MATHEMATICS MTH

Department of Mathematics
College of Natural Science

1005 Fundamentals of Algebra
Summer. 1(1-0)
Factoring. Rational and exponential expressions. Linear and quadratic relations. Fractions and distributive laws. Functions

100E Intermediate Algebra Workshop for the Mathematics Enrichment Program
Fall, Spring. 1(0-4) R: Approval of department. C: MTH 1825 concurrently.
Enrichment topics in intermediate algebra for students in the Mathematics Enrichment Program.

103 College Algebra
Fall, Spring, Summer. 3(3-0) P: (MTH 1825) or designated score on Mathematics Placement test SA: LBS 117 Not open to students with credit in MTH 116.
Number systems; functions and relations; exponents and logarithms; elementary theory of equations; inequalities; and systems of equations.

103E College Algebra Workshop for the Mathematics Enrichment Program
Fall, Spring. 1(0-4) R: Approval of department. C: MTH 103 concurrently.
Enrichment topics in college algebra for students in the Mathematics Enrichment Program.

110 Finite Mathematics and Elements of College Algebra
Fall, Spring, Summer. 5(5-0) P: (MTH 1825) or designated score on Mathematics Placement test Not open to students with credit in MTH 112.
Functions and graphs. Equations and inequalities. Systems of equations. Matrices. Linear programming. Simplex algorithm. Probability and statistics.

110E Finite Mathematics and Elements of College Algebra for Mathematics Enrichment
Spring. 1(0-2) R: Approval of department. C: MTH 110 concurrently.
Enrichment topics in finite mathematics and elements of college algebra.

112 Finite Mathematics: Applications of College Algebra
Fall, Spring, Summer. 3(3-0) P: (MTH 103) or designated score on Mathematics Placement test SA: MTH 106 Not open to students with credit in MTH 110.
Combinatorics, probability and statistics, mathematics of finance, geometry, transition matrices, and linear programming. The course emphasizes applications and includes work using spreadsheets.

112E Finite Mathematics Workshop for Mathematics Enrichment Program
Spring. 1(0-4) R: Approval of department SA: MTH 106E C: MTH 112 concurrently.
Enrichment topics in Finite Mathematics for students in the Mathematics Enrichment Program.

114 Trigonometry
Fall, Spring, Summer. 3(3-0) P: MTH 103 SA: MTH 104 Not open to students with credit in MTH 116.
Radian and degree measure of angles. Definitions and graphs of trigonometric functions and their inverses. Solving trigonometric equations. Applications including identities, indirect measurement and trigonometric modeling.

116 College Algebra and Trigonometry
Fall, Spring, Summer. 5(5-0) P: (MTH 1825) or designated score on Mathematics Placement test SA: LBS 117 Not open to students with credit in MTH 103.
Functions and graphs. Equations and inequalities. Exponential and logarithmic functions. Trigonometric functions. Systems of equations. Binomial theorem.

116E Precalculus Workshop for the Emerging Scholars Program
Fall. 1(0-4) R: Approval of department. C: MTH 116 concurrently.
Enrichment topics in precalculus for students in the Emerging Scholars Program.

124 Survey of Calculus I
Fall, Spring, Summer. 3(3-0) P: (MTH 103 or MTH 116) or designated score on Mathematics Placement test Not open to students with credit in LB 118 or MTH 132 or MTH 152H.
Study of limits, continuous functions, derivatives, integrals and their applications.

124E Survey of Calculus with Applications I Mathematics Enrichment Workshop
Fall. 1(0-4) R: Approval of department. C: MTH 124 concurrently.
Enrichment topics in Survey of Calculus with Applications I for students in the Mathematics Enrichment Program.

126 Survey of Calculus II
Fall, Spring, Summer. 3(3-0) P: MTH 124 Not open to students with credit in MTH 133 or MTH 153H.
Application of partial derivatives, integrals, optimization of functions of several variables and differential equations.

132 Calculus I
Fall, Spring, Summer. 3(3-0) P: (MTH 103 and MTH 114) or (MTH 116 or designated score on Mathematics Placement test) Not open to students with credit in LB 118 or MTH 152H.
Limits, continuous functions, derivatives and their applications. Integrals and the fundamental theorem of calculus.

