

# MATHEMATICS (MAT)

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## **MAT 100 Intermediate Algebra 3**

Real numbers and their properties, linear equations, systems of equations, polynomials and functions, fractional expressions, exponents and roots, quadratic equations, graphing, inequalities.

**Notes:** Credit does not apply toward graduation nor count in the student's GPA.

## **MAT 112 Contemporary Topics in Mathematics 3**

Practical mathematical topics including set theory, properties and operations of number systems, algebra, geometry and consumer mathematics. Additional topics may be selected from logic, systems of numeration, and mathematical systems.

**GE Core:** GMT

**Notes:** Students may not receive credit for both MAT 112 and RCO 112.

## **MAT 115 College Algebra 3**

Algebraic expressions, exponents, radicals, factoring, solving equations and inequalities, graphing, polynomial and rational functions.

**GE Core:** GMT

**Notes:** Credit can be earned for only one of MAT 115 or MAT 150.

## **MAT 120 Calculus with Business Applications 3**

Introductory survey of differential calculus with emphasis on techniques and applications related to business and the social sciences.

**GE Core:** GMT

**Prerequisites:** An acceptable score on the mathematics placement test or a minimum grade of C (2.0) in at least one of: MAT 115, MAT 150, MAT 151, and/or MAT 190.

**Notes:** This course does not serve as a prerequisite for MAT 292 (Calculus II). This is a terminal course and not adequate preparation for MAT 292.

## **MAT 150 Precalculus I 3**

Review of elementary algebra, equations, inequalities, relations, functions, transformations, graphing, complex numbers, polynomial and rational functions.

**GE Core:** GMT

**Notes:** Credit can be earned for only one of MAT 115 or MAT 150.

## **MAT 151 Precalculus II 3**

Properties, graphs, and applications of exponential, logarithmic, trigonometric functions.

**GE Core:** GMT

**Prerequisites:** An acceptable score on the mathematics placement test, or a grade of C or better in MAT 115 or MAT 150.

## **MAT 181 Experimental Course: Foundations of Calculus I 3**

Foundational concepts that supplement topics covered in Calculus I.

**Corequisites:** MAT 191.

**Notes:** Grade: Pass/Not Pass (P/NP).

## **MAT 190 Precalculus 3**

This course covers essential prerequisites for calculus. Topics include functions and graphs, equations and inequalities, polynomial and rational functions, trigonometry, functions of trigonometric, exponential, and logarithmic type.

**GE Core:** GMT

**Prerequisites:** Acceptable score on the mathematics placement test.

## **MAT 191 Calculus I 3**

Limits and introductory differential calculus of the algebraic and transcendental functions of one variable.

**GE Core:** GMT

**Prerequisites:** An acceptable score on the mathematics placement test, or a grade of C or better in MAT 151 (or MAT 190).

## **MAT 220 Plane and Solid Analytic Geometry 3**

Study of conic sections (including rotation of axes), graphing with polar coordinates, quadric surfaces, and vectors.

**Prerequisites:** Grade of C or better in MAT 151 (or equivalent).

**Notes:** Hours do not count toward degree requirements for MATH major.

## **MAT 253 Discrete Mathematical Structures 3**

A rigorous introduction to discrete mathematical structures, proof techniques, and programming. Topics include sets, functions, sequences, relations, induction, propositional and predicate logic, modular arithmetic, and mathematical programming.

**Notes:** Only one of MAT 253 or MAT 295 can count toward degree requirements for MATH major.

## **MAT 292 Calculus II 3**

Introductory integral calculus of the algebraic and transcendental functions of one variable, techniques of integration.

**GE Core:** GMT

**Prerequisites:** Grade of C or better in MAT 191.

## **MAT 293 Calculus III 3**

Infinite sequences and series, conic sections, polar coordinates, vectors in dimensions two and three, vector-valued functions.

