MA - MATHEMATICS (MA)

MA 105 - Calculus A 5 Credits

Hours: 5R-0L-5C
Term Available: F
Graduate Studies Eligible: No
Prerequisites: None

Calculus and analytic geometry in the plane. Algebraic and trigonometric functions. Limits and continuity. Differentiation, geometric and physical interpretations of the derivative. Introduction to integration and the Fundamental Theorem of Calculus. A student cannot earn credit for both MA 105and MA 111.

MA 106 - Calculus B 4 Credits

Hours: 4R-0L-4C
Term Available: W
Graduate Studies Eligible: No
Prerequisites: MA 105

Definitions, properties, and derivatives of exponentials and logarithms. Antiderivatives, integral properties, integration by substitution, integration by parts, integrals of transcendental functions,numerical integration, applications of integration, and improper integrals. Applications of integration, e.g. area, displacement, volumes of revolution, arc length, surface area of revolution, and work. Newton's method. Computer algebra systems.

MA 107 - Calculus C 4 Credits

Hours: 4R-0L-4C
Term Available: S
Graduate Studies Eligible: No
Prerequisites: MA 106

Partial fractions and Integration. Hyperbolic functions. Separable first order differential equations, applications of separable first order differential equations. Series of constants, power series, Taylor polynomials, Taylor and McLaurin series. Computer algebra systems.

MA 111 - Calculus I 5 Credits

Hours: 5R-0L-5C
Term Available: F,W
Graduate Studies Eligible: No
Prerequisites: None

Calculus and analytic geometry in the plane. Algebraic and transcendental functions. Limits and continuity. Differentiation, geometric and physical interpretations of the derivative, Newton's method. Introduction to integration and the Fundamental Theorem of Calculus. A student cannot earn credit for both MA 105 and MA 111.

MA 112 - Calculus II 5 Credits

Hours: 5R-0L-5C
Term Available: F,W,S
Graduate Studies Eligible: No
Prerequisites: MA 111 or MA 102 or MA RA100

Techniques of integration, numerical integration, applications of integration. L'Hopital's rule and improper integrals. Separable first order differential equations, applications of separable first order differential equations. Series of constants, power series, Taylor polynomials, Taylor and McLaurin series.

MA 113 - Calculus III 5 Credits

Hours: 5R-0L-5C
Term Available: F,W,S
Graduate Studies Eligible: No
Prerequisites: MA 112 or MA 107

Vectors and parametric equations in three dimensions. Functions of several variables, partial derivatives, maxima and minima of functions of several variables, multiple integrals, and other coordinate systems. Applications of partial derivatives and multiple integrals.

MA 190 - Contemporary Mathematical Problems 2 Credits

Hours: 2R-0L-2C
Term Available: S
Graduate Studies Eligible: No
Prerequisites: None

A seminar-style course consisting of an overview of selected contemporary problems and areas in the mathematical sciences. Problems to be discussed will be selected from recent publications in research and applications, famous problems, and outstanding problems of great significance.

MA 195 - Topics in Mathematics 1-4 Credits

Hours: (1 - 4)R-0L-(1 - 4)C
Term Available: See Department
Graduate Studies Eligible: No
Prerequisites: None

This course will cover introductory-level topics in mathematics not offered in listed courses. A student may take the course for credit more than once provided the topics are different.

MA 199 - Professional Experience 1 Credit

Hours: 1R-0L-1C
Term Available: See Department
Graduate Studies Eligible: No
Prerequisites: None

The professional experiences course captures the practical work experiences related to the student's academic discipline. Students are required to submit a formal document of their reflections, which communicates how their employment opportunity reinforced and enhanced their academic studies.

MA 200 - Career Preparation 1 Credit

Hours: 1R-0L-1C
Term Available: W
Graduate Studies Eligible: No
Prerequisites: None

This course is for mathematics majors to be taken in the second year. The course addresses career choices, summer opportunities, employment and graduate school preparation, and curriculum vitae and resumes preparation. Cross-listed with CHEM 200 and PH200.

MA 221 - Matrix Algebra & Differential Equations I 4 Credits

Hours: 4R-0L-4C
Term Available: F,W,S
Graduate Studies Eligible: No
Prerequisites: MA 113 or 00 FTP

First order scalar differential equations including basic solution techniques and numerical methods. Second order linear, constant coefficient differential equations, including both the homogeneous and non-homogeneous cases. Basic matrix algebra with emphasis on understanding systems of linear equations from algebraic and geometric viewpoints, and eigenvalues and eigenvectors. Introduction to complex arithmetic. Applications to problems in science and engineering.

MA 222 - Matrix Algebra & Differential Equations II 4 Credits

Hours: 4R-0L-4C
Term Available: F,W,S
Graduate Studies Eligible: No
Prerequisites: MA 221

Laplace transforms. Solution of systems of first order linear differential equations by matrix methods and investigation of their solution structure determined by eigensystems. Phase portrait analysis and classification of the nature of the stability of critical points for linear and nonlinear systems. Fourier series and application to solving elementary boundary value problems. Applications to problems in science and engineering.

