Mth 511 - Introduction to Real Analysis I (3)
Sequences and series of functions; Lebesgue measure and integration; the Stone-Weierstrass and Baire category theorems; Fourier Series; elements of functional analysis. This is the first course in a sequence of three: Mth 511, Mth 512 and Mth 513 which must be taken in sequence. Also offered for undergraduate-level credit as Mth 411 and may be taken only once for credit.
Prerequisite: Mth 312.

Mth 512 - Introduction to Real Analysis II (3)
Sequences and series of functions; Lebesgue measure and integration; the Stone-Weierstrass and Baire category theorems; Fourier Series; elements of functional analysis. This is the second course in a sequence of three: Mth 511, Mth 512 and Mth 513 which must be taken in sequence. Also offered for undergraduate-level credit as Mth 412 and may be taken only once for credit.
Prerequisite: Mth 312.

Mth 513 - Introduction to Real Analysis III (3)
Sequences and series of functions; Lebesgue measure and integration; the Stone-Weierstrass and Baire category theorems; Fourier Series; elements of functional analysis. This is the third course in a sequence of three: Mth 511, Mth 512 and Mth 513 which must be taken in sequence. Also offered for undergraduate-level credit as Mth 413 and may be taken only once for credit.
Prerequisite: Mth 312.

Mth 520 - Introduction to Complexity Theory (3)
An introduction to theoretical computer science. Includes a study of models of computation, complexity classes, Cook's theorem, polynomial and nonpolynomial classes, discrete problems.
Prerequisite: Mth 344.

Mth 521 - Theory of Ordinary Differential Equations I (3)
Vector fields and phase flows in the plane. Geometric and algebraic properties of linear systems. Existence, uniqueness, and continuity theorems for systems. Additional topics. This is the first course in a sequence of three: Mth 521, Mth 522, and Mth 523 which must be taken in sequence. Also offered for undergraduate-level credit as Mth 421 and may be taken only once for credit.
Prerequisite: Mth 312.

Mth 522 - Theory of Ordinary Differential Equations II (3)
Vector fields and phase flows in the plane. Geometric and algebraic properties of linear systems. Existence, uniqueness, and continuity theorems for systems. Additional topics. This is the second course in a sequence of three: Mth 521, Mth 522, and Mth 523 which must be taken in sequence. Also offered for undergraduate-level credit as Mth 422 and may be taken only once for credit.
Prerequisite: Mth 312.

Mth 523 - Theory of Ordinary Differential Equations III (3)
Vector fields and phase flows in the plane. Geometric and algebraic properties of linear systems. Existence, uniqueness, and continuity theorems for systems. Additional topics. This is the third course in a sequence of three: Mth 521, Mth 522, and Mth 523 which must be taken in sequence. Also offered for undergraduate-level credit as Mth 423 and may be taken only once for credit.
Prerequisite: Mth 312.

Mth 524 - Elementary Differential Geometry I (3)
Differential geometry of curves and surfaces; elementary Riemannian geometry; the Gauss-Bonnet theorem; applications from mechanics and field theory. This is the first course in a sequence of two: Mth 524 and Math 525 which must be taken in sequence. Also offered for undergraduate-level credit as Mth 424 and may be taken only once for credit.
Prerequisite: Either Mth 421 or both Mth 254 and Mth 256.

Mth 525 - Elementary Differential Geometry II (3)
Differential geometry of curves and surfaces; elementary Riemannian geometry; the Gauss-Bonnet theorem; applications from mechanics and field theory. This is the second course in a sequence of two: Mth 424 and Math 425 which must be taken in sequence. Also offered for undergraduate-level credit as Mth 525 and may be taken only once for credit.
Prerequisite: Either Mth 421 or both Mth 254 and Mth 256.
Mth 527 - Partial Differential Equations I (3)
Solution techniques, qualitative analysis and applications: separation of variables, eigenfunction expansion, Sturm-Liouville problems, Green's functions, Fourier transform solutions, finite difference and finite element methods. This is the first course in a sequence of two: Mth 527 and Mth 528 which must be taken in sequence. Also offered for undergraduate-level credit as Mth 427 and may be taken only once for credit.
Prerequisite: Mth 256, Mth 253/254. Prior knowledge of PDEs (Mth 322) is recommended, but not required.