**Prerequisites:** Grade of C or better in MAT 292.

## **MAT 295 Proofs and Mathematical Structures 3**

An introduction to basic mathematical concepts needed for most upper level mathematics courses. The language and logic of proofs, basic set theory, relations, functions, numbers, counting, cardinalities, introduction to algebra.

**Prerequisites:** Grade of C or better in MAT 292.

**Notes:** At most one of MAT 253 or MAT 295 can count toward degree requirements for MATH major.

## **MAT 303 Topics in Mathematics 3**

Primarily for students seeking grades 6–9 certification. Extensive study of rational, irrational, and real numbers; selected topics from number theory; clock and modular arithmetic. Concrete models used to illustrate many of the mathematical concepts studied.

**Notes:** Hours do not count toward degree requirements for Mathematics majors.

## **MAT 304 Introduction to the Foundations of Geometry 3**

Introductory course primarily for students seeking grade 6–9 certification. Designed to develop an understanding of the fundamental ideas of geometry. Includes both an intuitive and deductive study of points, lines, planes, curves, surfaces, congruences, parallelism, similarity and linear, angular, area, and volume measures.

**Notes:** Hours do not count toward degree requirements for Mathematics majors.

## **MAT 310 Elementary Linear Algebra 3**

Linear systems, matrices, determinants, eigenvalues and eigenvectors, finite-dimensional vector spaces, linear transformations.

**Prerequisites:** Grade of C or better in MAT 292.

## **MAT 311 Introduction to Abstract Algebra 3**

Sets and mappings, equivalence relations, mathematical induction, introduction to theory of groups, rings, and fields.

**Prerequisites:** Grade of C or better in MAT 253 and MAT 310.

**MAT 320 Introduction to Topology 3**

Metric spaces, continuity, equivalence of various types of definitions of continuity, convergence, compactness, connectedness, topological spaces.

**Prerequisites:** Minimum grade of C in MAT 293 and a minimum grade of C in one of MAT 253 or MAT 310 or CSC 250.

**MAT 322 Linear Programming 3**

Covers simplex computational procedure, minimum feasible solutions, artificial-basis technique, slack variables, perturbation techniques, cycling, parametric objective and dual problems, sensitivity analysis, and decomposition algorithms.

**Prerequisites:** Grade of C or better in MAT 310.

**MAT 330 Axiomatic Foundations of Geometry 3**

Axiomatic systems, logic and proof, incidence geometries, absolute geometries, Euclidean geometry, and an introduction to non-Euclidean geometries and transformational geometry.

**Prerequisites:** Grade of C or better in MAT 292.

**Notes:** Required for students seeking secondary licensure in mathematics.

**MAT 345 Vector and Tensor Analysis 3**

Vectors, scalar fields, vector fields. Dot and cross product. Vector differentiation and integration. Gradient, divergence and curl. Green's theorem, divergence theorem, Stokes' theorem. Curvilinear coordinates. Tensor Analysis: Physical laws. Coordinate transformations. Contravariant and covariant vectors. Contravariant, covariant, and mixed tensors. Tensor fields. Symmetric and skew-symmetric tensors. Conjugate or reciprocal tensors. Associated tensors. Transformation laws of Christoffel's symbols. Tensor form of gradient, divergence, and curl.

**Prerequisites:** Grade of C or better in MAT 293 and MAT 390.

**MAT 349 Preparation for Industrial Careers in Mathematical Sciences 3**

This course prepares mathematical sciences students for industrial careers by engaging them in research problems that come directly from industry.

**Prerequisites:** Permission of instructor.

**MAT 353 Introduction to Discrete Mathematics 3**

Elementary graph theory, combinatorics, partially ordered sets.

**Prerequisites:** Grade of C or better in MAT 253 or CSC 250.

**MAT 371 Experimental Course: Mathematical Programming and Dynamics 3**

Introduction to mathematical programming and dynamical systems using Matlab. Solving application problems, analyzing data from multiple formats, and visualizing results in two and three dimensions. Dynamic stability, bifurcations, and chaos.