MA 223 - Engineering Statistics 4 Credits

Hours: 4R-0L-4C
Term Available: F,W,S
Graduate Studies Eligible: No
Prerequisites: (MA 111 or MA 101 or MA 105 or MA RA100) and (RH 131 or ENGD 100 or RH EXMPT or HUM H190 or ENGL H100)

This is an introductory course in applied statistics emphasizing data analysis. The course is designed to support the research cycle including the formulation of a question of interest, effective data collection techniques, informative data summaries, and appropriate inferences from data. Communication of results and statistical concepts is emphasized. Statistical software will be used for the data analysis throughout, including analysis of variance and simple linear regression. A student cannot take both MA223 and MA382 for credit.

MA 276 - Introduction to Proofs 4 Credits

Hours: 4R-0L-4C
Term Available: F,W
Graduate Studies Eligible: No
Prerequisites: MA 113

Introduction to writing mathematical proofs. Logic: direct proof, contradiction, contrapositive, counterexamples. Induction. Recursion. Sets: relations (order, equivalence), functions.Properties of infinite sets.Basic number theory.Important preparation for further courses in theoretical mathematics.

MA 290 - Topics in Mathematics 1-4 Credits

Hours: (1 - 4)R-0L-(1 - 4)C
Term Available: See Department
Graduate Studies Eligible: No
Prerequisites: None

MA 323 - Geometric Modeling 4 Credits

Hours: 4R-0L-4C
Term Available: See Department
Graduate Studies Eligible: No
Prerequisites: MA 113 or MA FTC

Covers some of the mathematical methods for describing physical or virtual objects in computer aided geometric design (CAGD) and computer graphics. Emphasizes methods for curve and surface modeling, and discusses both the underlying geometric concepts and the practical aspects of constructing geometric models of objects. Topics covered include Bezier curves, Hermite curves, B-splines, Bezier patches, subdivision surfaces. In discussing these, ideas from analytic geometry, differential geometry, affine geometry, combinatorial geometry, and projective geometry will be introduced.

MA 327 - Low Dimensional Topology 4 Credits

Hours: 4R-0L-4C
Term Available: See Department
Graduate Studies Eligible: No
Prerequisites: MA 113 or MA FTC

An introduction to the topology of one-, two-, and three-dimensional manifolds and its application to other areas of mathematics and science. Topics may include, but are not restricted to, classification of curves and surfaces, Euler characteristic, tiling and coloring theorems, graph embeddings, vector fields, knots and links, and elementary algebraic topology. Intended for science and engineering majors as well as mathematics majors.

MA 330 - Vector Calculus 4 Credits

Hours: 4R-0L-4C
Term Available: F,S
Graduate Studies Eligible: No
Prerequisites: MA 221

Calculus of vector- valued functions of one and several variables. Topics include differentiation (divergence, gradient and curl of a vector field) and integration (line integrals and surface integrals). Applications of Green's theorem, Stokes' theorem and the divergence theorem to potential theory and/or fluid mechanics will be provided.

MA 332 - Introduction to Computational Science 4 Credits

Hours: 4R-0L-4C
Term Available: F,W
Graduate Studies Eligible: No
Prerequisites: MA 212 or MA 221

An introduction to Computational Science using Matlab. Floating point arithmetic, Matlab programming, solution of nonlinear equations, interpolation, least squares problems, numerical differentiation and integration, solution of linear systems.

MA 335 - Introduction to Parallel Computing 4 Credits

Hours: 4R-0L-4C
Term Available: S
Graduate Studies Eligible: No
Prerequisites: MA 221 or MA 212

Principles of scientific computation on parallel computers. Algorithms for the solution of linear systems and other scientific computing problems on parallel machines. Course includes a major project on RHIT's parallel cluster. Same as CSSE 335.

MA 336 - Boundary Value Problems 4 Credits

Hours: 4R-0L-4C
Term Available: F,S
Graduate Studies Eligible: No
Prerequisites: MA 222 or (MA 211 and MA 212)

Introduction to boundary value problems and partial differential equations. Emphasis on boundary values problems that arise from the wave equation, diffusion equation, and Laplace's equation in one, two and three dimensions. Solutions to such boundary value problems will be discussed using Fourier series, numerical techniques, and integral transforms.

MA 341 - Topics in Mathematical Modeling 4 Credits

Hours: 4R-0L-4C
Term Available: W
Graduate Studies Eligible: No
Prerequisites: MA 222 or (MA 211 and MA 212)

An introduction to techniques of mathematical modeling involved in the analysis of meaningful and practical problems arising in many disciplines including mathematical sciences, operations research, engineering, and the management and life sciences. Topics may include creative and empirical model construction, model fitting, models requiring optimization, and modeling dynamic behavior. Student participation in significant individual and group projects will be emphasized.

