

MATHEMATICS

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<https://clas.wayne.edu/math> (<https://clas.wayne.edu/math/>)

The courses offered by the Department of Mathematics serve several purposes: they supply the mathematical preparation necessary for students specializing in the physical, biological or social sciences, in business administration, in engineering, and in education; they provide a route by which students may arrive at the level of research competency in any of several special mathematical areas; they allow students to prepare themselves for work as mathematicians and statisticians in industry and government; and they give an opportunity to all inquisitive students to learn something about modern mathematical ideas.

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GRAZIANA, ANNE: B.A.; Lecturer

HOCHSTADT, CAROLYN: M.A., B.S., Wayne State University; Lecturer

HU, PO: Ph.D., University of Michigan; B.A., Yale University; Professor

HUANG, TAO: Ph.D., University of Kentucky; Ph.D., Xiamen University; M.S., Shandong Normal University; Assistant Professor

ISAKSEN, DANIEL: Ph.D., M.S., University of Chicago; B.A., University of California, Berkeley; Professor

KAHN, STEVEN M.: Ph.D., M.A., University of Maryland; B.S., State University of New York at Stony Brook; Professor

KHURRAM, ALIA: Ph.D. and M.S., Southern Illinois University; M.S., Quaid-i-Azam University; B.S., University of the Punjab; Lecturer

KLEIN, JOHN R.: Ph.D., M.A., Brandeis University; B.A., Northwestern University; Professor

KUMAR, ROHINI: Ph.D., University of Wisconsin-Madison; M.S., B.S., Bangalore University; Associate Professor

LANNI, MELINDA: M.A., B.A., Wayne State University; Lecturer

LEBIEDZIK, CATHERINE: Ph.D., M.A., University of Virginia; B.S., Pennsylvania State University; Associate Professor

LEIRSTEIN, CHRISTOPHER: M.A., B.S., Wayne State University; Senior Lecturer

LI, HENGGUANG: Ph.D., Pennsylvania State University; B.S., Peking University; Professor and Chair

MAHABIR, NARESH: M.A., B.A., Wayne State University; Lecturer

MAKAR-LIMANOV, LEONID: Ph.D., M.S., Moscow State University; Professor

MARTELL, RAUL: M.A., B.A., Wayne State University; Lecturer

MENALDI, JOSE: M.S., University of Texas-Arlington; B.S., Michigan Tech University; Professor

MORDUKHOVICH, BORIS S.: Ph.D., M.S., Byelorussian State University; Distinguished Professor

NAZELLI, CHRISTOPHER: M.A., B.A., Wayne State University; Senior Lecturer

OKOH, FRANK: Ph.D., M.S., Queen's University; B.S., Imperial College of Science and Technology; Professor

PACHECO, OMAR M.: B.S., Wayne State University; Lecturer

PINEAU, RICHARD: M.P.A., G.C.E.D., M.A., B.A., Wayne State University; Senior Lecturer

SALCH, ANDREW: Ph.D., M.A., University of Rochester; B.S. Portland State University; Associate Professor

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SHERRY, DONALD: M.A., B.S., Wayne State University; Senior Lecturer

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UMIRBAEV, UALBAL: Ph.D., D.Sc., Sobolev Institute of Mathematics; M.S., Novosibirsk State University; Professor

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ZHANG, SHENG: Ph.D., Pennsylvania State University; Ph.D., Chinese Academy of Sciences; M.S., Xian Jiaotong University; B.S., Northwestern University of China; Associate Professor

ZHANG, ZHIMIN: Ph.D., University of Maryland at College Park; M.S., B.S., University of Science and Technology; Professor

- Mathematics (M.S.) (<http://bulletins.wayne.edu/graduate/college-liberal-arts-sciences/mathematics/mathematics-ms/>)
- Mathematics (M.A.) (<http://bulletins.wayne.edu/graduate/college-liberal-arts-sciences/mathematics/mathematics-ma/>)

- Mathematical Statistics (M.A.) (<http://bulletins.wayne.edu/graduate/college-liberal-arts-sciences/mathematics/mathematical-statistics-ma/>)
- Applied Mathematics (M.A.) (<http://bulletins.wayne.edu/graduate/college-liberal-arts-sciences/mathematics/applied-mathematics-ma/>)
- Data Science and Business Analytics (M.S. with a concentration in Statistics) (<http://bulletins.wayne.edu/graduate/college-liberal-arts-sciences/mathematics/data-science-business-analytics-ms/>)
- Mathematics (Ph.D.) (<http://bulletins.wayne.edu/graduate/college-liberal-arts-sciences/mathematics/mathematics-phd/>)

Mathematics

MAT 5000 Fundamental Concepts of Mathematics and Proof Writing Cr. 3

Fundamental concepts: basic logic, basic set theory, functions, equivalence relations. Proof: methods of proof, structures of proofs, proof-writing in a variety of mathematical subjects. Not considered a 5000+ level course for undergraduate degree requirements in mathematics; no credit towards graduate degree in mathematics. Offered Intermittently.

