DEPARTMENT OF MATHEMATICS

Office in Weber Building, Room 101
(970) 491-1303
math.colostate.edu (http://www.math.colostate.edu)

Professor Kenneth McLaughlin, Chair

Undergraduate

Majors
- Major in Mathematics
  - Actuarial Science Concentration
  - Applied Mathematics Concentration
  - Computational Mathematics Concentration
  - General Mathematics Concentration
  - Mathematics Education Concentration
  - Mathematics of Information Concentration

Minors
- Minor in Mathematics
- Minor in Mathematical Biology

Graduate

Graduate Programs in Mathematics
The department offers the Master of Science and Doctor of Philosophy degrees with programs in Pure and Applied Mathematics. Students interested in graduate work should refer to the Graduate and Professional Bulletin and the Department of Math (http://www.math.colostate.edu).

Master Programs
- Master of Science in Mathematics, Plan A*
- Master of Science in Mathematics, Plan B*

Ph.D.
- Ph.D. in Mathematics*

* Please see department for program of study.

Courses

Mathematics (MATH)

MATH 101 Math in the Social Sciences (GT-MA1) Credits: 3 (2-2-0)
Course Description: Voting theory, power indices, fair division, apportionment, circuits and trees, list processing, descriptive statistics, probability.
Prerequisite: None.
Registration Information: Mathematics Placement Examination or Mathematics Challenge Exam required.
Terms Offered: Fall, Spring, Summer.
Grade Mode: Traditional.
Special Course Fee: No.
Additional Information: Mathematics 1B, Mathematics (GT-MA1).

MATH 105 Patterns of Phenomena (GT-MA1) Credits: 3 (2-0-1)
Course Description: Applications of mathematical ideas and mode of thought in the arts and humanities, focusing on classification, recognition.
Prerequisite: None.
Registration Information: Mathematics Placement Examination or Mathematics Challenge Exam required.
Terms Offered: Fall, Spring.
Grade Mode: Traditional.
Special Course Fee: No.

MATH 117 College Algebra in Context I (GT-MA1) Credit: 1 (1-0-0)
Course Description: Functions as mathematical models. Linear, quadratic, and polynomial functions considered symbolically, graphically, numerically, and contextually.
Prerequisite: None.
Registration Information: Mathematics Placement Examination or Mathematics Challenge Exam required. Sections may be offered: Online.
Terms Offered: Fall, Spring, Summer.
Grade Mode: Instructor Option.
Special Course Fee: No.

MATH 118 College Algebra in Context II (GT-MA1) Credit: 1 (1-0-0)
Course Description: Reciprocals of linear functions, rational functions, and power functions considered symbolically, graphically, numerically, and contextually.
Prerequisite: MATH 117, may be taken concurrently.
Registration Information: Mathematics Placement Examination or Mathematics Challenge Examination required. Sections may be offered: Online.
Terms Offered: Fall, Spring, Summer.
Grade Mode: Instructor Option.
Special Course Fee: No.

MATH 122 Theory for Introductory Programming Credit: 1 (0-0-1)
Also Offered As: CS 122.
Course Description: Set theory, definitions operations, Venn diagrams, power sets, propositional logic and proofs. Functions; loop invariants.
Prerequisite: MATH 118.
Registration Information: Must have concurrent registration in CS 161. Credit not allowed for both MATH 122 and CS 122. Credit not allowed for students who have completed CS 160. Sections may be offered: Online.
Terms Offered: Fall, Spring.
Grade Mode: Traditional.
Special Course Fee: No.
MATH 124 Logarithmic and Exponential Functions (GT-MA1) Credit: 1 (1-0-0)
Course Description: Definition and graphs of exponential and logarithmic functions, properties of logarithmic functions, exponential and logarithmic equations, applications.
Prerequisite: MATH 118, may be taken concurrently.
Registration Information: Required: MATH 118 or Mathematics Placement Examination or Mathematics Challenge Examination. Sections may be offered: Online.
Terms Offered: Fall, Spring, Summer.
Grade Mode: Instructor Option.
Special Course Fee: No.
Additional Information: Mathematics 1B, Mathematics (GT-MA1).

MATH 125 Numerical Trigonometry (GT-MA1) Credit: 1 (1-0-0)
Course Description: Definition and graphs of trigonometric functions, laws of sines and cosines, solutions of right and oblique triangles, applications.
Prerequisite: MATH 118, may be taken concurrently.
Registration Information: MATH 118 or Mathematics Placement Examination or Mathematics Challenge Examination required. Sections may be offered: Online.
Terms Offered: Fall, Spring, Summer.
Grade Mode: Instructor Option.
Special Course Fee: No.
Additional Information: Mathematics 1B, Mathematics (GT-MA1).

MATH 126 Analytic Trigonometry (GT-MA1) Credit: 1 (1-0-0)
Course Description: Inverse trigonometric functions, trigonometric identities, solving trigonometric equations.
Prerequisite: MATH 125, may be taken concurrently.
Registration Information: MATH 125 or Mathematics Placement Examination or Mathematics Challenge Examination required. Sections may be offered: Online.
Terms Offered: Fall, Spring, Summer.
Grade Mode: Instructor Option.
Special Course Fee: No.
Additional Information: Mathematics 1B, Mathematics (GT-MA1).

MATH 141 Calculus in Management Sciences (GT-MA1) Credits: 3 (3-0-0)
Course Description: Analytic geometry, limits, equilibrium of supply and demand, differentiation, integration, applications of the derivative, integral.
Prerequisite: MATH 118.
Registration Information: Credit allowed for only one of the following courses: MATH 141, MATH 155 or MATH 160.
Terms Offered: Fall, Spring, Summer.
Grade Mode: Traditional.
Special Course Fee: No.
Additional Information: Mathematics 1B, Mathematics (GT-MA1).