MA 342 - Computational Modeling 4 Credits

Hours: 4R-0L-4C
Term Available: S
Graduate Studies Eligible: No
Prerequisites: (MA 212 or MA 222) and (CHE 310 or CE 310 or MA 332 or ME 327)

Computational modeling and simulation of scientific problems using Matlab. Students will create and utilize computer-based models to solve practical problems. Monte Carlo methods, linear systems, solution of ODEs.

MA 351 - Problem Solving Seminar 1 Credit

Hours: 1R-0L-1C
Term Available: F,W,S
Graduate Studies Eligible: No
Prerequisites: None

MA 352 - Problem Solving Seminar 1 Credit

Hours: 1R-0L-1C
Graduate Studies Eligible: No
Prerequisites: None

MA 353 - Problem Solving Seminar 1 Credit

Hours: 1R-0L-1C
Graduate Studies Eligible: No
Prerequisites: None

MA 354 - Problem Solving Seminar 1 Credit

Hours: 1R-0L-1C
Graduate Studies Eligible: No
Prerequisites: None

MA 355 - Problem Solving Seminar 1 Credit

Hours: 1R-0L-1C
Graduate Studies Eligible: No
Prerequisites: None

MA 356 - Problem Solving Seminar 1 Credit

Hours: 1R-0L-1C
Graduate Studies Eligible: No
Prerequisites: None

MA 366 - Introduction to Real Analysis 4 Credits

Hours: 4R-0L-4C
Term Available: F,W
Graduate Studies Eligible: No
Prerequisites: (MA 275 or MA 276) and MA 371

Calculus of functions of a single variable. A more careful development of the basic concepts of analysis, including sequences, limits, continuity, differentiability, integration, infinite series, power series, Taylor's Theorem, and uniform convergence, with an emphasis on proof.

MA 367 - Functions of a Complex Variable 4 Credits

Hours: 4R-0L-4C
Term Available: S
Graduate Studies Eligible: No
Prerequisites: MA 221 or MA 212

Elementary properties of analytic functions including Cauchy's theorem and its consequences, Laurent series, the Residue Theorem, and mapping properties of analytic functions.

MA 371 - Linear Algebra I 4 Credits

Hours: 4R-0L-4C
Term Available: F,S
Graduate Studies Eligible: No
Prerequisites: MA 221 or MA 212

Similar to MA373, but with an emphasis on the theory behind matrices and vector spaces. Systems of linear equations, Gaussian elimination, and the LU decomposition of a matrix. Projections, least squares approximations, and the Gram-Schmidt process. Eigenvalues and eigenvectors of a matrix. The diagonalization theorem. The singular value decomposition of a matrix. Introduction to vector spaces. Some proof writing will be required. Those interested in applications of matrices and vector spaces should take MA373. A student cannot take both MA 371 and MA 373 for credit.

MA 373 - Applied Linear Algebra for Engineers 4 Credits

Hours: 4R-0L-4C
Term Available: W
Graduate Studies Eligible: No
Prerequisites: MA 221 or MA 212

Similar to MA373, but with an emphasis on the theory behind matrices and vector spaces. Systems of linear equations, Gaussian elimination, and the LU decomposition of a matrix. Projections, least squares approximations, and the Gram-Schmidt process. Eigenvalues and eigenvectors of a matrix. The diagonalization theorem. The singular value decomposition of a matrix. Introduction to vector spaces. Some proof writing will be required. Those interested in applications of matrices and vector spaces should take MA373. A student cannot take both MA 371 and MA 373 for credit.

MA 374 - Combinatorics 4 Credits

Hours: 4R-0L-4C
Term Available: F,W,S
Graduate Studies Eligible: No
Prerequisites: MA 221

A first course in combinatorics.Basic counting principles, permutations, combinations.Combinatorial proof.The pigeonhole principle. The principle of inclusion/exclusion. Generating functions. Recurrence relations.Additional topics in combinatorics, which may include permutation groups and Burnside's Lemma, Polya enumeration, multivariate generating functions, combinatorial designs, Ramsey theory, order relations, or other topics at the discretion of the instructor.

MA 376 - Abstract Algebra 4 Credits

Hours: 4R-0L-4C
Term Available: S
Graduate Studies Eligible: No
Prerequisites: MA 275 or MA 276

An introduction to Group Theory. Topics include: matrix groups, groups of integers modulo a natural number, symmetric and dihedral groups, homomorphisms, subgroups, cosets, quotient groups and group actions. Applications, possibly including games and puzzles, cryptography, and coding theory. Other topics may also be introduced according to time and student interest.

MA 378 - Number Theory 4 Credits

Hours: 4R-0L-4C
Term Available: S
Graduate Studies Eligible: No
Prerequisites: None

Divisibility, congruences, prime numbers, factorization algorithms, RSA encryption, solutions of equations in integers, quadratic residues, reciprocity, generating functions, multiplicative and other important functions of elementary number theory. Mathematical conjecture and proof, mathematical induction.