Prerequisites: MAT 2250 with a minimum grade of C- or MAT 2860

MAT 5070 Elementary Analysis Cr. 4

Topics include: the real numbers, cardinality, sequences, limits, continuity, uniform continuity, differentiation, integration. Offered Fall, Winter.

Prerequisites: MAT 2030 with a minimum grade of C- and (MAT 2150 with a minimum grade of C-, MAT 2250 with a minimum grade of C-, or MAT 2350 with a minimum grade of C-)

MAT 5100 Numerical Methods I Cr. 3

Numerical errors; solutions of nonlinear equations; polynomial interpolation; numerical approximation; numerical integration and differentiation; numerical solutions of systems of linear equations; numerical solutions of ordinary differential equations. Offered Fall.

Prerequisites: MAT 2030 with a minimum grade of C-, MAT 2250 with a minimum grade of C-, and (BE 1500 with a minimum grade of C- or (CSC 1100 with a minimum grade of C- and CSC 1101 with a minimum grade of C-))

MAT 5110 Numerical Methods II Cr. 3

Numerical linear algebra topics, including eigenvalue problems, conjugate-gradient method, GMRES method; numerical solution of ordinary differential equations, Runge-Kutta methods; numerical solutions of partial differential equations, finite difference methods. Offered Winter.

Prerequisites: MAT 5100 with a minimum grade of C- and (MAT 2150 with a minimum grade of C- or MAT 2350 with a minimum grade of C-)

MAT 5120 Abstract Algebra for Middle School Teachers Cr. 3

Topics from elementary abstract algebra underpinning middle school mathematics curriculum; historical connections; role of abstraction and proof in mathematics. No credit towards major in mathematics or secondary mathematics. Offered Every Other Year.

Prerequisites: MAT 1120 with a minimum grade of C- and MAT 1800 with a minimum grade of C-

Equivalent: MAE 5120

MAT 5130 Problem Solving for Middle School Teachers Cr. 3

Development of mathematical problem solving in middle grades mathematics education; study of non-routine problems; problem solving strategies; historical connections; connections to selected mathematics content and to topics in other disciplines. No credit towards a mathematics major or secondary mathematics education major. Offered Every Other Year.

Prerequisites: MAT 1120 with a minimum grade of C- and MAT 1800 with a minimum grade of C-

Equivalent: MAE 5130

MAT 5180 Geometry for Middle School Teachers Cr. 3

Development of Euclidean geometry as a mathematical system; related historical topics; introduction to other geometries; selected topics such as transformations and tessellations. No credit toward a major or minor for secondary mathematics teaching. Offered Every Other Year.

Prerequisites: MAT 1110 with a minimum grade of C- and MAT 1120 with a minimum grade of C-

Equivalent: MAE 5100

MAT 5190 Number Theory for Middle School Teachers Cr. 3

Topics from elementary theory of numbers which underlie middle school mathematics; historical connections; role of abstraction and proof in mathematics. No credit toward a major or minor for secondary mathematics teaching. Offered Every Other Year.

Prerequisites: MAT 1800 with a minimum grade of C- or MAT 1120 with a minimum grade of C-

Equivalent: MAE 5110

MAT 5210 Advanced Calculus Cr. 4

Functions of many variables; limits, continuity; differentiation, mean value theorems; implicit and inverse function theorems; extremal problems, Lagrange multipliers; fixed-point methods; Taylor series; Fourier series, uniform convergence; improper integrals. Offered Intermittently.

Prerequisites: MAT 2250 with a minimum grade of C-

MAT 5220 Partial Differential Equations Cr. 4

Partial differential equations of mathematical physics; method of separation of variables; Fourier series; Sturm-Liouville eigenvalue problems; boundary-value problems; method of eigenfunction expansion. Optional topics include: Green's functions; solutions by Fourier transform; method of characteristics. Offered Winter.

Prerequisites: MAT 5070 with a minimum grade of C-

MAT 5230 Complex Variables and Applications Cr. 4

Cauchy-Riemann equations; elementary functions; mappings by elementary functions; the Cauchy integral formula; Morera's theorem; Taylor series; Laurent series; residues and poles; conformal mappings. Optional topics: improper integrals, the Schwarz-Christoffel transformations; potential theory; applications to differential and integral equations. No credit after MAT 6600. Offered Fall, Winter.

Prerequisites: MAT 5070 with a minimum grade of C-

MAT 5280 Methods of Differential Equations Cr. 3

Linear nth order differential equations; linear systems of differential equations (constant and periodic coefficients); oscillation and comparison theorems for second order differential equations; boundary value problems; stability theory (Liapunov's direct method and frequency domain stability criteria); asymptotic solutions; autonomous non-linear systems; classification of singularities. Offered Fall.