MATH 151 Mathematical Algorithms in Matlab I Credit: 1 (0-2-0)
Course Description: Statements, expressions and variable assignments, scripts, control statements and logical statements. Newton's method, Simpson's rule, recursion.
Prerequisite: MATH 141 or MATH 155 or MATH 160.
Term Offered: Spring.
Grade Mode: Traditional.
Special Course Fee: No.

MATH 152 Mathematical Algorithms in Maple Credit: 1 (0-2-0)
Course Description: Iteration and recursion, control and logical statements, expressions, functions, data types, binary numbers, symbolic manipulation of terms.
Prerequisite: MATH 141 or MATH 155 or MATH 160.
Term Offered: Spring.
Grade Mode: Traditional.
Special Course Fee: No.

MATH 155 Calculus for Biological Scientists I (GT-MA1) Credits: 4 (4-0-0)
Course Description: Limits, continuity, differentiation, and integration of elementary functions with applications in the biosciences.
Prerequisite: (MATH 124) and (MATH 125).
Registration Information: Credit allowed for only one of the following courses: MATH 141, MATH 155, or MATH 160. Programmable graphing calculator required.
Terms Offered: Fall, Spring, Summer.
Grade Mode: Traditional.
Special Course Fee: No.
Additional Information: Mathematics 1B, Mathematics (GT-MA1).

MATH 157 One Year Calculus IA (GT-MA1) Credits: 3 (3-0-0)
Course Description: Algebra and trigonometry, study skills for calculus. Limits, continuity, differentiation of elementary functions with applications.
Prerequisite: (MATH 124, may be taken concurrently) and (MATH 126).
Term Offered: Fall.
Grade Mode: Traditional.
Special Course Fee: No.
Additional Information: Mathematics 1B, Mathematics (GT-MA1).

MATH 158 Mathematical Algorithms in C Credit: 1 (0-2-0)
Also Offered As: CS 158.
Course Description: Compilers, expressions, variable types, control statements, pointers, logical statements, plotting, secant method, trapezoidal rule, recursion.
Prerequisite: MATH 151 and CS 156 and MATH 160.
Registration Information: Credit not allowed for both MATH 158 and CS 158.
Term Offered: Spring.
Grade Mode: Traditional.
Special Course Fee: No.

MATH 159 One Year Calculus IB (GT-MA1) Credits: 3 (3-0-0)
Course Description: Study skills for calculus. Differentiation and integration of elementary functions with applications, Conic section.
Prerequisite: MATH 157.
Registration Information: Credit allowed for only one of the following: MATH 141, MATH 155, MATH 159, MATH 160.
Term Offered: Spring.
Grade Mode: Traditional.
Special Course Fee: No.
Additional Information: Mathematics (GT-MA1).
MATH 160 Calculus for Physical Scientists I (GT-MA1) Credits: 4 (3-2-0)
Course Description: Limits, continuity, differentiation, and integration of elementary functions with applications; conic sections.
Prerequisite: (MATH 124 with a minimum grade of B) and (MATH 126 with a minimum grade of B).
Registration Information: Written consent of department chair. Credit allowed for only one of the following courses: MATH 141, MATH 155, MATH 159 or MATH 160. Must register for lecture and laboratory. Sections may be offered: Online.
Terms Offered: Fall, Spring, Summer.
Grade Mode: Traditional.
Special Course Fee: No.
Additional Information: Mathematics 1B, Mathematics (GT-MA1).
MATH 161 Calculus for Physical Scientists II (GT-MA1) Credits: 4 (3-2-0)
Course Description: Transcendental functions, integration techniques, polar coordinates, sequences and series, with mathematical software.
Prerequisite: (MATH 124) and (MATH 155 or MATH 160).
Registration Information: Must register for lecture and laboratory. Sections may be offered: Online.
Terms Offered: Fall, Spring, Summer.
Grade Mode: Traditional.
Special Course Fee: No.
Additional Information: Mathematics 1B, Mathematics (GT-MA1).
MATH 192 First Year Seminar in Mathematical Sciences Credit: 1 (0-0-1)
Course Description: Introduction to the richness and variety of problems addressed by mathematical language and techniques; resources and available careers.
Prerequisite: None.
Term Offered: Fall.
Grade Mode: Traditional.
Special Course Fee: No.
MATH 229 Matrices and Linear Equations Credits: 2 (2-0-0)
Course Description: Linear systems, matrix arithmetic, homogeneous coordinates, complex numbers, eigenvalues, eigenvectors, applications to discrete dynamical systems.
Prerequisite: MATH 141 or MATH 155 or MATH 160.
Registration Information: Sections may be offered: Online.
Terms Offered: Fall, Spring, Summer.
Grade Mode: Instructor Option.
Special Course Fee: No.
MATH 230 Discrete Mathematics for Educators Credits: 3 (2-2-0)
Course Description: Voting theory, fair division, graph theory, linear programming, probability, teaching in small groups, proof techniques, mathematical technology.
Prerequisite: MATH 161 and EDUC 275, may be taken concurrently.
Registration Information: Credit not allowed for both MATH 230 and MATH 330.
Term Offered: Fall.
Grade Mode: Traditional.
Special Course Fee: No.
MATH 235 Introduction to Mathematical Reasoning Credits: 2 (2-0-0)
Course Description: Mathematical statements and proof techniques, induction, set theory, inequalities, number systems, functions.
Prerequisite: MATH 161 or MATH 271.
Term Offered: Spring.
Grade Mode: Traditional.
Special Course Fee: No.
MATH 236 Introduction to Mathematical Reasoning II Credits: 2 (2-0-0)
Course Description: Mathematical statements and proof techniques, induction, set theory, inequalities, number systems, functions.
Prerequisite: MATH 161 or MATH 271.
Term Offered: Spring.
Grade Mode: Traditional.
Special Course Fee: No.
MATH 301 Introduction to Combinatorial Theory Credits: 3 (3-0-0)
Course Description: Matrices, orthogonal Latin squares, designs, difference sets, sets, binomial coefficients, inclusion and exclusion, recurrence, Ramsey's theorem, SDRs.
Prerequisite: MATH 160.
Term Offered: Fall.
Grade Mode: Traditional.
Special Course Fee: No.
MATH 317 Advanced Calculus of One Variable Credits: 4 (4-0-0)
Course Description: Convergence of sequences, series: limits, continuity, differentiation, integration of one-variable functions; development of skills for proving theorems.
Prerequisite: MATH 161.
Term Offered: Fall, Spring, Summer.
Grade Modes: S/U within Student Option, Trad within Student Option.
Special Course Fee: No.
MATH 255 Calculus for Biological Scientists II (GT-MA1) Credits: 4 (4-0-0)
Course Description: Derivatives and integrals of functions of several variables, differential and difference equations, matrices, applications in the biosciences.
Prerequisite: (MATH 126, may be taken concurrently) and (MATH 155).
Registration Information: Credit not allowed for both MATH 255 and MATH 261. Programmable graphing calculator required.
Terms Offered: Fall, Spring.
Grade Mode: Traditional.
Special Course Fee: No.
Additional Information: Mathematics 1B, Mathematics (GT-MA1).
MATH 261 Calculus for Physical Scientists III Credits: 4 (4-0-0)
Course Description: Vector functions, partial differentiation, cylindrical and spherical coordinates, multiple integrals, line integrals, Green's theorem.
Prerequisite: MATH 161.
Registration Information: Credit not allowed for both MATH 261 and MATH 255.
Terms Offered: Fall, Spring, Summer.
Grade Modes: S/U within Student Option, Trad within Student Option.
Special Course Fee: No.
MATH 265 Introduction to Mathematical Reasoning III Credits: 2 (2-0-0)
Course Description: Mathematical statements and proof techniques, induction, set theory, inequalities, number systems, functions.
Prerequisite: MATH 161 or MATH 271.
Term Offered: Spring.
Grade Mode: Traditional.
Special Course Fee: No.
MATH 331 Introduction to Mathematical Modeling Credits: 3 (3-0-0)
Prerequisite: (MATH 161, may be taken concurrently) and (MATH 229, may be taken concurrently or MATH 369, may be taken concurrently).
Term Offered: Fall.
Grade Mode: Traditional.
Special Course Fee: No.

