911A. History of Market Thought
Fall, 4(4-0) May reenroll for a maximum of 15 credits. MTH 851.
Traces the evolution of marketing institutions, techniques, theories and criticisms. The influence of changing environmental and technological factors on marketing practice and thought. Readings in retrospective and original materials, discussion and research paper.

911B. Seminar in Macro Marketing
Winter, 4(4-0) May reenroll for a maximum of 15 credits. MTH 811A.
Examines the relationships between competition, marketing and corporate and economic growth. Emphasis is given to a functional examination of competition and the central role of innovation in the process.

912. Research Methodology in Transportation-Distribution Systems
Winter, 4(4-0) MTH 812, MTH 909.
Research methodology in the design and administration of transportation-distribution systems. Emphasis on technique and methodology for conducting system design studies and evaluation of common implementational problems.

941. Transportation-Distribution Development Policy
Spring, 4(4-0) MTH 820, MTH 912.
Applications in theory, principles, and processes developed in MTH 909 and MTH 912 to the design of research processes and reports in significant transport and distribution problems.

957. Seminar in Micro Marketing
Spring, 4(4-0) MTH 911A.
Examines the current state of theory concerning the planning and implementation of marketing strategies and programs, and tries to identify where future research is needed and/or will be most useful to marketing and business managers.

999. Doctoral Dissertation Research
Fall, Winter, Spring, Summer. Variable credit. Approval of department.

MATHEMATICS

MTH

College of Natural Science
One and one-half years of high school algebra and one year of geometry and a satisfactory score on the placement test are prerequisites for all courses in the Department of Mathematics which carry credit.

0823. Intermediate Algebra
Fall, Winter, Spring, Summer, 0(2-0) [2(2-0) See page A-1 item 3] Current enrollment in MTH 1043, one year of high school algebra, satisfactory score on placement examination.
Properties of real numbers, polynomials, factoring, rational functions, exponents, roots and radicals, first and second degree equations, linear inequalities, complex numbers, word problems. Approved through Spring 1982.

1033. Elements of Algebra
Fall, Winter, Spring, Summer, 2(2-0) Current enrollment in MTH 0813. Fractions, decimals, real number properties, algorithms of arithmetic, simple factoring, parentheses, reciprocals, linear equations, integer exponents, applied problems, coordinate systems, graphing, solving equations by graphing. Approved through Spring 1982.

1043. Intermediate Algebra
Fall, Winter, Spring, Summer, 3(3-0) Current enrollment in MTH 0823, one year of high school algebra, satisfactory score on placement examination.
Properties of real numbers, polynomials, factoring, rational functions, exponents, roots and radicals, first and second degree equations, linear inequalities, complex numbers, word problems. Approved through Spring 1982.

108. College Algebra and Trigonometry I
Fall, Winter, Spring, 5(5-0) 1-1/2 high school units in algebra and satisfactory score on placement test, or MTH 0823; 1 high school unit in geometry. Not open to students with credit in MTH 111.
Number systems; variables; functions and relations; mathematical induction; exponents and radicals; elementary theory of equations; binomial theorem; determinants, matrices and systems of equations.

109. College Algebra and Trigonometry II
Fall, Winter, Spring, 5(5-0) 1-1/2 high school units in algebra and satisfactory score on placement test, or MTH 108; 1 high school unit in geometry. Not open to students with credit in MTH 102 or MTH 111.
Continuation of MTH 108 plus trigonometry including definition of circular functions, angular measure, fundamental identities.

110. Finite Mathematics with Applications
Fall, Winter, Spring, 5(5-0) MTH 108 or MTH 111.
Elementary combinatorial analysis, binomial theorem, vectors and matrices, convex sets and linear programming, graph theory, applications to theory of games.

111. College Algebra with Trigonometry
Fall, Winter, Spring, 5(5-0) 1-1/2 years of high school algebra, 1 year of high school geometry, satisfactory score in algebra placement examination, trigonometry or MTH 102 or concurrently. Not open to students with credit in MTH 102 or MTH 109.
Sets and equations, simultaneous equations and matrices, vectors, inequalities, functions and relations, inverse functions, elementary theory of equations, trigonometric equations and identities, polar coordinates, parametric equations, straight line analytic geometry.

