

MATHEMATICS-MATH (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: Does not satisfy the prerequisite for MATH 117. 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: 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.

Terms Offered: Fall, Spring.

Grade Mode: Traditional.

Special Course Fee: No.

Additional Information: 1B, Mathematics (GT-MA1).

MATH 112 Mathematics of Sustainability (GT-MA1) Credits: 3 (3-0-0)

Course Description: The role of mathematics in global sustainability challenges of population growth, health, food and agriculture, water, and energy. Followed by a selection of general mathematical explorations including Algebra and Trigonometry topics that can potentially provide Math Placement outcomes.

Prerequisite: None.

Restriction: Must be a: Undergraduate.

Registration Information: Sections may be offered: Online.

Terms Offered: Fall, Spring, Summer.

Grade Mode: Traditional.

Special Course Fee: No.

Additional Information: 1B, Mathematics (GT-MA1).

MATH 116 Precalculus Supplement for Success in Math Credit: 1 (1-0-0)

Course Description: Supplemental academic instruction developing skills to succeed in precalculus courses and future mathematics and STEM courses.

Prerequisite: None.

Restriction: Must be a: Undergraduate.

Registration Information: Concurrent registration in face-to-face section of MATH 117 and MATH 118. Approval by department representative 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: Math Placement Tool or ELM Tutorial required. Sections may be offered: Online.

Terms Offered: Fall, Spring, Summer.

Grade Mode: Instructor Option.

Special Course Fee: No.

Additional Information: 1B, Mathematics (GT-MA1).

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: MATH 117 or Math Placement Tool required. Sections may be offered: Online.

Terms Offered: Fall, Spring, Summer.

Grade Mode: Instructor Option.

Special Course Fee: No.

Additional Information: 1B, Mathematics (GT-MA1).

MATH 120 College Algebra (GT-MA1) Credits: 3 (3-0-0)

Course Description: Examine ideas of quantity, variable, rate of change, and formula. Develop meaningful formulas and graphs to represent the patterns (linear, quadratic, exponential) of how two quantities change together, and develop and interpret function formulas and graphs to represent quantitative relationships in applied contexts.

Prerequisite: None.

Registration Information: Math Placement Tool or ELM Tutorial required. Credit allowed for only one of the following: MATH 120, MATH 124, or MATH 127.

Terms Offered: Fall, Spring, Summer.

Grade Mode: Traditional.

Special Course Fee: No.

Additional Information: 1B, Mathematics (GT-MA1).

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: MATH 118 or Math Placement Tool required. Sections may be offered: Online. Credit not allowed for both MATH 120 and MATH 124.

Terms Offered: Fall, Spring, Summer.

Grade Mode: Instructor Option.

Special Course Fee: No.

Additional Information: 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 or MATH 120.

Registration Information: MATH 118 or Math Placement Tool required. Sections may be offered: Online. Credit not allowed for both MATH 125 and MATH 127.

Terms Offered: Fall, Spring, Summer.

Grade Mode: Instructor Option.

Special Course Fee: No.

Additional Information: 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 Math Placement Tool required. Sections may be offered: Online. Credit not allowed for both MATH 126 and MATH 127.

Terms Offered: Fall, Spring, Summer.

Grade Mode: Instructor Option.

Special Course Fee: No.

Additional Information: 1B, Mathematics (GT-MA1).

MATH 127 Precalculus (GT-MA1) Credits: 4 (4-0-0)

Course Description: Examine ideas of quantity, variable, rate of change, and formula that are necessary for succeeding in and learning precalculus and calculus. Develop meaningful formulas and graphs to represent the patterns (linear, quadratic, exponential, trigonometric) of how two quantities change together, and develop and interpret function formulas and graphs to represent quantitative relationships in applied contexts.

Prerequisite: None.

Registration Information: Math Placement Tool or ELM Tutorial required. Credit allowed for only one of the following: MATH 120, MATH 125, MATH 126, or MATH 127.

Terms Offered: Fall, Spring, Summer.

Grade Mode: Instructor Option.

Special Course Fee: No.

Additional Information: 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 or MATH 120 or MATH 127.

Registration Information: Sections may be offered: Online. Credit allowed for only one of the following courses: MATH 141 or MATH 155 or MATH 159 or MATH 160.

Terms Offered: Fall, Spring, Summer.

Grade Mode: Traditional.

Special Course Fee: No.

Additional Information: 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 120 or MATH 124) and (MATH 125).

Registration Information: Credit allowed for only one of the following courses: MATH 141, MATH 155, MATH 159, or MATH 160.

Terms Offered: Fall, Spring, Summer.

Grade Mode: Traditional.

Special Course Fee: No.

Additional Information: 1B, Mathematics (GT-MA1).

MATH 156 Mathematics for Computational Science I (GT-MA1) Credits: 4 (4-0-0)

Course Description: Sets; relations; number systems; functions; sequences and series; concepts of differential and integral calculus as relevant to computational science.

Prerequisite: None.

Registration Information: MATH 124 with a B- or better; MATH 126 with a B- or better or MATH 127 with a B- or better. Sections may be offered: Online.

Terms Offered: Fall, Spring, Summer.

Grade Mode: Traditional.

Special Course Fee: No.

Additional Information: 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 118) and (MATH 124, may be taken concurrently) and (MATH 125) and (MATH 126, may be taken concurrently).

Term Offered: Fall.

Grade Mode: Traditional.

Special Course Fee: No.

Additional Information: 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 124 and MATH 126 and MATH 157.

Registration Information: Credit allowed for only one of the following: MATH 141, MATH 155, MATH 159, or MATH 160.

Term Offered: Spring.

Grade Mode: Traditional.

Special Course Fee: No.

Additional Information: 1B, 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.

Prerequisite: (MATH 120 with a minimum grade of B- or MATH 124 with a minimum grade of B-) and (MATH 126 with a minimum grade of B-).

Registration Information: Must register for lecture and laboratory. Credit allowed for only one of the following courses: MATH 141, MATH 155, MATH 159, or MATH 160. Sections may be offered: Online.

Terms Offered: Fall, Spring, Summer.

Grade Mode: Traditional.

Special Course Fee: No.

Additional Information: 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 120 or MATH 124, may be taken concurrently) and (MATH 159 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: 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 211 Financial Mathematics for Actuarial Science Credits: 3 (3-0-0)

Course Description: Preparation for the Financial Mathematics (FM) Actuarial Examination. Topics covered are exactly the material the Society of Actuaries is testing on Exam FM each semester per the exam syllabus, which typically includes time value of money, annuities, bonds, convexity and cash flows, as well as the financial calculator skills needed to solve the associated exam problems.

