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.

862. International Marketing

Spring. 4(4-0) MTA 805.

Models for headquarters planning and control of international marketing operations are developed. Social, cultural, institutional, and econmic variables are considered in studying marketing operations in foreign environments.

863. 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 measurements and use of 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.

910A. 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(5-0) MTA 910A.

Continuation of MTA 910A.

911A. History of Market Thought

Fall. 4(4-0) May reenroll for a maximum of 15 credits. MTA 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. 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 812, 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.

941. Transportation-Distribution Development Policy

Spring. 4(4-0) MTA 909, MTA 912.

Applications in theory, principles, and proceses developed in MTA 909 and MTA 912 to the design of research processes and reports in signficant transport and distribution problems.

957. Seminar in Micro Marketing

Spring. 4(4-0) MTA 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.

0813. Elements of Algebra

Fall, Winter, Spring, Summer. 0(3-0) (3(3-0) See page A-2 item 3.) Current enrollment in MTH 103.

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.

0823. Intermediate Algebra

Fall, Winter, Spring, Summer. 0(2-0) (2(2-0) See page A-2 item 3.) Current enrollment in MTH 104, one year of high school algebra, satisfactory score on placement exam.

Properties of real numbers, polynomials, factoring, rational functions, exponents, roots and radicals, first and second degree equations, linear inequalities, complex numbers, word problems.

102. Trigonometry

Winter, Spring. 3(3-0) 1-1/2 high school units in algebra and satsfactory score on placement test, or MTH 082; 1 high school unit in geometry. Not open to students who have had trigonometry in high school or credit in MTH 109.

Trigonometric functions, identities, related angles, radian measure, graphs, sum and difference formulas, simple trigonometric equations, logarithms, solution of plane triangles, inverse functions.

1033. Elements of Algebra

Fall, Winter, Spring, Summer. 2(2-0) Current enrollment in MTH 081.

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.

1043. Intermediate Algebra

Fall, Winter, Spring, Summer. 3(3-0) Current enrollment in MTH 082, one year of high school algebra, satisfactory score on placement exam.

Properties of real numbers, polynomials, factoring, rational functions, exponents, roots and radicals, first and second degree equations, linear inequalities, complex numbers, word problems.

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 082; 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 superior 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, Summer. 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 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, Summer. 5(5-0) 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, transcendential 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-term 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-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 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, Summer. 4(4-0) 1-1/2 high school units in algebra and satisfactory score on placement test, or MTH 082-104; 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, Summer. 4(4-0) MTH 214.

Continuation of MTH 214.

216. *Mathematics of Finance*

Winter. 3(3-0) MTH 108 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.

227. *Calculus for Social Scientists*

Fall. 4(4-0) Graduate standing; 1-1/2 years of high school algebra or high placement score; 1 year of high school geometry. Not open to students who have credit for calculus.

The sequence MTH 227, MTH 228 intended for social science graduate students is mainly calculus. Course MTH 227 includes pre-calculus differentiation and integration of elementary functions, applications.

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.

290. *Special Topics in Mathematics*

Fall, Winter, Spring. 1 to 5 credits. May reenroll 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.

301. *Foundations of Mathematics*

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

Fundamental ideas underlying elementary mathematics. Basic set theory, relations, functions, mathematical induction, meaning of mathematical proof and the axiomatic method illustrated by examples from algebra, geometry and analysis.

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 minor and approval of department.

Professional organizations and their journals, mathematics curriculum in standard text series, new curriculum developments and projects, problems in assessments and evaluation.

309. *Theory of Equations*

Spring. 4(4-0) MTH 113 or approval of department.

Desirable for those preparing to teach mathematics in high schools. Mathematical induction, complex numbers, theorems in roots of polynomial equations, cyclotomic equations, ruler and compass constructions, solution of cubic and quartic equations, approximation to roots, theory of determinants, an introduction to matrices and some history of the theory of equations.

310. *Differential Equations*

Fall, Winter, Spring, Summer. 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 215 or MTH 301 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.

322. *Introduction to Complex Variables*

Spring. 4(4-0) MTH 310.

Elements of functions of a complex variable. Topics selected from complex number systems, infinite series, elementary functions, differentiation and integration, Taylor and Laurent series, conformal mapping, theory of residues.

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, Summer. 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 301 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 wave equation, LaPlace's equation and heat flow equations and their solutions by separation of variables.

351. *Introduction to Numerical Analysis*

(321.) 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 Equation*

Fall. 4(4-0) MTH 351.