MA 381 - Introduction to Probability with Applications to Statistics 4 Credits

Hours: 4R-0L-4C
Term Available: F,W,S
Graduate Studies Eligible: No
Prerequisites: MA 113 or MA FTC or MA 103

Introduction to probability theory; axioms of probability, sample spaces, and probability laws (including conditional probabilities). Univariate random variables (discrete and continuous) and their expectations including these distributions: binomial, Poisson, geometric, uniform, exponential, and normal. Introduction to moment generating functions. Introduction to jointly distributed random variables. Univariate and joint transformations of random variables. The distribution of linear combinations of random variables and an introduction to the Central Limit Theorem. Applications of probability to statistics.

MA 382 - Introduction to Statistics with Probability 4 Credits

Hours: 4R-0L-4C
Term Available: F
Graduate Studies Eligible: No
Prerequisites: MA 381

This is an introductory course in statistics. Dual emphasis is placed on deriving statistical techniques and using the methods within data analyses. Study design and informative data summaries motivate the statistical inference techniques for linear models. Statistical thinking and communication skills are developed through analysis of data from a variety of fields. A statistical programming language is used for data visualization, analysis, and simulations. A student cannot take both MA 223 and MA 382 for credit.

MA 384 - Data Mining 4 Credits

Hours: 404R-0L-4C
Term Available: F
Graduate Studies Eligible: No
Prerequisites: CSSE 120 and (MA 212 or MA 221) and (MA 223 or MA 381)

An introduction to data mining for large data sets, include data preparation, exploration, aggregation/reduction, and visualization. Elementary methods for classification, association, and cluster analysis are covered. Significant attention will be given to presenting and reporting data mining results. Students may not get credit for both this course and also the CSSE 386 Data Mining with Programming course.

MA 386 - Statistical Programming 4 Credits

Hours: 4R-0L-4C
Term Available: F
Graduate Studies Eligible: No
Prerequisites: MA 223 or MA 382

Computational data analysis is an essential part of modern statistics.This course provides a practical foundation for students to compute with data.This course will introduce students to tools for data management, manipulation and analysis that are common in statistics and data science.The R computing language will be introduced.Topics will include data structures in R, writing functions, webscraping, data cleaning (both quantitative and textual data), processing unstructured data, static and interactive graphical presentations of data, and coding of modern algorithms for data analysis (bootstrapping and Monte Carlo methods).

MA 390 - Topics in the Mathematics of Engineering 1-4 Credits

Hours: 0R-0L-(1 - 4)C
Term Available: See Department
Graduate Studies Eligible: No
Prerequisites: None

A succinct mathematical study that is supportive of the engineering curricula. Topics could be chosen from signal processing, fluid dynamics, thermodynamics, as well as others. A student may take the course for credit more than once provided the topics are different.

MA 415 - Machine Learning 4 Credits

Hours: 4R-0L-4C
Term Available: S
Graduate Studies Eligible: Yes
Prerequisites: (MA 212 or MA 221) and (MA 223 or MA 381) and (CHE 310 or CSSE 220 or ECE 230 or MA 332 or MA 386 or ME 323 or ME 327)

An introduction to machine learning. Topics include: error metrics, accuracy vs interpretability trade-off, feature selection, feature engineering, bias-variance trade-off, under-fitting vs. overfitting, regularization, cross-validation, the bootstrap method, the curse of dimensionality and dimensionality reduction using the singular value decomposition. Both parametric and nonparametric methods are covered including: k-nearest neighbors, linear and logistic regression, decision trees and random forests, and support vector machines.Same as CSSE415.

MA 416 - Deep Learning 4 Credits

Hours: 4R-0L-4C
Term Available: See Department
Graduate Studies Eligible: Yes
Prerequisites: (MA 212 or MA 221) and (MA 223 or MA 381) and (CHE 310 or CSSE 220 or ECE 230 or MA 332 or MA 386 or ME 327)

An introduction to deep learning using both fully-connected and convolutional neural networks. Topics include: least squares estimation and mean square error, maximum likelihood estimation and cross-entropy, convexity, gradient descent and stochastic gradient descent algorithms, multivariate chain rule and gradient computation using back propagation, linear vs nonlinear operations, convolution, over-fitting vs under-fitting and hyper-parameter optimization, L2, early stopping and dropout regularization, data augmentation and transfer learning. Same as CSSE416.

MA 421 - Tensor Calculus & Riemannian Geometry 4 Credits

Hours: 4R-0L-4C
Term Available: See Department
Graduate Studies Eligible: Yes
Prerequisites: MA 330

An introduction to the calculus of tensor fields and the local geometry of manifolds.Topics covered include: manifolds, tangent space, cotangent spaces, vector fields, differential forms, tensor fields, Riemannian metrics, covariant derivative and connections, parallel transport and geodesics, Ricci tensor, Riemannian curvature tensor. Applications will be given in physics (general relativity, mechanics, string theory) and engineering (continuum mechanics).

MA 423 - Topics in Geometry 4 Credits

Hours: 4R-0L-4C
Term Available: See Department
Graduate Studies Eligible: No
Prerequisites: MA 371 or MA 373

An advanced geometry course with topics possibly chosen from the areas of projective geometry, computational geometry, differential geometry algebraic geometry, Euclidean geometry or non-Euclidean geometry. A student may take the course for credit more than once provided the topics are different.

