865. Advanced Theory of Solids
Spring. 3(3-0)
P: MSM 851.
Quantum mechanics. Free electron theory. Energy bands, semiconductors. Dielectrics and ferroelectrics. Dia-, para-, ferro-, and antiferro-magnetism. Superconductivity. Thermal properties.
QP: MMM 825 QA: MMM 861

870. Electron Microscopy in Materials Science
Spring. 3(2-3)
P: MSM 451. R: Open only to majors in Materials Science.
Theory of electron diffraction. Electromagnetic lenses. Image formation in transmission electron microscopy. Defect analysis and diffraction contrast.
QP: MMM 430 QA: MMM 832

875. Engineering Ceramics
Fall of odd-numbered years. 3(3-0)
P: MSM 454, MSM 455.
Physical properties of engineering ceramics. Transport properties of ceramics, especially in ferrites and garnets. Optical ceramic materials.
QP: MMM 420, MMM 454 QA: MMM 849

876. Advanced Polymeric Materials
Fall of even-numbered years. 3(3-0)
P: MSM 380.
Advanced topics in polymer structure and properties. Thermoplastics, thermosets, polyblends and elastomers. Processing techniques. Deformation and mechanical properties. Thermal, optical and chemical properties. Composites.

885. Seminar
Fall, Spring. 1(1-0)
Oral presentations of students' research or literature survey.
QA: MMM 885

890. Independent Study
Fall, Spring, Summer. 1 to 3 credits. A student may earn a maximum of 6 credits in all enrollments for this course.
R: Approval of department.
Individualized reading and research of student's interest.
QA: MMM 800

891. Selected Topics
Fall, Spring, Summer. 1 to 3 credits. A student may earn a maximum of 6 credits in all enrollments for this course.
R: Approval of department.
Special topics in materials science or mechanics of current importance.
QA: MMM 890

899. Master's Thesis Research
Fall, Spring, Summer. 1 to 8 credits. A student may earn a maximum of 24 credits in all enrollments for this course.

QA: MMM 899

905. Optical Methods of Measurement
Fall of even-numbered years. 3(2-3)
R: Approval of department.
Measurement of dimension, position, motion, strain, using optical methods including holography, speckle interferometry, Moire, photoelasticity, laser Doppler, electronic imaging, model analysis. Relevant optics theory.
QA: MMM 806

909. Boundary Element Method
Spring of even-numbered years. 3(3-0)
P: MSM 813.
Theory and application of the boundary element method to the solution of continuum type problems in heat transfer, fluid mechanics and stress analysis. Computer applications.
QP: MMM 813

915. Nonlinear Elasticity
Spring of odd-numbered years. 3(3-0)
P: MSM 813.
Kinematics and kinetics of large deformations. Incompressible and compressible finite elasticity. Solution of basic problems. Nonuniqueness, stability and buckling. Singular fields near cracks and flaws.
QP: MMM 813 QA: MMM 915

918. Thermoelasticity and Viscoelasticity
Spring of odd-numbered years. 3(3-0)
P: MSM 810, MTH 443.
Thermomechanics of solids. Theory of thermoelasticity. Boundary value problems in thermoelasticity. Linear and nonlinear viscoelasticity. Model representation. Boltzmann superposition. Correspondence principle.
QP: MMM 810, MTH 422 QA: MMM 918

922. Micromechanics
Spring of even-numbered years. 3(3-0)
P: MSM 813.
Models of microstructures. Inclusion problems. Eigenstrain method. Upper and lower bounds. Methods of statistical elasticity. Approximate methods. Mechanics of random networks. Percolation models of damage.
QP: MMM 813

960. Advanced Physical and Mechanical Properties of Materials (MTC)
Fall. 3(3-0) A student may earn a maximum of 9 credits in all enrollments for this course.
Topics vary each semester. Topics such as microcracking in brittle materials, anisotropic crystalline properties, or surfaces, interfaces and thin film structures.