Prerequisite: MATH 161.

Registration Information: Credit not allowed for both MATH 211 and MATH 280A4.

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 156 or MATH 161 or MATH 271.

Terms Offered: Fall, Spring.

Grade Mode: Traditional.

Special Course Fee: No.

MATH 255 Calculus for Biological Scientists II 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 or MATH 127, 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: 1B.

MATH 256 Mathematics for Computational Science II Credits: 4 (4-0-0)

Course Description: Methods from vector calculus, advanced calculus, and analytic geometry as relevant to machine learning and data science. Optimization.

Prerequisite: (MATH 156 or MATH 161) and (DSCI 369 or MATH 369).

Registration Information: Sections may be offered: Online. Credit not allowed for both MATH 256 and MATH 281A2.

Term Offered: Spring.

Grade Mode: Traditional.

Special Course Fee: No.

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: Sections may be offered: Online. Credit not allowed for both MATH 255 and MATH 261.

Terms Offered: Fall, Spring, Summer.

Grade Modes: S/U within Student Option, Trad within Student Option.

Special Course Fee: No.

MATH 269 Geometric Introduction to Linear Algebra Credits: 2 (2-0-0)

Course Description: A first introduction to linear algebra with a geometric rather than a computational approach.

Prerequisite: MATH 117 or MATH 120 or MATH 127.

Restriction: Must be a: Undergraduate.

Term Offered: Fall.

Grade Mode: Traditional.

Special Course Fee: No.

MATH 271 Applied Mathematics for Chemists I Credits: 4 (4-0-0)

Course Description: Series and limits, Taylor series, complex variables, first- and second- order ordinary differential equations, matrices, linear transformations, determinants, and eigenvalues.

Prerequisite: MATH 155 or MATH 159 or MATH 160.

Term Offered: Fall.

Grade Mode: Traditional.

Special Course Fee: No.

MATH 272 Applied Mathematics for Chemists II Credits: 4 (4-0-0)

Course Description: Vector fields, partial differentiation, cylindrical and spherical coordinates, multiple integrals, line integrals, the Wave and the Schrödinger equations, separation of variables method. Inner Product Spaces. Fourier Series.

Prerequisite: 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: Counting problems; binomial coefficients; proof techniques in combinatorics; recurrence relations and generating functions; graph theory, including walks, trees, and planar graphs.

Prerequisite: DSCI 369 and MATH 156 or MATH 161.

Registration Information: Sections may be offered: Online.

Terms Offered: Fall, Spring, Summer.

Grade Mode: Traditional.

Special Course Fee: No.

MATH 317 Advanced Calculus of One Variable Credits: 3 (3-0-0)

Course Description: Convergence of sequences, series: limits, continuity, differentiation, integration of one-variable functions.

Prerequisite: (MATH 156 or MATH 161) and (CS 220 or MATH 230 or MATH 235).

Terms Offered: Fall, Spring, Summer.

Grade Modes: S/U within Student Option, Trad within Student Option.

Special Course Fee: No.

MATH 320 Optimization Methods in Data Science Credits: 3 (3-0-0)

Also Offered As: DSCI 320.

Course Description: Linear and non-linear programming, convex sets and functions, convex and non-convex optimization problems, duality, Newton's methods, barrier methods, linear equality and inequality constraints. Emphasis on computation methods and programming.

Prerequisite: (CS 163 or CS 164 or CS 165 or CS 220 or DSCI 235) and (DSCI 369 or MATH 369) and (MATH 255 or MATH 256 or MATH 261).

Registration Information: Credit not allowed for both DSCI 320 and MATH 320.

Term Offered: Fall.

Grade Mode: Traditional.

Special Course Fee: No.

MATH 331 Introduction to Mathematical Modeling Credits: 3 (3-0-0)

Course Description: Problem formulation. Modeling, theoretical and empirical. Variable selection. Derivation and simulation of solutions. Model testing including prediction.

Prerequisite: (DSCI 369, may be taken concurrently or MATH 369, may be taken concurrently) and (MATH 161 or MATH 256).

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 Intro 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: Sections may be offered: Online. 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 255 or MATH 261) and (DSCI 369 or MATH 369).

Registration Information: Must register for lecture and laboratory. Credit not allowed for both MATH 340 and MATH 345.

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: BZ 348, BZ 548, MATH 348.

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 156 or MATH 161) and (CS 220 or MATH 235).

Registration Information: Sections may be offered: Online.

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 156 or 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: Linear systems, matrices, subspaces of Euclidean spaces, linear transformations on Euclidean spaces, eigenvalues, eigenvectors.

Prerequisite: MATH 156 or MATH 161 or MATH 255 or MATH 271.

Registration Information: Sections may be offered: Online.

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 411 Stochastic Calculus and Financial Mathematics Credits: 3 (3-0-0)

Course Description: Elements of probability theory and optimization, portfolio theory, martingales, stochastic processes, stochastic differential equations, financial derivatives, and the Black-Scholes model.

Prerequisite: (MATH 317) and (DSCI 369 or MATH 332 or MATH 340 or MATH 345 or MATH 369).

Registration Information: Sections may be offered: Online. Credit not allowed for both MATH 411 and MATH 480A3.

Term Offered: Spring.

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 317) and (DSCI 369 or MATH 369).

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 (DSCI 369 and MATH 317 or DSCI 369 and MATH 366 or 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.

Registration Information: Credit not allowed for both ECE 430 and MATH 430.

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 150A or CS 150B or CS 152 or CS 163 or CS 164 or CS 165 or CS 253 or MATH 151) and (DSCI 369 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 150A or CS 150B or CS 152 or CS 163 or CS 164 or CS 165 or CS 253 or MATH 151) and (MATH 255 or MATH 256 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 150A or CS 150B or CS 152 or CS 163 or CS 164 or CS 165 or CS 253 or MATH 151) and (MATH 340 or MATH 345).

Term Offered: Spring.

Grade Mode: Traditional.

Special Course Fee: No.

MATH 455 Mathematics in Biology and Medicine Credits: 3 (3-0-0)

Course Description: Models in population biology, cell division, host-parasitoid 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 or MATH 366) and (DSCI 369 or MATH 369).

Term Offered: Spring.

Grade Mode: Traditional.

Special Course Fee: No.

MATH 463 Post-Quantum Cryptography Credits: 3 (3-0-0)

Course Description: Exploration of secure communication in an environment where an adversary has a quantum computer. Survey of known quantum attacks on classical public key cryptosystems, and a detailed study of some of the leading candidates for quantum-resistant protocols.