Mth 528 - Partial Differential Equations II (3)
Solution techniques, qualitative analysis and applications: separation of variables, eigenfunction expansion, Sturm-Liouville problems, Green's functions, Fourier transform solutions, finite difference and finite element methods. This is the second course in a sequence of two: Mth 527 and Mth 528 which must be taken in sequence. Also offered for undergraduate-level credit as Mth 428 and may be taken only once for credit.
Prerequisite: Mth 256, Mth 253/254. Prior knowledge of PDEs (Mth 322) is recommended, but not required.

Mth 530 - Topics in Mathematical Modeling (3)
Basic introduction to mathematical model building starting with prototype, model purpose definition, and model validation. Models will be chosen from life, the physical and social sciences. Applications chosen from differential equations, linear programming, group theory, probability or other fields. Also offered for undergraduate-level credit as Mth 430.
Prerequisite: Consent of instructor and either Mth 256 or 421/521. With approval, this course may be repeated for credit.

Mth 531 - Topics in Geometry I (3)
Topics selected from projective geometry, non-Euclidean geometry, algebraic geometry, convexity, differential geometry, foundations of geometry, combinatorial topology. This is the first course in a sequence of three: Mth 531, Mth 532, and Mth 533; with departmental approval, this sequence may be repeated for credit. Also offered for undergraduate-level credit as Mth 431.
Prerequisite: Mth 311, Mth 338, or Mth 344.

Mth 532 - Topics in Geometry II (3)
Topics selected from projective geometry, non-Euclidean geometry, algebraic geometry, convexity, differential geometry, foundations of geometry, combinatorial topology. This is the second course in a sequence of three: Mth 531, Mth 532, and Mth 533; with departmental approval, this sequence may be repeated for credit. Also offered for undergraduate-level credit as Mth 432.
Prerequisite: Mth 311, Mth 338, or Mth 344.

Mth 533 - Topics in Geometry III (3)
Topics selected from projective geometry, non-Euclidean geometry, algebraic geometry, convexity, differential geometry, foundations of geometry, combinatorial topology. This is the third course in a sequence of three: Mth 531, Mth 532, and Mth 533; with departmental approval, this sequence may be repeated for credit. Also offered for undergraduate-level credit as Mth 433.
Prerequisite: Mth 311, Mth 338, or Mth 344.

Mth 534 - Set Theory and Topology I (3)
Cardinal and ordinal numbers. The axiom of choice and equivalent formulations. Introduction to general topology with the notions of interior, closure, topological space, continuity, and homeomorphism. Construction techniques and properties of point-set topology, especially connectedness, compactness, and separation. Additional topics. This is the first course in a sequence of three: Mth 534, Mth 535, and Mth 536 which must be taken in sequence. Also offered for undergraduate-level credit as Mth 434 and may be taken only once for credit.
Prerequisite: Mth 311.

Mth 535 - Set Theory and Topology II (3)
Cardinal and ordinal numbers. The axiom of choice and equivalent formulations. Introduction to general topology with the notions of interior, closure, topological space, continuity, and homeomorphism. Construction techniques and properties of point-set topology, especially connectedness, compactness, and separation. Additional topics. This is the second course in a sequence of three: Mth 534, Mth 535, and Mth 536 which must be taken in sequence. Also offered for undergraduate-level credit as Mth 435 and may be taken only once for credit.
Prerequisite: Mth 311.

Mth 536 - Set Theory and Topology III (3)
Cardinal and ordinal numbers. The axiom of choice and equivalent formulations. Introduction to general topology with the notions of interior, closure, topological space, continuity, and homeomorphism. Construction techniques and properties of point-set topology, especially connectedness, compactness, and separation. Additional topics. This is the third course in a sequence of three: Mth 534, Mth 535, and Mth 536 which must be taken in sequence. Also offered for undergraduate-level credit as Mth 436 and may be taken only once for credit.
Prerequisite: Mth 311.
Mth 540 - Boolean Algebra (4)
Prerequisite: Mth 344.

Mth 541 - Introduction to Abstract Algebra I (3)
Groups and rings with homomorphism theorems, vector spaces, modules, algebraic theory of fields and Galois theory, lattices, algebras. This is the first course in a sequence of three: Mth 541, Mth 542, and Mth 543 which must be taken in sequence. Also offered for undergraduate-level credit as Mth 441 and may be taken only once for credit.
Prerequisite: Mth 344.

Mth 542 - Introduction to Abstract Algebra II (3)
Groups and rings with homomorphism theorems, vector spaces, modules, algebraic theory of fields and Galois theory, lattices, algebras. This is the second course in a sequence of three: Mth 541, Mth 542, and Mth 543 which must be taken in sequence. Also offered for undergraduate-level credit as Mth 442 and may be taken only once for credit.
Prerequisite: Mth 344.