970. Advanced Analytical Techniques (MTC)
Spring. 3(3-0) A student may earn a maximum of 9 credits in all enrollments for this course.
Topics vary each semester. Topics such as advanced techniques in electron microscopy, advanced analytical methods in materials science, or advanced X-ray methods.

980. Advanced Processing Techniques (MTC)
Spring. 3(3-0) A student may earn a maximum of 9 credits in all enrollments for this course.
Topics vary each semester. Topics such as ceramic processing, or high temperature deformation and processing, or laser and plasma processing.

990. Independent Study
Fall, Spring, Summer. 1 to 3 credits. A student may earn a maximum of 6 credits in all enrollments for this course.
Individualized reading and research.
QA: MMM 900

991. Selected Topics
Fall, Spring, Summer. 1 to 3 credits. A student may earn a maximum of 6 credits in all enrollments for this course.
R: Open only to graduate students in Materials Science or Mechanics. Approval of department.
Special advanced topics in materials science and engineering, and mechanics.

999. Doctoral Dissertation Research
Fall, Spring, Summer. 1 to 24 credits. A student may earn a maximum of 72 credits in all enrollments for this course.

QA: MMM 999

MATHEMATICS MTH

Department of Mathematics
College of Natural Science

103. College Algebra
Fall, Spring, Summer. 3(3-0)
P: MTH 1825 or designated score on mathematics placement test. R: Not open to students with credit in MTH 110 or MTH 116 or MTH 120 or LBS 117.
Number systems; variables; functions and relations; mathematical induction; exponents and radicals; elementary theory of equations; binomial theorem; determinants, matrices, and systems of equations.
QP: MTH 082 QA: MTH 108, MTH 111

110. College Algebra and Finite Mathematics
Fall, Spring, Summer. 5(5-0)
P: MTH 1825 or designated score on mathematics placement test. R: Not open to students with credit in MTH 103 or MTH 116 or MTH 120 or LBS 117.
Functions and graphs. Equations and inequalities. Systems of equations. Matrices. Linear programming. Simplex algorithm. Probability.
QP: MTH 108 QA: MTH 110, MTH 108

116. College Algebra and Trigonometry
Fall, Spring, Summer. 5(5-0)
P: MTH 1825 or designated score on mathematics placement test. R: Not open to students with credit in MTH 110 or MTH 113 or MTH 120 or LBS 117.
Functions and graphs. Equations and inequalities. Exponential and logarithmic functions. Trigonometric functions. Systems of equations. Binomial theorem.
QP: MTH 108 QA: MTH 111, MTH 109, MTH 108

120. Algebra and a Survey of Calculus
Fall, Spring, Summer. 5(5-0)
P: MTH 1825 or designated score on mathematics placement test. R: Not open to students with credit in MTH 103 or MTH 110 or MTH 116 or MTH 124 or LBS 117.
Functions and graphs. Equations and inequalities. Systems of equations. Limits. Continuous functions. Derivatives. Applications of derivatives. Integrals. Fundamental theorem of calculus.

124. Survey of Calculus with Applications I
Fall, Spring, Summer. 3(3-0)
P: Designated score on mathematics placement test or MTH 103. R: Not open to students with credit in MTH 120 or MTH 132 or MTH 152H or LBS 118.
Study of limits, continuous functions, derivatives, integrals and their applications.
QP: MTH 108 or MTH 111

126. Survey of Calculus with Applications II
Fall, Spring, Summer. 3(3-0)
P: MTH 120 or MTH 124. R: Not open to students with credit in MTH 133 or MTH 153H.
Application of partial derivatives, integrals, optimization of functions of several variables and infinite series

132. Calculus I
Fall, Spring, Summer. 3(3-0)
P: MTH 116 or designated score on mathematics placement test. R: Not open to students with credit in MTH 120 or MTH 124 or MTH 152H or LBS 118.
Limits, continuous functions, derivatives and their applications. Integrals and the fundamental theorem of calculus.
QP: MTH 109 or MTH 111 QA: MTH 112, MTH 122