**Prerequisites:** MAT 191.

**MAT 390 Ordinary Differential Equations 3**

First order differential equations and linear equations of finite order, Laplace transforms, undetermined coefficients, variation of parameters, applications, numerical methods.

**Prerequisites:** Grade of C or better in MAT 292.

**MAT 394 Calculus IV 3**

Multivariable functions, partial differentiation, multiple integrals, vector calculus.

**Prerequisites:** Grade of C or better in MAT 293.

**MAT 395 Introduction to Mathematical Analysis 3**

Properties of real numbers, sequences, limits of sequences and functions, continuity, differentiation, Riemann integral.

**Prerequisites:** Grade of C or better in MAT 253, MAT 293, and MAT 310.

**MAT 405 Foundations of Mathematics for Teaching I 3**

Capstone survey of real and complex numbers; polynomial, rational, exponential, logarithmic, and trigonometric functions; calculus concepts. Special teaching problems and procedures for secondary topics in relation to their mathematical foundations.

**Prerequisites:** Grade of C (2.0) or better in MAT 310.

**MAT 406 Foundations of Mathematics for Teaching II 4**

Capstone survey of geometry, probability, data analysis, and discrete mathematics. Special teaching problems and procedures for secondary topics related to their mathematical foundations, including 50-hour internship in secondary math classroom.

**Prerequisites:** Minimum grade of C (2.0) in MAT 405 and minimum grade of C (2.0) in one of either MAT 311 or MAT 395. Admission to the Teacher Education Program.

**MAT 465 Student Teaching and Seminar-Secondary Mathematics 12**

Supervised student teaching in senior high school under direction of university supervisor. Observation, participation, and appropriate classroom teaching experience on full-time teaching assignment for full semester with weekly seminar.

**Prerequisites:** MAT 406. Admission to the Teacher Education Program.

**MAT 490 Senior Seminar in Mathematics 3**

Oral presentations on topics in mathematics, including current mathematics literature.

**Prerequisites:** Senior standing and mathematics major, or permission of instructor.

**MAT 493 Honors Work 3-6**

**Prerequisite:** Permission of instructor; 3.30 GPA in the major, 12 s.h. in the major;

**Notes:** May be repeated for credit if the topic of study changes.

**MAT 503 Problem Solving in Mathematics 3**

Investigates the nature of problem solving, covers procedures involved in problem solving, develops individual problem solving skills, and collects a set of appropriate problems. Required for middle grades mathematics concentration.

**Prerequisites:** Grade of at least C in MAT 191 and MAT 303 or permission of instructor.

**Notes:** Hours do not count toward degree requirements for Mathematics majors. This course cannot be applied toward the requirements for the M.A. degree in Mathematics.

**MAT 504 Foundations of Geometry for Teachers 3**

Primarily for students seeking teacher certification. Includes logic and axiom systems, history, plane and solid Euclidean geometry, proof strategies, introduction to non-Euclidean geometries, and transformational geometry.

**Prerequisites:** Grade of C or better in MAT 292. or permission of instructor;

**Notes:** Hours do not count toward degree requirements for MATH major nor for the M.A. degree in Mathematics.

**MAT 505 Foundations of Mathematics for Teachers 3**

Primarily for students seeking teacher certification. Includes properties and algebra of real numbers; analytic geometry; polynomial, rational, exponential, logarithmic, and trigonometric functions; complex numbers; concept of limits of functions.

**Prerequisites:** Grade of C or better in MAT 292 (or MAT 303). or permission of instructor;

**Notes:** Hours do not count toward degree requirements for MATH major nor for the M.A. degree in Mathematics.

**MAT 513 Historical Development of Mathematics 3**

Study of the historical development of mathematics, not a history of persons involved in development.

