

# Mathematics

**MA 105 Algebra for Math Placement 4 cr**

Introduction to equations of straight lines in various forms and transition between these forms; Manipulation and solution of linear equations and linear inequalities; graphing solution sets on the number line and expression of solution sets in both set and interval notation. Simplification, multiplication, and division of polynomials; Factoring quadratic expressions and the solution of quadratic equations by factoring; Solution of basic rational equations; Addition, subtraction, multiplication and division of rational expressions; simplification of complicated ratios of rational expressions. Working with set operations: Absolute value inequalities and equations and compound inequalities; Addition, subtraction, multiplication, division, and simplification of expressions with radicals and/or rational exponents and rationalization of numerator or denominator. Credit for both MTH 100, MTH 101 and MA 105 is not allowed.

**MA 110 Finite Mathematics 3 cr**

This course is intended to give an overview of topics in finite mathematics together with their applications. The course includes logic, sets, counting, permutations, combinations, basic probability, descriptive statistics and their applications. Students are required to have a scientific calculator. Core Course. Note: May be offered for Honors credit NOTE: MA 110 is not a Pre-requisite for nor is it intended to be preparatory for any course listed below except MA 201 and MA 202.

**MA 112 Precalculus Algebra 3 cr**

The course covers algebraic, graphical and numerical properties of functions, focusing on linear, quadratic, general polynomial, absolute value, rational, exponential, and logarithmic functions. Topics also include equations, inequalities, and complex numbers. Applications of mathematics to modeling real world situations are emphasized. Credit for both MA 112 and MA 115 not allowed. Core Course.

Pre-requisite: ACT Math 22 or MTH 100 Minimum Grade of C or MyMathTest 070 or MTH 101 Minimum Grade of C or MA 105 Minimum Grade of C or SAT Mathematics 560 or MATH SECTION SCORE 580 or TRNFR Math Placement 2 .

**MA 113 Precalculus Trigonometry 3 cr**

Continuation of MA 112. Topics include numerical, graphical and algebraic properties of trigonometric functions, inverse trigonometric functions, right angle trigonometry, parametric equations, polar coordinates, and conic sections. Development and application of mathematical models to real-world situations is emphasized. Credit for both MA 113 and MA 115 not allowed. Core Course.

Pre-requisite: ACT Math 24 or MyMathTest 080 or MA 112 Minimum Grade of C or SAT Mathematics 590 or MATH SECTION SCORE 610 .

**MA 115 Precal Algebra-Trigonometry 4 cr**

This fast-paced course is designed as a review of the algebra and trigonometry needed in calculus. It covers the material of MA 112 and MA 113 in one semester. Topics include numerical, graphical and algebraic properties of polynomial, rational, exponential, logarithmic, and trigonometric functions; inverse trigonometric functions; right angle trigonometry; parametric equations; polar coordinates and conic sections. Applications of mathematics to modeling real world situations are emphasized. Credit for both MA 112 and MA 115 not allowed; credit for both MA 113 and MA 115 not allowed. Core Course.

Pre-requisite: ACT Math 25 or MyMathTest 080 or SAT Mathematics 620 or MATH SECTION SCORE 640

**MA 120 Calculus and Its Applications 3 cr**

Introduction to calculus with an emphasis on problem solving and applications. Key concepts are presented graphically, numerically and algebraically, although the stress is on a clear understanding of graphs and tabular data. The course covers: algebraic, exponential and logarithmic functions, their properties and their use in modeling; the concepts of derivative and definite integral and applications. Students are encouraged to have a graphing calculator. Credit for both MA 120 and MA 125 not allowed. Students must have sufficient Mathematics Placement Exam score. MA 120 is not a prerequisite for subsequent calculus courses. Core Course.

Pre-requisite: ACT Math 23 or MyMathTest 080 or MA 112 Minimum Grade of C or MA 113 Minimum Grade of C or MA 115 Minimum Grade of C or SAT Mathematics 575 or MATH SECTION SCORE 595 .

**MA 125 Calculus I 4 cr**

The course provides an introduction to calculus with emphasis on differential calculus. Topics include limits of functions, derivatives of algebraic and transcendental functions, application of the derivative to curve sketching, optimization problems, and examples in the natural sciences, engineering, and economics. The course concludes with an introduction to anti-derivatives, definite integrals, and the fundamental theorem of calculus. Credit for both MA 120 and MA 125 is not allowed. Prerequisite: Sufficient Mathematics Placement Exam score. Core Course. NOTE: MA 110, MA 112, MA 113, MA 115, MA 120, and MA 125 have strict Pre-requisites. To be able to enroll in these courses a student needs either to pass the Pre-requisite course with C or better or to have a sufficient Mathematics Placement Exam score.