133. Calculus II
Fall, Spring, Summer. 4(4-0)
P: MTH 132 or MTH 152H. R: Not open to students with credit in MTH 126 or MTH 153H.
Applications of the integral and methods of integration. Improper integrals. Polar coordinates and parametric curves.
QA: MTH 113, MTH 123

152H. Honors Calculus I
Fall. 3(3-0)
R: Open only to Honors College students. Not open to students with credit in MTH 120 or MTH 124 or MTH 132 or LBS 118.
Limits, continuous functions, derivatives, integrals, fundamental theorem of calculus. Special emphasis on concepts and theory.
QA: MTH 112

153H. Honors Calculus II
Spring. 3(3-0)
P: MTH 152H. R: Honors College student. Not open to students with credit in MTH 133 or MTH 126.
The integral. Improper integrals. Polar coordinates and parametric curves. Special emphasis on concepts and theory.
QA: MTH 113

1825. Intermediate Algebra
Fall, Spring, Summer. 3(3-0)
R: Designated score on mathematics placement test. Not open to students with credit in MTH 0823.
Properties of real numbers. Factoring. Roots and radicals. First and second degree equations. Linear inequalities. Polynomials. Systems of equations.
QA: MTH 0823, MTH 1043

201. Mathematical Investigations I
Fall, Spring, Summer. 3(3-0)
P: MTH 103.
Problem solving in doing mathematics: collecting data, searching for patterns, conjecturing, verification (reasoning), application, and finding connections.
QP: MTH 108 QA: MTH 201

202. Mathematical Investigations II
Fall, Spring, Summer. 3(3-0)
P: MTH 201.
A continuation of MTH 201.
QP: MTH 201 QA: MTH 204

234. Multivariable Calculus I
Fall, Spring, Summer. 4(4-0)
P: MTH 133 or MTH 153H. R: Not open to students with credit in MTH 254H.
Infinite Series. Vectors in space. Functions of several variables and partial derivatives.
QA: MTH 214, MTH 215

235. Multivariable Calculus II and Differential Equations
Fall, Spring, Summer. 3(3-0)
P: MTH 234 or MTH 254H. R: Not open to students with credit in MTH 255H.
Multiple integrals. Vector analysis. Green's Theorem. Systems of ordinary differential equations.
QA: MTH 310

254H. Honors Multivariable Calculus I
Fall. 3(3-0)
P: MTH 153H. R: Honors College student. Not open to students with credit in MTH 234.
Infinite series, vectors in space, partial derivatives.
QA: MTH 214

255H. Honors Multivariable Calculus II and Differential Equations
Spring. 3(3-0)
P: MTH 254H. R: Honors College student. Not open to students with credit in MTH 235.
Multiple integrals. Vector analysis. Green's Theorem. Ordinary differential equations.
QA: MTH 310

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.
QA: MTH 290

310. Abstract Algebra I and Number Theory
Fall, Spring, Summer. 3(3-0)
P: MTH 133 or MTH 153H.
A writing course with an emphasis on proofs. Structure of the integers, congruences, polynomial rings, ideals and fields.
QP: MTH 214 QA: MTH 337

314. Linear Algebra I
Fall, Spring, Summer. 3(3-0)
P: MTH 234 or MTH 254H.
Vectors, matrices, and linear transformations. Operations on matrices, inner products, dimension, eigenvalues and eigenvectors. Applications to systems of equations and to geometry.
QP: MTH 214 QA: MTH 334

320. Analysis I
Fall, Spring, Summer. 3(3-0)
P: MTH 234 or MTH 254H; MTH 310. R: Not open to students with credit in MTH 424.
Convergence of sequences and series. Upper and lower limits, completeness, limits and continuity. Derivatives, integrals. Fundamental Theorem of Calculus.
QP: MTH 324 QA: MTH 424, MTH 427

330. Higher Geometry
Fall. 3(3-0)
P: MTH 310.
Topics in transformations: isometries, similarities, inversion. Advanced Euclidean geometry: theorems of Menelaus, Ceva, and Desargue. Cross ratio, harmonic points, analytic, metric and vector methods, convexity.
QP: MTH 215 QA: MTH 316