112. Calculus and Analytic Geometry I
Fall, Winter, Spring, Summer, 5(5-0) MTH 106 or MTH 111.
The sequence MTH 112, MTH 113, MTH 214, MTH 215, is an integrated course in calculus and analytic geometry, covering derivatives, curve sketching, definite and indefinite integrals, area volume, transcendental functions, vector analysis, solid geometry, partial differentiation, multiple integrals, infinite series, power series.

113. Calculus and Analytic Geometry II
Fall, Winter, Spring, Summer, 5(5-0) MTH 112.
A continuation of MTH 112.

122. Calculus I
Fall, Winter, Spring, 5(5-0) MTH 109 or MTH 111; not open to engineers, physical science or mathematics majors or to students with credit in MTH 112.
The first of a two-semester course in primarily single variable calculus with and introduction to several variables for students who want only one or two terms of calculus.

123. Calculus II
Fall, Winter, Spring, 5(5-0) MTH 122, not open to engineers, physical science or mathematics majors or to students with credit in MTH 113.
The second of a two-semester course in primarily single variable calculus with an introduction to several variables for students who want only one or two terms of calculus.

190. Freshman Mathematics Seminar
Winter, Spring, 3(3-0) Freshmen Mathematics majors; prior or concurrent calculus enrollment.
Intended to introduce mathematics majors to the type of mathematical reasoning and subject matter they can expect to encounter in advanced mathematics courses. Specific content will vary.

201. Mathematical Foundations for Elementary School Teachers
Fall, Winter, Spring, 4(4-0) 1-1/2 high school units in algebra and satisfactory score on placement test, or MTH 0823-1043; 1 high school unit in geometry. Open only to elementary education majors.
Fundamental concepts and processes of mathematics for prospective elementary school teachers.

202. Foundations of Algebra
Winter, Spring, 4(4-0) MTH 201; elementary education majors.
Fundamental concepts of algebra for elementary school teachers.

203. Foundations of Geometry
Spring, 4(4-0) MTH 201; elementary education majors.
Fundamental concepts of geometry for prospective elementary school teachers.

214. Calculus and Analytic Geometry III
Fall, Winter, Spring, Summer, 4(4-0) MTH 113.
Continuation of MTH 113.

215. Calculus and Analytic Geometry IV
Fall, Winter, Spring, 4(4-0) MTH 214.
Continuation of MTH 214.
216. Mathematics of Finance
Winter, 3(3-0) MTH 106 or MTH 111.
Mathematical theory of interest with application
to such topics as ordinary, due, and deferred
annuities; amortization of debts; depreciation;
capitalized cost; purchase price of bonds.

290. Special Topics in Mathematics
Fall, Winter, Spring. 1 to 5 credits.
May enroll for a maximum of 9 credits. Approval
of department.
Individualized study adapted to the preparation
and interests of the student. Topics studied will
generally supplement and enrich the regular
course.

302. Introduction to Combinatorics
and Its Applications
Spring. 4(4-0) MTH 113.
Permutations combinations, the binomial and
multinomial theorems, the principle of inclu­
dition and exclusion, derangements, recurrence
relations, Fibonacci sequences, generating
functions, trees, graphs, chromatic polynomials,
paths in networks.

305. Elementary Mathematics
Education
Spring. 4(4-0) Elementary education
mathematics minor and approval of departmen­t.
Professional organizations and their journals,
mathematics curriculum in standard text series,
novel curriculum developments and projects,
problems in assessment and evaluation.

309. Theory of Equations
Spring. 4(4-0) MTH 113 or approval of
department.
Desirable for those preparing to teach mathe­
matics in high schools. Mathematical induction,
complex numbers, theorems in roots of
polynomials, approximation to roots,
theory of determinants, an introduction to
quadratic forms, Hermitian matrices, similarity
transformations, characteristic values, linear
transformations.

334. Theory of Matrices
Fall, Winter, Spring. 4(4-0) MTH 214 or
approval of department.
Algebra of matrices, vector spaces, rank, in­
verses, determinants, systems of linear
equations, quadratic forms, Hermitian matrices, similarity
transformations, characteristic values, linear
transformations.

337. Concepts of Algebra
Winter. 3(3-0) MTH 214 or approval of
department.
Rings, integral domains, properties of integers,
fields, groups, polynomials.

341. Initial and Boundary Value
Problems
Winter. 3(3-0) MTH 310.
Introduction to partial differential equations
and initial and boundary value problems; em­
phasis on the wave equation, Laplace's equation
and heat flow equations and their solutions
by separation of variables.