Mth 543 - Introduction to Abstract Algebra III (3)
Groups and rings with homomorphism theorems, vector spaces, modules, algebraic theory of fields and Galois theory, lattices, algebras. This is the third course in a sequence of three: Mth 541, Mth 542, and Mth 543 which must be taken in sequence. Also offered for undergraduate-level credit as Mth 443 and may be taken only once for credit.
Prerequisite: Mth 344.

Mth 544 - Advanced Linear/Multilinear Algebra I (3)
A second course in linear algebra. Products, quotients, and duals of vector spaces. Multilinear maps, tensor products, exterior algebra. Minimal and characteristic polynomials, canonical forms. Finite dimensional spectral theory. This is the first course in a sequence of two: Mth 544 and Mth 545 which must be taken in sequence. Also offered for undergraduate-level credit as Mth 444 and with departmental approval, this sequence may be repeated for credit.
Prerequisite: Mth 344.

Mth 545 - Advanced Linear/Multilinear Algebra II (3)
A second course in linear algebra. Products, quotients, and duals of vector spaces. Multilinear maps, tensor products, exterior algebra. Minimal and characteristic polynomials, canonical forms. Finite dimensional spectral theory. This is the second course in a sequence of two: Mth 544 and Mth 545 which must be taken in sequence. Also offered for undergraduate-level credit as Mth 445 and with departmental approval, this sequence may be repeated for credit.
Prerequisite: Mth 344.

Mth 549 - Topics in Advanced Number Theory (3)
A study of advanced topics selected from the areas of algebraic or analytic theory. With departmental approval, this course may be repeated for credit. Also offered for undergraduate-level credit as Mth 449 and may be taken only once for credit.
Prerequisite: Mth 346.

Mth 551 - Numerical Calculus I (3)
Computer arithmetic. Solution of nonlinear equations. Interpolation. Numerical integration and differentiation. Solution of linear equation systems. Eigenvalue problem, least square, Chebyshev, trigonometric and rational function approximation. Numerical solution of differential equations. This is the first course in a sequence of three: Mth 551, Mth 552, and Mth 553 which must be taken in sequence. Also offered for undergraduate-level credit as Mth 451 and may be taken only once for credit.
Prerequisite: knowledge of a programming language such as MATLAB or C/C++, Mth 253 and Mth 261.

Mth 552 - Numerical Calculus II (3)
Computer arithmetic. Solution of nonlinear equations. Interpolation. Numerical integration and differentiation. Solution of linear equation systems. Eigenvalue problem, least square, Chebyshev, trigonometric and rational function approximation. Numerical solution of differential equations. This is the second course in a sequence of three: Mth 551, Mth 552, and Mth 553 which must be taken in sequence. Also offered for undergraduate-level credit as Mth 452 and may be taken only once for credit.
Prerequisite: knowledge of a programming language such as MATLAB or C/C++, Mth 253 and Mth 261.
Mth 553 - Numerical Calculus III (3)

Computer arithmetic. Solution of nonlinear equations. Interpolation. Numerical integration and differentiation. Solution of linear equation systems. Eigenvalue problem, least square, Chebyshev, trigonometric and rational function approximation. Numerical solution of differential equations. This is the third course in a sequence of three: Mth 551, Mth 552, and Mth 553 which must be taken in sequence. Also offered for undergraduate-level credit as Mth 453 and may be taken only once for credit.

Prerequisite: knowledge of a programming language such as MATLAB or C/C++, Mth 253 and Mth 261.

Mth 556 - Topics in Combinatorics (3)

Selected topics from: permutations, combinations, partitions, generating functions, inclusion/exclusion, recursion, Polya counting, block designs, orthogonal polynomials, and error-correcting codes. Also offered for undergraduate-level credit as Mth 456; with departmental approval may be repeated for credit.

Prerequisite: Mth 356 or CS 251.

Mth 557 - The Mathematical Theory of Games (3)

Introduction to mathematical game theory and game theoretic analysis. Topics include: combinatorial and strategic games, Perfect Competition, Zermelo's Algorithm, Payoffs, cooperative and non-cooperative games, bargaining, mixed strategies, Nash Equilibrium, repeated games and finite automata, common knowledge and incomplete information, the prisoner's dilemma. Selected applications to economics, biology, computer science, and political science. This is the first course in a sequence of two: Mth 557 and Mth 558. Also offered for undergraduate-level credit as Mth 457 and may be taken only once for credit.