351. Elements of Numerical Analysis
Fall. 3(3-0)
P: MTH 235 or MTH 255H. R: Not open to Mathematics majors. Not open to students with credit in MTH 451.
Techniques and elementary theory of numerical analysis for engineering and science students.
QP: MTH 310 QA: MTH 351

411. Abstract Algebra II
Fall, Spring. 3(3-0)
P: MTH 310. R: 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.
QP: MTH 215 QA: MTH 432, MTH 433

412. Topics in Algebra
Spring. 3(3-0)
P: MTH 411. R: Not open to students with credit in MTH 419H.
A capstone course. Sylow theory, solvable groups, permutation groups. Extension fields, Galois groups, the classification of finite fields, constructibility. Applications to classical geometry and polynomial equations.
QP: MTH 432

414. Linear Algebra II
Fall, Spring. 3(3-0)
P: MTH 310, MTH 314. R: 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.
QP: MTH 334 QA: MTH 335

415. Applied Linear Algebra
Fall, Spring. 3(3-0)
P: MTH 314. R: 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, exponentials.
QP: MTH 334 QA: MTH 335

416. Introduction to Algebraic Coding
Fall. 3(3-0)
P: MTH 314.
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.
QP: MTH 334 QA: MTH 430

417. Topics in Number Theory
Spring of even-numbered 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.
QP: MTH 331 QA: MTH 437

418H. Honors Algebra I
Fall. 3(3-0)
P: MTH 310. R: 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.
QP: MTH 215 QA: MTH 432, MTH 433

419H. Honors Algebra II
Spring. 3(3-0)
P: MTH 418H. R: Not open to students with credit in MTH 412.
Algebraic field extensions, Galois theory. Classification of finite fields. Fundamental Theorem of Algebra.
QA: MTH 433, MTH 434

421. Analysis II
Fall, Spring, Summer. 3(3-0)
P: MTH 320. R: Not open to students with credit in MTH 424 or MTH 428H.
Continuation of MTH 320. Euclidean spaces: differentiation and integration in higher dimensions. Convergence of sequences of functions.
QP: MTH 424 QA: MTH 425

422. Analysis on Manifolds
Spring. 3(3-0)
P: MTH 314, MTH 421.
A capstone course. A modern treatment of differential and integral calculus on manifolds in Euclidean space. Differential forms, generalized Stokes's Theorem. Interaction among linear algebra, topology, and analysis.
QP: MTH 334, MTH 429 or MTH 426

424. Applied Advanced Calculus
Spring, Summer. 3(3-0)
P: MTH 314; MTH 235 or 255H. R: Not open to students with credit in MTH 421 or MTH 428H.
Vector analysis for scientists and engineers. Inverse and implicit function theorems, divergence and curl, Stokes's theorem. Sequences and series, uniform convergence.
QP: MTH 334 QA: MTH 421

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.
QP: MTH 424 QA: MTH 423

428H. Honors Analysis I
Fall. 3(3-0)
R: Honors College students or approval of department. Not open to students with credit in MTH 421.
Honors analysis with emphasis on metric topology, differentiation, and integration in higher dimensional settings. Convergence of sequences of functions.
QA: MTH 427, MTH 428

429H. Honors Analysis II
Spring. 3(3-0)
P: MTH 428H. R: Not open to students with credit in MTH 422.
Continuation of MTH 428H. Convergence of sequences of functions, inverse and implicit function theorems, integration in higher dimensional settings.
QP: MTH 428 QA: MTH 428, MTH 429

432. Axiomatic Geometry
Spring. 3(3-0)
P: MTH 310.
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.
QP: MTH 214 QA: MTH 315

434. Differential Geometry
Fall. 3(3-0)
P: MTH 310; MTH 314; MTH 235 or MTH 255H.
Curves and surfaces in Euclidean space. Curvature of curves on a surface. First and second fundamental forms. Geodesics, parallel transaction, Gaussian and mean curvatures, special surfaces. Gauss-Bonnet theorem, other global results.
QP: MTH 215, MTH 334 QA: MTH 414