Prerequisites: MAT 2150 with a minimum grade of C- or MAT 2350 with a minimum grade of C-

MAT 5350 Logical Systems I Cr. 4

Metaresults concerning formal systems of sentential and first-order logics; soundness, completeness; independence of axioms; introduction to recursive functions; formalization of elementary arithmetic; discussion of Godel's incompleteness theorem and Church's Theorem. Offered Every Other Year.

Prerequisites: MAT 5600 with a minimum grade of C-, PHI 2850 with a minimum grade of C-, PHI 2860 with a minimum grade of C-, PHI 5050 with a minimum grade of C-, or MAT 5420 with a minimum grade of C-

Equivalent: PHI 5350

MAT 5400 Elementary Theory of Numbers Cr. 3

Primes and the Fundamental Theorem of Arithmetic; greatest common divisor, least common multiple, Euclidean Algorithm; congruences, theorems of Fermat, Wilson and Euler; arithmetic functions; linear Diophantine equations; quadratic congruences and the Law of Quadratic Reciprocity. Optional topics include: applications to cryptography, perfect numbers, primitive roots and indices, Fibonacci numbers, Pythagorean triples, sums of squares, continued fractions. Offered Yearly.

Prerequisites: MAT 2030 with a minimum grade of C- and MAT 2250 with a minimum grade of C-

MAT 5410 Applied Linear Algebra Cr. 4

Gaussian elimination, vector spaces, the four fundamental subspaces, orthogonality, least squares approximation, determinants, eigenvalues and eigenvectors, positive definite matrices, singular value decomposition, linear transformations, complex matrices. Applications such as differential and difference equations, Markov processes, graphs and networks, Fourier series, computer graphics, numerical linear algebra. Offered Winter.

Prerequisites: MAT 2030 with a minimum grade of C- and MAT 2250 with a minimum grade of C-

MAT 5420 Algebra I Cr. 4

Abstract concepts: sets, mappings, equivalence relations, induction, general methods of proof. Group theory: groups, subgroups, cyclic groups, direct products, cosets, Lagrange's Theorem, quotient groups, homomorphisms, permutation groups. Rings and fields (basic definitions). Only two credits apply after either MAT 6170 or 6180; no credit after both MAT 6170 and 6180. Offered Fall, Winter.

Prerequisites: MAT 2030 with a minimum grade of C- and MAT 2250 with a minimum grade of C-

MAT 5430 Algebra II Cr. 4

Group theory continued: Sylow Theorems, finite abelian groups. Ring theory: rings, integral domains, fields of quotients, homomorphisms, ideals, quotient rings, P.I.D.s, U.F.D.s, polynomial rings. Advanced topics in linear algebra: canonical forms. Field theory: extensions, splitting fields, finite fields, geometric constructions. Offered Fall, Winter.

Prerequisites: MAT 5420 with a minimum grade of C-

MAT 5520 Introduction to Topology Cr. 3

An introduction to topology, mostly through an intuitive approach. Topics chosen from among: topological equivalence and topological properties, complexes, Euler characteristic, connectedness, compactness, continuity, Brouwer's Fixed Point Theorem, vector fields, Hairy Ball Theorem, n-dimensional spaces, classification of surfaces, cut and paste techniques, the Moebius band, orientability, the fundamental group. No credit toward graduate degree in mathematics or statistics. Offered Intermittently.

Prerequisites: MAT 2030 with a minimum grade of C- and MAT 5000 with a minimum grade of C-

MAT 5530 Elementary Differential Geometry and its Applications Cr. 3

Introduction to the differential geometry of curves and surfaces in three-dimensional space. Curvature, torsion, Frenet formulas, fundamental theorem of space curves. Gauss and mean curvature, asymptotic and principal curves, geodesics, Gauss-Bonnet theorem. Applications such as pursuit curves, roulettes, brachistochrones, precession of Foucault's pendulum, design of packaging machines, shapes and soap films. Offered Intermittently.

Prerequisites: MAT 2030 with a minimum grade of C- and MAT 2250 with a minimum grade of C-

MAT 5540 Topological Data Analysis Cr. 3

Application of topological methods to reveal structure in data that are not visible by classical statistical methods. Basic ideas in topology, including topological spaces, continuous functions, homeomorphisms, simplicial complexes, simplicial homology, and the Vietoris-Rips complex. Use of computer software to calculate persistent homology of data sets from the applied sciences and elsewhere. Practical data analysis tools for mathematical sciences, as well as for engineering, physics, biology, medicine, economics, sociology, and any other subject in which experimental data is produced and analyzed. Offered Winter.

Prerequisites: MAT 2250 with a minimum grade of C-

MAT 5600 Introduction to Analysis I Cr. 4

Completeness, convergence, compactness, connectedness and continuity in the context of metric spaces; applications to differential calculus. Offered Fall, Winter.

Prerequisites: MAT 5070 with a minimum grade of C-

MAT 5610 Introduction to Analysis II Cr. 3

Integration, point-wise and uniform convergence of sequences and series of functions; power series; introduction to analytic functions; Fourier series; possible additional topics. Offered Fall, Winter.

