834. Marketing Channel Management  
Spring 4(4-0) MTA 805.  
Seminar in selected organizational, social, political, economic and cultural issues related to management in marketing channels.

835. Food Marketing Management  
Fall, Spring 4(4-0) May reenroll for a maximum of 8 credits. Interdepartmental with the Department of Agricultural Economics.  
Food industry adjustment to changing social, economic and internal company environment. Managerial principles and techniques applied to food processing and distribution. Student interaction with industry, labor and government representatives.

841. Materials and Logistics Management Policy  
Spring, Summer 4(4-0) MGT 805 plus 30 credits in the MBA Program. Interdepartmental with the Department of Management.  
Case course that integrates the materials and logistics management program. Emphasis on problem recognition, applying course materials and preparation of plans that improve total system performance.

851. Market Behavior and Competitive Strategy  
Fall, Winter, Summer 4(4-0) MTA 805.  
Industrial and consumer market structure and behavior and their impact upon the firm’s competitive operations and actions.

855. Market Cost-Revenue Analysis  
Winter 4(4-0) One course in accounting and one on marketing. Interdepartmental with the Department of Accounting and Financial Administration.  
Analytical tools for use in planning and controlling marketing activities. Emphasis on the determination of factors causing marketing cost differences and the assignment of costs to those factors. Application of tools to determination of expenditure-revenue patterns and market potentials.

860. International Business  
Winter, Summer 4(4-0)  
The economic environment within which the international firm operates is presented. Special emphasis on relating trade and payments theory, regional analysis, and economic development to strategy formulation of the firm. Marketing, financial, and organizational factors are considered.

861. International Marketing  
Spring 4(4-0) MTA 805.  
Models for headquarters planning and control of international marketing operations are developed. Social, cultural, institutional, and economic variables are considered in studying marketing operations in foreign environments.

862. Problems in International Business  
Fall 4(4-0) MTA 860 or MTA 862 or approval of department.  
Examination of strategies and organization for international business. In-depth consideration of headquarters and overseas personnel, marketing, financial, and legal issues.

890. Special Problems  
Fall, Winter, Spring, Summer. Variable credit. Approval of department.

905. Analysis of Business Enterprise Systems  
Fall 3 credits. MTA 805; MGT 806.  
Research concepts and scientific methods for the study of business enterprise systems. The design of research, formulation of hypotheses, concepts of measurement, and quantitative methods in the study of business systems.

909. Theory of Transportation-Distribution Systems  
Fall 4(4-0)  
Examines the functions of transportation-distribution systems. Develops the relevant elements of networks, systems, and economic theory with empirical design. Applications to the design evaluation, and control of representative macro and micro systems.

909A. Advanced Research in Marketing I  
Winter 4(4-0) Second-year doctoral students in marketing. Advanced concepts and quantitative methods in the scientific investigation of market phenomena and the tools of market cultivation.

910B. Advanced Research in Marketing II  
Spring 5(3-0) MTA 910A.  
Continuation of MTA 910A.

911A. History of Market Thought  
Fall 4(4-0) May reenroll for a maximum of 15 credits. MTA 853.  
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. MTA 911A.  
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) MTA 852, MTA 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.
103. Intermediate Algebra
Fall, Winter, Spring. 3(3-0)
Current enrollment in MTH 0823, one year of high school algebra, satisfactory score on placement exam, or MTH 0823; 1 high school unit in geometry. Not open to students with credit in MTH 111.
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. 3(3-0) 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. 3(3-0) 1/2 high school units in algebra and superior score on placement test, or MTH 0823; 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 definitions of circular functions, angular measure, fundamental identities.

110. Finite Mathematics with Applications
Fall, Winter, Spring. 3(3-0) 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, Summer. 3(3-0) 1-1/2 years of high school algebra, 1 year of high school geometry, satisfactory score in algebra placement examination, trigonometry or MTH 0823; 1 high school unit in geometry. Not open to students with credit in MTH 108 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. 3(3-0) MTH 109 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. 3(3-0)
MTH 112
A continuation of MTH 112.

122. Calculus I
Fall, Winter, Spring. 3(3-0) 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-term course in primarily single variable calculus with an introduction to several variables for students who want only one or two terms of calculus.

123. Calculus II
Fall, Winter, Spring. 3(3-0) MTH 122; not open to engineers, physical science or mathematics majors or to students with credit in MTH 112.
The second of a two-term 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 integrate the mathematics majors to the type of mathematical reasoning and subject matter they can expect to encounter in advanced mathematics courses. Specific content will vary.