441. Ordinary Differential Equations
Fall. 3(3-0)
P: MTH 314, MTH 320.
Existence and uniqueness theorems, linearization, stability theory, and phase space analysis.
QP: MTH 334, MTH 424 QA: MTH 420

442. Partial Differential Equations
Spring. 3(3-0)
P: MTH 320; MTH 235 or MTH 255H.
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.
QP: MTH 424

443. Boundary Value Problems for Engineers
Fall. 3(3-0)
P: MTH 235 or MTH 255H. R: Not open to Mathematics majors.
Fourier series and orthogonal functions, method of separation of variables for partial differential equations, Sturm-Liouville problems.
QP: MTH 310 QA: MTH 422

451. Numerical Analysis I
Fall. 3(3-0)
P: CPS 130 or CPS 131 or CPS 230; MTH 314; MTH 320 or MTH 424. R: Not open to students with credit in 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.
QP: MTH 424 QA: MTH 451

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

461. Metric and Topological Spaces
Fall. 3(3-0)
P: MTH 421.
Set theory, metric spaces, topological spaces, maps, product and quotient topologies. Connected and compact spaces, separation axioms, pointwise and uniform convergence.
QP: MTH 426 QA: MTH 461

464. Geometric Topology
Spring. 3(3-0)
P: MTH 421.
A capstone course. Topology of surfaces and higher dimensional manifolds, studied from combinatorial, algebraic or differential viewpoints.
QP: MTH 426, MTH 461

471. Computational Complexity
Fall. 3(3-0)
P: MTH 310.
Partially computable and computable functions. Primitive recursive functions and the loop complexity classification. Godel numbering and unsolvable problems. The P and NP classification of solvable problems.
QP: MTH 334 QA: MTH 470

472. Mathematical Logic
Spring. 3(3-0)
P: MTH 310.
Logics and formal systems, syntax and semantics. Completeness and axiomatizability. Decidable and undecidable theories and Goedel's theorems. Peano arithmetic.
QP: MTH 215 QA: MTH 471

481. Discrete Mathematics I
Fall, Spring. 3(3-0)
P: MTH 310.
Binomial and multinomial theorems. Graphs and digraphs, graph coloring. Generating functions, asymptotic analysis, trees. Representing graphs in computers.
QP: MTH 215 QA: MTH 382, MTH 383

482. Discrete Mathematics II
Spring. 3(3-0)
P: MTH 481.
Recurrence and generating functions, Ramsey theory. Block designs, Latin squares, Eulerian and Hamiltonian paths. Minimum spanning trees, network flows.
QA: MTH 383, MTH 484

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.
QA: MTH 490

496. Capstone in Mathematics
Fall, Spring. 3(3-0)
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.
QA: MTH 801, MTH 802

802A. Critical Content of School Mathematics: Algebra and Analysis
Spring of even-numbered years. 3(3-0)
P: MTH 310, MTH 320, MTH 801.
Foundations and development, evolution and applications in the school curriculum. Connections among content areas. Learning and teaching mathematics.
QP: MTH 324, MTH 337, MTH 801 QA: MTH 802, MTH 803

802B. Critical Content of School Mathematics: Geometry and Discrete Mathematics
Spring of odd-numbered years. 3(3-0)
P: MTH 330, MTH 481, 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.
QP: MTH 315, MTH 382, MTH 801 QA: MTH 802, MTH 803

803. Topics in Mathematics Education Research
Spring of even-numbered years. 3(3-0)
P: MTH 802A or MTH 802B. R: Open only to graduate students.
Research in mathematics education and its effect on policy, curriculum, and the teaching and learning of mathematics.
QP: MTH 803

810. Error-Correcting Codes
Spring. 3(3-0)
P: 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.
QP: MTH 335, MTH 434 QA: MTH 830