**Prerequisites:** Grade of C or better in MAT 292.

**Notes:** Hours do not count toward degree requirements for MATH major nor for the M.A. degree in Mathematics.

**MAT 514 Theory of Numbers 3**

An introductory course to both multiplicative and additive number theory. Divisibility, prime numbers, congruencies, linear and nonlinear Diophantine equations (including Pell's equation), quadratic residues, number-theoretic functions, and other topics.

**Prerequisites:** Grade of C or better in either MAT 311 or MAT 395.

**MAT 515 Mathematical Logic 3**

Formal languages, recursion, compactness, and effectiveness. First-order languages, truth, and models. Soundness and completeness theorems. Models of theories.

**Prerequisites:** Grade of C or better in MAT 311 (or MAT 353).

**MAT 516 Intermediate Abstract Algebra 3**

Rings, integral domains, fields, division algorithm, factorization theorems, zeros of polynomials, greatest common divisor, formal derivatives, prime polynomials, Euclidean domains, the fundamental theorem of algebra.

**Prerequisites:** Grade of C or better in MAT 311.

**MAT 519 Intuitive Concepts in Topology 3**

Basic concepts, vector fields, the Jordan curve theorem, surfaces, homology of complexes, continuity.

**Prerequisites:** Grade of C or better in MAT 311 (or MAT 395).

**MAT 520 Non-Euclidean Geometry 3**

Fifth postulate, hyperbolic geometries, elliptic geometries, consistency of non-Euclidean geometries, models for geometries, elements of inversion.

**Prerequisites:** Grade of C or better in MAT 311 (or MAT 395).

**MAT 521 Projective Geometry 3**

Transformation groups and projective, affine and metric geometries of the line, plane, and space. Homogeneous coordinates, principles of duality, involutions, cross-ratio, collineations, fixed points, conics, models, and Euclidean specializations.

**Prerequisites:** Permission of instructor.

**MAT 522 Introductory Functional Analysis 3**

Basic concepts in Banach spaces, Hilbert spaces, linear operators, and their applications.

**Prerequisites:** Grade of C or better in MAT 395.

**MAT 523 Numerical Methods 3**

Number systems and errors, solutions of non-linear and linear systems, interpolation, numerical differentiation and integration, solution of differential equations. Implementation of numerical methods using a high-level programming language.

**Prerequisites:** A grade of at least C in MAT 293.

**MAT 525 Intermediate Mathematical Analysis 3**

Integration, infinite series, sequences and series of functions.

**Prerequisites:** Grade of C or better in MAT 395.

**MAT 531 Combinatorial Analysis 3**

The pigeon-hole principle, permutations, combinations, generating functions, principle of inclusion and exclusion, distributions, partitions, recurrence relations.

**Prerequisites:** Grade of C or better in MAT 253 (or MAT 295 or MAT 311 or MAT 395), or permission of instructor.

**MAT 540 Introductory Complex Analysis 3**

The complex number system, holomorphic functions, power series, complex integration, representation theorems, the calculus of residues.

**Prerequisites:** Grade of C or better in MAT 394.

**MAT 541 Stochastic Processes 3**

Markov processes, Markov reward processes, queuing, decision making, graphs, and networks. Applications to performance, reliability, and availability modeling.

**Prerequisites:** Grade of C or better in MAT 394 and MAT 353. or equivalents.

**MAT 542 Stochastic Processes 3**

Markov processes, Markov reward processes, queuing, decision making, graphs, and networks. Applications to performance, reliability, and availability modeling.

**Prerequisites:** Grade of C or better in MAT 394 and MAT 353. or equivalents.

**MAT 545 Differential Equations and Orthogonal Systems 3**

An introduction to Fourier series and orthogonal sets of functions, with applications to boundary value problems.

**Prerequisites:** Grade of C or better in MAT 293 and MAT 390. or permission of instructor.

**MAT 546 Partial Differential Equations with Applications 3**

Fourier integrals, Bessel functions, Legendre polynomials and their applications. Existence and uniqueness of solutions to boundary value problems.

