

# MATHEMATICS (MTH)

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## **MTH 099. Intermediate Algebra. 3 Credit Hours.**

Real number operations, polynomials, factoring, rational numbers and rational expressions. Cannot be used to fulfill the 120 credits required for graduation.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Fall, Spring, & Summer.

## **MTH 101. Algebra for College Students. 3 Credit Hours.**

Algebraic operations and properties of the real numbers; linear and quadratic equations and inequalities; polynomials and factoring; rational expressions; radical expressions; graphs of lines; systems of linear equations.

Requisite: SAT Math Section Score  $\geq 550$  or Math ACT Score  $\geq 22$  or ALEKS score  $\geq 40$  or passing grade in MTH 099.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Fall, Spring, & Summer.

## **MTH 105. Algebra and Trigonometry. 5 Credit Hours.**

An intensive course in algebra and trigonometry as covered in MTH 107-108, but without analytic geometry.

Requisite: SAT Math Section Score  $\geq 620$  OR Math ACT Score  $\geq 27$  OR ALEKS score  $\geq 61$  OR passing grade in MTH 101.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Fall & Spring.

## **MTH 107. Precalculus Mathematics I. 4 Credit Hours.**

Algebraic operations; equations and inequalities; complex numbers; functions and their graphs; polynomial, rational, exponential, and logarithmic functions; inverse functions; systems of non-linear equations.

Requisite: SAT Math Section Score  $\geq 620$  OR Math ACT Score  $\geq 27$  OR ALEKS score  $\geq 61$  OR passing grade in MTH 101.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Fall, Spring, & Summer.

## **MTH 108. Precalculus Mathematics II. 3 Credit Hours.**

Trigonometric functions, identities and equations, applications involving vectors, systems of nonlinear equations and inequalities and analytic geometry.

Requisite: SAT Math Section Score  $\geq 670$  OR Math ACT Score  $\geq 29$  OR AP Calculus AB score of 3 OR ALEKS score  $\geq 70$  OR a passing grade in MTH 107.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Fall, Spring, & Summer.

## **MTH 113. Finite Mathematics. 3 Credit Hours.**

Sets, logic, counting techniques, elementary probability and statistics, mathematics in finance, linear programming, algebraic structures, symmetry. The selection of topics may vary by instructor. Intended for BA students.

Requisite: ALEKS score  $\geq 70$  OR SAT Math Section Score  $\geq 670$  OR Math ACT Score  $\geq 29$  OR AP Calculus AB score of 3 OR Passing Grade in MTH107 or MTH107.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Fall, Spring, & Summer.

## **MTH 130. Introductory Calculus. 3 Credit Hours.**

A one-semester survey of the fundamental principles of calculus, functions, limits, derivatives, definite integrals, applications. Not for students planning further study of calculus beyond this course.

Requisite: ALEKS score  $\geq 70$  OR SAT Math Section score  $\geq 670$  or ACT Math score  $\geq 29$  or AP Calculus AB score of 3 or passing grade in MTH 107.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Fall, Spring, & Summer.

## **MTH 133. Games and Strategies. 3 Credit Hours.**

A mathematical introduction to the theory of games, strategies, and optimal responses. Primarily intended for students in a B.A. program.

Prerequisite: MTH 113 or MTH 130.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Offered by Announcement Only.

**MTH 140. Calculus Concepts with Foundations A. 4 Credit Hours.**

Tools from algebra and trigonometry for calculus. Functions and graphs, limits and continuity, the derivative and applications.

Requisite: ALEKS score  $\geq 70$  OR SAT Math Section Score  $\geq 670$  OR Math ACT Score  $\geq 29$  OR AP Calculus AB score of 3.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Fall, Spring, & Summer.

**MTH 141. Calculus Concepts with Foundations B. 4 Credit Hours.**

Tools from algebra, trigonometry, and analytic geometry for calculus. Further aspects of differentiation. Antiderivatives, definite integrals, and their applications.

Prerequisite: MTH 140. Min Grade C-.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Fall & Spring.