818. Algebra I
Fall. 3(3-0)
P: 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.
QP: MTH 434 QA: MTH 834, MTH 835

819. Algebra II
Spring. 3(3-0)
P: 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 semisimple rings with the descending chain condition.
QP: MTH 834 QA: MTH 835, MTH 836

828. Real Analysis I
Fall. 3(3-0)
P: MTH 421, 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.
QP: MTH 426 QA: MTH 824, MTH 825

829. Complex Analysis I
Spring. 3(3-0)
P: MTH 421, 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.
QP: MTH 426 QA: MTH 826

841. Boundary Value Problems I
Fall. 3(3-0)
P: MTH 414, MTH 421.
Methods for solving boundary and initial value problems for ordinary and partial differential equations.
QP: MTH 335, MTH 426 QA: MTH 841, MTH 842

842. Boundary Value Problems II
Spring. 3(3-0)
P: MTH 841.
Continuation of MTH 841.
QP: MTH 841 QA: MTH 842, MTH 843

848. Ordinary Differential Equations
Fall. 3(3-0)
P: MTH 414, 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.
QP: MTH 426 QA: MTH 847, MTH 848

849. Partial Differential Equations
Spring. 3(3-0)
P: MTH 414, 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.
QP: MTH 426 QA: MTH 886, MTH 887

850. Numerical Analysis I
Fall. 3(3-0)
P: MTH 414, MTH 421.
Convergence and error analysis of numerical methods in applied mathematics.
QP: MTH 335, MTH 426 QA: MTH 851, MTH 852

851. Numerical Analysis II
Spring. 3(3-0)
P: MTH 850.
Numerical methods for differential equations based on their discretizations. Introduction to stability and convergence.
QP: MTH 851 QA: MTH 850, MTH 857

868. Geometry and Topology I
Fall. 3(3-0)
P: MTH 422.
Fundamental group and covering spaces, van Kampen's theorem. Differentiable manifolds, vector bundles, transversality, calculus on manifolds. Differential forms, tensor bundles, deRham theorem, Frobenius theorem.
QP: MTH 426

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

870. Set Theory and Foundations of Mathematics
Spring. 3(3-0)
P: MTH 411 or MTH 421.
Zermelo-Fraenkel axioms. Cardinals and ordinals and their arithmetics. Axiom of choice and maximal principles. Transfinite induction and recursion, consistency and independence.
QP: MTH 335, MTH 426 QA: MTH 800

880. Combinatorics
Fall. 3(3-0)
P: MTH 411 or MTH 482.
Enumerative combinatorics, recurrence relations, generating functions, asymptotics, applications to graphs, partially ordered sets, generalized Moebius inversions, combinatorial algorithms.
QP: MTH 434 QA: MTH 817

881. Graph Theory
Spring. 3(3-0)
P: MTH 880.
Graph theory, connectivity, algebraic and topological methods. Networks, graph algorithms, Hamiltonian and Eulerian graphs, extremal graph theory, random graphs.
QP: MTH 817 QA: MTH 818

890. Readings in Mathematics
Fall, Spring, Summer. 1 to 3 credits. A student may earn a maximum of 12 credits in all enrollments for this course.
R: Approval of department.
Individualized study for Master's level students.
QA: MTH 890

910. Commutative Algebra I
Fall of odd-numbered years. 3(3-0)
P: 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.
QP: MTH 836

911. Commutative Algebra II
Spring of odd-numbered years. 3(3-0)
P: 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-numbered years. 3(3-0)
P: MTH 819.
Permutation groups, solvable and nilpotent groups, simple groups. Representation and character theory. Extension theory and cohomology groups.
QP: MTH 836 QA: MTH 934, MTH 935

913. Group Theory II
Spring of even-numbered years. 3(3-0)
P: MTH 912.
Groups of Lie type, linear groups, locally finite groups, free groups and free products, the subgroup theorems.
QP: MTH 934 QA: MTH 935, MTH 936