Pre-requisite: ACT Math 27 or MyMathTest 090 or MA 113 Minimum Grade of C or MA 115 Minimum Grade of C or SAT Mathematics 665 or MATH SECTION SCORE 695 .

**MA 126 Calculus II** 4 cr

This course is a continuation of MA 125 with emphasis on integral calculus. Topics include techniques of integration; applications of the definite integral to geometry, natural sciences, engineering, and economics; improper integrals; infinite sequences and series; Taylor polynomials and Taylor series; parametric equations and polar coordinates. Core Course.

Pre-requisite: MA 125 Minimum Grade of C.

**MA 150 Contemporary Math-Stat Seminar** 1 cr

This course gives an overview of modern mathematics and statistics from the point of view of the practitioners. The course is designed for majors in mathematics and statistics at all levels as well as those student who are considering mathematics or statistics as a major or minor area of study. Topics usually included are elements of geometry, algebra, analysis, methods of statistical inference, the role of the computer in the analytical sciences; these topics vary from semester to semester. This course cannot be taken for credit simultaneously with ST 150. NOTE: May be offered for Honors Credit.

**MA 201 Math for Elem Teachers I** 3 cr

An examination of some of the major ideas encountered in the teaching of elementary mathematics. Topics include introduction to problem solving, sets, relations, logic, numeration systems, elementary number theory, properties and operations for whole numbers, integers, rational numbers, and real numbers. NOTE: MA 201 does not fulfill graduation requirements for any curriculum other than College of Education and Professional Studies.

Pre-requisite: MA 110 Minimum Grade of C or MA 112 Minimum Grade of C or MA 113 Minimum Grade of C or MA 115 Minimum Grade of C or MA 120 Minimum Grade of C or MA 125 Minimum Grade of C or MA 126 Minimum Grade of C or MA 150 Minimum Grade of C.

**MA 202 Math for Elem Teachers II** 3 cr

Topics covered are those that a prospective elementary or middle school teacher should expect to encounter in the teaching of geometry in elementary or middle school. Topics include geometric shapes, measurement, triangle congruence and similarity, and coordinate geometry. NOTE: MA 202 does not fulfill graduation requirements for any curriculum other than College of Education and Professional Studies.

Pre-requisite: MA 110 Minimum Grade of C or MA 112 Minimum Grade of C or MA 113 Minimum Grade of C or MA 115 Minimum Grade of C or MA 120 Minimum Grade of C or MA 125 Minimum Grade of C or MA 126 Minimum Grade of C or MA 150 Minimum Grade of C.

**MA 227 Calculus III** 4 cr

Vectors; functions of several variables; partial derivatives; local linearity; directional derivatives; the gradient; differential of a function; the chain rule; higher order partial derivatives; optimization of functions of several variables; multiple integrals and their applications; parametric curves and surfaces; vector fields; line and surface integrals; vector calculus. Core Course.

Pre-requisite: MA 126 Minimum Grade of C.

**MA 237 Linear Algebra I** 3 cr

This course provides an introduction to linear algebra. Topics include systems of linear equations, matrices, Gaussian elimination, rank, linear independence, subspaces, basis, dimension, linear transformations, determinants, eigenvalues and eigenvectors, change of basis, diagonalization, the abstract concept of a vector space, and applications. Core Course.

Pre-requisite: MA 126 Minimum Grade of C.

**MA 238 Differential Equations I** 3 cr

This course provides an introduction to ordinary differential equations. Topics include first order differential equations, higher order linear differential equations, systems of first order linear differential equations, Laplace transforms, methods for approximating solutions to first order differential equations, applications. Students should have taken or be taking MA 227. Core Course.

Pre-requisite: MA 227 Minimum Grade of D. MA 227 can be taken concurrently with this course.

**MA 267 Discrete Math Structures** 3 cr

This course is an introduction to discrete mathematics for students majoring in computer-related areas. Students will be introduced to concepts and methods that are essential to theoretical computer science. A strong emphasis is placed on mathematical reasoning and proofs. Topics include sets, functions, induction, recursion, combinatorics and graphs. Students must have sufficient mathematics placement exam score.