**MTH 151. Calculus I for Engineers. 5 Credit Hours.**

Analytic geometry, limits and continuity, derivatives, the definite integral, and applications relevant to engineering. Intended for students taking PHY 221 concurrently.

Requisite: SAT Math Section Score  $\geq 730$  OR Math ACT Score  $\geq 31$  OR ALEKS score  $\geq 78$  OR AP Calculus AB score of 4 or AP Calculus BC score of 3 OR C- or higher in MTH 105 or MTH 108.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Fall & Spring.

**MTH 161. Calculus I. 4 Credit Hours.**

Limits and continuity, derivatives and applications, the definite integral and applications.

Requisite: ALEKS score  $\geq 78$  or SAT Math Section score  $\geq 730$  or Math ACT score  $\geq 31$  or score of 4 AP Calculus (AB) or score of 3 in AP Calculus (BC) or a C- or higher in MTH 108.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Fall, Spring, & Summer.

**MTH 162. Calculus II. 4 Credit Hours.**

Transcendental functions, methods of integration, improper integrals, infinite series, polar coordinates, and introduction to differential equations.

Prerequisite: MTH 141 or MTH 151 or MTH 161 or MTH 171.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Fall, Spring, & Summer.

**MTH 171. Calculus I. 4 Credit Hours.**

The theory of limits, the derivative and the definite integral, techniques and applications. The sequence MTH 171-172 is more conceptually-oriented than MTH 161-162.

Requisite: Prism Program.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Fall.

**MTH 172. Calculus II. 4 Credit Hours.**

Continuation of MTH 171. Additional topics on the derivative and definite integral, improper integrals, infinite series, and introduction to differential equations.

Prerequisite: MTH 171.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Fall & Spring.

**MTH 200. Introduction to Probability. 1 Credit Hour.**

This is an experimental course specifically designed for mathematically talented female high school juniors and seniors to complement their calculus based curriculum. There are several primary objectives of the course: 1) to encourage them to continue a mathematics and STEM based focus when they matriculate at university; 2) to engage them in the reasoning and conceptual skills that underlie modern mathematics; 3) enhance their competitiveness to be accepted at leading universities including the University of Miami; 4) offer them a unique opportunity to bond with like-minded talented girls for mutual support and long-term career-based relationship into an empowering community. There will be two options for students, one in probability theory for more applied oriented students and the other in abstract algebra for those with a more theoretical bent. The probability course will meet on Mondays for 1.5 hours in the late afternoon to accommodate students after the end of their school day. There will twelve course meetings for a total of 18 in class contact hours on the following dates: 9/12, 9/19, 9/26, 10/3, 10/10, 10/17, 10/24, 10/31, 11/7, 11/14, 11/28 and 12/5. Details of expectations are given in the grading policy in the syllabus. Enrollment is limited to high school students in the Girls are for STEM program.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Fall.

**MTH 200B. Introduction to Abstract Algebra. 1 Credit Hour.**

This is an experimental course specifically designed for mathematically talented female high school juniors and seniors to complement their calculus based curriculum. There are several primary objectives of the course: 1) to encourage them to continue a mathematics and STEM based focus when they matriculate at university; 2) to engage them in the reasoning and conceptual skills that underlie modern mathematics; 3) enhance their competitiveness to be accepted at leading universities including the University of Miami; 4) offer them a unique opportunity to bond with like-minded talented girls for mutual support and long-term career-based relationships into an empowering community. There will be two options for students, one in probability theory for more applied oriented students and the other in abstract algebra for those with a more theoretical bent. The abstract algebra course will meet on Wednesdays for 1.5 hours in the late afternoon to accommodate students after the end of their school day. There will twelve course meetings for a total of 18 in class contact hours on the following dates: 9/14, 9/21, 9/28, 10/5, 10/12, 10/19, 10/26, 11/2, 11/9, 11/16, 11/30 and 12/7. Details of expectations are given in the grading policy in the syllabus. Enrollment is limited to high school students in the Girls are for STEM program.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Fall.