345. Mathematical Modeling for
Teachers
Spring, Summer. 3(3-0) MTH 215.
Mathematical topics covered include: binary,
sequential, and recursive relations, matrices,
augmented matrices, matrix inversion, solution
of linear systems, determinants, eigenvalues
and eigenvectors, linear programming,
combinatorial problems, graphs, and network
flow.

401. Geometry for Teachers
Summer. 3(3-0) Approval of department;
not applicable to major or minor require­
ments.
Topics in geometry for junior and senior high
school teachers.
427. **Real Analysis I**

Fall. 4(3-0). Approval of department.

Topology, limits and continuity in En, functions of bounded variation, Riemann integration, calculus of several variables, linear transformations and derivatives.

428. **Real Analysis II**

Winter. 4(3-0) MTH 427.

Continuation of MTH 427.

429. **Real Analysis III**

Spring. 4(3-0) MTH 428.

Continuation of MTH 428.

430. **Introduction to Error-Correcting Codes**

Winter. 3(3-0) MTH 434.

Block codes and maximum likelihood decoding; Galois field theory, encoding and decoding linear codes, cyclic codes (using shift registers), burst-error-correcting codes, convolutional codes.

432. **Abstract Algebra I**

Fall, Winter. 4(4-0) MTH 415.

Introduction to the concepts of basic algebraic structures, namely: group, ring, integral domain, field, polynomial ring, module, vector space, linear transformation, etc.

433. **Abstract Algebra II**

Winter, Spring. 4(4-0) MTH 432.

Continuation of MTH 432.

434. **Abstract Algebra III**

Spring. 4(4-0) MTH 433.

Continuation of MTH 433.

437. **Theory of Numbers II**

Spring. 3(3-0) MTH 431 or MTH 432 or approval of department.

Dirichlet series, distribution of primes, sums of squares, Pell's equation, continued fractions, Hurwitz theory.

450. **Mathematical Programming**

Fall of even-numbered years. 3(2-1) MTH 452 or computer science, MTH 534, knowledge of FORTRAN programming.

Finite dimensional convexity, theorems of the alternative, LP factorization, simplex algorithm, quasi-Newton methods, nonlinear duality theory, dual algorithms.

451. **Numerical Analysis I**

Winter, Spring. 4(4-0) MTH 430, MTH 334, MTH 424 or approval of department. Students may not receive credit in both MTH 351 and MTH 451.

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. 4(4-0) MTH 451.

Continuation of MTH 451.

461. **Topology**

Winter, Spring. 3(2-0) MTH 424.

Introduction to fundamental concepts in topology, to metric and topological spaces, connectedness, compactness, continuity and simple connectedness.

462. **Combinatorial Topology**

Spring. 3(3-0) MTH 461 or MTH 424.

Uncursal graphs, surface topology, classification of surfaces, elementary set-theoretic topology, complexes.

471. **Mathematical Logic**

Fall. 4(4-0) MTH 415 or approval of department.


480. **Mathematics for Economists**

Fall. 5(5-0) MTH 115, graduate status in either economics, agricultural economics or College of Business, or approval of department. Interdepartmental with the Department of Economics.


481. **Selected Mathematical Ideas in Biology**

Winter, Spring. 4(4-0) MTH 414 or MTH 424.

Continuation of MTH 427.

490. **Mathematical Problems**

Fall, Winter, Spring. 1 to 4 credits. May retake for a maximum of 8 credits. Approval of department.

Individualized study adapted to the preparation and interests of the student.

500. **Set Theory and Foundations of Mathematics**

Spring, Summer. 4(4-0) MTH 424 or approval of department.

Axiomatic method, various formulations of the axiom of choice, cardinal and ordinal numbers.

501. **Mathematics Education I**

Fall. 3(3-0) Doctoral student in mathematical education or approval of department.

Historical origin of the content, methodology, forces, issues in mathematics education in the United States, Canada and Europe. Examination of the important issues and problems.

502. **Mathematics Education II**

Winter. 3(3-0) MTH 501.

Consideration of the historical development, philosophy, and psychological considerations underlying the various contemporary mathematics curriculum projects for grades K-12. Examination of the forces and issues surrounding the projects.

503. **Mathematics Education III**

Spring. 3(3-0) MTH 802.