MA 430 - Topics in Applied Mathematics 4 Credits

Hours: 4R-0L-4C
Term Available: See Department
Graduate Studies Eligible: No
Prerequisites: None

A topics course in the general area of continuous applied mathematics. Topics may include mathematical physics, mathematical biology, mathematical finance, mathematics of vision, PDEs, image processing methods, continuum mechanics, dynamical systems, and mathematical modeling. A student may take the course for credit more than once provided the topics are different.

MA 431 - Calculus of Variations 4 Credits

Hours: 4R-0L-4C
Term Available: See Department
Graduate Studies Eligible: Yes
Prerequisites: MA 330

Euler-Lagrange and Hamiltonian equations, with possible applications in mechanics, electrostatics, optics, quantum mechanics and elasticity theory. An introduction to "direct methods." Applications will be chosen in accordance with the interest of the students. Both classical and numerical methods have their place in this course.

MA 433 - Numerical Analysis 4 Credits

Hours: 4R-0L-4C
Term Available: W
Graduate Studies Eligible: Yes
Prerequisites: MA 332 or MA 366 or MA 371 or MA 435

Root-finding, computational matrix algebra, nonlinear optimization, polynomial interpolation, splines, numerical integration, numerical solution of ordinary differential equations. Principles of error analysis and scientific computation. Selection of appropriate algorithms based on the numerical problem and on the software and hardware (such as parallel machines) available.

MA 434 - Topics In Numerical Analysis 4 Credits

Hours: 4R-0L-4C
Term Available: See Department
Graduate Studies Eligible: No
Prerequisites: MA 433

An extension of the material presented in MA433. Topics may include numerical problems, numerical solution of partial differential equations (finite differences, finite elements, spectral methods), sparse matrices, global optimization, approximation theory. A student may take the course for credit more than once provided the topics are different.

MA 435 - Finite Difference Methods 4 Credits

Hours: 4R-0L-4C
Term Available: W
Graduate Studies Eligible: No
Prerequisites: MA 332 or MA 371 or MA 373 or MA 433

MA 436 - Introduction to Partial Differential Equations 4 Credits

Hours: 4R-0L-4C
Term Available: See Department
Graduate Studies Eligible: Yes
Prerequisites: MA 330

Partial differential equations, elliptic, hyperbolic, and parabolic equations. Boundary and initial value problems. Separation of variables, special functions. Eigenfunction expansions. Existence and uniqueness of solutions. Sturm-Liouville theory, Green's function.

MA 438 - Advanced Engineering Mathematics 4 Credits

Hours: 4R-0L-4C
Term Available: W
Graduate Studies Eligible: No
Prerequisites: MA 222 or (MA 211 and MA 212)

A fast-paced course in advanced applied mathematics for engineering and physics students that combines aspects of MA330, MA336, and MA373. Applied linear algebra, including abstract vector spaces, linear operators, eigentheory, diagonalization, and the matrix exponential; review of partial differentiation and multiple integration, including Lagrange multipliers and other optimization topics; vector analysis, including the Jacobian matrix and the del operator in standard coordinate systems; and Fourier series with application to the solution of partial differential equation boundary value problems. Students who receive credit for MA438 may only receive credit for at most one of MA330, MA336, MA371, and MA373.

MA 439 - Mathematical Methods of Image Processing 4 Credits

Hours: 4R-0L-4C
Term Available: See Department
Graduate Studies Eligible: Yes
Prerequisites: MA 221 or MA 212

Mathematical formulation and development of methods used in image processing, especially compression. Vector space models of signals and images, one- and two-dimensional discrete Fourier transforms, the discrete cosine transform, and block transforms. Frequency domain, basis waveforms, and frequency domain representation of signals and images. Convolution and filtering. Filter banks, wavelets and the discrete wavelet transform. Application to Fourier based and wavelet based compression such as the JPEG compression standard. Compression concepts such as scalar quantization and measures of performance.

MA 444 - Deterministic Models in Operations Research 4 Credits

Hours: 4R-0L-4C
Term Available: W
Graduate Studies Eligible: Yes
Prerequisites: MA 371 or MA 373

Formulation of various deterministic problems as mathematical optimization models and the derivation of algorithms to solve them. Optimization models studied include linear programs, integer programs, and various network models. The course will emphasize modeling, algorithm design, and the associated mathematical theory, e.g. polyhedral, duality, convex analysis. Some computer programming is expected.

MA 445 - Stochastic Models in Operations Research 4 Credits

Hours: 4R-0L-4C
Term Available: See Department
Graduate Studies Eligible: Yes
Prerequisites: MA 381 and (MA 212 or MA 221)

Introduction to stochastic mathematical models and techniques that aid in the decision-making process. Topics covered include a review of conditional probability, discrete and continuous Markov chains, Poisson processes, queueing theory (waiting line problems), and reliability.