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

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

202. Foundations of Geometry
Winter, 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, Summer. 4(4-0) MTH 214.
Continuation of MTH 214.

216. Mathematics of Finance
Winter. 3(3-0) MTH 109 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.

228. Calculus for Social Scientists
Winter. 4(4-0) MTH 227.
Mean value theorems, approximate integration, infinite series, Taylor series, partial derivatives, double and triple integration, and applications. Approved through Winter 1981.

290. Special Topics in Mathematics
Fall, Winter, Spring. 1 to 5 credits. May repeat for a maximum of 9 credits. Approval of department.
Individualized study adapted to the preparation and interest 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 inclusion 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 major and approval of department.
Professional organizations and their journals, mathematics curriculum in standard test series, new curriculum developments and projects, problems in assessments and evaluation.

310. Differential Equations
Fall, Winter, Spring. 3(3-0) MTH 215 or concurrently.
First and second order equations; solutions in series, higher order equations; systems of differential equations, applications.

315. Concepts of Geometry I
Fall, Winter, Spring. 3(3-0) MTH 214 or approval of department.
Axiomatic structure of geometries including Euclidean, the classical non-Euclidean and projective geometries. Coordinate systems and geometric transformations.

316. Concepts of Geometry II
Winter, Spring. 3(3-0) MTH 315.
Continuation of MTH 315.

324. Foundations of Analysis
Fall, Winter, Spring. 4(4-0) MTH 215.
Elementary set theory; functions, mappings, equivalence relations; sequences and series; Cauchy sequences; least upper bound; countability; connected and compact sets; Bolzano Weierstrass Theorem; continuity.

331. Theory of Numbers
Fall, Winter, Spring. 3(3-0) MTH 113 or approval of department.
Diophantine equations, congruences, quadratic residues, finite fields.

334. Theory of Matrices
Fall, Winter, Spring. 4(4-0) MTH 214 or approval of department.
Algebra of matrices, vector spaces, rank, inverses, determinants, systems of 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, Spring, 4(4-0) MTH 310
Introduction to partial differential equations and initial and boundary value problems; emphasis on the heat equation, LaPlace's equation and heat flow equations and their solutions by separation of variables.

350. Mathematical Modeling for Teachers
Spring, Summer, 3(3-0) MTH 215.
Mathematical topics covered include: binary, octal and hexadecimal arithmetic, Euclidean algorithm and prime number generators, root finding for polynomials, approximation of functions, difference equations, combinatorics and probability problems, topics from geometry, and mathematical modeling and simulation.

351. Introduction to Numerical Analysis
Winter, Spring, 4(4-0) MTH 310 and knowledge of FORTRAN programming; students may not receive credit in both MTH 351 and MTH 451.
Introduction to numerical analysis; computer coding using a compiler language; approximation to roots of equations, interpolation, numerical quadrature, numerical solution of ordinary differential equations.

352. Introduction to Numerical Solutions of Partial Differential Equations
Fall, 4(4-0) MTH 351.
Numerical solutions of boundary value problems, both two point and in the plane. Iterative methods for solving equations. Introduction to stability and error analysis.

381. Chemical Engineering Analysis
Fall, Spring, 3(3-0) Students may not receive credit in both MTH 381 and MTH 341.
MTH 310. Interdepartmental with and administered by the Department of Chemical Engineering.
Formulation of ordinary and partial differential equations describing chemical systems. Boundary value problems, numerical methods, matrices and applications, to chemical engineering systems.

400H. Honors Work
Fall, Winter, Spring, 1 to 16 credits.
MTH 215 or approval of department.
Individualized reading and study in mathematics for students of high intellectual promise.

401. Geometry for Teachers
Summer, 3(3-0) Approval of department; not applicable to major or minor requirements.
Topics in geometry for junior and senior high school teachers.

405. Mathematical Topics for Teachers
Fall, Winter, Spring, Summer, 3(3-0)
May repeat for a maximum of 12 credits.
Approval of department, open only to teachers participating in teacher institutes or special extension courses.

412. Axiomatic Geometry
Fall of odd numbered years, 4(4-0) MTH 215 or approval of department.
Euclid's and Hilbert's axioms; non-Euclidean geometries; the space concept, metric spaces and basic, topological concepts, the Erlanger Program.