132E Calculus I Workshop for the Emerging Scholars Program
Fall, Spring. 2(0-6) R: Approval of department. C: MTH 132 concurrently.
Enrichment topics in Calculus I for students in the Emerging Scholars Program.

133 Calculus II
Fall, Spring, Summer. 4(4-0) P: MTH 132 or MTH 152H Not open to students with credit in LB 118 or LB 119 or MTH 153H.
Applications of the integral and methods of integration. Improper integrals. Polar coordinates and parametric curves. Sequences and series. Power series.

133E Calculus II Workshop for the Emerging Scholars Program
Fall, Spring. 1(0-4) R: Approval of department. C: MTH 133 concurrently.
Enrichment topics in Calculus II for students in the Emerging Scholars Program.

152H Honors Calculus I
Fall. 3(3-0) R: Open to students in the Honors College or approval of department. Not open to students with credit in LB 118 or MTH 132.
Limits, continuous functions, derivatives, integrals, fundamental theorem of calculus. Special emphasis on concepts and theory.

153H Honors Calculus II
Fall, Spring. 3(3-0) P: MTH 152H R: Open to students in the Honors College or approval of department. Not open to students with credit in LB 119 or MTH 133.
The integral. Improper integrals. Polar coordinates and parametric curves. Sequences and series. Power and Taylor series. Special emphasis on concepts and theory.

1825 Intermediate Algebra
Fall, Spring, Summer. 3(3-0)
Properties of real numbers. Factoring. Roots and radicals. First and second degree equations. Linear inequalities. Polynomials. Systems of equations.

201 Elementary Mathematics for Teachers I
Fall, Spring, Summer. 3(3-0) P: (MTH 103 or MTH 110 or MTH 116 or MTH 124 or MTH 132 or MTH 152H or LB 118) or designated score on Mathematics Placement test R: Open to students in the Child Development major or in the Education major or in the Special Education-Deaf Education major or in the Special Education-Learning Disabilities major or in the Teacher Certification Internship Year Studies Program.
Mathematics needed for K-8 teaching. Place value and models for arithmetic, mental math, word problems, and algorithms. Factors, primes, proofs, and prealgebra. Fractions, ratios, rates, and percentages. Negative, rational, and real numbers. Special emphasis on the appropriate sequential order for teaching.

202 Elementary Mathematics for Teachers II
Fall, Spring, Summer. 3(3-0) P: MTH 201 R: Open to students in the Child Development major or in the Education major or in the Special Education-Deaf Education major or in the Special Education-Learning Disabilities major or in the Teacher Certification Internship Year Studies Program.
A continuation of MTH 201. Geometry,measurement,and elementary data analysis.

234 Multivariable Calculus
Fall, Spring, Summer. 4(4-0) P: MTH 133 or MTH 153H or LB 119 Not open to students with credit in MTH 254H or LB 220.
Vectors in space. Functions of several variables and partial differentiation. Multiple integrals. Line and surface integrals. Green`s and Stokes`s theorems.

235 Differential Equations
Fall, Spring, Summer. 3(4-0) P: MTH 234 or MTH 254H or LB 220 R: Not open to students in the Department of Mathematics or in the Lyman Briggs Computational Mathematics Coordinate Major or in the Lyman Briggs Mathematics Coordinate Major. Not open to students with credit in MTH 255H.
Separable and exact equations. Linear equations and variation of parameters. Higher order linear equations. Laplace transforms. Systems of first-order linear equations. Introduction to partial differential equations and Fourier series.

254H Honors Multivariable Calculus
Fall, Spring. 3(3-0) P: MTH 153H R: Open to students in the Honors College or approval of department. Not open to students with credit in LB 220 or MTH 234.
Vectors in space. Functions of several variables and partial differentiation. Multiple integrals. Line and surface integrals. Green`s and Stokes`s Theorems.

255H Honors Differential Equations
Fall, Spring. 3(3-0) P: MTH 254H R: Not open to students in the Bachelor of Arts in Mathematics or Bachelor of Science in Mathematics or Lyman Briggs School Mathematics coordinate majors. Not open to students with credit in MTH 235.
Topics chosen from separable and exact equations, linear equations and variation of parameters, series solutions, higher order linear equations, Laplace transforms, systems of first-order linear equations, nonlinear equations and stability, introduction to partial differential equations.