MATH 332 Partial Differential Equations Credits: 3 (3-0-0)
Course Description: Partial differential equations, separation of variables, Fourier series and transforms, Laplace, heat and wave equations.
Prerequisite: MATH 340 or MATH 345.
Registration Information: Credit not allowed for both MATH 332 and MATH 530.
Term Offered: Spring.
Grade Mode: Traditional.
Special Course Fee: No.

MATH 340 Introduction to Ordinary Differential Equations Credits: 4 (3-2-0)
Course Description: First and second order equations, series, Laplace transforms, linear algebra, eigenvalues, first order systems of equations, numerical techniques.
Prerequisite: MATH 255 or MATH 261.
Registration Information: Must register for lecture and laboratory. Credit not allowed for both MATH 340 and MATH 345.
Terms Offered: Fall, Spring, Summer.
Grade Modes: S/U within Student Option, Trad within Student Option.
Special Course Fee: No.

MATH 345 Differential Equations Credits: 4 (3-2-0)
Course Description: First and second order equations, LaPlace transforms, first order systems of equations, numerical methods, applied linear algebra, linearization.
Prerequisite: (MATH 229 or MATH 369) and (MATH 255 or MATH 261).
Registration Information: Must register for lecture and laboratory. Credit not allowed for both MATH 345 and MATH 340.
Terms Offered: Fall, Spring.
Grade Modes: S/U within Student Option, Trad within Student Option.
Special Course Fee: No.

MATH 348 Theory of Population and Evolutionary Ecology Credits: 4 (3-3-0)
Also Offered As: BZ 348.
Course Description: Principles and methods for building, analyzing, and interpreting mathematical models of ecological and evolutionary problems in biology.
Prerequisite: MATH 155 or MATH 160.
Registration Information: Must register for lecture and laboratory. Credit allowed for only one of the following: MATH 348, BZ 348, BZ 548.
Term Offered: Fall.
Grade Mode: Traditional.
Special Course Fee: No.

MATH 360 Mathematics of Information Security Credits: 3 (3-0-0)
Course Description: Codes, ciphers, Chinese remainder theorem, primality testing, public key ciphers, RSA, finite fields, discrete algorithms, AES encryption.
Prerequisite: (MATH 229 or MATH 369) and (MATH 161).
Term Offered: Fall.
Grade Mode: Traditional.
Special Course Fee: No.

MATH 366 Introduction to Abstract Algebra Credits: 3 (3-0-0)
Course Description: Sets, integers, polynomials, real and complex numbers, groups, integral domains, and fields; development of skills for proving theorems.
Prerequisite: MATH 161 or MATH 271.
Terms Offered: Fall, Spring, Summer.
Grade Modes: S/U within Student Option, Trad within Student Option.
Special Course Fee: No.

MATH 369 Linear Algebra I Credits: 3 (3-0-0)
Course Description: Linearity, linear systems, matrices, subspaces of Euclidean spaces, linear transformations on Euclidean spaces, eigenvalues, eigenvectors.
Prerequisite: MATH 161 or MATH 255 or MATH 271.
Terms Offered: Fall, Spring, Summer.
Grade Mode: Traditional.
Special Course Fee: No.