Pre-requisite: ACT Math 23 or MyMathTest 080 or MA 113 Minimum Grade of C or MA 115 Minimum Grade of C.

**MA 290 Special Topics -** 1 TO 3 cr

Selected topics in elementary undergraduate mathematics. This course may be repeated for a maximum of six credits.

**MA 303 Math for Elem Teachers III** 3 cr

An exploration of problem solving strategies. Problems exemplifying the various problem solving strategies studied. Emphasis on the development of problem solving skills by exploring interesting problems which demand for their solution that the student select from a wide variety of possible strategies and use a wide variety of conceptual tools. NOTE: MA 303 does not fulfill graduation requirements for any curriculum other than elementary education.

Pre-requisite: MA 202 Minimum Grade of C.

**MA 311 Intro to Number Theory 3 cr**

An introduction to classical number theory with a balance between theory and computation. Topics include mathematical induction, divisibility properties, properties of prime numbers, the theory of congruences, number theoretic functions, continued fractions.  
Pre-requisite: MA 126 Minimum Grade of C.

**MA 316 Linear Algebra II 3 cr**

A continuation of MA 237. Topics include inner product spaces, spectral theorem for symmetric operators, complex vector spaces, Jordan canonical form. Additional topics such as duality and Tensor products among others to be included at the discretion of the instructor.  
Pre-requisite: MA 237 Minimum Grade of C.

**MA 320 Foundations of Math - W 3 cr**

A transition to higher mathematics with an emphasis on proof techniques. Topics include symbolic logic, elementary set theory, induction, relations, functions, and the structure of the number system. Mathematics and Statistics majors are encouraged to take MA 320 as soon as possible after completing MA 125.  
Pre-requisite: MA 125 Minimum Grade of C and (EH 102 Minimum Grade of C or EH 105 Minimum Grade of C).

**MA 321 Elementary Geometry 3 cr**

This course covers the major topics from the secondary school curriculum of plane and solid geometry from a modern viewpoint. Emphasis will be placed on axioms, undefined terms, definitions, theorems, and proofs. Topics include straightedge and compass constructions, Euclidean geometry, Euclidean space, congruence, isometry, reflection, rotation, translation, vectors, parallel postulate, similarity, Pythagorean theorem, coordinate geometry, non-Euclidean geometry, projective geometry, projective space, perspective, homogenous coordinates.  
Pre-requisite: MA 320 Minimum Grade of C.

**MA 332 Differential Equations II 3 cr**

Series solutions of second order linear equations. Numerical methods. Nonlinear differential equations and stability. Partial differential equations and Fourier series. Sturm-Liouville problems.  
Pre-requisite: MA 227 Minimum Grade of C and MA 238 Minimum Grade of C.

**MA 334 Advanced Calculus I 3 cr**

This is the first of a two course sequence designed to provide students with the theoretical context of concepts encountered in MA 125 through MA 227. Topics covered include Completeness Axiom, sequences of real numbers, suprema and infima, Cauchy sequences, open sets and accumulation points in Euclidean space, completeness of Euclidean space, series of real numbers and vectors, compactness, Heine- Borel Theorem, connectedness, continuity, Extremum Theorem, Intermediate Value Theorem, differentiation of functions of one variable.  
Pre-requisite: MA 227 Minimum Grade of C and MA 237 Minimum Grade of C and MA 320 Minimum Grade of C.

**MA 335 Advanced Calculus II 3 cr**

This is the second of a two course sequence designed to provide students with the theoretical context of concepts encountered in MA 125 through MA 227. Topics covered include integration of functions of one variable, pointwise and uniform convergence, integration and differentiation of series, differentiable mappings of several variables, chain rule, product rule and gradients, Mean Value Theorem, Taylor's Theorem, Inverse Function Theorem, Implicit Function Theorem.  
Pre-requisite: MA 334 Minimum Grade of C.

**MA 354 Comp Assist Math Modeling - W 3 cr**

This course is intended to provide the basic ideas regarding formulation, development, testing and reporting of mathematical models of various real world problems. Deterministic and stochastic models, optimization and simulations will be covered. Emphasis will be on careful mathematical formulations and the use of computer software, such as Microsoft Excel, Mathematica and Matlab. A term project will be an important component of this course. The course is taught in a laboratory setting with computers as lab equipment.  
Pre-requisite: (EH 102 Minimum Grade of C or EH 105 Minimum Grade of C) and MA 227 Minimum Grade of C and MA 238 Minimum Grade of C.