**Prerequisites:** Grade of C or better in MAT 545.

**MAT 549 Topics in Applied Mathematics 3**

Selected topics of current interest in applied mathematics.

**Prerequisites:** Grade of C or better in MAT 293 and MAT 390. or permission of instructor;

**Notes:** May be repeated for credit with approval of the Department Head.

**MAT 586 Financial Mathematics for Actuaries 3**

Measurement of interest, present and accumulated value, amortization, sinking funds, bonds, duration, immunization, and an introductory analysis of financial derivatives. Intended to help prepare for the FM/2 actuarial exam.

**Prerequisites:** Minimum grade of C (2.0) in MAT 394 or permission of instructor. Graduate students in MA in Mathematics, Ph.D. students in Computational Mathematics, or undergraduate students in the accelerated BS to MA in Mathematics.

**MAT 590 Introduction to Mathematical Models in Biology 3**

Exploration of research and methodology at the interface of mathematics and biology, with an overview of relevant fields and in-depth case studies. Focus will be on mathematical models in biology.

**Prerequisites:** B- or higher in BIO 112 and either MAT 191 or STA 271. or instructor's permission;

**Notes:** Same as BIO 590.

**MAT 591 Advanced Abstract Algebra 3**

Groups: homomorphisms, quotient groups, Sylow theorems, finitely generated abelian groups. Rings: homomorphisms, ideals, quotient rings, integral domains, Euclidean domains, factorization. Fields: algebraic extensions of fields, Galois theory.

**Prerequisites:** Grade of C or better in MAT 516.

**MAT 592 Advanced Abstract Algebra 3**

Groups: homomorphisms, quotient groups, Sylow theorems, finitely generated abelian groups. Rings: homomorphisms, ideals, quotient rings, integral domains, Euclidean domains, factorization. Fields: algebraic extensions of fields, Galois theory.

**Prerequisites:** Grade of C or better in MAT 516.

**MAT 593 Directed Study in Mathematics 1-3****MAT 594 Directed Study in Mathematics 1-3****MAT 595 Mathematical Analysis 3**

Real number axioms, metric spaces, sequences, series, continuity, differentiation, the Riemann-Stieltjes integral.

**Prerequisites:** MAT 395. or permission of instructor.

**MAT 596 Mathematical Analysis 3**

Real number axioms, metric spaces, sequences, series, continuity, differentiation, the Riemann-Stieltjes integral.

**Prerequisites:** MAT 395. or permission of instructor.

**MAT 601 Seminar in the Teaching of Mathematics I 1**

Seminar on practices and principles of undergraduate teaching in mathematics and statistics.

**Notes:** Required for all teaching assistants. Grade: Satisfactory/Unsatisfactory (S/U).

**MAT 602 Seminar in Mathematical Software 3**

Variety of issues in the design of mathematical software, i.e., type systems, user interfaces, and memory management. Each student investigates one computer algebra system more closely.

**Prerequisites:** Knowledge of a programming language.

**MAT 603 Practicum in the Teaching of Mathematics 2**

Practicum in teaching mathematics at the college/university level. Topics include course design, class materials, exams, grading, syllabus, choosing textbooks, dealing with difficult matters, and mathematical typesetting.

**Corequisites:** MAT 601.

**MAT 606 Calculus for Middle Grade Teachers 3**

History, developments, major concepts, and applications of differential and integral calculus covering functions of several variables.

**Prerequisites:** MAT 505 or permission of instructor.

**Notes:** No credit toward mathematics degrees.

**MAT 607 Abstract Algebra for Middle Grade Teachers 3**

Development and major concepts of abstract algebraic structures including groups, rings, fields, vector spaces, and matrix algebra.