Prerequisite: (MATH 161) and (DSCI 369 or MATH 369).

Registration Information: Credit not allowed for both MATH 463 and MATH 480A1.

Term Offered: Spring (odd years).

Grade Mode: Traditional.

Special Course Fee: No.

MATH 466 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 467 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: (DSCI 369, may be taken concurrently or MATH 369, may be taken concurrently) and (MATH 466).

Term Offered: Spring (odd years).

Grade Mode: Traditional.

Special Course Fee: No.

MATH 469 Linear Algebra II Credits: 3 (3-0-0)

Course Description: Abstract vector spaces, general theory of linear transformations, theory of determinants, canonical forms.

Prerequisite: (MATH 161) and (DSCI 369 or MATH 369).

Term Offered: Spring.

Grade Mode: Traditional.

Special Course Fee: No.

MATH 470 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 261) and (DSCI 369 or MATH 369).

Term Offered: Spring.

Grade Modes: S/U within Student Option, Trad within Student Option.

Special Course Fee: No.

MATH 472 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 474 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 (DSCI 369 or 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:

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 487 Internship Credits: Var[1-16] (0-0-0)

Course Description: A work-learn experience integrating classroom theory with practical experience.

Prerequisite: None.

Registration Information: Written consent of instructor.

Terms Offered: Fall, Spring, Summer.

Grade Mode: Instructor Option.

Special Course Fee: No.

MATH 495 Independent Study Credits: Var[1-18] (0-0-0)

Prerequisite: None.

Grade Mode: Instructor Option.

Special Course Fee: No.

MATH 498 Undergraduate Research in Mathematics Credits: Var[1-3] (0-0-0)

Prerequisite: None.

Grade Mode: Instructor Option.

Special Course Fee: No.

MATH 501 Combinatorics I Credits: 3 (3-0-0)

Course Description: Fundamental concepts in combinatorics (the art of counting). Enumeration techniques such as bijections, inclusion-exclusion, binomial coefficients, and Stirling numbers; tools such as generating functions and recursions; topics such as graph theory, symmetric functions, partition theory, posets, and finite geometries.

Prerequisite: (MATH 301) and (MATH 360 or MATH 366).

Registration Information: Sections may be offered: Online.

Term Offered: Fall.

Grade Mode: Traditional.

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 Modes: 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 507 Advanced Reasoning in Mathematics Credits: 3 (3-0-0)

Course Description: General proof techniques, proof in abstract algebra, proof in analysis, and proof in combinatorics.

Prerequisite: None.

Registration Information: This is a partial semester course. Sections may be offered: Online.

Term Offered: Summer.

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: Metric spaces, spaces of functions, sequences and convergence, completeness, compactness, contraction mappings, fixed point theorems, implicit and inverse function theorems, and Lebesgue integration.

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, d-bar operator. Exponential, Logarithm, and Trigonometric functions. Branch cuts and Riemann Surfaces. Power series, analytic continuation, integrals along curves, Cauchy inequalities, Liouville Theorem, and the Fundamental Theorem of Algebra. Maximum modulus principle, Classification of singularities, Laurent series, and residue calculus. Rouché's Theorem, Hurwitz Theorem, Open Mapping Theorem, Conformal Mappings, and Linear Fractional Transformations.

Prerequisite: MATH 317.

Term Offered: Spring.

Grade Mode: Traditional.

Special Course Fee: No.

MATH 520 Nonlinear Programming Credits: 3 (3-0-0)

Prerequisite: MATH 510.

Grade Mode: Traditional.

Special Course Fee: No.

MATH 522 Random Walks Credits: 3 (3-0-0)

Also Offered As: ECE 522.

Course Description: Mathematical aspects of random walks and diffusion processes. Stochastic modeling of complex systems.

Prerequisite: (ECE 303 with a minimum grade of C or STAT 303 with a minimum grade of C or STAT 315 with a minimum grade of C) and (ECE 312 with a minimum grade of C or ECE 457 with a minimum grade of C or MATH 469 with a minimum grade of C).

Registration Information: Junior standing. Sections may be offered: Online. Credit allowed for only one of the following: ECE 522, ECE 681A2, and MATH 522.

Term Offered: Fall (even years).

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: 3 (3-0-0)

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 332 and MATH 530.

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 partial differential equations (PDEs), elliptic, hyperbolic and parabolic equations and their derivation from physical principles, separation of variables and Fourier series, Green's functions, maximum principles, shockwaves.

Prerequisite: MATH 340 or MATH 345 or MATH 530.

Term Offered: Fall.

Grade Mode: Traditional.

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: Numerical methods, including finite elements, finite differences, spectral methods, method of lines, and conservation laws; stability and convergence analysis for PDEs; and applications in science and engineering.

Prerequisite: MATH 340 or MATH 345 or MATH 530.

Registration Information: Sections may be offered: Online. Credit not allowed for both ENGR 550 and MATH 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.

Registration Information: Sections may be offered: Online.

Term Offered: Fall.

Grade Mode: Traditional.

Special Course Fee: No.

MATH 561 Numerical Analysis I Credits: 3 (3-0-0)

Course Description: Numerical linear algebra, solving nonlinear systems, least squares, and minimization.

Prerequisite: (CS 156 or CS 253 or MATH 151) 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: Algebraic Structures: Groups, Rings; both abstract theory and investigation of relevant examples. Substructures, Quotients, Homomorphisms. Group Actions, Unique Factorization.

Prerequisite: MATH 366.

Term Offered: Fall.

Grade Mode: Traditional.

Special Course Fee: No.

MATH 567 Introduction to Abstract Algebra II Credits: 3 (3-0-0)

Course Description: Field theory, Galois theory, and advanced linear algebra.

Prerequisite: MATH 566.

Term Offered: Spring.

Grade Modes: S/U within Student Option, Trad within Student Option.

Special Course Fee: No.

MATH 569A Linear Algebra for Data Science: Matrices and Vector Spaces Credit: 1 (1-0-0)

Also Offered As: DSCI 569A.

Course Description: A basic introduction to matrices and linear algebra with preparation to pursue further studies in the applications of matrices with an emphasis on the foundations of data science.

Prerequisite: MATH 124 and MATH 126 or MATH 127.

Restriction: Must be a: Graduate.

Registration Information: Graduate standing. Offered as an online course only. Credit not allowed for both DSCI 569A and MATH 569A.

Terms Offered: Fall, Spring, Summer.

Grade Mode: Traditional.

Special Course Fee: No.