MATH 384 Supervised College Teaching Credit: 1 (1-0-0)
Course Description: Skills for effective tutoring of precalculus mathematics, design and implementation of the Individualized Mathematics Program.
Prerequisite: None.
Registration Information: Written consent of instructor. May not be used to satisfy Mathematics degree requirements. A maximum of 10 combined credits for all 384 and 484 courses are counted towards graduation requirements.
Terms Offered: Fall, Spring.
Grade Mode: Instructor Option.
Special Course Fee: No.

MATH 405 Introduction to Number Theory Credits: 3 (3-0-0)
Course Description: Diophantine equations; distribution of primes; multiplicative functions; finite fields; quadratic reciprocity; quadratic number fields.
Prerequisite: MATH 360 or MATH 366.
Term Offered: Spring (even years).
Grade Mode: Traditional.
Special Course Fee: No.

MATH 417 Advanced Calculus I Credits: 3 (3-0-0)
Course Description: Topology of Euclidean spaces, limits, derivatives and integrals on Euclidean spaces. Implicit functions and the implicit function theorem.
Prerequisite: MATH 369 and MATH 317.
Term Offered: Fall.
Grade Modes: S/U within Student Option, Trad within Student Option.
Special Course Fee: No.

MATH 418 Advanced Calculus II Credits: 3 (3-0-0)
Course Description: Line and surface integrals, series, sequences and series of functions.
Prerequisite: MATH 417.
Term Offered: Spring (even years).
Grade Mode: Traditional.
Special Course Fee: No.

MATH 419 Introduction to Complex Variables Credits: 3 (3-0-0)
Course Description: Analyticity, Cauchy integral theorem and formula, Taylor and Laurent series, residue calculus, conformal mapping and harmonic functions.
Prerequisite: MATH 261.
Term Offered: Fall.
Grade Mode: Traditional.
Special Course Fee: No.
MATH 425 History of Mathematics Credits: 3 (3-0-0)
Course Description: Historical development of geometry, arithmetic, algebra, and calculus from ancient times to 20th century.
Prerequisite: (EDUC 331) and (MATH 317 and MATH 366 or MATH 317 and MATH 369 or MATH 366 and MATH 369).
Term Offered: Fall.
Grade Mode: Traditional.
Special Course Fee: No.

MATH 430 Fourier and Wavelet Analysis with Apps Credits: 3 (3-0-0)
Also Offered As: ECE 430.
Course Description: Fourier analysis and transforms, FFTs; sampling theorems, computational algorithms; wavelets; applications to communication, imaging, and compression.
Prerequisite: MATH 340 or MATH 345.
Term Offered: Spring.
Grade Mode: Traditional.
Special Course Fee: No.

MATH 435 Projects in Applied Mathematics Credits: 3 (1-4-0)
Course Description: Open-ended projects with emphasis on problem identification and formulation, team approach, and reporting results.
Prerequisite: (CS 156 or CS 160 or CS 163 or CS 164 or CS 253 or MATH 151) and (MATH 229 or MATH 369) and (MATH 340 or MATH 345).
Registration Information: Must register for lecture and laboratory.
Term Offered: Spring.
Grade Mode: Traditional.
Special Course Fee: No.

MATH 450 Introduction to Numerical Analysis I Credits: 3 (3-0-0)
Course Description: Solutions of systems of linear and nonlinear equations, interpolation, approximation.
Prerequisite: (CS 156 or CS 160 or CS 163 or CS 164 or CS 253 or MATH 151) and (MATH 255 or MATH 261).
Term Offered: Fall.
Grade Mode: Traditional.
Special Course Fee: No.

MATH 451 Introduction to Numerical Analysis II Credits: 3 (3-0-0)
Course Description: Numerical computation of eigenvalues, numerical solution of ordinary and partial differential equations.
Prerequisite: (CS 156 or CS 160 or CS 163 or CS 164 or CS 253 or MATH 151) and (MATH 340 or MATH 345).
Term Offered: Spring.
Grade Mode: Traditional.
Special Course Fee: No.

MATH 452 Mathematics in Biology and Medicine Credits: 3 (3-0-0)
Course Description: Models in population biology, cell division, host-parasoid systems, bacterial growth and predator-prey systems.
Prerequisite: BZ 348 or MATH 255 or MATH 340 or MATH 345 or MATH 348.
Term Offered: Fall (odd years).
Grade Mode: Traditional.
Special Course Fee: No.

MATH 460 Information and Coding Theory Credits: 3 (3-0-0)
Course Description: Entropy, mutual information, channel capacity, channel coding theorem, syndrome decoding, BCH codes, recent developments.
Prerequisite: MATH 360 and MATH 369 or MATH 366.
Term Offered: Spring.
Grade Mode: Traditional.
Special Course Fee: No.

MATH 461 Abstract Algebra I Credits: 3 (3-0-0)
Course Description: Comprehensive introduction to groups, rings, and fields.
Prerequisite: MATH 235 or MATH 360 or MATH 366.
Term Offered: Fall.
Grade Mode: Traditional.
Special Course Fee: No.

MATH 462 Abstract Algebra II Credits: 3 (3-0-0)
Course Description: Advanced topics in abstract algebra: Euclidean domains, abstract vector spaces, extension fields, Galois theory.
Prerequisite: MATH 461 and MATH 369, may be taken concurrently.
Term Offered: Spring (odd years).
Grade Mode: Traditional.
Special Course Fee: No.

MATH 463 Euclidean and Non-Euclidean Geometry Credits: 3 (3-0-0)
Course Description: Topics from real Euclidean, affine metric and non-Euclidean geometries emphasizing methods and connections with other areas of mathematics.
Prerequisite: (MATH 229 or MATH 369) and (MATH 261).
Term Offered: Spring.
Grade Modes: S/U within Student Option, Trad within Student Option.
Special Course Fee: No.