**Prerequisites:** MAT 303 and MAT 505 or permission of instructor.

**Notes:** No credit toward mathematics degrees.

**MAT 613 Development of Mathematics 3**

Development of Mathematics.

**MAT 614 Advanced Number Theory 3**

Advanced Number Theory.

**MAT 615 Symbolic Logic 3**

Symbolic Logic.

**MAT 616 Polynomials over General Rings 3**

Polynomials over General Rings.

**MAT 617 Algebraic Theory of Semigroups 3**

Algebraic Theory of Semigroups.

**MAT 618 Transfinite Ordinal Cardinal Nos 3**

Transfinite Ordinal and Cardinal Numbers.

**MAT 619 Conceptual Topology 3**

Conceptual Topology.

**MAT 620 A Survey of Geometry 3**

A Survey of Geometry.

**MAT 621 Advanced Linear Geometry 3**

Advanced Linear Geometry.

**MAT 645 Approximation Theory 3**

Normed linear spaces. Convexity. Existence and unicity of best approximations. Tchebycheff approximation by polynomials and other linear families. Least-squares approximation and related topics. Rational approximation. The characterization of best approximations. The Stone Approximation Theorem. The Muntz Theorem. Polygonal approximation and bases. Approximation in the mean.

**Prerequisites:** MAT 390, MAT 595, MAT 596.

**MAT 646 Approximation Theory 3**

Normed linear spaces. Convexity. Existence and unicity of best approximations. Tchebycheff approximation by polynomials and other linear families. Least-squares approximation and related topics. Rational approximation. The characterization of best approximations. The Stone Approximation Theorem. The Muntz Theorem. Polygonal approximation and bases. Approximation in the mean.

**Prerequisites:** MAT 390, MAT 595, MAT 596.

**MAT 649 Topics in Operations Research 3**

Advanced linear programming. Integer programming, nonlinear programming, inventory models and queueing models. Application of these optimization techniques in the general area of administration are demonstrated through examples via the digital computer.

**Prerequisites:** Permission of instructor.

**MAT 650 Management Decision-Making Under Uncertainty 3**

Models and techniques to be used in making decisions under uncertainty. Markov Chains, Linear Programming Under Uncertainty, and Chance-Constrained programming.

**Prerequisites:** Permission of instructor.

**MAT 659 Advanced Topics in Mathematics 3**

Topics vary according to interest and demand, and include algebra, applied mathematics, combinatorics, dynamics, mathematical logic, topology, and other topics.

**Prerequisites:** Permission of instructor.

**Notes:** May be repeated for credit when topic varies.

**MAT 687 Project in Mathematics 3**

Directed research project in Mathematics.

**Prerequisites:** Admission to the MA in Mathematics and Permission of Instructor.

**MAT 688 Mathematical Logic and Axiomatic Set Theory 3**

Quantification theory, completeness theorems, prenex normal forms, categoricity. The characterization problem, consistency, the theory of models, isomorphisms and substructures, cardinality of models, joint consistency. Incompleteness and undecidability, recursive functions, Church's thesis, Recursion theory, Set theory, the axiom of constructability, forcing, the independence proofs.

**Prerequisites:** MAT 311, MAT 394, or equivalents.

**MAT 689 Mathematical Logic and Axiomatic Set Theory 3**

Quantification theory, completeness theorems, prenex normal forms, categoricity. The characterization problem, consistency, the theory of models, isomorphisms and substructures, cardinality of models, joint consistency. Incompleteness and undecidability, recursive functions, Church's thesis, Recursion theory, Set theory, the axiom of constructability, forcing, the independence proofs.

**Prerequisites:** MAT 311, MAT 394, or equivalents.

**MAT 690 Mathematics Seminar 2**

Topics in mathematics suitable for development into a master's thesis. Current mathematical literature.

**Prerequisites:** Admission to candidacy for master's degree.

**MAT 699 Thesis 1-6****MAT 701 Graduate Seminar in Computational Mathematics 3**

Readings from the literature of computational mathematics.