MATH 569B Linear Algebra for Data Science: Geometric Techniques for Data Reduction Credit: 1 (1-0-0)

Also Offered As: DSCI 569B.

Course Description: Projections, data fitting and over-determined linear systems, eigenvectors and eigenvalues, the spectral theorem for symmetric matrices, data driven bases, principal component analysis, the singular value decomposition.

Prerequisite: DSCI 569A or MATH 569A.

Restriction: Must be a: Graduate.

Registration Information: Graduate standing. Sections may be offered: Online. Credit allowed for only one of the following: DSCI 569B, MATH 569B, or MATH 580A3.

Terms Offered: Fall, Spring, Summer.

Grade Mode: Traditional.

Special Course Fee: No.

MATH 569C Linear Algebra for Data Science: Matrix Factorizations and Transformations Credit: 1 (1-0-0)**Also Offered As:** DSCI 569C.**Course Description:** Advanced algorithms for the characterization of data using matrix factorizations and transformations.**Prerequisite:** DSCI 569B or MATH 569B.**Restriction:** Must be a: Graduate.**Registration Information:** Graduate standing. Sections may be offered: Online. Credit allowed for only one of the following: DSCI 569C, MATH 569C, or MATH 580A4.**Terms Offered:** Fall, Spring, Summer.**Grade Mode:** Traditional.**Special Course Fee:** No.**MATH 569D Linear Algebra for Data Science: Theoretical Foundations Credit: 1 (1-0-0)****Also Offered As:** DSCI 569D.**Course Description:** Theoretical development of linear algebraic tools for data science; theorem and proof driven.**Prerequisite:** DSCI 569C or MATH 569C.**Restriction:** Must be a: Graduate.**Registration Information:** Graduate standing. Sections may be offered: Online. Credit allowed for only one of the following: DSCI 569D, MATH 569D, or MATH 580A5.**Terms Offered:** Fall, Spring, Summer.**Grade Mode:** Traditional.**Special Course Fee:** No.**MATH 570 Topology I Credits: 3 (3-0-0)****Course Description:** Topological spaces, continuous functions, homeomorphisms, homotopy, simplicial and CW complexes, fundamental groups, covering spaces, Van Kampen's theorem, singular and cellular homology, Euler characteristic, and exact sequences.**Prerequisite:** MATH 417 or MATH 472.**Term Offered:** Fall (odd years).**Grade Mode:** Traditional.**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 574 Intro to Mathematics Education Research Credits: 3 (3-0-0)****Course Description:** Synthesize mathematics education research, learn about research methods in mathematics education research, suggest areas of research most useful to advancing the field, and discuss classroom practice implications.**Prerequisite:** None.**Restriction:** Must be a: Graduate.**Registration Information:** Graduate standing. Credit not allowed for both MATH 574 and MATH 581A4.**Term Offered:** Fall.**Grade Mode:** Traditional.**Special Course Fee:** No.**MATH 584A Supervised College Teaching: Incoming GTAs Credit: 1 (0-0-2.5)****Course Description:** Best teaching practices for graduate teaching assistants. Focus on creating a sense of community in the classroom, crafting rich tasks, fostering student centered learning, and providing access to mathematics.**Prerequisite:** None.**Restriction:** Must be a: Graduate.**Registration Information:** Graduate standing. Written consent of instructor.**Term Offered:** Fall.**Grade Mode:** Traditional.**Special Course Fee:** No.**MATH 584B Supervised College Teaching: Continuing GTAs Credit: 1 (0-0-2.5)****Course Description:****Prerequisite:** None.**Restriction:** Must be a: Graduate.**Registration Information:** Graduate standing. Written consent of instructor.**Terms Offered:** Fall, Spring.**Grade Mode:** Instructor Option.**Special Course Fee:** No.**MATH 592A Seminar in Mathematics: Applications of Math Credit: 1 (0-0-1)****Course Description:** Seminar focusing on how mathematics can be applied to many different fields outside of mathematics.**Prerequisite:** None.**Restriction:** Must be a: Graduate.**Registration Information:** Graduate standing. Written consent of instructor. Sections may be offered: Online.**Term Offered:** Fall.**Grade Mode:** Traditional.**Special Course Fee:** No.**MATH 592B Seminar in Mathematics: Math and Mathematicians in the 20th Century Credit: 1 (0-0-1)****Course Description:** Seminar focusing on the diversity of people who have contributed to modern mathematics, in historical and social context.**Prerequisite:** None.**Restriction:** Must be a: Graduate.**Registration Information:** Graduate standing. Written consent of instructor. Sections may be offered: Online.**Term Offered:** Spring.**Grade Mode:** Traditional.**Special Course Fee:** No.**MATH 592C Seminar in Mathematics: MS Students Credit: 1 (0-0-1)****Course Description:****Prerequisite:** None.**Restriction:** Must be a: Graduate.**Registration Information:** Graduate standing. 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:

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:

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:

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: 3 (3-0-0)

Course Description: Riemann-Cauchy integration theory, sigma-algebras, Lebesgue theory of measure and integration, Fubini's Theorem, Radon-Nikodym theorem, L_p 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 II Credits: 3 (3-0-0)

Course Description: Interpolation, approximation, quadrature, initial and boundary value problems.

Prerequisite: MATH 561.

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 666 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 667 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 674 Mathematics Education Theoretical Perspective Credits: 3 (3-0-0)

Course Description: Analysis, synthesis, and re-conceptualization of theoretical perspectives that are adopted in mathematics education research.

Prerequisite: MATH 574.

Restriction: Must be a: Graduate, Professional.

Registration Information: Credit not allowed for both MATH 674 and MATH 680A2.

Term Offered: Spring.

Grade Mode: Traditional.

Special Course Fee: No.

MATH 675 Topics in Mathematics Education Credits: 3 (3-0-0)

Course Description: Contemporary topics in mathematics education research. Content will vary and may include assessment, access and equity in mathematics teaching and learning, embodied cognition at the collegiate level, backwards design, research in undergraduate mathematics education, technology for teaching and learning mathematics, etc.

Prerequisite: MATH 574.

Restriction: Must be a: Graduate, Professional.

Registration Information: May be taken up to 5 times for credit.

Term Offered: Fall.

Grade Mode: Traditional.

Special Course Fee: No.

MATH 676 Topics in Mathematics Credits: 3 (3-0-0)

Course Description: Advanced study experiences which deal with established content areas in mathematics.

Prerequisite: None.

Restriction: Must be a: Graduate, Professional.

Registration Information: May be taken up to 5 times for credit.

Terms Offered: Fall, Spring, Summer.