MA 446 - Combinatorial Optimization 4 Credits

Hours: 4R-0L-4C
Term Available: See Department
Graduate Studies Eligible: Yes
Prerequisites: MA 375 or (MA 276 and CSSE 220)

An introduction to graph- and network-based optimization models, including spanning trees, network flow, and matching problems. Focus is on the development of both models for real-world applications and algorithms for their solution.

MA 450 - Mathematics Seminar 1 Credit

Hours: 1R-0L-1C
Term Available: F,W,S
Graduate Studies Eligible: No
Prerequisites: None

A student must attend at least 10 mathematics seminars or colloquia and present at one of the seminars, based on material mutually agreed upon by the instructor and the student. A successful presentation is required for a passing grade. As seminars may not be offered every week during the quarter a student may extend the course over more than one quarter, but it must be completed within two consecutive quarters. A student may take this course a maximum of four times.

MA 460 - Topics in Analysis 4 Credits

Hours: 4R-0L-4C
Term Available: See Department
Graduate Studies Eligible: No
Prerequisites: None

An advanced topics course in analysis. Topic of the course could be advanced topics in real analysis, advanced topics in complex analysis, analysis on manifolds, measure theory or an advanced course in applied analysis (differential equations). May be taken more than once provided topics are different

MA 461 - Topics in Topology 4 Credits

Hours: 4R-0L-4C
Term Available: See Department
Graduate Studies Eligible: No
Prerequisites: MA 366

Introduction to selected topics from point-set topology or algebraic topology from a rigorous point of view. Possible topics include metric spaces, general topological spaces, compactness, connectedness, separation axioms, compactification and metrization theorems, homotopy and homology, and covering spaces. Intended for mathematics majors planning to pursue graduate study in mathematics.

MA 466 - Introduction to Functional Analysis 4 Credits

Hours: 4R-0L-4C
Term Available: See Department
Graduate Studies Eligible: Yes
Prerequisites: MA 366 or MA 306

An introduction to the theory of Banach spaces emphasizing properties of Hilbert spaces and linear operators. Special attention will be given to compact operators and integral equations.

MA 470 - Topics in Algebra 4 Credits

Hours: 4R-0L-4C
Term Available: See Department
Graduate Studies Eligible: No
Prerequisites: None

An advanced topics course in algebra. Topic of the course could be commutative algebra, Galois theory, algebraic geometry, Lie groups and algebras, or other advanced topics in algebra. May be taken more than once provided topics are different.

MA 471 - Linear Algebra II 4 Credits

Hours: 4R-0L-4C
Term Available: See Department
Graduate Studies Eligible: Yes
Prerequisites: MA 371 or MA 373

Continuation of Linear Algebra I. Properties of Hermitian and positive definite matrices and factorization theorems (LU, QR, spectral theorem, SVD). Linear transformations and vector spaces.

MA 473 - Design & Analysis of Algorithms 4 Credits

Hours: 4R-0L-4C
Term Available: W
Graduate Studies Eligible: Yes
Prerequisites: CSSE 230 and (MA 375 or (MA 276 and MA 374))

Students study techniques for designing algorithms and for analyzing the time and space efficiency of algorithms. The algorithm design techniques include divide-and-conquer, greedy algorithms, dynamic programming, randomized algorithms and parallel algorithms. The algorithm analysis includes computational models, best/average/worst case analysis, and computational complexity (including lower bounds and NP-completeness). Same as CSSE 473.

MA 474 - Theory of Computation 4 Credits

Hours: 4R-0L-4C
Term Available: S
Graduate Studies Eligible: Yes
Prerequisites: CSSE 230 and (MA 375 or (MA 276 and MA 374))

Students study mathematical models by which to answer three questions: What is a computer? What limits exist on what problems computers can solve? What does it mean for a problem to be hard? Topics include models of computation (including Turing machines), undecidability (including the Halting Problem) and computational complexity (including NP-completeness). Same as CSSE 474.

MA 475 - Topics in Discrete Mathematics 4 Credits

Hours: 4R-0L-4C
Term Available: See Department
Graduate Studies Eligible: No
Prerequisites: MA 375 or (MA 276 and MA 374)

An extension of the material presented in MA 275 and 375. Topics may include combinatorial design, Fibonacci numbers, or the Probabilistic Method, among others. A student may take the course for credit more than once provided the topics are different.

MA 476 - Algebraic Codes 4 Credits

Hours: 4R-0L-4C
Term Available: See Department
Graduate Studies Eligible: Yes
Prerequisites: MA 375 or (MA 276 and MA 374)

Construction and theory of linear and nonlinear error correcting codes. Generator matrices, parity check matrices, and the dual code. Cyclic codes, quadratic residue codes, BCH codes, Reed-Solomon codes, and derived codes. Weight enumeration and information rate of optimum codes.