**MTH 210. Introduction to Linear Algebra. 3 Credit Hours.**

Vectors, matrix algebra, systems of linear equations, and related geometry in Euclidean spaces. Fundamentals of vector spaces, linear transformations, determinants, eigenvalues, and eigenspaces.

Pre/Corequisite: MTH 162 or MTH 172.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Fall, Spring, & Summer.

**MTH 211. Calculus III. 3 Credit Hours.**

Vectors in space, partial differentiation, multiple integration.

Prerequisite: MTH 162 or MTH 172. Requisite: Not open to students with credit in MTH 310 or MTH 433 or MTH 533.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Fall, Spring, & Summer.

**MTH 224. Introduction to Probability and Statistics. 3 Credit Hours.**

Probability distributions, random variables, expectation and variance, point estimation, interval estimation, testing of hypotheses, analysis of variance.

Pre/Corequisite: MTH 162 or MTH 172.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Fall, Spring, & Summer.

**MTH 230. Introduction to Abstract Mathematics. 3 Credit Hours.**

Fundamentals of set theory, logic and methods of mathematical proof.

Pre/Corequisite: MTH 162 or MTH 172.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Fall & Spring.

**MTH 309. Discrete Mathematics I. 3 Credit Hours.**

Mathematical methods of Computer Science and Computer Engineering. Mathematical reasoning, sets, relations, functions, Boolean algebra, combinatorics, graphs.

Prerequisite: MTH 141 or MTH 151 or MTH 161 or MTH 171.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Fall, Spring, & Summer.

**MTH 310. Multivariable Calculus. 3 Credit Hours.**

Equations of curves, surfaces, solids; vector differential calculus; integration of scalar valued functions. Applications. Intended for mathematics majors.

Prerequisite: MTH 210 and MTH 162 or MTH 172. Requisite: Not open to students with credit in MTH 433 OR MTH 533.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Fall & Spring.

**MTH 311. Introduction to Ordinary Differential Equations. 3 Credit Hours.**

Theory and applications of first-order differential equations. Theory and applications of higher order linear equations and first order linear systems, including matrix methods.

Prerequisite: MTH 162 or MTH 172.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Fall, Spring, & Summer.

**MTH 320. Introduction to Numerical Analysis. 3 Credit Hours.**

Interpolation, quadrature, numerical solution of algebraic and transcendental equations, and optimization.

Prerequisite: MTH 210 and MTH 211 or MTH 310.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Spring.

**MTH 359. Mathematical Models in Biology and Medicine. 3 Credit Hours.**

Fundamentals of the dynamical systems approach to modeling temporal change in biological systems. An introduction to the analysis of mathematical models in biology and medicine with detailed, concrete examples drawn from ecology, cell biology, neuro-science, and physiology.

Prerequisite: MTH 162 or MTH 172.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Fall.

**MTH 433. Advanced Calculus. 3 Credit Hours.**

A rigorous and comprehensive treatment of the theoretical concepts of calculus. The real number system; sequences; series; continuity, differentiation, and integration of functions of one variable.

Prerequisite: MTH 230 and MTH 310 or MTH 211. Not open for Students with Credit in MTH 533.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Fall.

**MTH 461. Survey of Modern Algebra. 3 Credit Hours.**

Algebraic systems, equivalence classes, groups, rings, fields, unique factorization domains.

Prerequisite: MTH 210 and MTH 230. Requisite: Not open to students with credit in MTH 561.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Spring.

**MTH 471. Directed Readings. 1-3 Credit Hours.**

Topics selected from algebra, geometry, analysis, topology.

**Components:** THI.

**Grading:** GRD.

**Typically Offered:** Offered by Announcement Only.

**MTH 472. Directed Readings. 1-3 Credit Hours.**

Topics selected from algebra, geometry, analysis, topology.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Offered by Announcement Only.

**MTH 502. History of Mathematics. 3 Credit Hours.**

The development of mathematics from its earliest beginnings through the first half of the twentieth century. Numeral systems, geometry, algebra, analysis and set theory.

Prerequisite: 2 Courses in MTH 200 or Higher.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Offered by Announcement Only.