Research in mathematics education, emphasis on identification of strengths and weaknesses in recent research practices, identification of specific, crucial problems, pertinent issues, consideration of research models, designs, and methods.

504. **Linear Algebra and Analysis I**

Fall. 3(3-0) MTH 334, MTH 424.

Linear and matrix algebra, Grassmann algebras, differential and integral calculus in En, linear differential equations, differential forms, closed and exact forms, Stokes' theorem and elements of differential manifolds.

505. **Linear Algebra and Analysis II**

Winter. 3(3-0) MTH 804.

Continuation of MTH 804.

506. **Linear Algebra and Analysis III**

Spring. 3(3-0) MTH 805.

Continuation of MTH 805.

511. **Theory of Relativity**

Winter of even-numbered years. 4(4-0) MTH 516.

Physical bases of theory of relativity. Introduction to space-time of two and four dimensions, and to relativistic dynamics, hydrodynamics and electromagnetism. Relativistic effects in solar gravitation field.

512. **Foundations of Geometry**

Fall. 4(4-0) MTH 426 or approval of department.

Incidence, affine and projective geometries. Finite projective planes, block designs, lattice representations, coordination, transformations, Erlangen program, classical geometries, Metric topology, programs of Blumenthal and Busemann.

513. **Geometry of Linear Spaces**

Winter. 4(4-0) MTH 812.


514. **Introduction to Differential Geometry**

Spring. 4(4-0) MTH 426 or approval of department.

Curves and surfaces in 3-space, curvature, torsion, Ponset formula. Riemannian manifolds, Gauss and mean curvature, geodesics, theorem egregium, Gauss-Codazzi equations, Gauss-Bonnet and Hilbert theorems.

516. **Tensor Calculus and Riemannian Geometry**

Fall of odd-numbered years. 4(4-0) MTH 426.

Contravariant and covariant tensors, metric tensors, geodesics, Christoffel symbols, covariant differentiation, curvature, Ricci tensor, parallel propagation, relative tensors, extension, spaces with affine connection, Weyl spaces; applications to dynamics, hydrodynamics and electromagnetic radiation.

517. **Theory of Linear Graphs I**

Winter. 3(3-0) MTH 334, MTH 424, or approval of department.

Fundamental concepts of undirected and directed graphs, including connectivity, trees, blocks, partitions, isomorphism, Menger's theorem, line graphs, coverings, Kuratowski's theorem, chromatic numbers, incidence matrices, and automorphism groups.
818. Theory of Linear Graphs II
Spring of even-numbered years. 3(3-0) MTH 817.
Advanced topics in the theory of linear graphs and combinatorial analysis. Polya's theorem and its application to enumeration problems.

821. Topology and Analysis I
Fall. 3(3-0) MTH 426 or MTH 804 or MTH 804 concurrently. Continuation of MTH 820. Set theory, Zorn's Lemma, topology of Rn and metric spaces, topological spaces, Lebesgue integration, Hilbert and Banach spaces, linear operators.

822. Topology and Analysis II
Winter. 3(3-0) MTH 821. Continuation of MTH 821.

823. Topology and Analysis III
Spring. 3(3-0) MTH 822. Continuation of MTH 822.

824. Real and Complex Analysis
Fall. 3(3-0) MTH 426. Topics in this course, MTH 825 and MTH 826 selected from following: the real number system, linear point sets, theory of limits; continuity and differentiability properties of functions of one or more variables; sequences and series of functions; Riemann, Lebesgue and Stieltjes integrals, implicit function theory; existence theorems for differential equations.

825. Real and Complex Analysis
Winter. 3(3-0) MTH 824. Continuation of MTH 824.

826. Real and Complex Analysis
Spring. 3(3-0) MTH 825. Continuation of MTH 825.

830. Error-Correcting Codes
Fall. 3(3-0) MTH 534. Algebraic background; theory of linear and cyclic codes; advanced topics.

831. Applied Matrix Theory
Winter, Summer. 4(4-0) MTH 534, MTH 426 or approval of department. Row echelon form, inner products, quadratic forms; Gram, Unitary and Hermitian matrices; Gram Schmidt process; orthotriangular factorization; least error, least effort problems; determinants, eigenvalues and eigenvectors, diagonalization methods, rank factorizations.