**Prerequisites:** MAT 748 or permission of instructor.

**Notes:** May be repeated for credit when topic varies.

**MAT 709 Topics in Computational Mathematics 3**

Advanced study in special topics in computational mathematics.

**Prerequisites:** MAT 748 or permission of instructor.

**Notes:** May be repeated for credit when topic varies.

**MAT 711 Experimental Course 3**

This number reserved for experimental courses. Refer to the Course Schedule for current offerings.

**MAT 721 Mathematical Cryptography 3**

Mathematics of cryptography with emphasis on public key systems. Applications of elliptic and hyperelliptic curves and lattice theory in attacking and evaluating the security of cryptographic systems.

**Prerequisites:** MAT 748 or permission of instructor.

**MAT 723 Numerical Mathematics 3**

Functional analytic treatment of computation, approximation, optimization, interpolation, smoothing equations, linear systems, differential equations. Emphasis on the mathematical development and analysis of numerical techniques.

**Prerequisites:** MAT 390, MAT 595, MAT 596, or equivalents.

**MAT 724 Numerical Mathematics 3**

Functional analytic treatment of computation, approximation, optimization, interpolation, smoothing equations, linear systems, differential equations. Emphasis on the mathematical development and analysis of numerical techniques.

**Prerequisites:** MAT 390, MAT 595, MAT 596, or equivalents.

**MAT 726 Finite Element Methods 3**

Introduce the fundamental concepts of the finite element method for approximating solutions to boundary and initial boundary value problems. Topics include modeling, mathematical formulations, convergence analysis, and computer implementation.

**Prerequisites:** A grade of B or better in MAT 727.

**MAT 727 Linear Algebra and Matrix Theory 3**

Vector spaces. Linear operators and similarity. The eigenvalue problem and a special decomposition theorem. Normal forms: Smith form for matrices, rational and Jordan forms. Spectral resolution of matrix functions. Special topics.

**Prerequisites:** MAT 310, MAT 311 or permission of instructor.

**MAT 728 Linear Algebra and Matrix Theory 3**

Vector spaces. Linear operators and similarity. The eigenvalue problem and a special decomposition theorem. Normal forms: Smith form for matrices, rational and Jordan forms. Spectral resolution of matrix functions. Special topics.

**Prerequisites:** MAT 310, MAT 311 or permission of instructor.

**MAT 731 Combinatorics 3**

Topics include selections, arrangements, theory of generating functions, inclusion-exclusion principle, recurrences, Polya's theory, block designs, stirring numbers, coding theory.

**Prerequisites:** MAT 311 or permission of instructor.

**MAT 732 Graph Theory 3**

Topics include graphs, paths, trees, directed trees, networks, cycles and circuits, planarity, matching theory, independence, chromatic polynomials, Ramsey theory, extremal theory, the vector spaces associated with a graph.

**Prerequisites:** MAT 631 or permission of instructor.

**MAT 735 Ordinary Differential Equations 3**

Existence and uniqueness theorems for initial value problems, theory of linear equations, nonlinear equations, stability theory, boundary value problems.

**Prerequisites:** MAT 390 and MAT 595 or permission of instructor.

**MAT 736 Partial Differential Equations 3**

Derivation of partial differential equations (PDE) models and applications, linear first order PDE's, elliptic equations and Green's function, PDE's of parabolic and hyperbolic type.

**Prerequisites:** MAT 735 or permission of instructor.

**MAT 737 General Topology 3**

Topological spaces, point set topology, product and quotient spaces, embedding and metrization, uniform spaces, function spaces, homotopy theory, simplicial complexes and homology, more algebraic topology, general homology theories.

**Prerequisites:** Bachelor's degree with a major in mathematics. Credits equivalent to credits for mathematics MAT 310, MAT 311, MAT 595, and MAT 596, or permission of instructor and department head.