413. Projective Geometry
Winter of even-numbered years, 4(4-0) MTH 215 or approval of department.
Axioms: basic configurations, Synthetic and analytic treatment of projective transformations, duality, cones, poles, involution. Introduction of a metric.

414. Differential and Analytic Geometry
Spring, 4(4-0) MTH 215 or approval of department.

420. Ordinary Differential Equations
Fall, Winter, Spring, 4(4-0) MTH 310, MTH 334.
Existence and uniqueness theorems, linear systems, plane autonomous systems, introduction to stability theory, Lyapunov's second method, applications.

421. Vector and Tensor Analysis
Fall, Winter, Summer, 4(4-0) MTH 310, MTH 334 recommended.
Vector calculus. Line and surface integrals. Divergence and curl, theorems, orthogonal coordinate systems, introduction to tensors; applications to the physical sciences.

422. Boundary Value Problems and Fourier Series
Fall, Winter, Spring, 4(4-0) MTH 310, MTH 429.

423. Complex Variables
Winter, Spring, 4(4-0) MTH 310 or approval of department.
Analytic functions, integrals, power series, residues, poles, conformal mapping and applications.

424. Advanced Calculus
Fall, Winter, Spring, 4(4-0) MTH 215.
Limits and continuity, function of several variables, ordinary and partial derivatives; theory of integration; multiple, line and surface integrals; infinite series, improper integrals, Beta and Gamma functions and other topics.

425. Advanced Calculus
Winter, Spring, 3(3-0) MTH 424.
Continuation of MTH 424.

426. Advanced Calculus
Fall, Spring, 3(3-0) MTH 425.
Continuation of MTH 425.

427. Real Analysis I
Fall, 4(3-0) Approval of department.
Topology, limits and continuity in Fn, 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 334.
Block codes and maximum likelihood decoding; Galois fields; 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 431. Introduction to the concepts of basic algebraic structures, namely: group, ring, integral domain, field. Polynomials, 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 331 or MTH 432 or approval of department.
Dirichlet series, distribution of primes, sums of squares, Pell's equation, continued fractions, Hurwitz Theorem.

450. Mathematical Programming
Fall of even-numbered years. 3(3-1) MTH 424 or concurrently, MTH 334, knowledge of FORTRAN programming.
Finite dimensional convexity, theorems of the alternative, LR factorization, simplex algorithm, quasi-Newton methods, nonlinear duality theory, dual algorithms.

451. Numerical Analysis I
Winter, Spring, 4(4-0) MTH 310, 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(3-0) 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.
Unicursal graphs, surface topology, classification of surfaces, elementary set-theoretic topology, complexes.

471. Mathematical Logic
Fall, 4(4-0) MTH 215 or approval of department.
### 480. Mathematics for Economists

- **Fall**: 3(5-0) MTH 113, 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 214 or MTH 122.
- Matrix algebra, difference and differential equations, graphical and numerical methods, discrete and continuous population models, computational analysis, enzyme kinetics, theory of chemosensory, hormonal controls, diffusion processes, food chains, pollution problems.

### 490. Mathematical Problems

- **Fall, Winter, Spring**: 1-4 credits.
- May reenroll to maximum of 8 credits.
- Approval of department.
- Individualized study adapted to the preparation and interests of the student.

### 800. Set Theory and Foundations of Mathematics

- **Spring**: 4(4-0) MTH 424 or approval of department.
- Axiomatic method; various formulations of the axiom of choice; cardinal and ordinal numbers.

### 801. Mathematics Education I

- **Fall**: 3-3(0) Doctoral student in mathematical education or approval of department.
- Historical origin of the concept, methodology, forces, issues in mathematics education in the United States, Canada and Europe. Delimitation of the important issues and problems.

### 802. Mathematics Education II

- **Winter**: 3-3(0) MTH 801.
- 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.

### 803. 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, design, and methods.

### 804. Linear Algebra and Analysis I

- **Fall**: 3(5-0) MTH 334, MTH 424.

### 805. Linear Algebra and Analysis II

- **Winter**: 3-3(0) MTH 804.
- Continuation of MTH 804.

### 806. Linear Algebra and Analysis III

- **Spring**: 3(3-0) MTH 805.
- Continuation of MTH 805.

### 811. Theory of Relativity

- **Winter of even-numbered years**: 4(4-0) MTH 816.
- Physical basis of theory of relativity. Introduction to space-time of two and four dimensions, and to relativistic dynamics, hydrodynamics, and electromagnetism. Relativistic effects in solar gravitational field.