**MTH 504. Foundations of Geometry. 3 Credit Hours.**

Axiom systems and models of Euclidean and Non-Euclidean geometry.

Prerequisite: MTH 230 or MTH 309.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Offered by Announcement Only.

**MTH 505. Theory of Numbers. 3 Credit Hours.**

Divisibility, primes; congruences, quadratic residues and reciprocity; Diophantine equations. Applications to cryptography.

Prerequisite: MTH 210 or MTH 504.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Offered by Announcement Only.

**MTH 506. Mathematical Logic. 3 Credit Hours.**

Logics, truth, proof, logical consequence, model theory, formalization, and computation. Meta-theory of first-order logic, computability theory, and Godel's incompleteness theorems. Related results by Church, Turing, and Tarski. Discussion of their philosophical significance.

Prerequisite: MTH 230.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Offered by Announcement Only.

**MTH 510. Linear Algebra. 3 Credit Hours.**

Abstract vector spaces, bases and dimensions, linear maps, eigenvalues and eigenvectors, inner product spaces, operators, spectral theorems, canonical forms.

Prerequisite: MTH 210 and MTH 230 or MTH 309.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Offered by Announcement Only.

**MTH 512. Elementary Complex Analysis. 3 Credit Hours.**

Complex variables; conformal mapping, contour integration.

Prerequisite: MTH 310 or MTH 211.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Spring.

**MTH 513. Partial Differential Equations I. 3 Credit Hours.**

Derivation, well posedness, and qualitative properties of initial value and boundary value problems for the heat, wave and Laplace equations. Energy methods, causality, maximum principles, heat kernels, Fourier series, and potential theory.

Prerequisite: MTH 210 and MTH 311 and MTH 211 or MTH 310.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Fall.

**MTH 514. Partial Differential Equations II. 3 Credit Hours.**

Continuation of MTH 513. Approximations of solutions, distributions and integral transform methods, spectral theory and scattering. Applications to physical problems. Nonlinear equations and phenomena.

Prerequisite: MTH 513.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Spring.

**MTH 515. Ordinary Differential Equations. 3 Credit Hours.**

Linear systems, equilibrium and periodic solutions, stability analysis, bifurcation, phase plane analysis, boundary value problems, applications to engineering and physics.

Prerequisite: MTH 311 and MTH 211 or MTH 310.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Fall.

**MTH 516. Dynamics and Bifurcations. 3 Credit Hours.**

Bifurcation of equilibrium and periodic solutions, global theory of planar systems, planar maps, nonlinear vibrations, forced oscillations, chaotic solutions, Hamiltonian systems, applications to engineering and physics.

Prerequisite: MTH 515.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Spring.

**MTH 520. Numerical Linear Algebra. 3 Credit Hours.**

Topics from numerical linear algebra including solving systems of equations, LU, QR, and SVD factorizations, eigenvalues and eigenvectors, interactive methods, and applications.

Prerequisite: MTH 320.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Fall.

**MTH 521. Numerical Methods in Differential Equations. 3 Credit Hours.**

Numerical solution of ordinary and partial differential equations.

Prerequisite: MTH 320 or MTH 520.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Offered by Announcement Only.

**MTH 524. Introduction to Probability. 3 Credit Hours.**

Probability spaces, random variables, expectation, limit theorems.

Prerequisite: MTH 224 and MTH 211 or MTH 310.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Fall.

**MTH 525. Introduction to Mathematical Statistics. 3 Credit Hours.**

Probability distributions, theory of sampling and hypothesis testing.

Prerequisite: MTH 524.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Spring.

**MTH 527. Theory of Computing. 3 Credit Hours.**

Sets, relations, and languages. Automata theory. Basic computability theory. Turing machines. The complexity classes P and NP.

Prerequisite: MTH 309 or MTH 461.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Offered by Announcement Only.

**MTH 531. Topology I. 3 Credit Hours.**

Set theory, topological spaces, compactness, connectedness, separation properties, quotient spaces, Tychonoff Theorem, compactification, Urysohn Lemma and Tietze Extension Theorem, function spaces.