832. Symmetry Groups and Their Applications
Spring. 3(3-0) Matrix theory. Elementary Group Theory, orthogonal and isometry groups; isometries as transformations, rotations, glide reflections, screw rotations; symmetries for isometries, point and space groups, lattices, lattice groups, Bravais lattices, crystals.

833. Algebra
Fall. 3(3-0) Approval of department.
Elements of group theory; direct complement and chain decomposition, classification of groups; ring theory, integral domains, field theory, extensions, automorphisms, Galois theory; modules and vector spaces, Wedderburn structure theorem, linear and multilinear algebra.

835. Algebra II
Winter. 3(3-0) MTH 834. Continuation of MTH 834.

836. Algebra III
Spring. 3(3-0) MTH 835. Continuation of MTH 835.

841. Boundary Value Problems I
Fall. Summer of even-numbered years. 3(3-0) MTH 422, MTH 423; MTH 334 recommended.

842. Boundary Value Problems II
Winter. 3(3-0) MTH 841. Continuation of MTH 841.

843. Boundary Value Problems III
Spring. 3(3-0) MTH 842. Continuation of MTH 842.

844. Methods of Applied Analysis I
Fall. 3(3-0) MTH 534, MTH 423; MTH 426. Linear transformations on finite and infinite dimensional spaces, Fredholm and Hilbert-Schmidt theory, orthogonal polynomials, differential operators, Green's functions, Fourier transforms and distributions.

845. Methods of Applied Analysis II
Winter. 3(3-0) MTH 844. Continuation of MTH 844.

846. Methods of Applied Analysis III
Spring. 3(3-0) MTH 845. Continuation of MTH 845.

847. Theory of Ordinary Differential Equations I
Fall. 3(3-0) MTH 426; matrix theory. Existence theorems; uniqueness and continuation of solutions; dependence of solutions on a parameter; linear systems; phase plane analysis.

848. Theory of Ordinary Differential Equations II
Winter. 3(3-0) MTH 847. Continuation of MTH 847; oscillation theory, asymptotic behavior, Lyapunov stability, boundary value problems.

849. Theory of Ordinary Differential Equations III
Spring. 3(3-0) MTH 848; approval of department. Advanced topics in ordinary differential equations.

851. Numerical Analysis I
Fall. 3(3-0) MTH 426; FORTRAN programming and matrix theory recommended. Numerical methods for solving systems of linear equations with error analysis; linear programming, the simplex algorithm; numerical procedures for determining eigenvalues and eigenvectors of matrices. Emphasis on computer applications.

852. Numerical Analysis II
Winter. 3(3-0) MTH 551. Numerical methods with error analysis; solutions of nonlinear algebraic equations; Lagrange and Hermite interpolation; finite differences; approximation theory, including least square and Chebyshev approximations.

853. Numerical Analysis III
Spring. 3(3-0) MTH 852. Numerical methods with error analysis for: differentiation; quadrature including New Newton-Coates and Gaussian-type; difference equations; solutions of ordinary differential equations using one-step and multi-step predictor-corrector methods.

Fall. 3(3-0) MTH 804 or concurrently. An introduction to those aspects of convex sets and convex functions that are useful in applied mathematics, economics, and other areas together with applications to linear and nonlinear programming problems.

855. Mathematics of Operations Research II
Winter. 3(3-0) MTH 854, MTH 805 or concurrently. Continuation of MTH 854. Fixed point theorems, including Fan-Kakutani-Kuhn-Tucker theorems, duality theorems in nonlinear programming. Lagrangian conditions for constrained optima. Frobenius-Perron theory of non-negative matrices. Application to Economics and Business.

856. Mathematics of Operations Research III


858. General Topology I
Fall. 3(3-4) Approval of department. An introductory course in the topology of point sets. Concepts studied include topological spaces, products, homotopy and isotopy, separation, compactness, connectedness and path connectedness, metrizability and compactification.

859. General Topology II
Winter. 3(3-0) MTH 861. Continuation of MTH 861 dealing with identification topology, covering axioms, partitions of unity, K spaces, Baire-spaces and function spaces.

860. General Topology III
Spring. 3(3-0) MTH 862. Development of homotopy theory required for more advanced studies with applications to covering spaces and the fundamental group.