Grade Mode: Traditional.

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:****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.

Courses

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:** Does not satisfy the prerequisite for MATH 117. 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:** 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.**Terms Offered:** Fall, Spring.**Grade Mode:** Traditional.**Special Course Fee:** No.**Additional Information:** 1B, Mathematics (GT-MA1).**MATH 112 Mathematics of Sustainability (GT-MA1) Credits: 3 (3-0-0)****Course Description:** The role of mathematics in global sustainability challenges of population growth, health, food and agriculture, water, and energy. Followed by a selection of general mathematical explorations including Algebra and Trigonometry topics that can potentially provide Math Placement outcomes.**Prerequisite:** None.**Restriction:** Must be a: Undergraduate.**Registration Information:** Sections may be offered: Online.**Terms Offered:** Fall, Spring, Summer.**Grade Mode:** Traditional.**Special Course Fee:** No.**Additional Information:** 1B, Mathematics (GT-MA1).

MATH 116 Precalculus Supplement for Success in Math Credit: 1 (1-0-0)

Course Description: Supplemental academic instruction developing skills to succeed in precalculus courses and future mathematics and STEM courses.

Prerequisite: None.

Restriction: Must be a: Undergraduate.

Registration Information: Concurrent registration in face-to-face section of MATH 117 and MATH 118. Approval by department representative 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: Math Placement Tool or ELM Tutorial required.

Sections may be offered: Online.

Terms Offered: Fall, Spring, Summer.

Grade Mode: Instructor Option.

Special Course Fee: No.

Additional Information: 1B, Mathematics (GT-MA1).

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: MATH 117 or Math Placement Tool required.

Sections may be offered: Online.

Terms Offered: Fall, Spring, Summer.

Grade Mode: Instructor Option.

Special Course Fee: No.

Additional Information: 1B, Mathematics (GT-MA1).

MATH 120 College Algebra (GT-MA1) Credits: 3 (3-0-0)

Course Description: Examine ideas of quantity, variable, rate of change, and formula. Develop meaningful formulas and graphs to represent the patterns (linear, quadratic, exponential) of how two quantities change together, and develop and interpret function formulas and graphs to represent quantitative relationships in applied contexts.

Prerequisite: None.

Registration Information: Math Placement Tool or ELM Tutorial required. Credit allowed for only one of the following: MATH 120, MATH 124, or MATH 127.

Terms Offered: Fall, Spring, Summer.

Grade Mode: Traditional.

Special Course Fee: No.

Additional Information: 1B, Mathematics (GT-MA1).

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: MATH 118 or Math Placement Tool required.

Sections may be offered: Online. Credit not allowed for both MATH 120 and MATH 124.

Terms Offered: Fall, Spring, Summer.

Grade Mode: Instructor Option.

Special Course Fee: No.

Additional Information: 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 or MATH 120.

Registration Information: MATH 118 or Math Placement Tool required.

Sections may be offered: Online. Credit not allowed for both MATH 125 and MATH 127.

Terms Offered: Fall, Spring, Summer.

Grade Mode: Instructor Option.

Special Course Fee: No.

Additional Information: 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 Math Placement Tool required.

Sections may be offered: Online. Credit not allowed for both MATH 126 and MATH 127.

Terms Offered: Fall, Spring, Summer.

Grade Mode: Instructor Option.

Special Course Fee: No.

Additional Information: 1B, Mathematics (GT-MA1).

MATH 127 Precalculus (GT-MA1) Credits: 4 (4-0-0)

Course Description: Examine ideas of quantity, variable, rate of change, and formula that are necessary for succeeding in and learning precalculus and calculus. Develop meaningful formulas and graphs to represent the patterns (linear, quadratic, exponential, trigonometric) of how two quantities change together, and develop and interpret function formulas and graphs to represent quantitative relationships in applied contexts.

Prerequisite: None.

Registration Information: Math Placement Tool or ELM Tutorial required.

Credit allowed for only one of the following: MATH 120, MATH 125, MATH 126, or MATH 127.

Terms Offered: Fall, Spring, Summer.

Grade Mode: Instructor Option.

Special Course Fee: No.

Additional Information: 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 or MATH 120 or MATH 127.

Registration Information: Sections may be offered: Online. Credit allowed for only one of the following courses: MATH 141 or MATH 155 or MATH 159 or MATH 160.

Terms Offered: Fall, Spring, Summer.

Grade Mode: Traditional.

Special Course Fee: No.

Additional Information: 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 120 or MATH 124) and (MATH 125).

Registration Information: Credit allowed for only one of the following courses: MATH 141, MATH 155, MATH 159, or MATH 160.

Terms Offered: Fall, Spring, Summer.

Grade Mode: Traditional.

Special Course Fee: No.

Additional Information: 1B, Mathematics (GT-MA1).

MATH 156 Mathematics for Computational Science I (GT-MA1) Credits: 4 (4-0-0)

Course Description: Sets; relations; number systems; functions; sequences and series; concepts of differential and integral calculus as relevant to computational science.

Prerequisite: None.

Registration Information: MATH 124 with a B- or better; MATH 126 with a B- or better or MATH 127 with a B- or better. Sections may be offered: Online.

Terms Offered: Fall, Spring, Summer.

Grade Mode: Traditional.

Special Course Fee: No.

Additional Information: 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 118) and (MATH 124, may be taken concurrently) and (MATH 125) and (MATH 126, may be taken concurrently).

Term Offered: Fall.

Grade Mode: Traditional.

Special Course Fee: No.

Additional Information: 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 124 and MATH 126 and MATH 157.

Registration Information: Credit allowed for only one of the following: MATH 141, MATH 155, MATH 159, or MATH 160.

Term Offered: Spring.

Grade Mode: Traditional.

Special Course Fee: No.

Additional Information: 1B, 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.

Prerequisite: (MATH 120 with a minimum grade of B- or MATH 124 with a minimum grade of B-) and (MATH 126 with a minimum grade of B-).

Registration Information: Must register for lecture and laboratory. Credit allowed for only one of the following courses: MATH 141, MATH 155, MATH 159, or MATH 160. Sections may be offered: Online.

Terms Offered: Fall, Spring, Summer.

Grade Mode: Traditional.

Special Course Fee: No.

Additional Information: 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 120 or MATH 124, may be taken concurrently) and (MATH 159 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: 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 211 Financial Mathematics for Actuarial Science Credits: 3 (3-0-0)

Course Description: Preparation for the Financial Mathematics (FM) Actuarial Examination. Topics covered are exactly the material the Society of Actuaries is testing on Exam FM each semester per the exam syllabus, which typically includes time value of money, annuities, bonds, convexity and cash flows, as well as the financial calculator skills needed to solve the associated exam problems.