**MAT 738 General Topology 3**

Topological spaces, point set topology, product and quotient spaces, embedding and metrization, uniform spaces, function spaces, homotopy theory, simplicial complexes and homology, more algebraic topology, general homology theories.

**Prerequisites:** Bachelor's degree with a major in mathematics. Credits equivalent to credits for mathematics MAT 310, MAT 311, MAT 595, and MAT 596, or permission of instructor and department head.

**MAT 740 Modern Abstract Algebra 3**

Real and complex number fields; rings, integral domains and fields; polynomial rings; extensions of rings and fields; elementary factorization theory; ideals; topics in linear algebra.

**MAT 741 Modern Abstract Algebra 3**

Real and complex number fields; rings, integral domains and fields; polynomial rings; extensions of rings and fields; elementary factorization theory; ideals; topics in linear algebra.

**Prerequisites:** Bachelor's degree with a major in mathematics. Credits equivalent to credits for mathematics MAT 310, MAT 311, MAT 595, and MAT 596, or permission of instructor and department head.

**MAT 742 Computational Number Theory 3**

Main algorithms used to compute basic information about algebraic number fields, including integral bases, ideal factorization, system of fundamental units, and class group structure.

**Prerequisites:** MAT 748 or permission of instructor.

**MAT 743 Complex Analysis 3**

The complex number system, holomorphic functions, power series, complex integration, representation theorems, the calculus of residues.

**Prerequisites:** Bachelor's degree with a major in mathematics. Credits equivalent to credits for mathematics MAT 310, MAT 311, MAT 595, and MAT 596, or permission of instructor and department head.

**MAT 744 Complex Analysis 3**

The complex number system, holomorphic functions, power series, complex integration, representation theorems, the calculus of residues.

**Prerequisites:** Bachelor's degree with a major in mathematics. Credits equivalent to credits for mathematics MAT 310, MAT 311, MAT 595, and MAT 596, or permission of instructor and department head.

**MAT 745 Real Analysis 3**

Lebesgue measure; the Lebesgue integral; differentiation and integration, the classical Banach spaces; metric spaces, topological spaces, compact spaces; Banach spaces, measure and integration, measure and outer measure; the Daniell integral; mappings of measure spaces.

**Prerequisites:** Bachelor's degree with a major in mathematics. Credits equivalent to credits for mathematics MAT 310, MAT 311, MAT 595, and MAT 596, or permission of instructor and department head.

**MAT 746 Real Analysis 3**

Lebesgue measure; the Lebesgue integral; differentiation and integration, the classical Banach spaces; metric spaces, topological spaces, compact spaces; Banach spaces, measure and integration, measure and outer measure; the Daniell integral; mappings of measure spaces.

**Prerequisites:** Bachelor's degree with a major in mathematics. Credits equivalent to credits for mathematics MAT 310, MAT 311, MAT 595, and MAT 596, or permission of instructor and department head.

**MAT 747 Computational Topology 3**

Triangulations and WRAP. Computing homology algorithmically. Morse theory and persistent homology. Computations on knots, braids, and links.

**Prerequisites:** MAT 748 or permission of instructor.

**MAT 748 Computational Algebra 3**

Variety of basic subjects in computational algebra: fast arithmetic, algorithms for finite fields, matrix normal forms over rings, polynomial factorization, and Groebner bases.

**Prerequisites:** MAT 591, MAT 592, and knowledge of a programming language. or permission of instructor.

**MAT 790 Directed Doctoral Research 1-6**

Individual work on a dissertation research problem, which could also include original research or a review of current literature leading to a dissertation proposal.

**Prerequisites:** Permission of Director of Graduate Study.

**MAT 799 Dissertation 1-12**

**MAT 801 Thesis Extension 1-3**

Thesis Extension.

**MAT 802 Dissertation Extension 1-3**

Dissertation Extension.

**MAT 803 Research Extension 1-3**