290 Directed Study
Fall, Spring, Summer. 1 to 4 credits. A student may earn a maximum of 6 credits in all enrollments for this course.
Faculty directed study of selected mathematical topics.

301 Foundations of Higher Mathematics
Fall, Spring. 3(3-0) P: MTH 133 or MTH 153H or LBS 119
Elementary set theory including permutations, combinations, cardinality theorems, relations functions and quotient sets. Basic principles of logic and proof techniques. Elementary number theory and abstract algebra.

309 Linear Algebra I
Fall, Spring, Summer. 3(3-0) P: (MTH 234 or MTH 254H or LB 220) and completion of Tier I writing requirement
Matrices, systems of linear equations, vector spaces, linear transformations, inner products and orthogonal spaces, eigenvalues and eigenvectors, and applications to geometry. A writing course with emphasis on proofs.

310 Abstract Algebra I and Number Theory
Fall, Spring, Summer. 3(3-0) P: (MTH 309) and completion of Tier I writing requirement
Structure of the integers, congruences, polynomial rings, and ideals. A writing course with emphasis on proofs.

314 Matrix Algebra with Applications
Fall, Spring, Summer. 3(3-0) P: MTH 234 or MTH 254H or LB 220 R: Not open to students in the Department of Mathematics or in the Lyman Briggs Computational Mathematics Coordinate Major or in the Lyman Briggs Mathematics Coordinate Major.
Problem-solving and applications in matrix algebra for scientists and engineers. Vectors, matrices, linear transformations, inner products, dimension, eigenvalues and eigenvectors. Applications to systems of equations and to geometry.

320 Analysis I
Fall, Spring, Summer. 3(3-0) P: (MTH 234 or MTH 254H or LB 220) and (MTH 309 or MTH 310) Not open to students with credit in MTH 428H.
Convergence of sequences and series. Upper and lower limits, completeness, limits and continuity. Derivatives. Uniform convergence.

330 Higher Geometry
Fall, Spring. 3(3-0) P: MTH 301 or MTH 309
Topics in transformations: isometries, similarities, inversion. Advanced Euclidean geometry: theorems of Menelaus, Ceva, and Desargue. Cross ratio, harmonic points, analytic, metric, and vector methods, and convexity.

340 Ordinary Differential Equations I
Fall, Spring, Summer. 3(3-0) P: MTH 309
Techniques for solving differential equations, existence and uniqueness theorems, qualitative theory, Fourier series and applications.

360 Theory of Mathematical Interest
Fall, Spring. 3(3-0) P: (MTH 234 or concurrently) or (MTH 254H or concurrently) or (LBS 220 or concurrently) or approval of department
Measurement of interest rates, basic problems in interest theory, basic annuities, continuous and varying annuities, yield rates, amortization, bonds and other securities, practical applications, and stochastic approaches to interest.

370 Mathematical Biology
Fall. 3(3-0) P: (MTH 132 or LBS 118 or approval of department) and (MTH 133 or LBS 119 or approval of department) and (BS 110 or BS 111 or BS 148H or BS 149H or LBS 144 or LBS 145 or LBS 148H or LBS 149H)
First-order linear ordinary differential equations and systems. Qualitative theory of nonlinear continuous dynamical systems. Reaction-diffusion equations. Numerical analysis and computer simulation of solutions to nonlinear systems of differential equations. Numerical linear algebra. Applications to biological sciences.

371 Statistical Biology
Spring. 3(3-0) Interdepartmental with Statistics and Probability. Administered by Statistics and Probability. P: (MTH 132 or LB 118 or approval of department) and (STT 231 or STT 351 or STT 421 or STT 441 or STT 464 or approval of department) and (BS 110 or BS 111 or BS 148H or BS 149H or LB 144 or LB 145 or LB 148H or LB 149H)
Probability models in biological systems. Design and analysis of biological experiments including ANOVA models. Multiple testing. Classification and clustering for genomic and proteomic data. Computational software packages. Internet-based query systems.

411 Abstract Algebra II
Fall, Spring. 3(3-0) P: MTH 310 Not open to students with credit in MTH 418H.
Continuation of MTH 310. Permutation groups, groups of transformations, normal subgroups, homomorphism theorems, modules. Principal ideal rings, unique factorization domains, noncommutative rings, rings of fractions, ideals.