MATH 464 Introduction to Topology Credits: 3 (3-0-0)
Course Description: Topologies on sets, continuous functions, homeomorphisms. Sequences and convergence, metric spaces, connectedness, path-connectedness. Separation properties. Compactness, Countability axioms.
Prerequisite: MATH 317.
Term Offered: Fall (even years).
Grade Mode: Traditional.
Special Course Fee: No.

MATH 465 Introduction to Differential Geometry Credits: 3 (3-0-0)
Course Description: Local and global geometry of curves and surfaces in Euclidean space, curvature, covariant differentiation, geodesics and the Gauss-Bonnet theorem.
Prerequisite: MATH 261 and MATH 369.
Term Offered: Fall (odd years).
Grade Mode: Traditional.
Special Course Fee: No.
MATH 476  Topics in Mathematics  Credits: 3 (3-0-0)
Course Description: Study experiences which deal with established content areas in mathematics.
Prerequisite: None.
Registration Information: Written consent of instructor.
Terms Offered: Fall, Spring, Summer.
Grade Mode: Traditional.
Special Course Fee: No.

MATH 484  Supervised College Teaching  Credits: Var[1-3] (0-0-0)
Course Description: Special study experiences which deal with established content areas in mathematics.
Prerequisite: None.
Registration Information: Written consent of instructor. A maximum of 10 combined credits for all 384 and 484 courses are counted towards graduation requirements.
Terms Offered: Fall, Spring.
Grade Mode: Instructor Option.
Special Course Fee: No.

MATH 498  Undergraduate Research in Mathematics  Credits: Var[1-3] (0-0-0)
Course Description: Study experiences which deal with established content areas in mathematics.
Prerequisite: None.
Registration Information: Written consent of instructor.
Terms Offered: Fall, Spring.
Grade Mode: Instructor Option.
Special Course Fee: No.

MATH 501  Combinatorics I  Credits: 3 (3-0-0)
Course Description: Puzzles, numbers and counting, subsets, recurrence relations, generating functions, inversion, counting with symmetry, networks, matchings.
Prerequisite: MATH 340 or MATH 345.
Terms Offered: Fall, Spring, Summer.
Grade Mode: S/U within Student Option, Trad within Student Option.
Special Course Fee: No.

MATH 502  Combinatorics II  Credits: 3 (3-0-0)
Course Description: Graph algorithms, external set theory; partitions, Hadamard matrices, q-binomials, finite geometries, strongly regular graphs, triple systems, designs.
Prerequisite: MATH 501.
Term Offered: Spring.
Grade Mode: S/U within Student Option, Trad within Student Option.
Special Course Fee: No.

MATH 505  Teaching Problem Solving in Mathematics K-12  Credits: 3 (0-0-3)
Course Description: Problem-solving strategies, cooperative learning, and manipulatives for K-12 classroom.
Prerequisite: None.
Registration Information: Offered as telecourse only. Teacher licensure required.
Terms Offered: Fall, Spring.
Grade Mode: Traditional.
Special Course Fee: No.

MATH 510  Linear Programming and Network Flows  Credits: 3 (3-0-0)
Course Description: Optimization methods; linear programming, simplex algorithm, duality, sensitivity analysis, minimal cost network flows, transportation problem.
Prerequisite: MATH 261 or MATH 315.
Registration Information: Credit not allowed for both MATH 510 and ENGR 510.
Terms Offered: Fall, Spring, Summer.
Grade Modes: S/U within Student Option, Trad within Student Option.
Special Course Fee: No.

MATH 517  Introduction to Real Analysis  Credits: 3 (3-0-0)
Course Description: Euclidean and metric spaces, compactness, continuity, sequences, series, multivariable differentiation, inverse and implicit function theorems.
Prerequisite: MATH 417 and MATH 369.
Term Offered: Fall.
Grade Mode: Traditional.
Special Course Fee: No.

MATH 519  Complex Variables I  Credits: 3 (3-0-0)
Course Description: Analytic functions, complex integration theory, singularities, elementary functions, and mapping.
Prerequisite: MATH 317.
Term Offered: Spring.
Grade Modes: S/U within Student Option, Trad within Student Option.
Special Course Fee: No.

MATH 520  Nonlinear Programming  Credits: 3 (3-0-0)
Course Description: Theoretical, computational, practical aspects of nonlinear programming (NLP); unconstrained, constrained NLP; quadratic programming; large-scale NLP.
Prerequisite: MATH 510.
Term Offered: Spring.
Grade Mode: Traditional.
Special Course Fee: No.

MATH 525  Optimal Control  Credits: 3 (3-0-0)
Course Description: Theory and application of optimal control and optimal estimation theory; continuous and discrete time systems; Pontryagin maximum principle.
Prerequisite: MATH 340 or MATH 345.
Term Offered: Spring (odd years).
Grade Mode: Traditional.
Special Course Fee: No.
MATH 530 Mathematics for Scientists and Engineers Credits: 4 (4-0-0)
Course Description: Proof-oriented linear algebra, ordinary and partial differential equations.
Prerequisite: MATH 340 or MATH 345.
Registration Information: Primarily for students in the Mathematics Graduate Interdisciplinary Studies Program. Credit not allowed for both MATH 530 and MATH 332.
Term Offered: Fall.
Grade Mode: Traditional.
Special Course Fee: No.

MATH 532 Mathematical Modeling of Large Data Sets Credits: 3 (3-0-0)
Course Description: Mathematical theory and algorithms for modeling large data sets. Application to real world problems. Emphasis on geometric ideas.
Prerequisite: MATH 369 or MATH 530.
Registration Information: Preparedness to do programming in a standard language required.
Term Offered: Spring.
Grade Mode: Traditional.
Special Course Fee: No.

MATH 535 Foundations of Applied Mathematics Credits: 3 (3-0-0)
Course Description: Calculus of variations, perturbation methods, models of continuum, dimensional analysis, stochastic models, integral equations, diffusion.
Prerequisite: MATH 340 or MATH 345.
Term Offered: Fall.
Grade Mode: Traditional.
Special Course Fee: No.