Numerical solutions of boundary value problems, both two point and in the plane. Iterative methods for matrix 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 reenroll 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. 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, Summer of odd-numbered years. 4(4-0) MTH 215 or approval of department.

Axioms. Basic configurations. Synthetic and analytic treatment of projective transformations, duality, conics, poles, involution. Introduction of a metric.

414. Differential and Analytic Geometry

Spring. 4(4-0) MTH 215 or approval of department.

Coordinate systems in Euclidean three-space. Basic configurations. Vectors and the geometry of n-space. Transformations. Elementary differential geometry of curves and surfaces.

420. Ordinary Differential Equations

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 Stokes theorem, 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 424.

Power series solutions of ordinary differential equations, Fourier series and orthogonal functions, partial differential equations of second order.

423. Complex Variables

Winter, Spring. 4(4-0) MTH 424 or MTH 427.

Analytic functions, integrals, power series, residues, poles, conformal mapping and applications.

424. Advanced Calculus

Fall, Winter, Spring, Summer. 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

Fall, Winter, Spring, Summer. 3(3-0) MTH 424.

Continuation of MTH 424.

426. Advanced Calculus

Fall, Winter, 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 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 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 215.

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 331 or MTH 432 or approval of department.

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

Language of mathematics. Informal axiomatic method. Propositional logic, validity, axiom and rules of inference, introduction to algebra of sets. Predicate logic. Logic of identity.

480. Mathematics for Economists

Fall. 5(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.

Matrix algebra, determinants, quadratic forms, characteristic values. Partial derivatives, chain rule, Jacobian matrix, Taylor series, constrained optimization, linear differential equations. Mathematics introduced and developed using student's background in economics.

481. Selected Mathematical Ideas in Biology

Winter, Spring. 4(4-0) MTH 214 or MTH 123.

Matrix algebra, difference and differential equations, graphical and numerical methods, discrete and continous population models, compartmental analysis, enzyme kinetics, theory of chemostat, hormonal controls, diffusion processes, food chains, pollution problems.

490. Mathematical Problems

Fall, Winter, Spring. 1 to 4 credits. May reenroll for a 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. Summer. 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 content, methodology, forces, issues in mathematics education in the United States, Canada and Europe. Delineation 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, designs, and methods.

804. *Linear Algebra and Analysis I*

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

Linear and matrix algebra, Grassman algebra, differential and integral calculus in Rn, linear differential equations, differential forms, closed and exact forms, Stokes theorem and elements of differential manifolds.

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 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.

812. *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 Busmann.

813. *Geometry of Linear Spaces*

Winter. 4(4-0) MTH 812.

Linear topological spaces, Banach spaces, locally convex spaces. Linear transformations and functionals, extension theorems, conjugate spaces, weak topologies. Convexity, Krien-Milman theorem. Minkowski spaces, Helly's theorem. Caratheodory's theorem. Extremal structure.

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.

816. *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.

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 theroem, 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 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.

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; orthotriangular factorization; least error, least effort problems; determinants, eigen values and eigen vectors, diagonalization methods, rank factorizations.

832. *Symmetry Groups and Their Applications*

Spring. 3(3-0) Matrix theory.

Elementary Group Theory, orthogonal and isometry groups; isometrices as translations, rotations; glide reflections, screw rotations; symbols for isometries, point and space groups, lattices, latice 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. Summer or even-numbered years. 3(3-0) MTH 422, MTH 423; MTH 334 recommended.

Linear spaces, Fourier series. Boundary value problems for ordinary and partial differential equations. Variational methods. Fredholm integral equations. Integral transform. Distribution theory.

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 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-Cotes and Gaussian-type; difference equations; solutions of ordinary differential equations using one-step and multi-step predictor-corrector methods.

854. *Mathematics of Operations Research I*

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*

Spring. 3(3-0) MTH 806 or concurrently.

Classical problems of variational calculus. Allocation and optimal control problems. Necessary conditions. Infinite dimensional programming and duality theory. Sufficiency conditions. Generalized Lagrange multipliers. Saddle point theory. Dynamic programming.

857. *Numerical Methods in Partial Differential Equations*

Spring. 4(4-0) MTH 422, knowledge of matrices recommended. Knowledge of computer programming desirable.

Numerical methods for solving initial and boundary value problems of partial differential equations.

861. *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.

862. *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.

863. *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 862.

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.

881. *Foundations of Applied Mathematics I*

Fall. 3(3-0) MTH 426 or MTH 423.

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.

882. *Foundations of Applied Mathematics II*

Winter. 3(3-0) MTH 881.

Continuation of MTH 881.