414 Linear Algebra II
Fall. 3(3-0) P: MTH 309 or MTH 314 Not open to students with credit in MTH 415.
Linear transformations on finite dimensional vector spaces. Invariant subspaces, rank, eigenvalues and eigenvectors. Canonical forms. Bilinear and multilinear forms.

415 Applied Linear Algebra
Fall, Spring, Summer. 3(3-0) P: (MTH 235 or MTH 255H or MTH 340) and (MTH 309 or MTH 314) Not open to students with credit in MTH 414.
Matrices and linear algebra. General linear systems of equations. Least squares minimization techniques. Eigenvalues and eigenvectors, spectral decompositions, and exponentials.

416 Introduction to Algebraic Coding
Fall. 3(3-0) P: MTH 309
Concepts and techniques of abstract algebra applied to the design of communication systems for use in imperfect circumstances. Theory of codes designed by algebraic means.

417 Topics in Number Theory
Spring of even years. 3(3-0) P: MTH 310
Congruences of higher degree, primitive roots and quadratic reciprocity. Number-theoretic functions, algebraic numbers. Dirichlet Series, p-order expansion, continued fractions.

418H Honors Algebra I
Fall. 3(3-0) P: Completion of Tier I writing requirement. RB: MTH 309 R: Approval of department. Not open to students with credit in MTH 411.
Theory of groups, Sylow theory, the structure of finite Abelian groups, ring theory, ideals, homomorphisms, and polynomial rings.

419H Honors Algebra II
Spring. 3(3-0) P: MTH 418H R: Approval of department.
Algebraic field extensions, Galois theory. Classification of finite fields. Fundamental Theorem of Algebra.

421 Analysis II
Fall, Spring, Summer. 3(3-0) P: MTH 320 Not open to students with credit in MTH 424 or MTH 429H.
Continuation of MTH 320. Euclidean spaces: differentiation and integration in higher dimensions. Convergence of sequences of functions.

424 Applied Advanced Calculus
Spring, Summer. 3(3-0) P: MTH 235 or MTH 255H R: Not open to students in the Department of Mathematics. Not open to students with credit in MTH 421 or MTH 429H.
Vector analysis for scientists and engineers. Inverse and implicit function theorems, divergence and curl, and Stokes's theorem. Sequences and series. Uniform convergence.

425 Complex Analysis
Fall, Spring. 3(3-0) P: MTH 320
Analytic functions of a complex variable, Cauchy integral theorem, conformal maps, bilinear transformation, harmonic functions. Classification of singularities, residues, conformal mappings.

428H Honors Analysis I
Fall. 3(3-0) R: Approval of department. Not open to students with credit in MTH 320.
Honors analysis with emphasis on metric topology, differentiation, and integration in higher dimensional settings. Convergence of sequences of functions.

429H Honors Analysis II
Spring. 3(3-0) P: MTH 428H R: Approval of department. Not open to students with credit in MTH 421 or MTH 424.
Continuation of MTH 428H. Convergence of sequences of functions, inverse and implicit function theorems, integration in higher dimensional settings.

432 Axiomatic Geometry
Spring. 3(3-0) P: MTH 309
Axiomatic systems and finite geometries: axioms of Euclidean and hyperbolic geometry, the Poincare model, independence of the parallel postulate. Classical constructions and the impossibility of angle trisection.

441 Ordinary Differential Equations II
Fall. 3(3-0) P: (MTH 235 or MTH 255H or MTH 340) and (MTH 309 or MTH 415 or MTH 314)
Existence and uniqueness theorems, linearization, stability theory, and phase space analysis.

442 Partial Differential Equations
Spring. 3(3-0) P: MTH 235 or MTH 255H or MTH 340
Classification and canonical forms for second order partial differential equations. Well-posed boundary and initial value problems for the wave equation, the heat equation, and the Laplace equation.

443 Boundary Value Problems for Engineers
Fall. 3(3-0) P: MTH 235 or MTH 255H R: Not open to students in the Department of Mathematics.
Fourier series and orthogonal functions. Method of separation of variables for partial differential equations. Sturm-Liouville problems.