MATH 540 Dynamical Systems Credits: 3 (3-0-0)
Course Description: Linear and nonlinear systems, orbits, phase space, flows of vector fields, stability, bifurcation theory, chaos, strange attractors and applications.
Prerequisite: MATH 369 and MATH 417.
Term Offered: Fall.
Grade Modes: S/U within Student Option, Trad within Student Option.
Special Course Fee: No.

MATH 545 Partial Differential Equations I Credits: 3 (3-0-0)
Course Description: Second order linear PDEs, elliptic and parabolic equations, equations of math physics, separation of variables, Fourier series.
Prerequisite: MATH 340 or MATH 345 or MATH 530.
Term Offered: Fall.
Grade Modes: S/U within Student Option, Trad within Student Option.
Special Course Fee: No.

MATH 546 Partial Differential Equations II Credits: 3 (3-0-0)
Course Description: Distribution theory, Green's functions, Sobolev spaces, elliptic and parabolic equations.
Prerequisite: MATH 545.
Term Offered: Spring.
Grade Modes: S/U within Student Option, Trad within Student Option.
Special Course Fee: No.

MATH 550 Numerical Methods in Science and Engineering Credits: 3 (3-0-0)
Also Offered As: ENGR 550.
Course Description: Finite elements, finite differences, spectral methods, method of lines, conservation laws; stability and convergence analysis for PDEs.
Prerequisite: MATH 340 or MATH 345 or MATH 530.
Registration Information: Credit not allowed for both MATH 550 and ENGR 550.
Terms Offered: Fall, Spring.
Grade Mode: Traditional.
Special Course Fee: No.

MATH 560 Linear Algebra Credits: 3 (3-0-0)
Course Description: Finite dimensional vector spaces, inner products, dual spaces, transformations, projections, adjoints, norms, eigenvalues, eigenvectors.
Prerequisite: MATH 369.
Term Offered: Fall.
Grade Mode: Traditional.
Special Course Fee: No.

MATH 561 Numerical Analysis I Credits: 4 (4-0-0)
Course Description: Numerical linear algebra, solving nonlinear systems, least squares, and minimization.
Prerequisite: (MATH 151 or CS 156 or CS 160 or CS 253) and (MATH 560).
Term Offered: Spring.
Grade Modes: S/U within Student Option, Trad within Student Option.
Special Course Fee: No.

MATH 566 Introduction to Abstract Algebra I Credits: 3 (3-0-0)
Course Description: Analysis of algebraic structures including groups, rings, fields, and vector spaces.
Prerequisite: MATH 366.
Term Offered: Fall.
Grade Modes: S/U within Student Option, Trad within Student Option.
Special Course Fee: No.

MATH 570 Topology I Credits: 3 (3-0-0)
Course Description: Point-set topology including basic set theory, continuity, product and quotient spaces, metrization, compactness, and connectedness.
Prerequisite: MATH 417 or MATH 472.
Term Offered: Fall (odd years).
Grade Modes: S/U within Student Option, Trad within Student Option.
Special Course Fee: No.

MATH 571 Topology II Credits: 3 (3-0-0)
Course Description: Fundamental group, free groups and presentations, and manifolds.
Prerequisite: MATH 566 and MATH 570.
Term Offered: Spring (even years).
Grade Mode: Traditional.
Special Course Fee: No.
MATH 584 Supervised College Teaching Credit: 1 (0-0-1)
Course Description: None.
Registration Information: Written consent of instructor.
Terms Offered: Fall, Spring.
Grade Mode: Instructor Option.
Special Course Fee: No.

MATH 592 Seminar in Mathematics Credit: 1 (0-0-1)
Course Description: None.
Registration Information: Written consent of instructor.
Terms Offered: Fall, Spring, Summer.
Grade Mode: Instructor Option.
Special Course Fee: No.

MATH 601 Advanced Combinatorics I Credits: 3 (3-0-0)
Course Description: Special numbers, mobius inversions, transversals, partial orders, different sets, codes, t-designs.
Prerequisite: MATH 502 and MATH 566.
Restriction: Must be a: Graduate, Professional.
Term Offered: Fall.
Grade Modes: S/U within Student Option, Trad within Student Option.
Special Course Fee: No.

MATH 602 Advanced Combinatorics II Credits: 3 (3-0-0)
Course Description: Hypergeometric functions, graph algorithms, hadamard matrices, strongly regular graphs, association schemes.
Prerequisite: MATH 601.
Restriction: Must be a: Graduate, Professional.
Term Offered: Spring.
Grade Modes: S/U within Student Option, Trad within Student Option.
Special Course Fee: No.

MATH 605A Number Theory: Algebraic Number Theory Credits: 3 (3-0-0)
Course Description: Special numbers, mobius inversions, transversals, partial orders, different sets, codes, t-designs.
Prerequisite: MATH 519, may be taken concurrently and MATH 566 and MATH 567, may be taken concurrently.
Restriction: Must be a: Graduate, Professional.
Term Offered: Spring.
Grade Mode: Traditional.
Special Course Fee: No.

MATH 605B Number Theory: Arithmetic Geometry Credits: 3 (3-0-0)
Course Description: Special numbers, mobius inversions, transversals, partial orders, different sets, codes, t-designs.
Prerequisite: MATH 519, may be taken concurrently and MATH 566 and MATH 567, may be taken concurrently.
Restriction: Must be a: Graduate, Professional.
Term Offered: Spring.
Grade Mode: Traditional.
Special Course Fee: No.