Prerequisite: MTH 230.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Fall.

**MTH 532. Topology II. 3 Credit Hours.**

Differential and topological manifolds, classical groups and associated manifolds, tangent and tensor bundles, vector fields, differential forms, transversality, Sard's theorem, Stokes' Theorem.

Prerequisite: MTH 210 and MTH 531.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Spring.

**MTH 533. Introduction to Real Analysis I. 3 Credit Hours.**

Sequences and series in Euclidean space; sequences and series of functions; Fourier series; continuity, differentiation, and integration of functions between Euclidean spaces; implicit and inverse function theorems.

Prerequisite: MTH 230 And MTH 211 Or MTH 310.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Fall.

**MTH 534. Introduction to Real Analysis II. 3 Credit Hours.**

Continuation of MTH 533.

Prerequisite: MTH 533.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Spring.

**MTH 542. Statistical Analysis. 3 Credit Hours.**

Statistical inference about one or two populations from interval, ordinal and categorical data; analysis of variance; simple and multiple linear regression; designing research studies.

Prerequisite: MTH 210 and MTH 224.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Fall.

**MTH 547. Introduction to Mathematical Finance. 3 Credit Hours.**

Models of financial markets. Derivative securities: European and American options. Tools of mathematical finance: binomial trees, martingales, stopping times. Concepts of arbitrage and hedging. Risk-neutral valuation of financial derivatives; the Black-Scholes formula and its applications.

Prerequisite: MTH 224 and MTH 211 or MTH 310.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Offered by Announcement Only.

**MTH 551. Introduction to Differential Geometry. 3 Credit Hours.**

Geometry of curves and surfaces in Euclidean space. Local space curve theory, intrinsic and extrinsic curvature of surfaces, geodesics, parallelism, and differential forms.

Prerequisite: MTH 210 And MTH 211 Or MTH 310.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Fall.

**MTH 561. Abstract Algebra I. 3 Credit Hours.**

Groups; rings; linear algebra; modules.

Prerequisite: MTH 210 and MTH 230.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Fall.

**MTH 562. Abstract Algebra II. 3 Credit Hours.**

Continuation of MTH 561.

Prerequisite: MTH 561.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Spring.

**MTH 571. Directed Readings in Mathematics. 1-3 Credit Hours.**

Readings in special topics.

**Components:** THI.

**Grading:** GRD.

**Typically Offered:** Offered by Announcement Only.

**MTH 591. Topics in Mathematics. 1-3 Credit Hours.**

Topics will vary by semester and will be announced in the schedule of course offerings.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Offered by Announcement Only.

**MTH 592. Topics in Mathematics. 1-3 Credit Hours.**

Topics will vary by semester and will be announced in the schedule of course offerings.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Offered by Announcement Only.

**MTH 593. Topics in Mathematics. 1-3 Credit Hours.**

Topics will vary by semester and will be announced in the schedule of course offerings.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Offered by Announcement Only.

**MTH 602. History of Mathematics. 3 Credit Hours.**

The development of mathematics from its earliest beginnings through the first half of the twentieth century. Numeral systems, geometry, algebra, analysis and set theory.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Offered by Announcement Only.

**MTH 604. Foundations of Geometry. 3 Credit Hours.**

Axiom systems and models of Euclidean and Non-Euclidean geometry

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Offered by Announcement Only.

**MTH 605. Theory of Numbers. 3 Credit Hours.**

Divisibility, primes; congruences, quadratic residues and reciprocity; Diophantine equations. Applications to cryptography.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Offered by Announcement Only.

**MTH 606. Mathematical Logic. 3 Credit Hours.**

Logics, truth, proof, logical consequence, model theory, formalization, and computation. Meta-theory of first-order logic, computability theory, and Godel's incompleteness theorems. Related results by Church, Turing, and Tarski. Discussion of their philosophical significance.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Offered by Announcement Only.

**MTH 610. Linear Algebra. 3 Credit Hours.**

Abstract vector spaces, bases and dimensions, linear maps, eigenvalues and eigenvectors, inner product spaces, operators, spectral theorems, canonical forms.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Offered by Announcement Only.