451 Numerical Analysis I
Fall. 3(3-0) P: (CSE 131 or CSE 231) and (MTH 309 or MTH 314 or MTH 415) and (MTH 235 or MTH 255H or MTH 340) SA: MTH 351
Numerical solution of linear and nonlinear algebraic equations and eigenvalue problems. Curve fitting. Interpolation theory. Numerical integration, differentiation, and solution of differential equations. Algorithms and computer programming.

452 Numerical Analysis II
Spring. 3(3-0) P: MTH 451
A continuation of MTH 451.

455 Actuarial Models
Spring. 3(3-0) Interdepartmental with Statistics and Probability. Administered by Statistics and Probability. RB: STT 441 and MTH 360
Stochastic models used in insurance. Survival distributions, life insurance, life annuities, benefit premiums, benefit reserves, and analysis of benefit reserves.

457 Introduction to Financial Mathematics
Spring. 3(3-0) P: MTH 309 and (MTH 340 or MTH 235 or MTH 255H) and (STT 441 or STT 351)
Mathematical overview of basic financial instruments. A unified partial differential equation approach to model derivative securities. Partial differential equations in financial mathematics, Black-Scholes equation. Numerical methods for valuing derivatives.

461 Metric and Topological Spaces
Fall. 3(3-0) P: MTH 320 or MTH 428H
Set theory, metric spaces, topological spaces, maps, product and quotient topologies. Connected and compact spaces, separation axioms, pointwise and uniform convergence.

481 Discrete Mathematics I
Fall, Spring. 3(3-0) P: MTH 309
Binomial and multinomial theorems. Graphs and digraphs, graph coloring. Generating functions, asymptotic analysis, trees. Representing graphs in computers.

482 Discrete Mathematics II
Spring. 3(3-0) P: MTH 481 RB: MTH 310
Recurrence and generating functions, Ramsey theory. Block designs, Latin squares, Eulerian and Hamiltonian paths. Minimum spanning trees, network flows.

490 Directed Studies
Fall, Spring, Summer. 1 to 4 credits. A student may earn a maximum of 9 credits in all enrollments for this course. R: Approval of department.
Faculty directed study in a selected mathematical topic.

496 Capstone in Mathematics
Fall, Spring. 3(3-0) P: Completion of Tier I writing requirement. R: Approval of department.
A capstone course integrating several areas of mathematics.

801 Current Issues in Mathematics Education
Fall. 3(3-0) R: Approval of department.
Recent developments in K-16 mathematics curriculum, teaching, learning, and evaluation.

802A Critical Content of School Mathematics: Algebra and Analysis
Spring of odd years. 3(3-0) RB: MTH 310 and MTH 320 and MTH 801
Foundations and development, evolution and applications in the school curriculum. Connections among content areas. Learning and teaching mathematics.

802B Critical Content of School Mathematics: Geometry and Discrete Mathematics
Spring of even years. 3(3-0) RB: MTH 330 and MTH 481 and MTH 801 R: Open only to graduate students.
Foundations and development, evolution and applications in the school curriculum. Connections among content areas. Learning and teaching mathematics.

810 Error-Correcting Codes
Spring. 3(3-0) RB: MTH 411 or MTH 414 or MTH 415
Block codes, maximum likelihood decoding, Shannon's theorem. Generalized Reed-Solomon codes, modification of codes, subfield codes. Alterant and Goppa codes, cyclic codes and BCH codes.

818 Algebra I
Fall. 3(3-0) RB: MTH 411
Group theory: Sylow theory, permutation groups, Jordon-Hoelder theory, Abelian groups, free groups. Ring theory: algebra of ideals, unique factorization, polynomial rings, finitely generated modules over PIDs.

819 Algebra II
Spring. 3(3-0) RB: MTH 818
Modules and vector spaces, projectives modules, tensor algebra. Fields and Galois groups, algebraic and transcendental numbers, non-commutative rings. The Jacobson radical, the structure of semi-simple rings with the descending chain condition.

828 Real Analysis I
Fall. 3(3-0) RB: MTH 421 and MTH 461
Lebesgue measure on real line, general measure theory. Convergence theorems, Lusin's theorem, Egorov's theorem, Lp-spaces, Fubini's theorem. Functions of bounded variation, absolutely continuous functions, Lebesgue differentiation theorem.