MATH 605C Number Theory: Elliptic Curves Credits: 3 (3-0-0)
Course Description: Special numbers, mobius inversions, transversals, partial orders, different sets, codes, t-designs.
Prerequisite: MATH 519, may be taken concurrently and MATH 566 and MATH 567, may be taken concurrently.
Restriction: Must be a: Graduate, Professional.
Term Offered: Spring.
Grade Mode: Traditional.
Special Course Fee: No.

MATH 605D Number Theory: Analytic Number Theory Credits: 3 (3-0-0)
Course Description: Special numbers, mobius inversions, transversals, partial orders, different sets, codes, t-designs.
Prerequisite: MATH 519, may be taken concurrently and MATH 566 and MATH 567, may be taken concurrently.
Restriction: Must be a: Graduate, Professional.
Term Offered: Spring.
Grade Mode: Traditional.
Special Course Fee: No.

MATH 617 Integration and Measure Theory Credits: 4 (4-0-0)
Course Description: Riemann-Cauchy integration theory, sigma-algebras, Lebesgue theory of measure and integration, Fubini's Theorem, Radon-Nikodym theorem, Lp spaces.
Prerequisite: MATH 517.
Restriction: Must be a: Graduate, Professional.
Term Offered: Spring.
Grade Modes: S/U within Student Option, Trad within Student Option.
Special Course Fee: No.

MATH 618 Advanced Real Analysis Credits: 3 (3-0-0)
Course Description: Normed linear spaces, Banach and Hilbert spaces, elements of functional analysis.
Prerequisite: MATH 560 and MATH 617.
Restriction: Must be a: Graduate, Professional.
Term Offered: Fall.
Grade Modes: S/U within Student Option, Trad within Student Option.
Special Course Fee: No.

MATH 619 Complex Variables II Credits: 3 (3-0-0)
Course Description: Infinite products, entire functions, analytic continuation, Riemann surfaces, other topics.
Prerequisite: MATH 519.
Restriction: Must be a: Graduate, Professional.
Term Offered: Spring.
Grade Mode: Traditional.
Special Course Fee: No.

MATH 620 Variational Methods and Optimization I Credits: 3 (3-0-0)
Course Description: Unconstrained and constrained infinite dimensional optimization, calculus of variations, applications.
Prerequisite: MATH 570 or MATH 517.
Restriction: Must be a: Graduate, Professional.
Term Offered: Fall.
Grade Modes: S/U within Student Option, Trad within Student Option.
Special Course Fee: No.

MATH 621 Variational Methods and Optimization II Credits: 3 (3-0-0)
Course Description: Unconstrained and constrained infinite dimensional optimization, variational inequalities, Lagrange multipliers, control, applications.
Prerequisite: MATH 620.
Restriction: Must be a: Graduate, Professional.
Term Offered: Spring.
Grade Mode: Traditional.
Special Course Fee: No.

MATH 633 Industrial and Applied Mathematics Credits: 3 (2-2-0)
Course Description: Team solution of problems arising in industrial and applied mathematics. Problem formulation, solution proposal, implementation and analysis.
Prerequisite: MATH 530 or MATH 560 or MATH 561.
Restriction: Must be a: Graduate, Professional.
Registration Information: Preparedness to do programming in a standard language required. Must register for lecture and laboratory.
Term Offered: Spring.
Grade Mode: Traditional.
Special Course Fee: No.
MATH 640 Ordinary Differential Equations I Credits: 3 (3-0-0)
Course Description: Existence and uniqueness, continuation, continuous dependence, linear systems, and stability.
Prerequisite: (MATH 340 or MATH 345 or MATH 530) and (MATH 369 and MATH 517).
Restriction: Must be a: Graduate, Professional.
Term Offered: Fall (odd years).
Grade Modes: S/U within Student Option, Trad within Student Option.
Special Course Fee: No.

MATH 641 Ordinary Differential Equations II Credits: 3 (3-0-0)
Course Description: Topics selected from nonlinear boundary value problems, periodic phenomena, differential operators, and others.
Prerequisite: MATH 640.
Restriction: Must be a: Graduate, Professional.
Term Offered: Spring (even years).
Grade Modes: S/U within Student Option, Trad within Student Option.
Special Course Fee: No.

MATH 645 Advanced Partial Differential Equations I Credits: 3 (3-0-0)
Course Description: Abstract methods for linear partial differential equations.
Prerequisite: MATH 546.
Restriction: Must be a: Graduate, Professional.
Term Offered: Fall (even years).
Grade Mode: Traditional.
Special Course Fee: No.

MATH 646 Advanced Partial Differential Equations II Credits: 3 (3-0-0)
Course Description: Problems in nonlinear partial differential equations.
Prerequisite: MATH 645.
Restriction: Must be a: Graduate, Professional.
Term Offered: Spring (odd years).
Grade Mode: Traditional.
Special Course Fee: No.

MATH 651 Numerical Analysis I Credits: 4 (4-0-0)
Course Description: Interpolation, approximation, quadrature, initial and boundary value problems.
Prerequisite: (CS 156 or CS 160 or CS 253 or MATH 151) and (MATH 340 or MATH 345 or MATH 369 or MATH 530).
Restriction: Must be a: Graduate, Professional.
Term Offered: Fall.
Grade Mode: Traditional.
Special Course Fee: No.

MATH 652 Advanced Numerical Methods for PDEs Credits: 3 (3-0-0)
Course Description: Theory of numerical methods for solution of PDEs: convergence and stability properties; error estimation; approximation theory.
Prerequisite: MATH 545 or MATH 560 or MATH 617.
Restriction: Must be a: Graduate, Professional.
Term Offered: Fall.
Grade Mode: Traditional.
Special Course Fee: No.

MATH 656 Advanced Algebra I Credits: 3 (3-0-0)
Course Description: Theory of rings and algebras with applications.
Prerequisite: MATH 567.
Restriction: Must be a: Graduate, Professional.
Term Offered: Fall.
Grade Modes: S/U within Student Option, Trad within Student Option.
Special Course Fee: No.

