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 or LB 118 Not open to students with credit in LB 119 or MTH 153H.

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 119 or MTH 132.
Limits, continuous functions, derivatives, integrals, fundamental theorem of calculus. Special emphasis on concepts and theory.
Mathematics—MTH

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.

291 Mathematics Snapshots
Spring. 1(2-0) A student may earn a maximum of 2 credits in all enrollments for this course. P: MTH 116 or approval of department.
Selected topics in mathematics and its applications. Emphasis will be on important and intriguing ideas in mathematics without indulging in technical details.

290 Transitions
Fall, Spring, Summer. 4 credits. P: MTH 132 or LB 118 RB: (MTH 133 or concurrently) or (LB 119 or concurrently)
Introduction to mathematical reasoning, basic logic, set theory, integers, natural numbers and induction, basic number theory, real numbers, limits, sequences, series.

301 Foundations of Higher Mathematics
Fall, Spring. 3(3-0) P: MTH 133 or MTH 153H or LB 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.

304 Algebra for Elementary and Middle School Teachers
Fall. 3 credits. Interdepartmental with Teacher Education. Administered by Mathematics. P: (MTH 201 and MTH 202 and MTH 301) and completion of Tier I writing requirement R: Open to undergraduate students in the College of Education or in the Department of Teacher Education. Approval of department.
Algebra needed for understanding connections between topics of algebra and the mathematics taught in elementary and middle school.

305 Functions and Calculus for Elementary and Middle School Teachers (W)
Spring. 3 credits. Interdepartmental with Teacher Education. Administered by Mathematics. P: MTH 304
Functions and calculus needed for understanding connections between topics of calculus and the mathematics taught in middle school.

309 Linear Algebra I
Fall, Spring, Summer. 3(3-0) P: (MTH 133 or MTH 153H or LB 119) and completion of Tier I writing requirement and (MTH 299 or approval of department)
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 299 or MTH 317H) or approval of department and completion of Tier I writing requirement
Structure of the integers, congruences, rings, ring homomorphisms, ideals, quotient rings. A writing course with an 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.

317H Honors Linear Algebra
Fall, Spring, Summer. 4 credits. P: MTH 133 or MTH 153H or LB 119 R: Open to students in the Honors College or approval of department.

320 Analysis I
Fall, Spring, Summer. 3(3-0) P: (MTH 133 or MTH 153H or LB 119) and (MTH 299 or MTH 317H or approval of department) Not open to students with credit in MTH 327H.

327H Honors Introduction to Analysis
Fall, Spring. 3(3-0) P: MTH 317H R: Approval of department. Not open to students with credit in MTH 320.
Emphasis on foundations and metric topology. Convergence of sequences and series, continuity of functions. Differentiation and integration in one dimension.

330 Higher Geometry
Fall, Spring, Summer. 3(3-0) P: MTH 301 or MTH 309 or MTH 299 or MTH 317H
Topics in transformations: isometries, similarities, inversion. Advanced Euclidean geometry: theorems of Menelaus, Ceva, and Desargues. 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.

347H Advanced Ordinary Differential Equations
Spring. 3(3-0) P: MTH 317H R: Approval of department.
Separable and exact equations, linear equations and variation of parameters, higher order linear equations, Laplace Transforms, first-order linear systems, classification of singularities, nonlinear systems, partial differential equations and Fourier Series, existence and uniqueness theorems. There will be an emphasis on theory.

360 Theory of Mathematical Interest
Fall, Spring. 3(3-0) P: MTH 234 or concurrently) or (MTH 254H or concurrently) or (LB 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 133 or LB 119) and (BS 161 or BS 162 or BS 181H or BS 182H or LB 144 or LB 145)

371 Statistical Biology
Spring. 3(3-0) Interdepartmental with 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 161 or BS 162 or BS 181H or BS 182H or LB 144 or LB 145)
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.

396 Capstone in Mathematics for Secondary Education (W)
Spring. 3(3-0) P: ((MTH 309 and MTH 310 and MTH 320) or approval of department) and completion of Tier I writing requirement R: Approval of department. Not open to students with credit in MTH 496.
A capstone course for secondary education math majors. High school mathematics from an advanced viewpoint.

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.


Mathematics—MTH

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, Jordan-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

829 Complex Analysis I  
Spring. 3(3-0) RB: MTH 421 and MTH 425

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.
Chotic 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 masters 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 masters 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

849 Partial Differential Equations  
Spring. 3(3-0) RB: MTH 414 and MTH 421

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  
Fall. 3(3-0) RB: MTH 850 and MTH 852

852 Numerical Methods for Ordinary Differential Equations  
Spring. 3(3-0) RB: MTH 850

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.

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

879 Teaching College Mathematics  
Fall of even years. 3(3-0) A student may earn a maximum of 6 credits in all enrollments for this course. R: Approval of department.
Individualized study for Master's level students.

910 Commutative Algebra  
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-Macaulay 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  
Fall of odd years. 3(3-0) RB: MTH 819
Nilpotent and semisimple algebras, the ad joint 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) P: MTH 916
Continuation of MTH 916.

918 Number Theory I
Fall of even years. 3(3-0): P: MTH 819 or approval of department
Number fields and algebraic integers, prime ideals and factorization, cyclotomic fields, the class group, the Dirichlet unit theorem, different, discriminant, decomposition and inertia groups, local fields.

919 Number Theory II
Spring of odd years. 3(3-0): P: MTH 918 or approval of department
Topics from: class field theory, zeta and L-functions, modular forms, theory of elliptic curves, diophantine approximation, diophantine geometry.

920 Functional Analysis I
Spring. 3(3-0) RB: MTH 828

921 Functional Analysis II
Fall of even years. 3(3-0): RB: MTH 829 and MTH 920

922 Harmonic Analysis
Fall of odd years. 3(3-0): RB: MTH 829 and MTH 920
Fourier series, mean and pointwise convergence, conjugate functions, Fourier transform, Plancherel theorem, Paley-Wiener theorem, interpolation of operators, Hausdorff-Young theorem.

926 Proseminar in Mathematics Education I
Fall of odd years. 3(3-0): RB: MTH 826 and 829
Interdepartmental with Counseling, Educational Psychology and Special Education and Mathematics Education and Teacher Education. Administered by Mathematics Education. SA: SME 926
Research on the learning and teaching of mathematics. Focus on curriculum, discourse, equity and teacher education.

927 Proseminar in Mathematics Education II
Fall of even years. 3(3-0): RB: MTH 927
Interdepartmental with Counseling, Educational Psychology and Special Education and Mathematics Education and Teacher Education. Administered by Mathematics Education. SA: SME 927
Research on the learning and teaching of mathematics. Focus on teaching, student learning, assessment and policy.

928 Real Analysis II
Fall. 3(3-0) RB: MTH 828

929 Complex Analysis II
Spring. 3(3-0): RB: MTH 828 and MTH 829

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

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

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 Mathematics Education and Teacher Education. Administered by Mathematics Education. RB: (MTHE 927) and at least one approved research methods course. SA: SME 954
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 research design 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 24 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 24 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 36 credits in all enrollments for this course. R: Approval of department.
Doctoral dissertation research.