**MTH 612. Elementary Complex Analysis. 3 Credit Hours.**

Complex variables; conformal mapping, contour integration.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Spring.

**MTH 613. Partial Differential Equations I. 3 Credit Hours.**

Derivation, well posedness, and qualitative properties of initial value and boundary value problems for the heat, wave and Laplace equations. Energy methods, causality, maximum principles, heat kernels, Fourier series, and potential theory.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Fall.

**MTH 614. Partial Differential Equations II. 3 Credit Hours.**

Continuation of MTH 513. Approximations of solutions, distributions and integral transform methods, spectral theory and scattering. Applications to physical problems. Nonlinear equations and phenomena.

Prerequisite: MTH 613.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Spring.



**MTH 615. Ordinary Differential Equations. 3 Credit Hours.**

Linear systems, equilibrium and periodic solutions, stability analysis, bifurcation, phase plane analysis, boundary value problems, applications to engineering and physics.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Fall.

**MTH 616. Dynamics and Bifurcations. 3 Credit Hours.**

Bifurcation of equilibrium and periodic solutions, global theory of planar systems, planar maps, nonlinear vibrations, forced oscillations, chaotic solutions, Hamiltonian systems, applications to engineering and physics.

Prerequisite: MTH 615.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Spring.

**MTH 620. Numerical Linear Algebra. 3 Credit Hours.**

Topics from numerical linear algebra including solving systems of equations, LU, QR, and SVD factorizations, eigenvalues and eigenvectors, interactive methods, and applications.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Fall.

**MTH 621. Numerical Methods in Differential Equations. 3 Credit Hours.**

Numerical solution of ordinary and partial differential equations.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Offered by Announcement Only.

**MTH 624. Introduction to Probability Theory. 3 Credit Hours.**

Probability spaces, random variables, expectation, limit theorems.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Fall.

**MTH 625. Introduction to Mathematical Statistics. 3 Credit Hours.**

Probability distributions, theory of sampling and hypothesis testing.

Prerequisite: MTH 624.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Spring.

**MTH 627. Theory of Computing. 0 Credit Hours.**

Sets, relations, and languages. Automata theory. Basic computability theory. Turing machines. The complexity classes P and NP.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Offered by Announcement Only.

**MTH 631. Topology I. 3 Credit Hours.**

Set theory, topological spaces, compactness, connectedness, separation properties, quotient spaces, Tychonoff Theorem, compactification, Urysohn Lemma and Tietze Extension Theorem, function spaces.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Fall.

**MTH 632. Topology II. 3 Credit Hours.**

Differential and topological manifolds, classical groups and associated manifolds, tangent and tensor bundles, vector fields, differential forms, transversality, Sard's theorem, Stokes' Theorem.

Prerequisite: MTH 631.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Spring.

**MTH 633. Introduction to Real Analysis I. 3 Credit Hours.**

Sequences and series in Euclidean space; sequences and series of functions; Fourier series; continuity, differentiation, and integration of functions between Euclidean spaces; implicit and inverse function theorems.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Fall.

**MTH 634. Introduction to Real Analysis II. 3 Credit Hours.**

Continuation of MTH 533.

Prerequisite: MTH 633.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Spring.

**MTH 642. Statistical Analysis. 3 Credit Hours.**

Statistical inference about one or two populations from interval, ordinal and categorical data; analysis of variance; simple and multiple linear regression; designing research studies.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Fall.

**MTH 643. Statistical Analysis II with Financial Applications. 3 Credit Hours.**

Exploratory data analysis. Designing parametric models and assessing their uncertainty. Techniques for resampling. Using multivariate distributions to model financial data; families of copulas. Analyzing time series, including ARIMA and GARCH models.

Prerequisite: MTH 642 or MTH 542.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Offered by Announcement Only.

**MTH 645. Optimization Methods. 3 Credit Hours.**

Linear optimization: simplex method and simplex tableaus, sensitivity analysis. Quadratic optimization and its applications in finance: risk modeling and portfolio construction. Integer programming techniques, branch and bound method. Dynamic programming - deterministic and probabilistic techniques. Software tools of optimization.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Offered by Announcement Only.