Prerequisites: MAT 5600 with a minimum grade of C-

MAT 5700 Introduction to Probability Theory Cr. 4

Probability spaces; combinatorial analysis; independence and conditional probability; discrete and continuous random variables including binomial, Poisson, exponential and normal distributions; expectations; joint, marginal and conditional distribution functions; law of large numbers; central limit theorems. Offered Fall, Winter.

Prerequisites: MAT 2030 with a minimum grade of C-

MAT 5710 Introduction to Stochastic Processes Cr. 3

Non-measure-theoretic introduction to the theory of stochastic processes and its applications, with emphasis on Markov processes in both discrete and continuous time, the Poisson process, and Brownian motion. Offered Yearly.

Prerequisites: 2 of MAT 5700 with a minimum grade of C- and (MAT 2150 with a minimum grade of C-, MAT 2250 with a minimum grade of C-, or MAT 2350 with a minimum grade of C-)

MAT 5740 The Theory of Interest Cr. 3

Concrete problems used to explore concepts in the theory of interest, including measurement of interest, annuities, yield rates, amortization, bonds, and stochastic approaches. Students prepare for the actuarial examination FM/2. Offered Yearly.

Prerequisites: MAT 2020 with a minimum grade of C-

MAT 5750 Mathematics of Finance Cr. 3

Topics to be covered include: financial markets, binomial models, stocks and options, Black-Scholes formula, hedging, bond models and interest rate options, and computational methods for bonds. Offered Winter.

Prerequisites: (1 of (MAT 2150 or MAT 2350) and MAT 5700 with a minimum grade of C-)

MAT 5770 Mathematical Models in Operations Research Cr. 3

Deterministic and probabilistic mathematical modeling of real-world problems. Linear and nonlinear programming; Markov chains; queuing theory; inventory models; Markov decision processes. Offered Yearly.

Prerequisites: MAT 2030 with a minimum grade of C-, MAT 2250 with a minimum grade of C-, and MAT 5700 with a minimum grade of C-

MAT 5870 Methods of Optimization Cr. 3

Introduction to basic mathematical theory and computational methods of optimization; unconstrained and constrained optimization problems; optimality conditions in various optimization problems; numerical methods of optimization. Offered Winter.

Prerequisites: MAT 2150 with a minimum grade of C- or MAT 2350 with a minimum grade of C-

MAT 5890 Special Topics in Mathematics Cr. 3-4

Material currently of interest to students and faculty. Topics to be announced in Schedule of Classes. Offered Fall, Winter.

Prerequisites: MAT 2030 with a minimum grade of C- and (MAT 2150 with a minimum grade of C-, MAT 2250 with a minimum grade of C-, or MAT 2350 with a minimum grade of C-)

Repeatable for 12 Credits

MAT 5990 Directed Study Cr. 1-4

Undergraduates who elect this course must be mathematics majors of honors caliber. Content will vary to satisfy needs of individual student. Offered Every Term.

Repeatable for 8 Credits

MAT 5992 Teaching Mathematics in College Cr. 1

Preparation for first semester of teaching in developmental-level mathematics course. Content presentation, test-writing, grading, classroom management, use of technology. Students are videotaped and critiqued. Required of all graduate teaching assistants in Mathematics Department. Offered for S and U grades only. Offered Fall.

Restriction(s): Enrollment limited to students with a class of Senior; enrollment is limited to students with a major in Mathematics or Mathematics Honors; enrollment is limited to Graduate or Undergraduate level students.

MAT 5993 Writing Intensive Course in Mathematics Cr. 0

Satisfies General Education Requirement: Writing Intensive Competency Disciplinary writing assignments under the direction of a faculty member. Must be selected in conjunction with a course designated as a corequisite. See section listing in Schedule of Classes for corequisites available each term. Satisfies the University General Education Writing-Intensive Course in the Major requirement. Required for all majors. Offered Every Term.

Prerequisites: AFS 2390 with a minimum grade of C, ENG 2390 with a minimum grade of C, ENG 3010 with a minimum grade of C, ENG 3020 with a minimum grade of C, or ENG 3050 with a minimum grade of C

Restriction(s): Enrollment is limited to Undergraduate level students.

MAT 6130 Discrete Mathematics Cr. 3

Foundations of mathematics: logic, sets, functions, sequences. The integers. Matrices. Mathematical reasoning: induction, recursive definitions and recurrence relations. Combinatorics. Graph theory. Boolean algebra. No credit after former MAT 1860 or 1870. Not available to Math majors for degree credit. Offered Yearly.

Prerequisites: MAT 2010 with a minimum grade of C-

Restriction(s): Enrollment limited to students in the College of Education.

MAT 6140 Geometry: An Axiomatic Approach Cr. 3

Foundations: logic, axiom systems, models; Hilbert's axioms; the parallel postulate; Euclidean geometry; non-Euclidean geometries; hyperbolic geometry; philosophical questions. Offered Yearly.