883. *Foundations of Applied Mathematics III*

Spring. 3(3-0) MTH 882.

Continuation of MTH 882.

884. *Fluid Dynamics I*

Fall of even-numbered years. 3(3-0) MTH 426 or MTH 422 or 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.

885. *Fluid Dynamics II*

Winter of odd-numbered years. 3(3-0) MTH 884.

Continuation of MTH 884.

886. *Partial Differential Equations I*

Fall. 3(3-0) MTH 334, MTH 423, MTH 426.

Cauchy-Kowalewski theorem; classification, characteristics, normal forms: general theory of first order equations; potential theory.

887. *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.

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.

Topological groups and topological vector spaces, metrizability, locally convex spaces, Hahn-Banach and Krein-Milman theorems, dual spaces, Banach spaces, Hilbert spaces, Banach algebras.

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 even-numbered years. 3(3-0) MTH 925.

Continuation of MTH 925.

927. *Theory of Measure and Integration*

Spring. 3(3-0) MTH 822. Interdepartmental with the Department of Statistics and Probability.

Introduction to the theory of integration over abstract spaces. Topics include: measure spaces; measurable and integrable functions; modes of convergence, theorems of Egroff, Lusin, Riesz-Fisher, Lebesgue absolute continuity, and the Radon-Nikodym theroem; product measures and Fubini's theorem. Applications to some of the classical theories of integration and summability.

928. Harmonic Analysis II
Winter of odd-numbered years. 3(3-0) MTH 920.
Fourier transforms on Rn and R. Tempered distribution, inversion formula, Plancherel Theorem, pseudo-measures, almost-periodic functions, spectral properties, Wiener Tauberian Theorem, Paley-Wiener Theorems.

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 Rn, Hp theory in one and several variables or differentiation of integrals.

931. Non-Associative Algebras I
Fall of odd-numbered years. 3(3-0) MTH 836.
Non-associative algebras, radicals, idempotent decomposition of simple algebras.

932. Non-Associative Algebras II
Winter of even-numbered years. 3(3-0) MTH 931.
Continuation of MTH 931. Nil algebras, structure and representations, Lie algebras.

933. Non-Associative Algebras III
Spring of even-numbered years. 3(3-0) MTH 932.
Continuation of MTH 932. Relations between non-associative algebras, representations and cohomology theory.

934. Advanced Group Theory I
Fall. 3(3-0) MTH 836.
Permutation groups, characters, ⅛-properties, automorphisms, 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.

937. Commutative Algebra I
Fall of even-numbered years. 3(3-0) MTH 836.
Algebraic number theory, Noetherian rings, Dedekind domains and classical ideal theory, valuation theory, power series rings, local rings.

938. Commutative Algebra II
Winter of odd-numbered years. 3(3-0) MTH 937.
Continuation of MTH 937.

939. Commutative Algebra III
Spring of odd-numbered years. 3(3-0) MTH 938.
Continuation of MTH 938.

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 Uncity problem; degree of approximation; Berstein Polynomials; Remes algorithm, uniform approximation with constraints.

952. Approximation Theory II
Winter of even-numbered years. 3(3-0) MTH 951.
Continuation of MTH 951. Generalized methods of measuring error; Approximation in Li, and Lp norms, 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 823, 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-Steenrod axioms, chain complexes, cell complexes, applications to Euclidean spaces.

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

966. Algebraic Topology III
Spring. 3(3-0) MTH 965.
Continuation of MTH 965 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.
Nonlinear differential equations, asymptotic theory in differential equations, existence theorem, diffraction theory, Wiener-Hopf techniques.

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 M E

College of Engineering

201. The Science of Sound I: Rock, Bach and Oscillators
Winter. 3(3-0) or 4(4-0) Interdepartmental with and administered by the Department of Physics.
Man-sound relationship. Production, propagation, detection of sounds. Voice hearing, scales, timbre, musical instruments. Room acoustics. Electronic reproduction and synthesis of music. Demonstrations emphasized.

202. The Science of Sound II
Spring. 3(3-0) or 4(4-0) PHY 201. Interdepartmental with the Department of Physics.
Nature, generation, and progagation of sound. Acoustical phenomenon and measurements. Storage and manipulation of sound in numerical form. Music programming.

255. Computer Models in Science and Engineering
Spring. 3(3-0) CPS 110 or CPS 120 or equivalent FORTRAN. Interdepartmental with the Department of Computer Science.
Problem-solving; development of student's ability to formulate computable models based on finite physical elements, examples from statics, dynamics, electrical resistance, and conduction heat transfer.

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) MMM 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.

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.