### 812. Foundations of Geometry

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

### 813. Geometry of Linear Spaces

- **Winter**: 4(4-0) MTH 813.

### 814. Introduction to Differential Geometry

- **Spring**: 4(4-0) MTH 426 or approval of department.
- Curves and surfaces in 3-space, curvature, torsion, Frenet formulas. Riemannian manifolds. Gauss and mean curvature, geodesics, theorem egregium, Gauss-Codazzi equations, Gauss-Bonnet and Hilbert theorems.

### 815. 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, relation to tensor, extension, spaces with affine connection. Weyl spaces; applications to dynamics, hydrodynamics and electromagnetic radiation.

### 817. 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, or approval of department.
- 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 set, theory of limits; continuity and differentiability properties of functions of one or more variables; sequences and series of functions; Riemann, Lebesque 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.

### 828. Hilbert Spaces

- **Winter of even-numbered years**: 4(4-0) MTH 426.
- Normed linear spaces, with particular emphasis on Hilbert spaces and linear operators in these spaces; linear functionals, conjugate spaces, operator algebra, spectral theory; and applications.

### 830. Error-Correcting Codes

- **Fall**: 3-3(0) MTH 334.
- Algebraic background; theory of linear and cyclic codes; advanced topics.

### 831. Applied Matrix Theory

- **Winter, Summer**: 4(4-0) MTH 334, MTH 424 or approval of department.
- Row echelon form, inner products, quadratic forms; Gram, Unitary and Hermitian matrices; Gram Schmidt process; orthonormal factorization; least squares problems; determinants, eigen values and eigen vectors, diagonalization methods, rank factorizations.

### 832. Symmetry Groups and Their Applications

- **Spring**: 3-3(0) MTH 334.
- Elementary Group Theory, orthogonal and isometry groups; isometrics as translations, rotations, glide reflections, screw rotations; symbols for isometries, point and space groups, lattices, lattice groups, Bravais lattices, crystals.

### 834. Algebra I

- **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 theory, 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. 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 334, 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 851.
Numerical methods with error analysis for solutions of nonlinear algebraic equations: Lagrange and Hermite interpolation; finite differences; approximation theory, including least squares and Chebyshev approximations.

853. Numerical Analysis III
Spring. 3(3-0) MTH 852.
Numerical methods with error analysis for differentiation; quadrature including Newtton-Cotes 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. Lagrangean conditions for constrained optimum. Prohorov-Perron theory of non-negative matrices. Application to Economics and Business.

856. Mathematics of Operations Research III

Spring. 4(4-0) MTH 427, knowledge of matrices recommended. Knowledge of computer programming desirable.
Numerical methods for solving initial and boundary value problems of partial differential equations.

858. Numerical Methods in Partial Differential Equations II
Fall. 3(3-0) MTH 858.
Continuation of MTH 857: Trees, linear algebra, computational aspects of spectral analysis.

859. General Topology I
Fall. 3(3-0) 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, metrization and compactification.

860. General Topology II
Winter. 3(3-0) MTH 860.
Continuation of MTH 859: dealing with identification topology, covering axioms, partitions of unity, K spaces, Baire-spaces and function spaces.

861. 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.

862. Topological Differential Equations I
Fall. 3(3-0) MTH 863. Elliptic type equations: Green's, Neumann's and Kernel functions; boundary value problems and integral equations; hyperbolic equations; geometry of characteristics, Riemann's functions.

870. Foundations of Mathematics I
Fall. 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. 3(3-0) MTH 870. Problems in metamathematics. Topics include: axiomatic systems, predicate calculus, consistency, completeness, and independence results, model theorems, decision procedures, Godel's incompleteness theorem, recursive functions.

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

873. Foundations of Applied Mathematics I
Fall. 3(3-0) MTH 426 or MTH 432. Introduction to the mathematical theory of classical applied mathematics; properties and postulates of various theories such as ideal fluids and linear elasticity; derivation of field equations; formulation of initial and boundary value problems.

875. Foundations of Applied Mathematics II
Winter. 3(3-0) MTH 881. Continuation of MTH 875.

876. Foundations of Applied Mathematics III
Spring. 3(3-0) MTH 882. Continuation of MTH 876.

877. Fluid Dynamics I
Fall. 3(3-0) MTH 426 or MTH 422. Approval of department. Derivation of the equations of fluid mechanics. Comparisons of formulations, techniques and results in the basic disciplines of potential, viscous and gas dynamic flows.