Prerequisites: MAT 5000 with a minimum grade of C-

MAT 6150 Probability and Statistics for Teachers Cr. 4

Counting techniques, discrete sample spaces and probability, random variables, mean and variance, joint distributions, the binomial and normal distributions, central limit theorem, estimation and hypothesis testing. Not available to Math majors for degree credit. Offered Fall, Winter.

Prerequisites: MAT 1800 with a minimum grade of C

Restriction(s): Enrollment limited to students in the College of Education.

MAT 6170 Algebra: Ring Theory Through Exploration, Conjecture, and Proof Cr. 4

Rings: basic definitions; properties; examples including the integers, rationals, reals, and complex numbers; ideals; homomorphisms; and divisibility. Connections to high school algebra. Students will be involved in the mathematical processes of exploration, conjecture, and proof. Only two credits after MAT 5420; no credit after MAT 5430. Offered Yearly.

Prerequisites: MAT 5000 with a minimum grade of C-

MAT 6180 Algebra: Group Theory Through Exploration, Conjecture, and Proof Cr. 3

Groups: basic definitions, properties, examples, subgroups, cyclic groups, permutation groups, homomorphisms, quotient groups. Connections to high school algebra. Students will be involved in the mathematical processes of exploration, conjecture, and proof. Offered Every Other Winter.

Prerequisites: MAT 5000 with a minimum grade of C-

MAT 6200 Teaching Arithmetic, Algebra and Functions from an Advanced Perspective Cr. 3

Students gain profound understanding of K-12 mathematics. Concepts underlying K-12 topics and procedures; connections to higher mathematics. Teaching with Simplicity; applying mathematical understanding to teaching practices. Offered Fall.

Prerequisites: MAT 5120 with a minimum grade of C-, MAT 6170 with a minimum grade of C-, or MAT 6180 with a minimum grade of C-

Equivalent: MAE 6200

MAT 6210 Teaching Geometry, Probability and Statistics, and Discrete Mathematics from an Advanced Perspective Cr. 3

Historical perspectives, common conceptions and misconceptions, applications, technology, and mathematical connections relative to teaching geometry (including trigonometry), probability and statistics, and discrete mathematics in secondary school. Offered Winter.

Equivalent: MAE 6210

MAT 6300 Mathematical Epidemiology Cr. 3

This is a first course in the mathematical modeling of infectious diseases. The course starts with historical, biological, and mathematical background. We introduce basic epidemic models (SIR, SIS, SIRS) first without and then with demographics, and study the properties of these models. We will learn about more complex epidemic models (SEIR etc.), and how to validate models using real-world data. If time permits, other topics may include: vector-borne disease models, global stability, or control strategies. No credit will be awarded to students who have previously taken MAT 2300. Graduate students in mathematics should take advanced courses in differential equations instead. Offered Yearly.

Prerequisites: MAT 2020 with a minimum grade of C

Restriction(s): Enrollment is limited to Graduate level students.

MAT 6420 Advanced Linear Algebra Cr. 3

Vector spaces and linear maps from a basis free perspective. Vector spaces, linear transformations, dual spaces, quotient spaces, inner product spaces, quadratic forms, adjoint operators, normal operators, spectral theorem, Jordan canonical form, trace and determinant. Offered Winter.

Prerequisites: MAT 5430 with a minimum grade of C-

MAT 6480 Introduction to Quantum Computing Cr. 3

Serves as an introduction to quantum computing and brings together students with different backgrounds in mathematics, physics, chemistry, and computer science to foster interdisciplinary connections in the areas of quantum computing and quantum information. A strong background in linear algebra over the complex numbers as well as differential and integral calculus is required. Familiarity with quantum physics and complexity theory will be helpful, but it is not required. Offered Fall.

Equivalent: PHY 6480

MAT 6500 Topology I Cr. 3

Topological spaces and continuous functions; connectedness; compactness; product and quotient spaces; metric spaces; Urysohn's lemma; Tietze extension theorem; homotopy; covering spaces and path lifting; the fundamental group and examples; Brouwer fixed point theorem and applications. Offered Fall.

Prerequisites: MAT 5430 with a minimum grade of C- or MAT 5610 with a minimum grade of C-

MAT 6600 Complex Analysis Cr. 2-4

Complex differentiation; elementary functions; Cauchy's integral theorem; power series; Laurent expansions; singularities; residue theorem; entire and meromorphic functions; Riemann mapping theorem. Offered for three credits only, if student has taken MAT 5230. Offered Winter.

Prerequisites: MAT 5430 with a minimum grade of C- or MAT 5610 with a minimum grade of C-

MAT 6990 Internship in Mathematical Sciences Cr. 1-3

Experience in industry, or in a research laboratory, or in an institution, using tools from the mathematics curriculum. Students provide a written report based on the internship experience. Offered Every Term.