**MA 367 Combinatorial Enumeration 3 cr**

An introduction to the mathematical theory of counting. Basic counting principles, permutations and combinations, partitions, recurrence relations, and a selection of more advanced topics such as generating functions, combinatorial designs, Ramsey theory, or group actions and Poyla theory.  
Pre-requisite: MA 126 Minimum Grade of C.

**MA 390 Special Topics 1 TO 3 cr**

Selected topics in advanced undergraduate mathematics. This course may be repeated for a maximum of six credits.

**MA 410 History of Mathematics - W 3 cr**

Historical survey of the general development of mathematics with a balance of historical perspective and mathematical structure.  
Pre-requisite: ( (EH 102 Minimum Grade of C or EH 105 Minimum Grade of C) and MA 320 Minimum Grade of C).

**MA 413 Abstract Algebra I - W 3 cr**

An introduction to group theory and ring theory. Topics include permutations and symmetries, subgroups, quotient groups, homomorphisms, as well as examples of rings, integral domains, and fields.  
Pre-requisite: MA 237 Minimum Grade of C and (MA 311 Minimum Grade of C or MA 320 Minimum Grade of C or MA 334 Minimum Grade of C) and (EH 102 Minimum Grade of C or EH 105 Minimum Grade of C).

**MA 414 Abstract Algebra II - W** 3 cr

A continuation of MA 413 focusing on rings and fields. Topics include rings, ideals, integral domains, fields and extension fields. Geometric constructions and Galois theory are introduced.

Pre-requisite: MA 413 Minimum Grade of C and (EH 102 Minimum Grade of C or EH 105 Minimum Grade of C).

**MA 434 Topology** 3 cr

An introduction to topology with emphasis on the geometric aspects of the subject. Topics covered include surfaces, topological spaces, open and closed sets, continuity, compactness, connectedness, product spaces, and identification and quotient spaces. Credit for both MA 434 and MA 542 is not allowed.

Pre-requisite: MA 227 Minimum Grade of C and MA 237 Minimum Grade of C and MA 320 Minimum Grade of C.

**MA 436 Numerical Analysis** 3 cr

Topics include methods of numerical solution of nonlinear equations in one variable, fixed points, contraction mapping and functional iteration methods, interpolation and approximation methods, numerical differentiation and integration, numerical solution of ordinary differential equations, analysis of error for various numerical procedures. Implementation of Mathematica of all numerical methods discussed in class is an essential part of the course.

Pre-requisite: MA 227 Minimum Grade of C and MA 238 Minimum Grade of C. MA 238 can be taken concurrently with this course.

**MA 437 Complex Variables** 3 cr

Arithmetic of complex numbers; regions in the complex plane, limits, continuity and derivatives of complex functions; elementary complex functions; mapping by elementary functions; contour integration, power series, Taylor series, Laurent series, calculus of residues; conformal representation; applications. Credit for both MA 437 and MA 537 not allowed.

Pre-requisite: MA 238 Minimum Grade of C.

**MA 451 Probability** 3 cr

A comprehensive introduction to probability, the mathematical theory used to model uncertainty, covering the axioms of probability, random variables, expectation, classical discrete and continuous families of probability models, the law of large numbers and the central limit theorem. Credit for both MA 451 and MA 550 is not allowed.

Pre-requisite: MA 227 Minimum Grade of C and MA 237 Minimum Grade of C.

**MA 452 Financial Mathematics** 3 cr

Introduction to financial mathematics and a brief introduction to financial economics. Students will learn about the time value of money, annuities, loans, bonds, general cash flows and portfolios, immunization, general derivatives, options, forwards and futures, swaps and hedging from the point of view of an actuarial scientist.

Pre-requisite: MA 126 Minimum Grade of C.

**MA 458 Operations Research - W** 3 cr

An introduction to linear programming. The course will include a study of the simplex method as well as using computers to solve linear systems of equations. As time permits, topics covered will include sensitivity analysis, duality, integer programming, transportation, assignment, transshipment, and networks. Credit for both MA 458 and MA 567 is not allowed.

Pre-requisite: (MA 215 Minimum Grade of C or MA 237 Minimum Grade of C) and (EH 102 Minimum Grade of C or EH 105 Minimum Grade of C).