864. Differential Topology
Spring of odd-numbered years. 3(3-0) MTH 426, MTH 864. Smooth manifolds and maps. Submanifolds and embeddings. Mappings and approximations. Smoothing of maps and manifolds. Manifolds with boundary.
870. Foundations of Mathematics I  
Fall of even-numbered years. 3(3-0)  
MTH 424, MTH 471 recommended.  
Axiomatic set theory. Operations on sets, relations and functions, axiom of choice, maximal principles, cardinal and ordinal numbers, generalized, continuum hypothesis, axiom of constructibility, inaccessible cardinals.  

871. Foundations of Mathematics II  
Winter of odd-numbered years. 3(3-0)  
MTH 870.  
Problems in metamathematics. Topics include: axiomatic systems, predicate calculus, consistency, completeness, and independence results, model theoretics, decision procedures, Godel's incompleteness theorem, recursive functions.  

872. Foundations of Mathematics III  
Spring of odd-numbered years. 3(3-0)  
MTH 871.  
Continuation of MTH 871.  

880. Reading in Mathematics  
Fall, Winter, Spring, Summer. Variable credit. Approval of department.  

890. Master's Thesis Research  
Fall, Winter, Spring, Summer. Variable credit. Approval of department.  

900. Harmonic Analysis I  
Fall of even-numbered years. 3(3-0)  
MTH 823, MTH 852 or approval of department.  
Fourier series, mean and point-wise convergence, Fourier-Stieltjes series, Maximal functions and a.e. convergence, Conjugate functions, Interpolation of operators, Hausdorff-Young Theorems.  

901. Harmonic Analysis II  
Fall of odd-numbered years. 3(3-0)  
MTH 823, MTH 852 or approval of department.  

902. Functional Analysis I  
Fall of even-numbered years. 3(3-0)  
MTH 823, MTH 852 or approval of department.  
Continuation of MTH 924.  

903. Functional Analysis II  
Winter of even-numbered years. 3(3-0)  
MTH 924 or approval of department.  
Continuation of MTH 925.  

904. Functional Analysis III  
Spring of even-numbered years. 3(3-0)  
MTH 925.  
Continuation of MTH 925.  

905. Theory of Measure and Integration  
Spring. 3(3-0)  
MTH 822. Inter-departmental with the Department of Statistics and Probability.  

906. Harmonic Analysis II  
Winter of odd-numbered years. 3(3-0)  
MTH 920.  

907. Algebraic Topology I  
Fall. 3(3-0)  
MTH 834.  
Continuation of MTH 934.  

908. Algebraic Topology II  
Winter. 3(3-0)  
MTH 835.  
Continuation of MTH 935.  

909. Group Theory  
Spring. 3(3-0)  
MTH 836.  
Continuation of MTH 936.  

910. Advanced Group Theory I  
Fall. 3(3-0)  
MTH 937.  
Permutation groups, characters, l-properties, automorphisms, lattices of subgroups, classes of infinite groups, linear groups, recent literature.  

911. Advanced Group Theory II  
Winter. 3(3-0)  
MTH 938.  
Continuation of MTH 934.  

912. Advanced Group Theory III  
Spring. 3(3-0)  
MTH 935.  
Continuation of MTH 935.  

913. Fluid Dynamics I  
Fall of odd-numbered years. 3(3-0)  
MTH 883.  
General theory of perfect fluids including motion of incompressible fluids in two and three dimensions and applications to problems of wing profiles, viscous and compressible fluids discussed briefly.  

914. Fluid Dynamics II  
Fall of even-numbered years. 3(3-0)  
MTH 884.  
Continuation of MTH 915. Generalized methods of measuring error: Approximation in L1, and Lp norms, least-square approximation and orthogonal functions, spline functions; approximation in normed linear spaces.  

915. Approximation Theory I  
Spring of even-numbered years. 3(3-0)  
MTH 953.  
Continuation of MTH 952.  

916. Approximation Theory II  
Winter of even-numbered years. 3(3-0)  
MTH 954.  
Continuation of MTH 951.  

917. Approximation Theory III  
Spring of odd-numbered years. 3(3-0)  
MTH 955.  
Continuation of MTH 952.  

918. Topological Groups  
Winter of even-numbered years. 3(3-0)  
MTH 863.  
General properties of topological groups, classical groups and Lie groups.  

919. Point Set Topology  
Fall. 3(3-0)  
MTH 864.  
Continuation of MTH 919.  
Hausdorff continua, Hahn-Mazurkiewicz cyclic element theory, monotone decompositions, indecomposable continua, homogeneity.  