Restriction(s): Enrollment is limited to Graduate level students.

Repeatable for 3 Credits

MAT 7200 Ordinary Differential Equations Cr. 3

Existence and uniqueness of solutions; linear solutions and linearization; linear differential equations in the complex domain; solutions near regular and irregular singular points; autonomous systems; stability theory; limit cycles; perturbation theory; boundary value problems; Green's function; spectral theory. Offered Winter.

Prerequisites: MAT 5610 with a minimum grade of C or MAT 7600 with a minimum grade of C

Restriction(s): Enrollment is limited to Graduate level students.

MAT 7210 Partial Differential Equations Cr. 3

Linear partial differential equations; fundamental solutions; distributions and their Fourier transforms; hyperbolic equations; Cauchy-Kovalevsky theorem; energy inequalities; weak solutions; propagation of singularities; elliptic equations; maximum principles; Sobolev spaces and inequalities; Garding's inequality; existence and regularity of solutions of Dirichlet problems; fundamental solutions of parabolic equations; strongly continuous semigroups. Offered Fall.

Prerequisites: MAT 5610 with a minimum grade of C or MAT 7600 with a minimum grade of C

Restriction(s): Enrollment is limited to Graduate level students.

MAT 7230 Finite Element Methods Cr. 3

Topics chosen at discretion of instructor from topics similar to: regularity theory for second order elliptic partial differential equations; Hamilton-Jacobi equations; conservation laws; evolution equations; semigroup theory; calculation of variations; nonvariational methods. Offered Winter.

Prerequisite: MAT 5100 with a minimum grade of C- and MAT 5070 with a minimum grade of C-

Restriction(s): Enrollment is limited to Graduate level students.

MAT 7240 Advanced Partial Differential Equations Cr. 3

Continuation of MAT 7210. Variety of topics chosen by the instructor. Offered Winter.

Prerequisite: MAT 7210 with a minimum grade of C

Restriction(s): Enrollment is limited to Graduate level students.

MAT 7270 Topics in Applied Mathematics Cr. 3-4

Topics of special interest such as differential equations; calculus of variations; elliptic functions; orthogonal functions; numerical methods; systems and control theory. Topics to be announced in Schedule of Classes . Offered Yearly.

Restriction(s): Enrollment is limited to Graduate level students.

Repeatable for 12 Credits

MAT 7400 Advanced Algebra I Cr. 4

Permutation groups; Sylow Theorems; Jordan-Holder theorem; solvable and nilpotent groups; free groups; unique factorization domains; principal ideal domains; modules over principal ideal domains; linear transformations; Cayley-Hamilton theorem; free modules; noetherian rings; localization. Offered Fall.

Prerequisite: MAT 5430 with a minimum grade of C

Restriction(s): Enrollment is limited to Graduate level students.

MAT 7410 Advanced Algebra II Cr. 3

Field extensions; finite fields; Galois theory; classical applications of Galois theory; algebraic closure; tensor and exterior algebras; determinants; alternating, quadratic and hermitian forms. Offered Winter.

Prerequisite: MAT 7400 with a minimum grade of C

Restriction(s): Enrollment is limited to Graduate level students.

MAT 7470 Topics in Algebra Cr. 3-4

Selected topics from linear algebra; homological algebra; group theory; field theory. Topics to be announced in Schedule of Classes . Offered Yearly.

Prerequisite: MAT 7400 with a minimum grade of C

Restriction(s): Enrollment is limited to Graduate level students.

Repeatable for 12 Credits

MAT 7500 Topology II Cr. 3

Smooth manifolds and maps; examples from projective spaces, from Lie groups, and from low dimensions; local coordinates; partitions of unity; tangent vectors and tangent bundles; differentials of smooth maps; vector fields; local one-parameter groups of diffeomorphisms; differential forms; integration and Stokes theorem; definition of deRham cohomology. Offered Winter.

Prerequisite: MAT 6500 with a minimum grade of C

Restriction(s): Enrollment is limited to Graduate level students.

MAT 7510 Algebraic Topology I Cr. 3

Homology and its applications including fixed-point theorems; Jordan-Brouwer separation theorem; invariance of domain; CW-complexes; Kunneth theorem. Offered Every Other Fall.

Prerequisite: MAT 5430 with a minimum grade of C and MAT 6500 with a minimum grade of C

Restriction(s): Enrollment is limited to Graduate level students.

MAT 7520 Algebraic Topology II Cr. 3

Cohomology ring; orientation and duality on manifolds; homotopy theory, Hurewicz theorem. Offered Every Other Winter.

Prerequisite: MAT 7510 with a minimum grade of C

Restriction(s): Enrollment is limited to Graduate level students.

MAT 7570 Topics in Geometry and Topology Cr. 3-4

Selected topics from geometry and topology; Lie groups, Riemannian and differential geometry. Offered Yearly.

