855. Advanced Rate Theory and Diffusion
Spring. 3(3-0)
P: MSM 851.
Review of Fick's Laws. Atomistic aspects of diffusion. Defects in solids. Probabilistic basis of random walk. Green's function solutions.

860. Theory of Vibrations
Fall. 3(3-0) Interdepartmental with Mechanical Engineering. Administered by Mechanical Engineering.
P: ME 452.
Discrete systems and continua. Analytical mechanics. Variational principles. Modal analysis. Function spaces. Eigenfunction expansions. Integral transforms. Stability. Approximations. Perturbations.

862. Dislocation Theory
Spring. 3(3-0)
P: MSM 451.
Advanced theory of dislocations and other crystal defects in metals, ceramics, aggregates and ordered compounds. Elasticity theory of straight dislocations, dislocation strain energy, mobility, obstacle interactions, reactions, and core effects.

865. Advanced Theory of Solids
Spring. 3(3-0)
Quantum mechanics. Free electron theory. Energy bands, semiconductors. Dielectrics and ferroelectrics. Dia-, para-, ferro-, and antiferro-magnetism. Superconductivity. Thermal properties.

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

871. Material Surfaces and Interfaces
Fall of odd-numbered years. 3(3-0) Interdepartmental with Chemical Engineering. Administered by Chemical Engineering.
P: CEM 362 or MSM 351. R: Open only to Chemical Engineering, Materials Science, Chemistry, or Packaging majors.
Physical and chemical nature of solid surfaces and their interaction with gases, liquids, and other solids. Characterization of surfaces and solid-solid interfaces. Relation of surface and interfacial structure to engineering phenomena.

875. Engineering Ceramics
Fall of odd-numbered years. 3(3-0)
P: MSM 851.
Physical properties of engineering ceramics. Transport properties of ceramics, especially in ferrites and garnets. Optical ceramic materials.

876. Advanced Polymeric Materials
Fall of even-numbered years. 3(3-0)
C: MSM 810.
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.

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.

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.

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.

902. Random Vibration of Structural and Mechanical Systems
Spring of odd-numbered years. 3(3-0) Interdepartmental with Civil Engineering and Mechanical Engineering. Administered by Civil Engineering.
P: CE 802 or ME 860; CE 810.
Probabilistic modeling of random excitations (e.g., earthquake, aerodynamic, and ocean wave loadings). Response of single and multiple degree-of-freedom systems to random excitation. Designing against failure. Nonstationary and nonlinear problems.

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.

909. Boundary Element Method
Spring of odd-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.

915. Nonlinear Elasticity
Spring of even-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.

918. Thermoelasticity and Viscoelasticity
Spring of even-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.

922. Micromechanics
Spring of odd-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.

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)
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 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.

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: 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.

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; functions and relations; exponents and logarithms; elementary theory of equations; inequalities; and systems of equations.

104. Trigonometry
Fall, Spring, Summer. 3(3-0)
P: MTH 103. R: 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, law of sines, law of cosines, vectors in the plane, and polar coordinates.

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 and statistics.

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 103 or MTH 110 or MTH 120 or LBS 117.
Functions and graphs. Equations and inequalities. Exponential and logarithmic functions. Trigonometric functions. Systems of equations. Binomial theorem.

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.

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.

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 or LBS 118.
Applications of the integral and methods of integration. Improper integrals. Polar coordinates and parametric curves. Sequences and series. Power series.

152H. Honors Calculus I
Fall. 3(3-0)
R: Honors College student or approval of department. 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.

153H. Honors Calculus II
Fall, Spring. 3(3-0)
P: MTH 152H. R: Honors College student or approval of department. Not open to students with credit in MTH 133 or MTH 126.
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)
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.

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.

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

234. Multivariable Calculus
Fall, Spring, Summer. 4(4-0)
P: MTH 133 or MTH 153H. R: Not open to students with credit in MTH 254H.
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(3-0)
P: MTH 234 or MTH 254H. R: Not open to students with credit in MTH 255H.
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.

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

255H. Honors Differential Equations
Spring. 3(3-0)
P: MTH 254H. R: Honors College student or approval of department. 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.

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

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.

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. Uniform convergence.

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.

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.

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.

412. Topics in Algebra
Spring. 3(3-0)
P: MTH 411. R: Completion of Tier I writing requirement. 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.

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.

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.

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.

417. Topics in Number Theory
Spring of odd-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.

418H. Honors Algebra I
Fall. 3(3-0)
P: MTH 310. R: Completion of Tier I writing requirement. 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: Not open to students with credit in MTH 412.
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. 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.

422. Analysis on Manifolds
Spring. 3(3-0)
P: MTH 314, MTH 421. R: Completion of Tier I writing requirement.
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.

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.

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: 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.

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.

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.

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.

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

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.

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.

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.

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

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.

464. Geometric Topology
Spring. 3(3-0)
P: MTH 421. R: Completion of Tier I writing requirement.
A capstone course. Topology of surfaces and higher dimensional manifolds, studied from combinatorial, algebraic or differential viewpoints.

471. Computational Complexity
Fall. 3(3-0)
P: MTH 310, MTH 314.
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.

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.

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.

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.

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)
R: Completion of Tier I writing requirement. 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-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.

802B. Critical Content of School Mathematics: Geometry and Discrete Mathematics
Spring of even-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.

803. Topics in Mathematics Education Research
Spring of odd-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.

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.

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.

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.

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.

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.

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.

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

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.

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.

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

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

868. Geometry and Topology I
Fall. 3(3-0)
P: MTH 411, 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)
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.

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.

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.

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.

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.

911. Commutative Algebra II
Spring of even-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.

913. Group Theory II
Spring of odd-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.

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.