878. Fluid Dynamics II
Winter. 3(3-0) MTH 884. Continuation of MTH 878.

881. Partial Differential Equations
Fall. 3(3-0) MTH 476. Cauchy-Kowalewski theorem: classification, characteristics, normal forms; general theory of first order equations; potential theory.

882. Partial Differential Equations II
Winter. 3(3-0) MTH 886. Elliptic type equations: Green's, Neumann's and Kernel functions; boundary value problems and integral equations; hyperbolic equations; geometry of characteristics, Riemann's functions.
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888. Partial Differential Equations III
Spring, 3(3-0) MTH 887.
Continuation of hyperbolic equations; application of functional analysis to existence theorems, theory of Leray and Schauder.

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

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

920. Harmonic Analysis I
Fall of even-numbered years. 3(3-0) MTH 823, MTH 862 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.

924. Functional Analysis I
Fall of odd-numbered years. 3(3-0) MTH 823, MTH 862 or approval of department.

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

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

927. Theory of Measure and Integration
Spring. 3(3-0) MTH 922.
Interdepartmental with the Department of Statistics and Probability.

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

929. Harmonic Analysis III
Spring of odd-numbered years. 3(3-0) MTH 928.
Selected topics from Fourier analysis on compact groups, singular integrals, harmonic analysis in R^n, H^p theory in one and several variables or differentiation of integrals.

934. Advanced Group Theory I
Fall. 3(3-0) MTH 836.
Permutation groups, character theory, representations, homomorphisms, lattices of subgroups, classes of infinite groups, linear groups, recent literature.

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

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

948. Fluid Dynamics III
Spring of odd-numbered years. 3(3-0) MTH 885.
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.

951. Approximation Theory I
Fall of odd-numbered years. 3(3-0) MTH 823 or approval of department.
Tchebycheff, approximation with polynomials, rational functions and general linear families; the Unicity problem, degree of approximation; Berstein Polynomials; Remes algorithm, uniform approximation with constraints.

952. Approximation Theory II
Fall of even-numbered years. 3(3-0) MTH 951.
Continuation of MTH 951. Generalized methods of measuring error. Approximation in L^p, L^q, least-square approximation and orthogonal functions; spline functions; approximation in normed linear spaces.

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

961. Topological Groups
Winter of even-numbered years. 3(3-0) MTH 862.
General properties of topological groups, classical groups and Lie groups.

962. Point Set Topology
Fall of odd-numbered years. 3(3-0) MTH 923, MTH 861.
Hausdorff continua, Hahn-Mazurkiewicz cyclic element theory, monotone decompositions, indecomposable continua, homogeneity.

964. Algebraic Topology I
Fall. 3(3-0) MTH 834, MTH 862.
Simplicial and singular homotopy theory, Eilenberg-Zilber axioms, chain complexes, cell complexes, applications to Euclidean spaces.

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

966. Algebraic Topology III
Spring. 3(3-0) MTH 865.
Continuation of MTH 865 including homology groups of products, Eilenberg-Zilber theorems, cohomology products, differential topology.

991. Advanced Topics in Geometry
Fall, Winter, Spring, Summer. Variable credit.

992. Advanced Topics in Analysis
Fall, Winter, Spring, Summer. Variable credit.

993. 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.

994. Advanced Topics in Applied Mathematics
Fall, Winter, Spring, Summer. Variable credit. Approval of department.

996. Advanced Topics in Topology
Fall, Winter, Spring, Summer. Variable credit. Approval of department.
Topological groups, topology of Euclidean spaces, axiomatic homology theory, homotopy theory, function spaces.

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

MECHANICAL ENGINEERING

College of Engineering

201. The Science of Sound I: Rock, Bach and Oscillators
Winter. 3(3-0) or 4(4-0) PHY 201.
Interdepartmental with the Department of Physics.

202. The Science of Sound II
Spring. 3(3-0) or 4(4-0) PHY 201.
Interdepartmental with the Department of Physics.

300. Technology and Utilization of Energy
Winter. 3(3-0) Initial course in any sequence of courses in the Department of Natural Science. Interdepartmental with the Department of Engineering.
Problems of energy technology and its impact: energy sources, conversions, waste and environmental effects, future outlook for mankind.

303. Thermal-Fluid Phenomena
Spring. 3(3-0) MME 201 or approval of department.
Concepts and principles used to describe, predict, or explain thermal and fluid-flow phenomena. Constraints, approximations, engineering problem solving. Application to socio-technical questions.