829 Complex Analysis I
Spring. 3(3-0) RB: MTH 421 and MTH 425
Cauchy theorem, identity principle, Liouville's theorem, maximum modulus theorem. Cauchy formula, residue theorem, Rouche's theorem. Casorati-Weierstrass theorem, Arzela-Ascoli theorem. Conformal mapping, Schwarz lemma, Riemann mapping theorem.

840 Chaos and Dynamical Systems
Spring. 3(3-0) RB: (MTH 441 and MTH 320 and MTH 414) and some experience with mathematical software such as Mathematica or Matlab.
Chaotic or random motions in differential and difference equations.

841 Boundary Value Problems I
Fall. 3(3-0) RB: MTH 414 and MTH 421
Methods for solving boundary and initial value problems for ordinary and partial differential equations.

842 Boundary Value Problems II
Spring. 3(3-0) RB: MTH 841
Continuation of MTH 841.

843 Survey of Industrial Mathematics
Fall. 3(3-0) RB: ((MTH 414 or MTH 415) or Some familiarity with mathematical software such as Mathematica, Matlab, etc.) and (MTH 421 and MTH 442) R: Open only to master's students in the Industrial Mathematics major or approval of department.
Fundamentals of mathematical modeling in government and industry, including modes of industrial communication.

844 Projects in Industrial Mathematics
Spring. 3(3-0) RB: ((MTH 414 or MTH 415) or some familiarity with mathematical software such as Mathematica or Matlab.) and (MTH 421 and MTH 442 and MTH 843) R: Open only to master's students in the Industrial Mathematics major or approval of department.
Participation as a member of a 3-4 person team on a significant industrial problem, with participation of an industrial liaison, including project report generation and reporting.

848 Ordinary Differential Equations
Fall. 3(3-0) RB: MTH 414 and MTH 421
Existence and uniqueness theorems. Theory of linear differential equations. Floquet theory. Stability theory and Poincare-Bendixson theory. Green's functions and boundary value problems.

849 Partial Differential Equations
Spring. 3(3-0) RB: MTH 414 and MTH 421
Cauchy-Kowalewski theorem. Characteristics. Initial-boundary value problems for parabolic and hyperbolic equations. Energy methods, boundary value problems for elliptic equations, potential theory. Green's function, maximum principles, Schauder's method.

850 Numerical Analysis I
Fall. 3(3-0) RB: MTH 414 and MTH 421
Convergence and error analysis of numerical methods in applied mathematics.

851 Numerical Analysis II
Spring. 3(3-0) RB: MTH 850
Interpolation theory and approximation of functions. Numerical solutions of nonlinear equations. Numerical integration methods.

852 Numerical Methods for Ordinary Differential Equations
Fall. 3(3-0) RB: MTH 851
Linear multi-step methods and single step nonlinear methods for initial value problems. Consistency, stability and convergence. Finite difference, finite element, shooting methods for boundary value problems.

864 Geometric Topology
Spring. 3(3-0) RB: MTH 421 SA: MTH 464
Topology of surfaces and higher dimensional manifolds, studied from combinatorial, algebraic or differential viewpoints.

868 Geometry and Topology I
Fall. 3(3-0) RB: (MTH 411 and MTH 421) or approval of department.
Fundamental group and covering spaces, van Kampen's theorem. Homology theory, Differentiable manifolds, vector bundles, transversality, calculus on manifolds. Differential forms, tensor bundles, deRham theorem, Frobenius theorem.

869 Geometry and Topology II
Spring. 3(3-0) RB: MTH 868
Continuation of MTH 868.

879 Teaching College Mathematics
Fall. 3(3-0) A student may earn a maximum of 6 credits in all enrollments for this course. Interdepartmental with Counseling, Educational Psychology and Special Education and Science and Mathematics Education and Teacher Education. Administered by Science and Mathematics Education. RB: Past or concurrent mathematics teaching experience.
Curriculum materials, case studies, approaches to teaching and student learning of particular mathematics topics.

880 Combinatorics
Fall. 3(3-0) RB: MTH 411 or MTH 482
Enumerative combinatorics, recurrence relations, generating functions, asymptotics, applications to graphs, partially ordered sets, generalized Moebius inversions, combinatorial algorithms.