915. Lie Groups and Algebras II
Spring of even-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.

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.

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 thoerem.

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.

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.

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.

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

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.

936. Complex Manifolds II
Spring of even-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.

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.

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.

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

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

951. Numerical Methods for Partial Differential Equations II
Spring of even-numbered years. 3(3-0)
P: MTH 950.
Finite element methods for ordinary and partial differential equations.

960. Algebraic Topology I
Fall. 3(3-0)
P: 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)
P: MTH 960.
Continuation of MTH 960.

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.

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 18 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 99 credits in all enrollments for this course.
R: Approval of department.

MECHANICAL ENGINEERING ME

Department of Mechanical Engineering
College of Engineering

201. Thermodynamics
Fall, Spring. 3(3-0)
P: CEM 141, MTH 234 or concurrently. R: Not open to students with credit in CHE 311 or MSM 351.
Basic concepts of thermodynamics. Property evaluation of ideal gases and compressible substances. Theory and application of the first and second laws of thermodynamics. Entropy and Carnot efficiency.

311. Introduction to Biomedical Engineering
Fall. 3(3-0) Interdepartmental with Biomedical Engineering, Materials Science and Mechanics, and Electrical Engineering. Administered by Biomedical Engineering.
P: BS 111, MTH 235, PHY 184.
Physical and mechanical properties of soft and hard tissues. Biomaterials. Biocompatibility. Biochemical processes, biological transport, and thermodynamics. Bioelectronics and instrumentation.

332. Fluid Mechanics
Fall, Spring. 4(3-3)
P: MSM 306; CHE 311 or ME 201 or MSM 351; ME 391 or concurrently. R: Open only to juniors and seniors in Mechanical Engineering and Mechanics. Completion of Tier I writing requirement.
Statics, control volume equations, similitude, exact fluid solutions. Turbulence, pipe flow, boundary layer flow, compressible flow, and Navier-Stokes equations.

371. Mechanical Design I
Fall, Spring. 3(3-0)
P: MSM 306 or concurrently. R: Open only to Mechanical Engineering and Mechanics majors.
Analysis of displacement, velocity and acceleration in mechanical linkages. Kinematics and dynamics of machines.

391. Mechanical Engineering Analysis
Fall, Spring. 3(3-0)
P: MTH 235. R: Open only to majors in Mechanical Engineering, Agricultural Engineering, and Mechanics.
Analytical and numerical methods for the modeling and analysis of mechanical engineering systems. Applications to vibrating elements, heat transfer, linear springs, and coupled spring-mass systems.

410. Heat Transfer
Fall, Spring. 3(3-0)
P: ME 332 or CE 321 or CHE 311; ME 391. R: Open only to Mechanical Engineering, Food Engineering, and Mechanics majors.
Steady state and transient heat conduction. Natural and forced convection based on boundary layer theory. Application of Nusselt number correlations. Radiant heat transfer principles and applications including radiation networks.

411. Applied Thermal Science
Fall, Spring. 3(3-0)
P: ME 410. R: Open only to Mechanical Engineering majors.
Thermodynamic principles as applied to gas and vapor power and refrigeration cycles for reciprocating and turbo machinery. Combustion. Analysis and design of heat exchangers. Numerical analysis of heat conduction.

412. Heat Transfer Laboratory
Fall, Spring. 1(1-2)
P: ME 411 or concurrently. R: Open only to Mechanical Engineering majors. Completion of Tier I writing requirement.
Practices and measurement techniques for heat transfer and thermal systems. Experimental problem solving applied to heat transfer.

415. Solar Energy Conversion
Spring. 3(3-0)
P: ME 410. R: Open only to Mechanical Engineering majors.
Solar radiation: terrestrial diffuse and direct-beam insolation. Flat-plate and focusing collectors. Energy storage systems. Solar-assisted heat pumps. Photovoltaic, biomass and wind energy conversions.

416. Computer Assisted Design of Thermal Systems
Fall. 3(4-0)
P: ME 411. R: Open only to Mechanical Engineering majors.
Classifying, cataloging and processing design information. Modeling of thermal equipment. Simulation and optimization of thermal systems. Computer based design projects.

422. Introduction to Combustion
Fall. 3(3-0)
P: ME 332. R: Open only to Mechanical Engineering majors.
Thermodynamics, chemistry, fluid mechanics, and heat transfer principles applied to combustion.

432. Intermediate Fluid Mechanics
Spring. 3(3-0)
P: ME 332. R: Open only to Mechanical Engineering majors.
Deformable control volumes, Navier-Stokes equations, vorticity and circulation. Exact solutions. Turbulence, boundary layer flows, compressible flows.

433. Intermediate Fluid Mechanics Laboratory
Spring. 1(0-3)
P: ME 432 or concurrently. R: Open only to Mechanical Engineering majors.
Visualization and measurement of flow, jets and wakes. Flow separation and boundary layers.

435. Biological Transport Mechanisms
Fall of odd-numbered years. 3(3-0) Interdepartmental with Biomedical Engineering and Chemical Engineering. Administered by Biomedical Engineering.
P: BME 311, MTH 235.
Mechanisms of transport of momentum, heat and mass. Mathematical description of transport processes in biological systems. Solution of biomedical problems.

440. Aerospace Engineering I
Fall. 3(3-0)
P: ME 332. R: Open only to Mechanical Engineering and Mechanics majors.
Aerodynamics, propulsion and flight mechanics. Vehicle and propulsion engine performance and design characteristics.

441. Aerospace Engineering II
Spring. 3(3-0)
P: ME 440. R: Open only to Mechanical Engineering and Mechanics majors.
Computer analysis experiments associated with aerospace vehicle design. Application of aerospace engineering principles in design such as propulsion, aerodynamics, stability and control.