**MA 467 Mathematical Logic** 3 cr

An introduction to formal first-order logic, first-order systems and their models, completeness, compactness, and recursive sets and functions. Identical with PHL 467. Credit cannot be received for both PHL 467 and MA 467.

Pre-requisite: PHL 321 Minimum Grade of C or MA 311 Minimum Grade of C or MA 316 Minimum Grade of C or MA 318 Minimum Grade of C or MA 320 Minimum Grade of C or MA 321 Minimum Grade of C or MA 332 Minimum Grade of C or MA 334 Minimum Grade of C or MA 335 Minimum Grade of C or MA 354 Minimum Grade of C or MA 367 Minimum Grade of C or MA 410 Minimum Grade of C or MA 413 Minimum Grade of C or MA 414 Minimum Grade of C or MA 434 Minimum Grade of C or MA 436 Minimum Grade of C or MA 437 Minimum Grade of C or MA 451 Minimum Grade of C or MA 458 Minimum Grade of C or MA 490 Minimum Grade of C or MA 537 Minimum Grade of C or MA 542 Minimum Grade of C or MA 550 Minimum Grade of C.

**MA 481 Cryptography** 3 cr

This course provides an introduction to classical and modern methods of message encryption and decryption (cryptography) as well as possible attacks to cryptosystems (cryptanalysis). Topics include classical (symmetric) cryptosystems (DES, AES), public-key (asymmetric) cryptosystems (Diffie-Hellman, RSA, ElGamal), modes of operation, one-way and trapdoor functions, Hash functions, cryptographic protocols. Credit for both MA 481 and MA 581 is not allowed.

Pre-requisite: MA 311 Minimum Grade of C.

**MA 490 Special Topics** 1 TO 3 cr

Selected topics in advanced undergraduate mathematics. This course may be repeated for a maximum of six credits.

**MA 494 Directed Studies** 1 TO 3 cr

Directed individual study. Requires permission of department chair.

**MA 499 Honors Senior Project - H** 3 TO 6 cr

With the guidance and advice of a faculty mentor, honors students will identify, and carry out a research project in Mathematics. The outcome of the research project will include a formal presentation at the annual Honors Student Colloquium. The senior project will be judged and graded by three members of the faculty, chaired by the faculty mentor.