Prerequisite: MAT 7500 with a minimum grade of C

Restriction(s): Enrollment is limited to Graduate level students.

Repeatable for 12 Credits

MAT 7600 Real Analysis I Cr. 3

Lebesgue measure; general measures; measurable functions; integration (monotone and dominated convergence theorems); function spaces; Lebesgue spaces; modes of convergence; product measures; Fubini theorem. Offered Fall.

Prerequisite: MAT 5610 with a minimum grade of C

Restriction(s): Enrollment is limited to Graduate level students.

MAT 7610 Real Analysis II Cr. 3

Differentiation; relationship between differentiation and integration; Radon-Nikodym theorem; Fourier transforms; Hilbert and Banach spaces; selected topics. Offered Winter.

Prerequisite: MAT 7600 with a minimum grade of C

Restriction(s): Enrollment is limited to Graduate level students.

MAT 7670 Topics in Analysis Cr. 3

Topics include: advanced harmonic analysis theory, applications to PDEs, geometric analysis, Fourier analysis, advanced theory of complex variables, analysis on manifolds, advanced PDEs. Offered Yearly.

Prerequisite: MAT 7610 with a minimum grade of C

Restriction(s): Enrollment is limited to Graduate level students.

MAT 7700 Advanced Probability Theory I Cr. 3

Probability spaces; random variables; expectations and moments; convergence concepts; product spaces and Kolmogorov extension theorem; separability of random processes; continuity of random processes; conditional expectation; independence. Offered Every Other Fall.

Prerequisite: MAT 5700 with a minimum grade of C and MAT 7600 with a minimum grade of C

Restriction(s): Enrollment is limited to Graduate level students.

MAT 7710 Advanced Probability Theory II Cr. 3

Law of large numbers; characteristic functions; limit theorems; random walks; Markov processes; stationary processes; ergodic theory; martingales; stopping times. Offered Every Other Winter.

Prerequisite: MAT 7700 with a minimum grade of C

Restriction(s): Enrollment is limited to Graduate level students.

MAT 7770 Special Topics in Probability Cr. 3-4

Topics of special interest such as Markov processes; time series; ergodic theory; random equations; probability measures on algebraic structures; probability measures in Banach spaces; martingales; Brownian motion; stochastic integrals. Topics to be announced in Schedule of Classes . Offered Intermittently.

Prerequisite: MAT 7710 with a minimum grade of C

Restriction(s): Enrollment is limited to Graduate level students.

Repeatable for 12 Credits

MAT 7990 Directed Study Cr. 1-4

Offered Every Term.

Restriction(s): Enrollment is limited to Graduate level students.

Repeatable for 12 Credits

MAT 7999 Master's Essay Direction Cr. 1-3

Offered Every Term.

Restriction(s): Enrollment limited to students with a class of Candidate Masters; enrollment is limited to Graduate level students.

Repeatable for 3 Credits

MAT 8000 Advanced Topics in Mathematics Cr. 2-4

Topics to be announced in Schedule of Classes. Offered Yearly.

Restriction(s): Enrollment is limited to Graduate level students.

Repeatable for 24 Credits

MAT 8999 Master's Thesis Research and Direction Cr. 1-8

Offered Every Term.

Restriction(s): Enrollment limited to students with a class of Candidate Masters; enrollment is limited to Graduate level students.

Repeatable for 8 Credits

MAT 9990 Pre-Doctoral Candidacy Research Cr. 1-8

Research in preparation for doctoral dissertation. Offered Every Term.

Restriction(s): Enrollment is limited to Graduate level students.

Repeatable for 12 Credits

MAT 9991 Doctoral Candidate Status I: Dissertation Research and Direction Cr. 7.5

Offered Every Term.

Restriction(s): Enrollment is limited to Graduate level students.

MAT 9992 Doctoral Candidate Status II: Dissertation Research and Direction Cr. 7.5

Offered Every Term.

Prerequisite: MAT 9991 with a minimum grade of S

Restriction(s): Enrollment is limited to Graduate level students.

MAT 9993 Doctoral Candidate Status III: Dissertation Research and Direction Cr. 7.5

Offered Every Term.

Prerequisite: MAT 9992 with a minimum grade of S

Restriction(s): Enrollment is limited to Graduate level students.

MAT 9994 Doctoral Candidate Status IV: Dissertation Research and Direction Cr. 7.5

Offered Every Term.

Prerequisite: MAT 9993 with a minimum grade of S

Restriction(s): Enrollment is limited to Graduate level students.

MAT 9995 Candidate Maintenance Status: Doctoral Dissertation Research and Direction Cr. 0

Offered Every Term.

Prerequisite: MAT 9994 with a minimum grade of S

Restriction(s): Enrollment is limited to Graduate level students.