Prerequisite: MATH 161.

Registration Information: Credit not allowed for both MATH 211 and MATH 280A4.

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 156 or MATH 161 or MATH 271.

Terms Offered: Fall, Spring.

Grade Mode: Traditional.

Special Course Fee: No.

MATH 255 Calculus for Biological Scientists II 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 or MATH 127, 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: 1B.

MATH 256 Mathematics for Computational Science II Credits: 4 (4-0-0)

Course Description: Methods from vector calculus, advanced calculus, and analytic geometry as relevant to machine learning and data science. Optimization.

Prerequisite: (MATH 156 or MATH 161) and (DSCI 369 or MATH 369).

Registration Information: Sections may be offered: Online. Credit not allowed for both MATH 256 and MATH 281A2.

Term Offered: Spring.

Grade Mode: Traditional.

Special Course Fee: No.

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: Sections may be offered: Online. Credit not allowed for both MATH 255 and MATH 261.

Terms Offered: Fall, Spring, Summer.

Grade Modes: S/U within Student Option, Trad within Student Option.

Special Course Fee: No.

MATH 269 Geometric Introduction to Linear Algebra Credits: 2 (2-0-0)

Course Description: A first introduction to linear algebra with a geometric rather than a computational approach.

Prerequisite: MATH 117 or MATH 120 or MATH 127.

Restriction: Must be a: Undergraduate.

Term Offered: Fall.

Grade Mode: Traditional.

Special Course Fee: No.

MATH 271 Applied Mathematics for Chemists I Credits: 4 (4-0-0)

Course Description: Series and limits, Taylor series, complex variables, first- and second- order ordinary differential equations, matrices, linear transformations, determinants, and eigenvalues.

Prerequisite: MATH 155 or MATH 159 or MATH 160.

Term Offered: Fall.

Grade Mode: Traditional.

Special Course Fee: No.

MATH 272 Applied Mathematics for Chemists II Credits: 4 (4-0-0)

Course Description: Vector fields, partial differentiation, cylindrical and spherical coordinates, multiple integrals, line integrals, the Wave and the Schrödinger equations, separation of variables method. Inner Product Spaces. Fourier Series.

Prerequisite: 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: Counting problems; binomial coefficients; proof techniques in combinatorics; recurrence relations and generating functions; graph theory, including walks, trees, and planar graphs.

Prerequisite: DSCI 369 and MATH 156 or MATH 161.

Registration Information: Sections may be offered: Online.

Terms Offered: Fall, Spring, Summer.

Grade Mode: Traditional.

Special Course Fee: No.

MATH 317 Advanced Calculus of One Variable Credits: 3 (3-0-0)

Course Description: Convergence of sequences, series: limits, continuity, differentiation, integration of one-variable functions.

Prerequisite: (MATH 156 or MATH 161) and (CS 220 or MATH 230 or MATH 235).

Terms Offered: Fall, Spring, Summer.

Grade Modes: S/U within Student Option, Trad within Student Option.

Special Course Fee: No.

MATH 320 Optimization Methods in Data Science Credits: 3 (3-0-0)

Also Offered As: DSCI 320.

Course Description: Linear and non-linear programming, convex sets and functions, convex and non-convex optimization problems, duality, Newton's methods, barrier methods, linear equality and inequality constraints. Emphasis on computation methods and programming.

Prerequisite: (CS 163 or CS 164 or CS 165 or CS 220 or DSCI 235) and (DSCI 369 or MATH 369) and (MATH 255 or MATH 256 or MATH 261).

Registration Information: Credit not allowed for both DSCI 320 and MATH 320.

Term Offered: Fall.

Grade Mode: Traditional.

Special Course Fee: No.

MATH 331 Introduction to Mathematical Modeling Credits: 3 (3-0-0)

Course Description: Problem formulation. Modeling, theoretical and empirical. Variable selection. Derivation and simulation of solutions. Model testing including prediction.

Prerequisite: (DSCI 369, may be taken concurrently or MATH 369, may be taken concurrently) and (MATH 161 or MATH 256).

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 Intro 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: Sections may be offered: Online. 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 255 or MATH 261) and (DSCI 369 or MATH 369).

Registration Information: Must register for lecture and laboratory. Credit not allowed for both MATH 340 and MATH 345.

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: BZ 348, BZ 548, MATH 348.

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 156 or MATH 161) and (CS 220 or MATH 235).

Registration Information: Sections may be offered: Online.

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 156 or 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: Linear systems, matrices, subspaces of Euclidean spaces, linear transformations on Euclidean spaces, eigenvalues, eigenvectors.

Prerequisite: MATH 156 or MATH 161 or MATH 255 or MATH 271.

Registration Information: Sections may be offered: Online.

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 411 Stochastic Calculus and Financial Mathematics Credits: 3 (3-0-0)

Course Description: Elements of probability theory and optimization, portfolio theory, martingales, stochastic processes, stochastic differential equations, financial derivatives, and the Black-Scholes model.

Prerequisite: (MATH 317) and (DSCI 369 or MATH 332 or MATH 340 or MATH 345 or MATH 369).

Registration Information: Sections may be offered: Online. Credit not allowed for both MATH 411 and MATH 480A3.

Term Offered: Spring.

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 317) and (DSCI 369 or MATH 369).

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 (DSCI 369 and MATH 317 or DSCI 369 and MATH 366 or 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.

Registration Information: Credit not allowed for both ECE 430 and MATH 430.

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 150A or CS 150B or CS 152 or CS 163 or CS 164 or CS 165 or CS 253 or MATH 151) and (DSCI 369 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 150A or CS 150B or CS 152 or CS 163 or CS 164 or CS 165 or CS 253 or MATH 151) and (MATH 255 or MATH 256 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 150A or CS 150B or CS 152 or CS 163 or CS 164 or CS 165 or CS 253 or MATH 151) and (MATH 340 or MATH 345).

Term Offered: Spring.

Grade Mode: Traditional.

Special Course Fee: No.

MATH 455 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 or MATH 366) and (DSCI 369 or MATH 369).

Term Offered: Spring.

Grade Mode: Traditional.

Special Course Fee: No.

MATH 463 Post-Quantum Cryptography Credits: 3 (3-0-0)

Course Description: Exploration of secure communication in an environment where an adversary has a quantum computer. Survey of known quantum attacks on classical public key cryptosystems, and a detailed study of some of the leading candidates for quantum-resistant protocols.