- MA 501 Number Systems** 3 cr  
A case study of axiom systems and the deductive method for graduate students in Mathematics Education. It is expected that students in this course will practice and improve their logical skills, better understand proof as a mathematical activity, and study the similarities and differences between several commonly used number systems.  
Pre-requisite: MA 321 Minimum Grade of C or MA 413 Minimum Grade of C.
- MA 502 Intro to Abstract Algebra** 3 cr  
An introduction to the fundamental concepts of modern algebra such as groups, rings, and fields through concrete examples. This course is designed for graduate students in the College of Education and Professional Studies.  
Pre-requisite: MA 413 Minimum Grade of C.
- MA 503 Introduction to Analysis** 3 cr  
A careful look at the elements, procedures, and applications of differential and integral calculus. This course is designed for graduate students in the College of Education and Professional Studies.  
Pre-requisite: MA 227 Minimum Grade of C.
- MA 504 Introduction to Geometry** 3 cr  
An introduction to the foundations of geometry using both synthetic and metric approaches. Euclidean, finite, projective, and hyperbolic geometries are discussed. The axioms for various geometries are discussed. The course is designed for graduate students in the College of Education and Professional Studies.  
Pre-requisite: MA 321 Minimum Grade of C.
- MA 505 Mathematical Problem Solving** 3 cr  
An in-depth activity-based approach to the methods and strategies for mathematical problem solving for students in Mathematical Education. Problems selected from logic, algebra, analysis, geometry, combinatorics, number theory and probability. This course is designed for graduate students in the College of Education and Professional Studies.
- MA 506 Statistics for Teachers** 3 cr  
Prepares in-service and pre-service teachers to teach statistics in high schools using data-based approach. Uses hands-on-activities approach and simulation of situations to teach concepts and technology to teach data analysis. This course is designed for graduate students in the College of Education and Professional Studies.  
Pre-requisite: MA 126 Minimum Grade of C.
- MA 507 Adv Ordinary Differential Eqns** 3 cr  
A graduate-level introduction to topics of ordinary differential equations and their applications in physics and engineering.
- MA 508 Adv Partial Differential Eqns** 3 cr  
A continuation of MA 507 with more emphasis on theory of partial differential equations, as well as their applications in physics and engineering problems.
- MA 511 Algebra I** 3 cr  
A graduate level introduction to group theory. Topics include quotient groups, homomorphisms, group actions, Sylow theorems, composition series, simple groups, free groups, fundamental theorem of abelian groups.
- MA 512 Algebra II** 3 cr  
A graduate level introduction to ring theory and fields. Topics include ring homomorphisms, quotient rings, ideals, rings of fractions, Euclidean domains, principal ideal domains, unique factorization domains, modules, finite fields, field extensions.  
Pre-requisite: MA 511 Minimum Grade of C.
- MA 515 Number Theory** 3 cr  
Modular arithmetic, arithmetic functions; prime numbers; algebraic number theory.
- MA 516 Topics in Number Theory** 3 cr  
A second course in number theory, covering topics of interest to the students and instructor.  
Pre-requisite: MA 515 Minimum Grade of C.
- MA 518 Linear Algebra I** 3 cr  
Fields, vector spaces, dual spaces, quotient spaces, multilinear forms, linear transformations, algebras, adjoints, eigenvalues.
- MA 519 Linear Algebra II** 3 cr  
Triangular form, nilpotence, Jordan form, inner products, self-adjoint transformations, positive transformations, isometries, Spectral Theorem, polar decomposition, applications to analysis.  
Pre-requisite: MA 518 Minimum Grade of C.
- MA 521 Enumerative Combinatorics** 3 cr  
Pigeonhole principle, basic counting techniques, binomial coefficients, inclusion-exclusion principle, recurrence relations, generating functions, systems of distinct representatives, finite fields.
- MA 525 Graph Theory** 3 cr  
Fundamental concepts, connectedness, graph coloring, planarity and Kuratowski's theorem, four-color theorem, chromatic polynomial, Eulerian and Hamiltonian graphs, matching theory, network flows, NP-complete graph problems, Markov chains, matroids.
- MA 535 Real Analysis I** 3 cr  
An introduction to real analysis. Topics include: the metric topology of the reals, limits and continuity, differentiation, Riemann-Stieltjes integral. Prerequisite: Undergraduate course in advanced calculus.
- MA 536 Real Analysis II** 3 cr  
A continuation of MA 535. Topics covered include sequences and series of functions, differentiation and integration in several variables, an introduction to the Lebesgue integral and differential forms as time allows.  
Pre-requisite: MA 535 Minimum Grade of C.