914. Lie Groups and Algebras I
Fall of odd-numbered years. 3(3-0)
P: MTH 819.
Nilpotent and semisimple algebras, the adjoint representation, root spaces, Weyl groups, Dynkin diagrams, classification of simple algebras.
QP: MTH 836

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

920. Functional Analysis I
Fall. 3(3-0)
P: 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.
QP: MTH 825 QA: MTH 924, MTH 925

921. Functional Analysis II
Spring. 3(3-0)
P: MTH 829, MTH 920.
Topological vector spaces, convexity, Krein-Milman theorem, Banach algebras, operators on Banach spaces, spectral theorem, C*-algebras.
QP: MTH 924 QA: MTH 925, MTH 926

922. Harmonic Analysis
Spring. 3(3-0)
P: MTH 829, MTH 920.
Fourier series, mean and pointwise convergence, conjugate functions, Fourier transform, Plancherel theorem, Paley-Wiener theorem, interpolation of operators, Hausdorff-Young theorem.
QP: MTH 924 QA: MTH 920, MTH 928

928. Real Analysis II
Fall. 3(3-0)
P: MTH 828, MTH 920 or concurrently.
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.
QP: MTH 924

929. Complex Analysis II
Spring. 3(3-0)
P: MTH 828, 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.
QP: MTH 826

930. Riemannian Geometry I
Fall. 3(3-0)
P: 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.
QP: MTH 861 QA: MTH 814A, MTH 814B

931. Riemannian Geometry II
Spring. 3(3-0)
P: MTH 930.
Continuation of MTH 930.
QA: MTH 814B, MTH 814C

935. Complex Manifolds I
Fall of odd-numbered years. 3(3-0)
P: MTH 829, 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.
QP: MTH 826, MTH 861

936. Complex Manifolds II
Spring of odd-numbered years. 3(3-0)
P: MTH 935.
Continuation of MTH 935.

940. Applied Analysis I
Fall. 3(3-0)
P: MTH 828.
Sobolev spaces, trace theorem, imbedding theorems, sectorial forms. Linear elliptic boundary and eigenvalue problems.
QA: MTH 844, MTH 845

941. Applied Analysis II
Spring. 3(3-0)
P: MTH 940.
Fixed point theorems. Variational methods. Applications to nonlinear integral and elliptic differential equations. Semigroup theory.
QP: MTH 844 QA: MTH 845, MTH 846

942. Foundations of Applied Mathematics I
Fall. 3(3-0)
P: MTH 848, MTH 849.
Modeling in classical applied mathematics. Newtonian and continuum mechanics. Special mathematical techniques.
QP: MTH 847, MTH 886 QA: MTH 881, MTH 882

943. Foundations of Applied Mathematics II
Spring. 3(3-0)
P: MTH 942.
Continuation of MTH 942.
QP: MTH 881 QA: MTH 882, MTH 883

950. Advanced Numerical Analysis I
Fall. 3(3-0)
P: MTH 849, MTH 851.
Finite difference methods for ordinary and partial differential equations.
QP: MTH 853 QA: MTH 850, MTH 858

951. Advanced Numerical Analysis II
Spring. 3(3-0)
P: MTH 950.
Finite element methods for ordinary and partial differential equations.
QP: MTH 858 QA: MTH 859

960. Algebraic Topology I
Fall. 3(3-0)
P: MTH 869.
Homology, cohomology, products, orientation, and duality. Thom isomorphism homology. Hurewicz isomorphism theorem.
QP: MTH 863 QA: MTH 964, MTH 965

961. Algebraic Topology II
Spring. 3(3-0)
P: MTH 960.
Continuation of MTH 960.
QA: MTH 965, MTH 966

990. Reading in Mathematics
Fall, Spring, Summer. 1 to 3 credits. A student may earn a maximum of 8 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.
QA: MTH 993

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.
QA: MTH 992

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.
QA: MTH 991

994. Special Topics in Applied Mathematics
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 applied mathematics.
QA: MTH 994

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 99 credits in all enrollments for this course.

QA: MTH 999