Prerequisite: (MATH 161) and (DSCI 369 or MATH 369).

Registration Information: Credit not allowed for both MATH 463 and MATH 480A1.

Term Offered: Spring (odd years).

Grade Mode: Traditional.

Special Course Fee: No.

MATH 466 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 467 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: (DSCI 369, may be taken concurrently or MATH 369, may be taken concurrently) and (MATH 466).

Term Offered: Spring (odd years).

Grade Mode: Traditional.

Special Course Fee: No.

MATH 469 Linear Algebra II Credits: 3 (3-0-0)

Course Description: Abstract vector spaces, general theory of linear transformations, theory of determinants, canonical forms.

Prerequisite: (MATH 161) and (DSCI 369 or MATH 369).

Term Offered: Spring.

Grade Mode: Traditional.

Special Course Fee: No.

MATH 470 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 261) and (DSCI 369 or MATH 369).

Term Offered: Spring.

Grade Modes: S/U within Student Option, Trad within Student Option.

Special Course Fee: No.

MATH 472 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 474 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 (DSCI 369 or 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:

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 487 Internship Credits: Var[1-16] (0-0-0)

Course Description: A work-learn experience integrating classroom theory with practical experience.

Prerequisite: None.

Registration Information: Written consent of instructor.

Terms Offered: Fall, Spring, Summer.

Grade Mode: Instructor Option.

Special Course Fee: No.

MATH 495 Independent Study Credits: Var[1-18] (0-0-0)

Prerequisite: None.

Grade Mode: Instructor Option.

Special Course Fee: No.

MATH 498 Undergraduate Research in Mathematics Credits:

Var[1-3] (0-0-0)

Prerequisite: None.

Grade Mode: Instructor Option.

Special Course Fee: No.

MATH 501 Combinatorics I Credits: 3 (3-0-0)

Course Description: Fundamental concepts in combinatorics (the art of counting). Enumeration techniques such as bijections, inclusion-exclusion, binomial coefficients, and Stirling numbers; tools such as generating functions and recursions; topics such as graph theory, symmetric functions, partition theory, posets, and finite geometries.

Prerequisite: (MATH 301) and (MATH 360 or MATH 366).

Registration Information: Sections may be offered: Online.

Term Offered: Fall.

Grade Mode: Traditional.

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 Modes: 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 507 Advanced Reasoning in Mathematics Credits: 3 (3-0-0)

Course Description: General proof techniques, proof in abstract algebra, proof in analysis, and proof in combinatorics.

Prerequisite: None.

Registration Information: This is a partial semester course. Sections may be offered: Online.

Term Offered: Summer.

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: Metric spaces, spaces of functions, sequences and convergence, completeness, compactness, contraction mappings, fixed point theorems, implicit and inverse function theorems, and Lebesgue integration.

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, \bar{d} -bar operator. Exponential, Logarithm, and Trigonometric functions. Branch cuts and Riemann Surfaces. Power series, analytic continuation, integrals along curves, Cauchy inequalities, Liouville Theorem, and the Fundamental Theorem of Algebra. Maximum modulus principle, Classification of singularities, Laurent series, and residue calculus. Rouché's Theorem, Hurwitz Theorem, Open Mapping Theorem, Conformal Mappings, and Linear Fractional Transformations.

Prerequisite: MATH 317.

Term Offered: Spring.

Grade Mode: Traditional.

Special Course Fee: No.

MATH 520 Nonlinear Programming Credits: 3 (3-0-0)

Prerequisite: MATH 510.

Grade Mode: Traditional.

Special Course Fee: No.

MATH 522 Random Walks Credits: 3 (3-0-0)

Also Offered As: ECE 522.

Course Description: Mathematical aspects of random walks and diffusion processes. Stochastic modeling of complex systems.

Prerequisite: (ECE 303 with a minimum grade of C or STAT 303 with a minimum grade of C or STAT 315 with a minimum grade of C) and (ECE 312 with a minimum grade of C or ECE 457 with a minimum grade of C or MATH 469 with a minimum grade of C).

Registration Information: Junior standing. Sections may be offered: Online. Credit allowed for only one of the following: ECE 522, ECE 681A2, and MATH 522.

Term Offered: Fall (even years).

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: 3 (3-0-0)

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 332 and MATH 530.

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 partial differential equations (PDEs), elliptic, hyperbolic and parabolic equations and their derivation from physical principles, separation of variables and Fourier series, Green's functions, maximum principles, shockwaves.

Prerequisite: MATH 340 or MATH 345 or MATH 530.

Term Offered: Fall.

Grade Mode: Traditional.

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: Numerical methods, including finite elements, finite differences, spectral methods, method of lines, and conservation laws; stability and convergence analysis for PDEs; and applications in science and engineering.

Prerequisite: MATH 340 or MATH 345 or MATH 530.

Registration Information: Sections may be offered: Online. Credit not allowed for both ENGR 550 and MATH 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.

Registration Information: Sections may be offered: Online.

Term Offered: Fall.

Grade Mode: Traditional.

Special Course Fee: No.

MATH 561 Numerical Analysis I Credits: 3 (3-0-0)

Course Description: Numerical linear algebra, solving nonlinear systems, least squares, and minimization.

Prerequisite: (CS 156 or CS 253 or MATH 151) 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: Algebraic Structures: Groups, Rings; both abstract theory and investigation of relevant examples. Substructures, Quotients, Homomorphisms. Group Actions, Unique Factorization.

Prerequisite: MATH 366.

Term Offered: Fall.

Grade Mode: Traditional.

Special Course Fee: No.

MATH 567 Introduction to Abstract Algebra II Credits: 3 (3-0-0)

Course Description: Field theory, Galois theory, and advanced linear algebra.

Prerequisite: MATH 566.

Term Offered: Spring.

Grade Modes: S/U within Student Option, Trad within Student Option.

Special Course Fee: No.

MATH 569A Linear Algebra for Data Science: Matrices and Vectors Spaces Credit: 1 (1-0-0)

Also Offered As: DSCI 569A.

Course Description: A basic introduction to matrices and linear algebra with preparation to pursue further studies in the applications of matrices with an emphasis on the foundations of data science.

Prerequisite: MATH 124 and MATH 126 or MATH 127.

Restriction: Must be a: Graduate.

Registration Information: Graduate standing. Offered as an online course only. Credit not allowed for both DSCI 569A and MATH 569A.

Terms Offered: Fall, Spring, Summer.

Grade Mode: Traditional.

Special Course Fee: No.