- MA 537 Complex Analysis** 3 cr  
Arithmetic of complex numbers; regions in the complex plane; limits, continuity and derivatives of complex functions; elementary complex functions; mappings by elementary functions; contour integration; power series; Taylor series; Laurent series; calculus of residues; conformal representation; applications. Credit for both MA 537 and MA 437 is not allowed.  
Pre-requisite: MA 238 Minimum Grade of C or MA 338 Minimum Grade of C.
- MA 538 Topics in Complex Analysis** 3 cr  
A second course in complex analysis, covering topics of interest to the students and instructor.  
Pre-requisite: MA 537 Minimum Grade of C.
- MA 539 Measure Theory** 3 cr  
Foundations of the general theory of measure and integration with particular attention to the Lebesgue integral. Function spaces, product measure and Fubini's theorem, the Radon-Nikodym theorem and applications to probability theory are discussed, and possibly additional topics such as Haar measure or the Ergodic Theorem.  
Pre-requisite: MA 536 Minimum Grade of C.
- MA 540 Differential Geometry** 3 cr  
Local and global theory of curves and surfaces in three-dimensional space.
- MA 542 Topology I** 3 cr  
An introduction to topology with emphasis on the geometric aspects of the subject. Topics covered include surfaces, topological spaces, open and closed sets, continuity, compactness, connectedness, product spaces, and identification and quotient spaces. Credit for both MA 542 and MA 434 is not allowed.
- MA 543 Topology II** 3 cr  
A continuation of MA 542. Topics covered include the fundamental group, triangulations, classification of surfaces, homology, the Euler-Poincare formula, the Borsuk-Ulam theorem, the Lefschetz fixed-point theorem, knot theory, covering spaces, and applications.  
Pre-requisite: MA 542 Minimum Grade of C or MA 434 Minimum Grade of C.
- MA 550 Probability** 3 cr  
A comprehensive introduction to probability, the mathematical theory used to model uncertainty, covering the axioms of probability, random variables, expectation, classical discrete and continuous families of probability models, the law of large numbers and the central limit theorem. Credit for both MA 550 and MA 451 is not allowed.  
Pre-requisite: (MA 227 Minimum Grade of C or MA 237 Minimum Grade of C).
- MA 551 Theory of Statistics** 3 cr  
A comprehensive introduction to the mathematical foundations of statistics. Sufficient statistics and information, parameter estimation, maximum likelihood and moment estimation, optimality properties of estimators and confidence intervals. Hypothesis testing, likelihood ratio tests and power functions. Credit for both MA 551 and ST 470 is not allowed.  
Pre-requisite: MA 451 Minimum Grade of C or MA 550 Minimum Grade of C.
- MA 555 Statistical Analysis I** 3 cr  
A first course in an integrated two course sequence in applied statistical theory and methods for research workers in technical fields. Coverage includes probability and basic probability models, mathematical expectations, random sampling processes and central limit theorem, estimation, hypothesis testing and power analysis, some applications of the theory of least squares. Computer assisted data analysis is used.
- MA 560 Statistical Analysis II** 3 cr  
A second course (continuation of MA 555) in an integrated two-course sequence in applied statistical theory and methods for research workers in technical fields. Coverage includes regression analysis, design and analysis of experiments, factorial experiments, analysis of covariance, nonparametric analytical techniques, analysis of count data. Computer assisted data analysis is used.  
Pre-requisite: MA 555 Minimum Grade of C.
- MA 565 Numerical Analysis** 3 cr  
An introduction to Numerical Analysis. Topics include error analysis, systems of linear equations, nonlinear equations, integration, ordinary differential equations among others.  
Pre-requisite: MA 535 Minimum Grade of C.
- MA 567 Operations Research** 3 cr  
An introduction to linear programming. The course will include a study of the simplex method as well as using computers to solve linear systems of equations. As time permits, topics covered will include sensitivity analysis, duality, integer programming, transportation, assignment, transshipment, and networks. Credit for both MA 567 and MA 458 is not allowed.  
Pre-requisite: (MA 215 Minimum Grade of C or MA 237 Minimum Grade of C).
- MA 568 Topics in Operations Research** 3 cr  
A second course in operations research, covering topics of interest to the students and instructor.  
Pre-requisite: MA 567 Minimum Grade of C.

**MA 571 Ordinary Diff Equations 3 cr**

An introduction to ordinary differential equations from a dynamical systems perspective. Topics include existence and uniqueness theorems, dependence on initial data, linear systems and exponential of operators, stability of equilibria, Poincare-Bendixon theorem. Additional topics such as applications to population dynamics, classical mechanics, periodic attractors among others will be included at the discretion of the instructor.

Pre-requisite: MA 518 Minimum Grade of C.

**MA 572 Partial Differential Equations 3 cr**

An introduction to partial differential equations emphasizing spectral methods. Topics include elementary Hilbert spaces, Fourier series and integrals and their applications to the study of the basic partial differential equations of mathematical physics. More advanced topics such as asymptotic properties and regularity of solutions and nonlinear equations among others will be included at the discretion of the instructor.

Pre-requisite: MA 536 Minimum Grade of C.

**MA 581 Cryptography 3 cr**

This course provides an introduction to classical and modern methods of message encryption and decryption (cryptography) as well as possible attacks to cryptosystems (cryptanalysis). Topics include classical (symmetric) cryptosystems (DES, AES), public-key (asymmetric) cryptosystems (Diffie-Hellman, RSA, ElGamal), modes of operation, one-way and trapdoor functions, Hash functions, cryptographic protocols. Credit for both MA 481 and MA 581 is not allowed.

Pre-requisite: MA 311 Minimum Grade of C.

**MA 590 Special Topics - 1 TO 3 cr**

Selected topics in elementary graduate mathematics. This course may be repeated for a maximum of six credits.

**MA 592 Seminar 1 cr**

Student Seminar. Topics covered vary. This course may be repeated indefinitely, but only two credits count towards the degree. Grading system: satisfactory/unsatisfactory.

**MA 594 Directed Study 1 TO 3 cr**

Directed individual study. Prerequisites: Approval of the department chair.

**MA 599 Thesis 1 TO 6 cr**

Thesis. Requires approval of research prospectus by Department Graduate Committee.