920. Algebraic Topology I  
Fall. 3(3-0)  
MTH 834.  
Simplexical and singular homotopy theory, Eilenberg-Steenrod axioms, chain complexes, cell complexes, applications to Euclidean spaces.  

921. Algebraic Topology II  
Winter. 3(3-0)  
MTH 864.  
Continuation of MTH 964 including category and functor theory, general coefficient and cohomology theory.  

922. Algebraic Topology III  
Spring. 3(3-0)  
MTH 965.  
Continuation of MTH 962 including homology groups of products, Eilenberg-Zilber theorems, cohomology products, differential topology.  

923. Advanced Topology in Analysis  
Fall, Winter, Spring. Summer. Variable credit.  

924. Advanced Topics in Algebra  
Fall, Winter, Spring. Summer. Variable credit. Approval of department.  
Structure of rings and algebras, Lie Algebras, Jordan algebras, advanced algebraic number theory, advanced matrix theory, and advanced topics in group theory, Lattice theory.
311. Thermodynamics I
Fall, Winter, Spring, 3(3-0) MTH 215 or concurrently.

Zeroth, first and second laws of thermodynamics. General energy equation. Process relations. Concepts of equilibrium, reversibility, and irreversibility. Applications of these to systems describable by two independent properties.

312. Thermodynamics II
Winter, Spring, 3(3-0) M E 311.
Continuation of ME 311. Gas and vapor relations, reactive and non-reactive mixtures. Thermodynamic principle as applied to gas and vapor power and refrigeration cycles for reciprocating and turbo machinery.

320. Kinematics of Machines I
Fall, Spring, Summer, 4(3-3) EGR 260; M M M 306 or concurrently.
Analysis of displacement, velocity, and acceleration in mechanical linkages; cam analysis and design; analysis of spur, helical, bevel, and worm gears, including planetary systems.

322. Fluid Mechanics I
Winter, Spring, 4(3-3) M E 311; M E 351 or concurrently; M M M 306.
Fluid statics; Bernoulli equation; nondeformable control volume applied to conservation of mass, momentum and energy; derivation of differential equations of continuity and momentum; similitude.

332. Fluid Mechanics II
Fall, Spring, 4(3-3) M E 332.
Fluid flow phenomena, laminar flow, turbulent flow, pipe flow, inviscid flows; boundary layers; external flow; an introduction to compressible flow.

410. Thermomechanical Continua
Fall, 3(3-0) M M M 211.
Reexamination of the continuum concept in the modeling of the deformation of solids and the flow of fluids. Cartesian tensor formulation of the basic physical laws involving stress and strain.

411. Heat Transfer I
Fall, Summer, 3(3-0) M E 311.
Analysis of steady-state and transient heat conduction, numerical solutions. Radiant heat transfer, principles and applications including radiation networks, gaseous radiation exchange.

412. Heat Transfer II
Winter, Spring, 3(3-0) M E 322.
Natural and forced convection based on boundary layer theory. Heat transfer in fluids with phase change. Heat exchangers, mass transfer.

414. Energy Conversion
Winter, 3(3-0) M E 312.
Fundamental principles of energy conversion systems. Direct energy conversion. Thermoelectric, thermonic, nuclear, fuel cells, magnohydrodynamic, and other methods of power generation.

415. Solar Energy Conversion
Fall, 4(4-0) M E 311 or approval of department.

416. Statistical Thermodynamics
(3-3) Spring, 3(3-0) M E 311.

417. Propulsion
Spring, 3(3-0) M E 333.
Thermodynamics and fluid mechanics will be used to study rockets, turbomachines, reciprocating engines, propellers, turbogenerators, and turbines; a specific propulsion system will be designed.

421. Mechanical Design
Fall, Winter, 3(3-0) M M M 211.
Introduction to design, the design process, design considerations and design procedures. Application of design principles to machine elements.

422. Mechanical Design Projects
Winter, Spring, 3(3-0) M E 421.
Application of design concepts, such as optimization, economics and reliability, through several projects drawn from the basic areas of mechanical engineering (thermodynamics, heat transfer, fluid and solid mechanics).

424. Dynamics of Machines
Winter, 3(3-0) M E 320.
Analysis of static and dynamic forces in mechanical linkages, balancing of rotating and reciprocating machinery, flywheel requirements, gyroscopic forces, critical speeds.