Prerequisite: Mth 261 and/or Stat 243.

Mth 558 - The Mathematical Theory of Games (3)

Introduction to mathematical game theory and game theoretic analysis. Topics include: combinatorial and strategic games, Perfect Competition, Zermelo's Algorithm, Payoffs, cooperative and non-cooperative games, bargaining, mixed strategies, Nash Equilibrium, repeated games and finite automata, common knowledge and incomplete information, the prisoner's dilemma. Selected applications to economics, biology, computer science, and political science. This is the second course in a sequence of two: Mth 557 and Mth 558. Also offered for undergraduate-level credit as Mth 458 and may be taken only once for credit.

Prerequisite: Mth 261 and/or Stat 243.

Mth 561 - Graph Theory I (3)

Topics in graph theory, including connectivity, matchings, graph algorithms, network flows, graph matrices, isomorphisms, Eulerian and Hamiltonian graphs, spanning trees, decompositions, shortest paths, the matrix-tree theorem, colorings of graphs, planarity and embeddings, Kuratowski's theorem, matroids, and selected applications. This is the first course in a sequence of two: Mth 561 and Mth 562 which must be taken in sequence. Also offered for undergraduate-level credit as Mth 461 and may be taken only once for credit.

Prerequisite: Mth 261, 356.

Mth 562 - Graph Theory II (3)

Topics in graph theory, including connectivity, matchings, graph algorithms, network flows, graph matrices, isomorphisms, Eulerian and Hamiltonian graphs, spanning trees, decompositions, shortest paths, the matrix-tree theorem, colorings of graphs, planarity and embeddings, Kuratowski's theorem, matroids, and selected applications. This is the second course in a sequence of two: Mth 561 and Mth 562 which must be taken in sequence. Also offered for undergraduate-level credit as Mth 462 and may be taken only once for credit.

Prerequisite: Mth 261.

Mth 570 - Complex Analysis and Boundary Value Problems I (3)

Fundamental concepts of complex variables, partial differential equations and boundary value problems using Fourier series. This is the first course in a sequence of three: Mth 570, Mth 571, and Mth 572. Also offered for undergraduate-level credit as Mth 470 and may be taken only once for credit. Prerequisite: Mth 254 and either 256 or 421.

Mth 571 - Complex Analysis and Boundary Value Problems II (3)

Fundamental concepts of complex variables, partial differential equations and boundary value problems using Fourier series. This is the second course in a sequence of three: Mth 570, Mth 571, and Mth 572. Also offered for undergraduate-level credit as Mth 471 and may be taken only once for credit.

Prerequisite: Mth 254 and either 256 or 421.

Mth 572 - Complex Analysis and Boundary Value Problems III (3)

Fundamental concepts of complex variables, partial differential equations and boundary value problems using Fourier series. This is the third course in a sequence of three: Mth 570, Mth 571, and Mth 572. Also offered for undergraduate-level credit as Mth 472 and may be taken only once for credit.
Prerequisite: Mth 254 and either 256 or 421.

**Mth 577 - Mathematical Control Theory I (3)**

Mathematical foundations of linear time invariant control systems. Controllability, observability, stabilizability, feedback. Elements of the calculus of variations and optimal control. Dynamic programming. Pontryagin maximum principle. Applications. This is the first course in a sequence of two: Mth 577 and Mth 578. Also offered for undergraduate-level credit as Mth 477 and may be taken only once for credit.

Prerequisite: Mth 256. Expected preparation: Mth 253, 254.

**Mth 578 - Mathematical Control Theory II (3)**

Mathematical foundations of linear time invariant control systems. Controllability, observability, stabilizability, feedback. Elements of the calculus of variations and optimal control. Dynamic programming. Pontryagin maximum principle. Applications. This is the second course in a sequence of two: Mth 577 and Mth 578. Also offered for undergraduate-level credit as Mth 478 and may be taken only once for credit.

Prerequisite: Mth 256. Expected preparation: Mth 253, 254.

**Mth 580 - Systems Analysis: Calculus of Variations (3)**

Basic problems of the calculus of variations. Euler equations. Lagrange conditions. Lagrange multipliers. Lagrange equations. Hamilton's equations. Application to mechanical and electrical systems. Also offered for undergraduate-level credit as Mth 480 and may be taken only once for credit.

Prerequisite: Mth 256 or 422/522.