h.
Conservation laws, weak solutions, diffusion equation, Laplace's equation, finite difference methods, variational methods, finite element method. Prerequisites: MATH:2850 and MATH:3600 and (MATH:3770 or MATH:4210).

MATH:5800 Numerical Analysis: Nonlinear Equations and Approximation Theory 4 s.h.
Root finding for nonlinear equations; polynomial interpolation; polynomial approximation of functions; numerical integration. Prerequisites: MATH:2700 and (MATH:2850 or MATH:3550). Requirements: knowledge of computer programming. Same as CS:5710.

MATH:5810 Numerical Analysis: Differential Equations and Linear Algebra 4 s.h.
Numerical methods for initial value problems for ordinary differential equations; direct and iterative methods for linear systems of equations; eigenvalue problems for matrices. Prerequisites: MATH:2700 and MATH:5800 and (MATH:2850 or MATH:3550) and (MATH:3600 or MATH:2560). Requirements: knowledge of computer programming. Same as CS:5720.

MATH:5900 First-Year Graduate Seminar 1 s.h.
Introduction to mathematics graduate program. Requirements: first-year graduate standing in mathematics.

MATH:5950 Qualifying Exam Preparation Seminars 0 s.h.
Exam preparation in pure and applied mathematics.

MATH:6000 Introduction to Algebra I 3 s.h.
Abstract algebra: semigroups, groups, rings, integral domains, polynomial rings, division rings, fields, vector spaces, matrices, modules over rings, lattices, categories. Prerequisites: MATH:5010.

MATH:6010 Introduction to Algebra II 3 s.h.
Continuation of MATH:6000. Prerequisites: MATH:6000.

MATH:6200 Analysis I 3 s.h.
Lebesgue measure and integral, fundamental theorem of calculus, abstract measures and integration, Fubini's theorem, Radon-Nikodym theorem, Riesz representation theorem, L-p spaces. Prerequisites: MATH:5210.

MATH:6210 Analysis II 3 s.h.
Hilbert space, Banach space techniques; Hahn-Banach theorem, open mapping theorem, principle of uniform boundedness; reflexivity, H-p spaces, Paley-Wiener theorem, space of functions analytic on the open unit disk. Prerequisites: MATH:6200.

MATH:6400 Introduction to Algebraic Topology 3 s.h.
Homotopy, fundamental group and covering spaces, CW and simplicial complexes, simplicial homology, Euler characteristic. Prerequisites: MATH:5400.

MATH:6410 Introduction to Differential Topology 3 s.h.
Manifolds, functions: tangent bundle, Morse-Sard theorem, transversality, submanifolds, tubular neighborhoods, normal bundles, vector fields, degree and intersection theory, fixed-point theory, Morse theory. Prerequisites: MATH:5410.

MATH:6500 Differential Geometry I 3 s.h.
Differentiable manifolds, forms, tensors, Riemannian metrics, isometries, connections, geodesics, curvature, related topics. Prerequisites: MATH:5410.

MATH:6510 Differential Geometry II 3 s.h.
Continuation of MATH:6500; varied topics, may include study of existence and uniqueness of solutions to differential equations and systems related to geometry, indefinite metrics, Lie groups, attributes of manifolds with particular curvature properties, global Riemannian geometry, Kahler geometry, applications of differential geometry to other disciplines. Prerequisites: MATH:6500.

MATH:6600 Ordinary Differential Equations I 3 s.h.
Existence, uniqueness, continuous dependence of solutions to initial value problems, variational calculus, Lagrangian and Hamiltonian systems, differential inequalities, perturbation theory, normal forms, invariant manifolds, KAM theory, bifurcation theory, boundary value problems. Prerequisites: MATH:5210.

MATH:6610 Ordinary Differential Equations II 3 s.h.
Continuation of MATH:6600. Prerequisites: MATH:6600.

MATH:6700 Partial Differential Equations I 3 s.h.
Elliptic equations; potential theory, maximum principle, a priori estimate, Dirichlet problem; initial value problem for parabolic equations; hyperbolic equations; Duhamel's principle, Cauchy problem; nonlinear equations, characteristics, canonical form, first-order systems. Prerequisites: MATH:5210.

MATH:6710 Partial Differential Equations II 3 s.h.
Continuation of MATH:6700. Prerequisites: MATH:6700.

MATH:6850 Theoretical Numerical Analysis I 3 s.h.
Theoretical foundations of numerical analysis, within framework of functional analysis; application areas including approximation theory, numerical methods for partial differential equations, integral equations; introduction to functional analysis. Prerequisites: MATH:5200 and MATH:5210 and MATH:5800 and MATH:5810.

MATH:6860 Theoretical Numerical Analysis II 3 s.h.
Continuation of MATH:6850. Prerequisites: MATH:6850.

MATH:7000 Homological Algebra 2-3 s.h.
Modules, tensor products, groups of homomorphisms, categories, functors, homology functors, projective and injective modules, derived functors, torsion and extension functors, homological dimension. Prerequisites: MATH:6010.

MATH:7030 Topics in Algebra 2-3 s.h.
May include algebraic number theory, groups, representation theory, algebras, ideal theory, lattice theory. Prerequisites: MATH:6010.

MATH:7070 Seminar: Algebra arr.

MATH:7080 Seminar: Commutative Ring Theory arr.

MATH:7090 Seminar: Representation Theory arr.

MATH:7200 Functional Analysis I 2-3 s.h.
Locally convex topological vector spaces, duality, tensor products and nuclear spaces; Krein-Millman theorem, Choquet's theorem; geometry of Banach spaces, nonlinear functional analysis; operators on Hilbert spaces, spectral theorem, algebras of operators. Prerequisites: MATH:6210.

MATH:7210 Functional Analysis II 2-3 s.h.
Continuation of MATH:7200. Prerequisites: MATH:7200.

MATH:7250 Topics in Analysis 2-3 s.h.
Measure theory, integration, general topology.

MATH:7400 Topology of Manifolds  3 s.h.
Embedding, knotting, immersions; isotopy, homotopy, regular
neighborhoods, engulfing, surgery, cobordism; three-, four-, and higher dimensional manifolds. Prerequisites: MATH:6400
and MATH:6410.

MATH:7450 Topics in Topology  2-3 s.h.
May include homotopy theory, topology of 3-manifolds, 4-
manifolds, or higher-dimensional manifolds, knotting and
embedding problems, fiber bundles and characteristic classes,
K-theory, PL manifolds, infinite-dimensional manifolds.

MATH:7470 Seminar: Topology  arr.
MATH:7580 Seminar: Mathematical Physics  arr.
MATH:7630 Topics in Mathematical Biology  2-3 s.h.
Application of mathematics to biology.

MATH:7660 Seminar: Nonlinear Dynamics and
Differential Equations  arr.
MATH:7670 Seminar: Mathematical Biology  arr.
MATH:7730 Topics in Partial Differential
Equations  2-3 s.h.
Regularity theory, nonlinear analysis in partial differential
equations, fluid dynamics, harmonic analysis, conservation
laws, other topics.

MATH:7830 Topics in Applied Mathematics  arr.
Application of mathematics to other disciplines.

MATH:7870 Seminar: Numerical Analysis  arr.
MATH:7990 Reading Research  arr.