MA 477 - Graph Theory 4 Credits

Hours: 4R-0L-4C
Term Available: See Department
Graduate Studies Eligible: Yes
Prerequisites: MA 375 or (MA 276 and MA 374)

An introduction to the theory and applications of directed and undirected graphs. Possible topics include the following: Connectivity, subgraphs, graph isomorphism, Euler trails and circuits, planarity and the theorems of Kuratowski and Euler, Hamilton paths and cycles, graph coloring and chromatic polynomials, matchings, trees with applications to searching and coding, and algorithms dealing with minimal spanning trees, articulation points, and transport networks

MA 478 - Analytic Number Theory 4 Credits

Hours: 4R-0L-4C
Term Available: See Department
Graduate Studies Eligible: No
Prerequisites: MA 378 or MA 375 or MA 374

Advanced topics in Number Theory. Topics may include elliptic curve cryptography, the Fermat-Wiles Theorem, elliptic curves, modular forms, p-adic numbers, Galois theory, diophantine approximations, analytic number theory, algebraic number theory. A student may take the course for credit more than once provided the topics are different.

MA 479 - Cryptography 4 Credits

Hours: 4R-0L-4C
Term Available: S
Graduate Studies Eligible: Yes
Prerequisites: CSSE 220 and (MA 275 or MA 276)

Introduction to basic ideas of modern cryptography with emphasis on mathematical background and practical implementation. Topics include: the history of cryptography and cryptanalysis, public and private key cryptography, digital signatures, and limitations of modern cryptography. Touches upon some of the societal issues of cryptography (same as CSSE 479)

MA 480 - Topics in Probability or Statistics 4 Credits

Hours: 4R-0L-4C
Term Available: See Department
Graduate Studies Eligible: No
Prerequisites: None

An advanced course in probability or statistics. Possible topics include (but are not restricted to) reliability, discrete event simulation, multivariate statistics, Bayesian statistics, actuarial science, nonparametric statistics, categorical data analysis, and time series analysis. May be taken more than once provided topics are different.

MA 481 - Mathematical Statistics 4 Credits

Hours: 4R-0L-4C
Term Available: See Department
Graduate Studies Eligible: No
Prerequisites: MA 382

An introduction to mathematical statistics. Review of distributions of functions of random variables. Moment generating functions. Limiting distributions. Point estimation and sufficient statistics. Fisher information and Rao-Cramer inequality. Theory of statistical tests.

MA 482 - Biostatistics 4 Credits

Hours: 4R-0L-4C
Term Available: S
Graduate Studies Eligible: No
Prerequisites: MA 223 or MA 382

This course introduces statistical techniques for addressing the challenges that arise in the analysis of data from the biological sciences (including biology, biomedical engineering, and the medical community).Topics include linear regression modeling, nonlinear regression, repeated measures analysis (including mixed models), and survival/reliability analysis (analysis of time-to-event data).Flexible modeling strategies including relaxing linearity and distributional assumptions are discussed.Additional topics are introduced when discussing articles found in the literature, including properties of study design, power, meta-analysis, missing data, and causal inference.No prerequisite knowledge of biology is assumed.Review of fundamental prerequisite statistics will be included as necessary. Same as BE 482.

MA 483 - Bayesian Data Analysis 4 Credits

Hours: 4R-0L-4C
Term Available: See Department
Graduate Studies Eligible: Yes
Prerequisites: MA 381

This course offers an introduction to statistical inference under the Bayesian framework in addition to elements of basic study design. Building from Bayes' Rule for probability computations, we develop a framework of estimation, hypothesis testing and prediction. Topics include the construction of prior distributions to quantify a priori beliefs about unknown parameters, modeling available data, and using data to update beliefs about parameters.Applications include inference for a single response, comparing groups, and regression models; modern applications will be covered, time permitting. The course will make use of heavy use of computational tools for Bayesian inference, including Markov Chain Monte Carlo (MCMC) methods.

MA 485 - Applied Linear Regression 4 Credits

Hours: 4R-0L-4C
Term Available: See Department
Graduate Studies Eligible: Yes
Prerequisites: (MA 221 or MA 212) and (MA 223 or MA 382)

This is an applied course in multiple linear regression. The techniques presented, all with respect to linear models, develop skills in selecting an appropriate model and performing statistical inference. The use of data from a variety of fields helps demonstrate method implementation and the communication of results in practice. A statistical programming language aids in creating reproducible analysis results.

MA 487 - Design of Experiments 4 Credits

Hours: 4R-0L-4C
Term Available: See Department
Graduate Studies Eligible: Yes
Prerequisites: MA 223 or MA 227 or MA 311 or MA 381

This is an applied course in design of experiments. Emphasis is placed on designing statistical studies to solve problems in engineering and science. A variety of designs are presented, including the full factorial, screening, response surface, and split plot. It is demonstrated how constraints on the randomization process due to the design are related to the appropriate analysis method and meaning of the results. Statistical software is used for data analysis throughout.

MA 490 - Topics in Mathematics 1-4 Credits

Hours: (1 - 4)R-0L-(1 - 4)C
Term Available: See Department
Graduate Studies Eligible: No
Prerequisites: None

This course will cover advanced topics in mathematics not offered in listed courses.