MATH 569B Linear Algebra for Data Science: Geometric Techniques for Data Reduction Credit: 1 (1-0-0)

Also Offered As: DSCI 569B.

Course Description: Projections, data fitting and over-determined linear systems, eigenvectors and eigenvalues, the spectral theorem for symmetric matrices, data driven bases, principal component analysis, the singular value decomposition.

Prerequisite: DSCI 569A or MATH 569A.

Restriction: Must be a: Graduate.

Registration Information: Graduate standing. Sections may be offered: Online. Credit allowed for only one of the following: DSCI 569B, MATH 569B, or MATH 580A3.

Terms Offered: Fall, Spring, Summer.

Grade Mode: Traditional.

Special Course Fee: No.

MATH 569C Linear Algebra for Data Science: Matrix Factorizations and Transformations Credit: 1 (1-0-0)

Also Offered As: DSCI 569C.

Course Description: Advanced algorithms for the characterization of data using matrix factorizations and transformations.

Prerequisite: DSCI 569B or MATH 569B.

Restriction: Must be a: Graduate.

Registration Information: Graduate standing. Sections may be offered: Online. Credit allowed for only one of the following: DSCI 569C, MATH 569C, or MATH 580A4.

Terms Offered: Fall, Spring, Summer.

Grade Mode: Traditional.

Special Course Fee: No.

MATH 569D Linear Algebra for Data Science: Theoretical**Foundations Credit: 1 (1-0-0)****Also Offered As:** DSCI 569D.**Course Description:** Theoretical development of linear algebraic tools for data science; theorem and proof driven.**Prerequisite:** DSCI 569C or MATH 569C.**Restriction:** Must be a: Graduate.**Registration Information:** Graduate standing. Sections may be offered: Online. Credit allowed for only one of the following: DSCI 569D, MATH 569D, or MATH 580A5.**Terms Offered:** Fall, Spring, Summer.**Grade Mode:** Traditional.**Special Course Fee:** No.**MATH 570 Topology I Credits: 3 (3-0-0)****Course Description:** Topological spaces, continuous functions, homeomorphisms, homotopy, simplicial and CW complexes, fundamental groups, covering spaces, Van Kampen's theorem, singular and cellular homology, Euler characteristic, and exact sequences.**Prerequisite:** MATH 417 or MATH 472.**Term Offered:** Fall (odd years).**Grade Mode:** Traditional.**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 574 Intro to Mathematics Education Research Credits: 3 (3-0-0)****Course Description:** Synthesize mathematics education research, learn about research methods in mathematics education research, suggest areas of research most useful to advancing the field, and discuss classroom practice implications.**Prerequisite:** None.**Restriction:** Must be a: Graduate.**Registration Information:** Graduate standing. Credit not allowed for both MATH 574 and MATH 581A4.**Term Offered:** Fall.**Grade Mode:** Traditional.**Special Course Fee:** No.**MATH 584A Supervised College Teaching: Incoming GTAs Credit: 1 (0-0-2.5)****Course Description:** Best teaching practices for graduate teaching assistants. Focus on creating a sense of community in the classroom, crafting rich tasks, fostering student centered learning, and providing access to mathematics.**Prerequisite:** None.**Restriction:** Must be a: Graduate.**Registration Information:** Graduate standing. Written consent of instructor.**Term Offered:** Fall.**Grade Mode:** Traditional.**Special Course Fee:** No.**MATH 584B Supervised College Teaching: Continuing GTAs Credit: 1 (0-0-2.5)****Course Description:****Prerequisite:** None.**Restriction:** Must be a: Graduate.**Registration Information:** Graduate standing. Written consent of instructor.**Terms Offered:** Fall, Spring.**Grade Mode:** Instructor Option.**Special Course Fee:** No.**MATH 592A Seminar in Mathematics: Applications of Math Credit: 1 (0-0-1)****Course Description:** Seminar focusing on how mathematics can be applied to many different fields outside of mathematics.**Prerequisite:** None.**Restriction:** Must be a: Graduate.**Registration Information:** Graduate standing. Written consent of instructor. Sections may be offered: Online.**Term Offered:** Fall.**Grade Mode:** Traditional.**Special Course Fee:** No.**MATH 592B Seminar in Mathematics: Math and Mathematicians in the 20th Century Credit: 1 (0-0-1)****Course Description:** Seminar focusing on the diversity of people who have contributed to modern mathematics, in historical and social context.**Prerequisite:** None.**Restriction:** Must be a: Graduate.**Registration Information:** Graduate standing. Written consent of instructor. Sections may be offered: Online.**Term Offered:** Spring.**Grade Mode:** Traditional.**Special Course Fee:** No.**MATH 592C Seminar in Mathematics: MS Students Credit: 1 (0-0-1)****Course Description:****Prerequisite:** None.**Restriction:** Must be a: Graduate.**Registration Information:** Graduate standing. 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:**

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:**

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:**

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: 3 (3-0-0)

Course Description: Riemann-Cauchy integration theory, sigma-algebras, Lebesgue theory of measure and integration, Fubini's Theorem, Radon-Nikodym theorem, L_p 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 II Credits: 3 (3-0-0)

Course Description: Interpolation, approximation, quadrature, initial and boundary value problems.

Prerequisite: MATH 561.

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 666 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 667 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 674 Mathematics Education Theoretical Perspective Credits: 3 (3-0-0)

Course Description: Analysis, synthesis, and re-conceptualization of theoretical perspectives that are adopted in mathematics education research.

Prerequisite: MATH 574.

Restriction: Must be a: Graduate, Professional.

Registration Information: Credit not allowed for both MATH 674 and MATH 680A2.

Term Offered: Spring.

Grade Mode: Traditional.

Special Course Fee: No.

MATH 675 Topics in Mathematics Education Credits: 3 (3-0-0)

Course Description: Contemporary topics in mathematics education research. Content will vary and may include assessment, access and equity in mathematics teaching and learning, embodied cognition at the collegiate level, backwards design, research in undergraduate mathematics education, technology for teaching and learning mathematics, etc.

Prerequisite: MATH 574.

Restriction: Must be a: Graduate, Professional.

Registration Information: May be taken up to 5 times for credit.

Term Offered: Fall.

Grade Mode: Traditional.

Special Course Fee: No.

MATH 676 Topics in Mathematics Credits: 3 (3-0-0)

Course Description: Advanced study experiences which deal with established content areas in mathematics.

Prerequisite: None.

Restriction: Must be a: Graduate, Professional.

Registration Information: May be taken up to 5 times for credit.

Terms Offered: Fall, Spring, Summer.

Grade Mode: Traditional.

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:

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.