881 Graph Theory
Spring. 3(3-0) RB: MTH 880
Graph theory, connectivity, algebraic and topological methods. Networks, graph algorithms, Hamiltonian and Eulerian graphs, extremal graph theory, random graphs.

890 Readings in Mathematics
Fall, Spring, Summer. 1 to 6 credits. A student may earn a maximum of 24 credits in all enrollments for this course. R: Approval of department.
Individualized study for Master's level students.

910 Commutative Algebra I
Fall of odd years. 3(3-0) RB: MTH 819
Noetherian rings and modules, localization and tensor products, primary decomposition, Krull dimensions, graded rings and modules, Hilbert's Nullstellensatz, integral extensions, discrete valuation rings, Dedekind domains.

911 Commutative Algebra II
Spring of even years. 3(3-0) RB: MTH 910
Ext and Tor, regular sequences, Cohen-Macauley rings, regular rings, Gorenstein rings, completion, modules of differentials, Cohen's structure theorems.

912 Group Theory I
Fall of even years. 3(3-0) RB: MTH 819
Permutation groups, solvable and nilpotent groups, simple groups. Representation and character theory. Extension theory and cohomology groups.

913 Group Theory II
Spring of odd years. 3(3-0) RB: MTH 912
Groups of Lie type, linear groups, locally finite groups, free groups and free products, the subgroup theorems.

914 Lie Groups and Algebras I
Fall of odd years. 3(3-0) RB: MTH 819
Nilpotent and semisimple algebras, the adjoint representation, root spaces, Weyl groups, Dynkin diagrams, classification of simple algebras.

915 Lie Groups and Algebras II
Spring of even years. 3(3-0) RB: MTH 914
Weights, symmetric spaces, groups of Lie type, finite groups of Lie type, Lang's theorem.

916 Introduction to Algebraic Geometry I
Fall of even years. 3(3-0) RB: MTH 818 and MTH 819
Affine and projective algebraic varieties and their properties. Morphisms and singularities. Schemes and coherent sheaves. Sheaf cohomology and other related topics.

917 Introduction to Algebraic Geometry II
Spring of odd years. 3(3-0) RB: MTH 916
Continuation of MTH 916.

920 Functional Analysis I
Spring. 3(3-0) RB: MTH 828
Hilbert spaces: Riesz representation theorem, Parseval's identity, Riesz-Fisher theorem, Fourier series operators. Banach spaces: Hahn-Banach theorem, open mapping and closed graph theorems, Banach-Steinhaus theorem.

921 Functional Analysis II
Fall of even years. 3(3-0) RB: MTH 829 and MTH 920
Topological vector spaces, convexity, Krein-Milman theorem, Banach algebras, operators on Banach spaces, spectral theorem, C*-algebras.

926 Proseminar in Mathematics Education I
Fall. 3(3-0) Interdepartmental with Counseling, Educational Psychology and Special Education and Science and Mathematics Education and Teacher Education. Administered by Science and Mathematics Education.
Research on the learning and teaching of mathematics. Teaching, teacher and student learning, curriculum, and educational policy. Historical, philosophical, empirical, and theoretical perspectives.

927 Proseminar in Mathematics Education II
Spring. 3(3-0) Interdepartmental with Counseling, Educational Psychology and Special Education and Science and Mathematics Education and Teacher Education. Administered by Science and Mathematics Education. P: SME 926
Continuation of SME 926.

928 Real Analysis II
Fall. 3(3-0) RB: MTH 828
Positive Borel measure, complex measures. Riesz representation theorem, Radon-Nikodym theorem, Lebesgue decomposition theorem. Differentiable transformations and change of variables, differentiation of measures, maximal functions.

929 Complex Analysis II
Spring. 3(3-0) RB: MTH 828 and MTH 829
Phragmen-Lindelof method. Hadamard's theorem, Runge's thoerem, Weierstrass factorization theorem, Mittag-Leffler theorem, and Picard's theorem. Poisson integrals, Harnack's inequality, Dirichlet problem. Hp-spaces and Blaschke products.

930 Riemannian Geometry I
Fall of even years. 3(3-0) RB: MTH 869
Riemannian metrics, connections, curvature, geodesics. First and second variation, Jacobi fields, conjugate points. Rauch comparison theorems, Hodge theorem, Bochner technique, spinors. Further topics on curvature or submanifold theory.