MA 491 - Introduction to Mathematical Modeling 2 Credits

Hours: 2R-0L-2C
Term Available: F
Graduate Studies Eligible: No
Prerequisites: None

An introduction to the process of mathematically modeling a problem, including data collection, defining the appropriate mathematical model and interpreting the results of the proposed model. Emphasis placed on the modeling process, using examples from both continuous and discrete mathematics.

MA 492 - Senior Project I 2 Credits

Hours: 2R-0L-2C
Graduate Studies Eligible: No
Prerequisites: None

Either participation in a sponsored project or investigation of a problem with a substantial mathematical application, modeling and/or computational content.Students either work individually or in a team typically of 2 or 3, under the supervision of the faculty adviser (course instructor), interacting with the sponsor (if there is one).Problems vary considerably, depending upon student interest, but normally require computer implementation and documentation. All work required for completion of the Senior Project must be completed in a form acceptable to the adviser and the sponsor if there is one. A submitted written report and public presentation to department are required

MA 493 - Senior Project II 2 Credits

Hours: 2R-0L-2C
Graduate Studies Eligible: No
Prerequisites: MA 492

Either participation in a sponsored project or investigation of a problem with a substantial mathematical application, modeling and/or computational content.Students either work individually or in a team typically of 2 or 3, under the supervision of the faculty adviser (course instructor), interacting with the sponsor (if there is one).Problems vary considerably, depending upon student interest, but normally require computer implementation and documentation. All work required for completion of the Senior Project must be completed in a form acceptable to the adviser and the sponsor if there is one.A submitted written report and public presentation to department are required

MA 494 - Senior Project III 2 Credits

Hours: 2R-0L-2C
Graduate Studies Eligible: No
Prerequisites: MA 493

Either participation in a sponsored project or investigation of a problem with a substantial mathematical application, modeling and/or computational content.Students either work individually or in a team typically of 2 or 3, under the supervision of the faculty adviser (course instructor), interacting with the sponsor (if there is one).Problems vary considerably, depending upon student interest, but normally require computer implementation and documentation. All work required for completion of the Senior Project must be completed in a form acceptable to the adviser and the sponsor if there is one.A submitted written report and public presentation to department are required

MA 495 - Research Project in Mathematics 1-4 Credits

Hours: 0R-0L-(1 - 4)C
Term Available: F
Graduate Studies Eligible: No
Prerequisites: None

An undergraduate research project in mathematics or the application of mathematics to other areas. Students may work independently or in teams as determined by the instructor. Though the instructor will offer appropriate guidance in the conduct of the research, students will be expected to perform independent work and collaborative work if on a team. The course may be taken more than once provided that the research or project is different.

MA 496 - Senior Capstone I 2-4 Credits

Hours: 4R-0L-(2 - 4)C
Term Available: See Department
Graduate Studies Eligible: No
Prerequisites: None

Individual study and research of a topic in mathematics. Topic is expected to be at an advanced level.

MA 497 - Senior Capstone II 1-4 Credits

Hours: (1 - 4)R-0L-(1 - 4)C
Term Available: See Department
Graduate Studies Eligible: No
Prerequisites: MA 496

Individual study and research of a topic in mathematics. Topic is expected to be at an advanced level.

MA 498 - Senior Capstone III 2 Credits

Hours: 2R-0L-2C
Term Available: See Department
Graduate Studies Eligible: No
Prerequisites: MA 497

Individual study and research of a topic in mathematics. Topic is expected to be at an advanced level.

MA 538 - Advanced Engineering Mathematics 4 Credits

Hours: 4R-0L-4C
Term Available: W
Graduate Studies Eligible: Yes
Prerequisites: None

A fast-paced course in advanced applied mathematics for graduate-level engineering students.Applied linear algebra, including abstract vector spaces, linear operators, eigentheory, diagonalization, and the matrix exponential; review of partial differentiation and multiple integration, including Lagrange multipliers and other optimization topics; vector analysis, including the Jacobian matrix, the del operator in standard coordinate systems, and line integrals; and Fourier series with application to the solution of partial differential equation boundary value problems.Students may not receive credit for both MA438 and MA538. Students who receive credit for MA538 may only receive graduate credit for at most one of MA330, MA336, MA371, and MA373.

MA 580 - Topics in Advanced Probability Theory & Its Applications 4 Credits

Hours: 4R-0L-4C
Term Available: See Department
Graduate Studies Eligible: Yes
Prerequisites: MA 381

Advanced topics in probability theory as well as applications that are not offered in the listed courses.

MA 581 - Topics in Advanced Statistics 4 Credits

Hours: 4R-0L-4C
Term Available: See Department
Graduate Studies Eligible: Yes
Prerequisites: MA 223 or MA 381

This course will cover advanced topics in mathematical statistics as well as applied statistics that are not offered in the listed courses.

MA 590 - Graduate Topics in Mathematics 1-4 Credits

Hours: (1 - 4)R-0L-(1 - 4)C
Term Available: See Department
Graduate Studies Eligible: Yes
Prerequisites: None

This course will cover graduate-level topics in mathematics not offered in listed courses.