MATH 666 Advanced Algebra II Credits: 3 (3-0-0)
Course Description: Advanced topics from algebra: representation theory, Wedderburn theory, bilinear forms, multilinear and homological algebra.
Prerequisite: MATH 666.
Restriction: Must be a: Graduate, Professional.
Term Offered: Spring.
Grade Modes: S/U within Student Option, Trad within Student Option.
Special Course Fee: No.

MATH 670 Introduction to Differential Manifolds Credits: 3 (3-0-0)
Course Description: Finite-dimensional differential manifolds, submanifolds, vector fields and flows, Lie groups and algebras.
Prerequisite: MATH 560.
Restriction: Must be a: Graduate, Professional.
Term Offered: Spring (odd years).
Grade Mode: Traditional.
Special Course Fee: No.

MATH 672 Projective Geometry I Credits: 3 (3-0-0)
Course Description: Algebraic sets in projective space, the Nullstellensatz, rational maps and functions, coordinate rings, Hilbert functions, dimension, degree.
Prerequisite: MATH 567.
Restriction: Must be a: Graduate, Professional.
Term Offered: Fall.
Grade Mode: Traditional.
Special Course Fee: No.

MATH 673 Projective Geometry II Credits: 3 (3-0-0)
Course Description: Topics selected from curves and surfaces, sheaf theory, algebraic geometry, singularity theory, vector bundles.
Prerequisite: MATH 672.
Restriction: Must be a: Graduate, Professional.
Term Offered: Spring.
Grade Mode: Traditional.
Special Course Fee: No.

MATH 676 Advanced Algebra I Credits: 3 (3-0-0)
Course Description: Advanced topics from algebra: representation theory, Wedderburn theory, bilinear forms, multilinear and homological algebra.
Prerequisite: MATH 666.
Restriction: Must be a: Graduate, Professional.
Term Offered: Spring.
Grade Modes: S/U within Student Option, Trad within Student Option.
Special Course Fee: No.

MATH 677 Advanced Algebra II Credits: 3 (3-0-0)
Course Description: Advanced topics from algebra: representation theory, Wedderburn theory, bilinear forms, multilinear and homological algebra.
Prerequisite: MATH 666.
Restriction: Must be a: Graduate, Professional.
Term Offered: Spring.
Grade Modes: S/U within Student Option, Trad within Student Option.
Special Course Fee: No.

MATH 687 Internship Credits: Var[1-9] (0-0-0)
Course Description: A work-learn experience integrating classroom theory with practical experience.
Prerequisite: None.
Restriction: Must be a: Graduate, Professional.
Terms Offered: Fall, Spring, Summer.
Grade Mode: Instructor Option.
Special Course Fee: No.

MATH 693 Seminar in Mathematics Credits: 3 (0-0-3)
Course Description: Advanced study experiences which deal with established content areas in mathematics.
Prerequisite: None.
Restriction: Must be a: Graduate, Professional.
Terms Offered: Fall, Spring, Summer.
Grade Mode: Instructor Option.
Special Course Fee: No.
MATH 695  Independent Study  Credits: Var[1-18] (0-0-0)
Course Description:
Prerequisite: None.
Restriction: Must be a: Graduate, Professional.
Terms Offered: Fall, Spring, Summer.
Grade Mode: Instructor Option.
Special Course Fee: No.

MATH 699  Thesis  Credits: Var[1-18] (0-0-0)
Course Description:
Prerequisite: None.
Restriction: Must be a: Graduate, Professional.
Terms Offered: Fall, Spring, Summer.
Grade Mode: Instructor Option.
Special Course Fee: No.

MATH 717  Functional Analysis I  Credits: 3 (3-0-0)
Course Description: Topological vector spaces; Banach and Hilbert spaces.
Prerequisite: MATH 618.
Restriction: Must be a: Graduate, Professional.
Term Offered: Fall (odd years).
Grade Modes: S/U within Student Option, Trad within Student Option.
Special Course Fee: No.

MATH 718  Functional Analysis II  Credits: 3 (3-0-0)
Course Description: Spectral theory, operator theory, semigroups of transformations, and distribution theory.
Prerequisite: MATH 717.
Restriction: Must be a: Graduate, Professional.
Term Offered: Spring (even years).
Grade Mode: Traditional.
Special Course Fee: No.

MATH 750  Numerical Methods and Models I  Credits: 3 (3-0-0)
Course Description: Derivation of model equations, introduction to solution techniques and computing.
Prerequisite: MATH 561.
Restriction: Must be a: Graduate, Professional.
Term Offered: Fall.
Grade Modes: S/U within Student Option, Trad within Student Option.
Special Course Fee: No.

MATH 751  Numerical Methods and Models II  Credits: 3 (3-0-0)
Course Description: Convergence, stability, error estimates and computing.
Prerequisite: MATH 561.
Restriction: Must be a: Graduate, Professional.
Term Offered: Spring.
Grade Mode: Traditional.
Special Course Fee: No.

MATH 793  Seminar in Mathematics  Credits: Var[1-18] (0-0-0)
Course Description:
Prerequisite: None.
Restriction: Must be a: Graduate, Professional.
Terms Offered: Fall, Spring, Summer.
Grade Mode: Instructor Option.
Special Course Fee: No.

MATH 798  Research  Credits: Var[1-18] (0-0-0)
Course Description:
Prerequisite: None.
Restriction: Must be a: Graduate, Professional.
Terms Offered: Fall, Spring, Summer.
Grade Mode: Instructor Option.
Special Course Fee: No.

MATH 799  Dissertation  Credits: Var[1-18] (0-0-0)
Course Description:
Prerequisite: None.
Restriction: Must be a: Graduate, Professional.
Terms Offered: Fall, Spring, Summer.
Grade Mode: Instructor Option.
Special Course Fee: No.