Course Material Fees: \$402.01

Repeatable for 0 Credits

Statistics

STA 5030 Statistical Computing and Data Analysis Cr. 3

Computational aspect of statistics and data analysis for advanced undergraduate and beginning graduate students. Topics include descriptive statistics, probability distributions, hypothesis testing, ANOVA, linear regression and logistic regression. Data analysis by use of statistical packages such as R, SAS, Python, SPSS or Minitab. Satisfies Society of Actuaries Validation by Educational Experience (VEE) in Applied Statistics for regression component with a B- or better. Offered Fall.

Prerequisites: (MAT 2250 with a minimum grade of C- or MAT 2150 with a minimum grade of C-) and (MAT 2210 with a minimum grade of C-, STA 2210 with a minimum grade of C-, MAT 5700 with a minimum grade of C-, BE 2100 with a minimum grade of C-, ECO 5100 with a minimum grade of C-, or PH 3200 with a minimum grade of C-)

STA 5800 Introduction to Mathematical Statistics Cr. 4

A one-semester course for senior undergraduate and master's degree students. Introduction to basic mathematical theory of statistics. Topics include survey sampling, estimation theory, data analysis and sample statistics, testing hypothesis, two sample cases, analysis of variance, regression analysis, Bayesian inference. Satisfies Society of Actuaries Validation by Educational Experience (VEE) in Applied Statistics for regression component with a B- or better. Offered Winter.

Prerequisites: MAT 5700 with a minimum grade of C- and (MAT 2150 with a minimum grade of C-, MAT 2250 with a minimum grade of C-, or MAT 2350 with a minimum grade of C-)

STA 5820 Introduction to Data Science Cr. 3

An applied statistical learning course designed for upper level undergraduate students and graduate students in mathematics and other quantitative fields. Topics include: bias-variance trade-off, regression, classification, cross-validation, bootstrap, model selection, regularization, splines, generalized additive models, tree-based methods, support vector machines, principal component analysis and clustering. Computer implementation will be discussed for each of the methods, and students will run their own data analysis projects. Offered Winter.

Prerequisite: STA 5030 with a minimum grade of C or STA 5800 with a minimum grade of C or MAT 5800 with a minimum grade of C

STA 5830 Applied Time Series Cr. 3

Time series models, moving average models, autoregressive models, non-stationary models, and more general models; point estimators, confidence intervals, and forecast in the time domain. Statistical analysis in the frequency domain; spectral density and periodogram. Satisfies Society of Actuaries Validation by Educational Experience (VEE) in Applied Statistics for regression component with a B- or better. Offered Intermittently.

Prerequisites: (MAT 2250 with a minimum grade of C- or MAT 2150 with a minimum grade of C-) and (MAT 2210 with a minimum grade of C-, STA 2210 with a minimum grade of C-, BE 2100 with a minimum grade of C-, ECO 5100 with a minimum grade of C-, or PH 3200 with a minimum grade of C-)

STA 6830 Design of Experiments Cr. 3

Randomized blocks; Latin and Graeco-Latin squares; factorial designs; confounding; split plot; fractional replication; balanced incomplete blocks. Offered Intermittently.

Prerequisites: (MAT 2250 with a minimum grade of C- or MAT 2150 with a minimum grade of C-) and (MAT 2210 with a minimum grade of C-, STA 2210 with a minimum grade of C-, BE 2100 with a minimum grade of C-, ECO 5100 with a minimum grade of C-, or PH 3200 with a minimum grade of C-)

STA 6840 Applied Regression Analysis Cr. 3

Multiple linear regression; generalized linear models; random effect models; repeated measurements; mixed effect models; non-parametric additive models. Computer implementation using statistical software R; student project on real data analysis. Offered Fall.

Prerequisites: STA 5030 with a minimum grade of C- or STA 5800 with a minimum grade of C-

STA 7810 Advanced Statistics Theory I Cr. 3

First of two basic courses for Ph.D. students in the Mathematics Department who are interested in statistics. Topics include sample distribution theory, point and interval estimations, optimal estimates, theory of hypothesis testing, and most powerful tests. Offered Every Other Fall.

Prerequisite: MAT 5610 with a minimum grade of C and MAT 5700 with a minimum grade of C

Restriction(s): Enrollment is limited to Graduate level students.

STA 7820 Advanced Statistics Theory II Cr. 3

Continuation of STA 7810. Topics include regression analysis, linear models, analysis of categorical data, nonparametric statistics, decision theory, and Bayesian inference. Offered Intermittently.

Prerequisite: MAT 7810 with a minimum grade of C or STA 7810 with a minimum grade of C

Restriction(s): Enrollment is limited to Graduate level students.

STA 7870 Topics in Statistics Cr. 3-4

Selected topics such as statistical estimation theory; theory of statistical hypothesis testing; non-parametric methods in statistics; statistical sequential analysis; statistical multivariate analysis. Topics to be announced in Schedule of Classes. Offered Intermittently.

Prerequisite: MAT 7810 with a minimum grade of C or STA 7810 with a minimum grade of C

Restriction(s): Enrollment is limited to Graduate level students.

Repeatable for 12 Credits