**MTH 646. Quantitative Risk Analysis. 3 Credit Hours.**

The modeling, measuring, and managing of financial risk using statistical and stochastic methods. Following "Basel Committee on Banking Supervision" risk analysis is now a major issue for the banking Sector. Concepts and methods covered in this course can be applied to managing risk in various areas, but will proceed in the context related to risk analysis and management in finance and insurance.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Fall.

**MTH 647. Introduction to Mathematical Finance. 3 Credit Hours.**

Models of financial markets. Derivative securities: European and American options. Tools of mathematical finance: binomial trees, martingales, stopping times. Concepts of arbitrage and hedging. Risk-neutral valuation of financial derivatives; the Black-Scholes formula and its applications.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Offered by Announcement Only.

**MTH 648. Stochastic Calculus with Application to Finance. 3 Credit Hours.**

Stochastic calculus developing the basic probabilistic techniques necessary to study analytic models of financial markets. Brownian motion and the stochastic integral, stochastic differential equations, the Black-Scholes formula, Girsanov's theorem and applications to option pricing.

Prerequisite: MTH 647.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Offered by Announcement Only.

**MTH 649. Computational Methods of Finance. 3 Credit Hours.**

Solutions of nonlinear equations, interpolation, Monte Carlo methods, survey of matrix factorizations, numerical integration and differentiation, and introduction to finite different and finite element methods for PDEs with applications to finance.

Prerequisite: CSC 220 and MTH 643 and MTH 648.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Offered by Announcement Only.

**MTH 650. Machine Learning in Quantitative Finance. 3 Credit Hours.**

Machine learning techniques for financial applications. Best practices for model selection and construction of big financial data, including regression and classification techniques, and deep learning with application to forecasting financial time series.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Spring.

**MTH 651. Introduction to Differential Geometry. 3 Credit Hours.**

Geometry of curves and surfaces in Euclidean space. Local space curve theory, intrinsic and extrinsic curvature of surfaces, geodesics, parallelism, and differential forms.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Fall.

**MTH 661. Abstract Algebra I. 3 Credit Hours.**

Groups; rings; linear algebra; modules.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Fall.

**MTH 662. Abstract Algebra II. 3 Credit Hours.**

Continuation of MTH 661.

Prerequisite: MTH 661.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Spring.

**MTH 682. Blockchain and Cryptocurrency Platforms. 3 Credit Hours.**

A detailed introduction to blockchain, the underlying technology that powers cryptocurrency markets. The following topics will be covered: fundamentals of blockchain, decentralization, symmetric and public-key cryptography, Bitcoin network, Bitcoin clients and APIs, smart contracts, Ethereum blockchain, and Ethereum programming.

Prerequisite: MTH 647.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Offered by Announcement Only.

**MTH 683. Algorithmic and High-Frequency Trading. 3 Credit Hours.**

Topics to be covered: fundamentals of electronic markets and the limit order book, microstructure of financial markets, empirical properties of returns and market activity, introduction to stochastic optimal control and stopping, optimal execution with continuous trading, optimal execution with limit/market orders, pairs-trading and statistical arbitrage, market making, and order imbalance.

Prerequisite: MTH 647.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Offered by Announcement Only.

**MTH 686. Topics in Mathematical Finance. 1-3 Credit Hours.**

A variety of topics in Mathematical Finance (including data learning, data analysis and quantitative risk management)

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Offered by Announcement Only.

**MTH 687. Topics in Mathematical Finance. 1-3 Credit Hours.**

Topics in quantitative finance. Possible topics include machine learning techniques in finance, stochastic partial differential equations, mathematics of risk management etc.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Offered by Announcement Only.

**MTH 691. Topics in Mathematics. 1-3 Credit Hours.**

Topics will vary by semester and will be announced in the schedule of course offerings.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Offered by Announcement Only.