931 Riemannian Geometry II
Spring of odd years. 3(3-0) RB: MTH 930
Continuation of MTH 930.

935 Complex Manifolds I
Fall of odd years. 3(3-0) RB: MTH 829 and MTH 869
Riemann surfaces, Serre duality, Riemann-Roch theorem. Weierstrass points, Abel's theorem, Plucker formulas. Hermitian metrics, connections, curvature, Hodge theorem. Kaehler metrics, Kodaira vanishing theorem, Chern classes.

936 Complex Manifolds II
Spring of even years. 3(3-0) RB: MTH 935
Continuation of MTH 935.

940 Applied Analysis I
Fall. 3(3-0) RB: MTH 828
Sobolev spaces, trace theorem, imbedding theorems, sectorial forms. Linear elliptic boundary and eigenvalue problems.

941 Applied Analysis II
Spring. 3(3-0) RB: MTH 940
Fixed point theorems. Variational methods. Applications to nonlinear integral and elliptic differential equations. Semigroup theory.

942 Foundations of Applied Mathematics I
Fall. 3(3-0) RB: MTH 848 and MTH 849
Modeling in classical applied mathematics. Newtonian and continuum mechanics. Special mathematical techniques.

943 Foundations of Applied Mathematics II
Spring. 3(3-0) RB: MTH 942
Continuation of MTH 942.

950 Numerical Methods for Partial Differential Equations I
Spring of odd years. 3(3-0) RB: MTH 852
Finite difference methods for ordinary and partial differential equations.

951 Numerical Methods for Partial Differential Equations II
Spring of even years. 3(3-0)
Finite element methods for ordinary and partial differential equations.

954 Design and Methods in Mathematics Education Research
Fall. 3(3-0) Interdepartmental with Counseling, Educational Psychology and Special Education and Science and Mathematics Education and Teacher Education. Administered by Science and Mathematics Education. RB: SME 926 and SME 927
History, current trends, and issues pertaining to research design and methods in mathematics education research. Mathematics education research in the areas of policy, teaching, teacher learning, and student learning with particular attention to how features of research designs influence research findings.

960 Algebraic Topology I
Fall. 3(3-0) RB: MTH 869
Cohomology, products, duality, basic homotopy theory, bundles, obstruction theory, spectral sequences, characteristic classes, and other related topics.

961 Algebraic Topology II
Spring. 3(3-0) RB: MTH 960
Continuation of MTH 960.

990 Reading in Mathematics
Fall, Spring, Summer. 1 to 3 credits. A student may earn a maximum of 9 credits in all enrollments for this course. R: Approval of department.
Individualized study for doctoral level students.

991 Special Topics in Algebra
Fall, Spring. 3 to 6 credits. A student may earn a maximum of 18 credits in all enrollments for this course. R: Approval of department.
Advanced topics in algebra.

992 Special Topics in Analysis
Fall, Spring. 3 to 6 credits. A student may earn a maximum of 18 credits in all enrollments for this course. R: Approval of department.
Advanced topics in analysis.

993 Special Topics in Geometry
Fall, Spring. 3 to 6 credits. A student may earn a maximum of 18 credits in all enrollments for this course. R: Approval of department.
Advanced topics in geometry.

994 Special Topics in Applied Mathematics
Fall, Spring. 3 to 6 credits. A student may earn a maximum of 24 credits in all enrollments for this course. R: Approval of department.
Advanced topics in applied mathematics.

995 Special Topics in Numerical Analysis and Operations Research
Fall, Spring. 3 to 6 credits. A student may earn a maximum of 18 credits in all enrollments for this course. R: Approval of department.
Advanced topics in numerical analysis or operations research.

996 Special Topics in Topology
Fall, Spring. 3 to 6 credits. A student may earn a maximum of 18 credits in all enrollments for this course. R: Approval of department.
Advanced topics in topology.

998 Special Topics in Combinatorics and Graph Theory
Fall, Spring. 3 to 6 credits. A student may earn a maximum of 18 credits in all enrollments for this course. R: Approval of department.
Advanced topics in combinatorics and graph theory.

999 Doctoral Dissertation Research
Fall, Spring, Summer. 1 to 24 credits. A student may earn a maximum of 120 credits in all enrollments for this course. R: Approval of department.
Doctoral dissertation research.