**MTH 692. Topics in Mathematics. 1-3 Credit Hours.**

Topics will vary by semester and will be announced in the schedule of course offerings.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Offered by Announcement Only.

**MTH 693. Topics in Mathematics. 1-3 Credit Hours.**

Topics will vary by semester and will be announced in the schedule of course offerings.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Offered by Announcement Only.

**MTH 709. Data Security and Cryptography. 3 Credit Hours.**

Encryption algorithms; cryptographic techniques; access, information flow and inference controls.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Offered by Announcement Only.

**MTH 721. Mathematical Probability. 3 Credit Hours.**

Development of the measure-theoretic approach to probability. Random variables, central limit theory, laws of large numbers, martingales.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Offered by Announcement Only.

**MTH 722. Stochastic Processes. 3 Credit Hours.**

Properties of discrete-parameter and continuous-parameter processes. Markov chains and their attributes. Random walks, recurrence, stopping times, strong Markov property, invariant measures. Pure jump continuous-time processes, Poisson processes. Standard Brownian motion and applications.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Offered by Announcement Only.

**MTH 733. Real Variables. 3 Credit Hours.**

First semester of a two semester sequence: General measure theory, Lebesgue measure and integration,  $L_p$  spaces, Fourier series in one and many variables, Fourier transforms, distributions, Sobolev spaces, applications to partial differential equations.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Offered by Announcement Only.

**MTH 734. Real Variables. 3 Credit Hours.**

Second semester of a two semester sequence: General measure theory, Lebesgue measure and integration,  $L_p$  spaces, Fourier series in one and many variables, Fourier transforms, distributions, Sobolev spaces, applications to partial differential equations.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Offered by Announcement Only.

**MTH 735. Complex Variables. 3 Credit Hours.**

First semester of a two semester sequence: Analytic functions, conformality, Cauchy's Theorem, representation theorems, harmonic functions, calculus of residues, Riemann Mapping Theorem, entire and meromorphic functions, analytic continuation, normal families.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Offered by Announcement Only.

**MTH 736. Complex Variables. 3 Credit Hours.**

Second semester of a two semester sequence: Analytic functions, conformality, Cauchy's Theorem, representation theorems, harmonic functions, calculus of residues, Riemann Mapping Theorem, entire and meromorphic functions, analytic continuation, normal families.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Offered by Announcement Only.

**MTH 741. Algebraic Topology. 3 Credit Hours.**

First semester of a two semester sequence: Homotopy and homotopy type, fundamental group, covering spaces, higher homotopy groups, simplicial singular and cellular homology, Eilenberg-Steenrod axioms, cohomology, universal coefficient theorem, products, Kunnetth formula, duality theorems for manifolds, computations and applications.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Offered by Announcement Only.

**MTH 742. Algebraic Topology. 3 Credit Hours.**

Second semester of a two semester sequence: Homotopy and homotopy type, fundamental group, covering spaces, higher homotopy groups, simplicial singular and cellular homology, Eilenberg-Steenrod axioms, cohomology, universal coefficient theorem, products, Kunnetth formula, duality theorems for manifolds, computations and applications.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Offered by Announcement Only.

**MTH 751. Differential Geometry. 3 Credit Hours.**

First semester of a two semester sequence.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Offered by Announcement Only.

**MTH 752. Differential Geometry. 3 Credit Hours.**

Second semester of a two semester sequence.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Offered by Announcement Only.

**MTH 757. Lie Groups. 3 Credit Hours.**

Matrix Lie Groups, Lie Algebras, Lie Groups and Lie Algebra Homomorphisms, Basic Representation Theory, Baker-Campbell-Hausdorff Formula.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Offered by Announcement Only.

**MTH 761. Abstract Algebra I. 3 Credit Hours.**

First semester of a two semester sequence: Group theory, ring theory, module theory, linear algebra.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Offered by Announcement Only.

**MTH 762. Abstract Algebra II. 3 Credit Hours.**

Second semester of a two semester sequence: Group theory, ring theory, module theory, linear algebra.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Offered by Announcement Only.

**MTH 770. Directed Readings or Research. 2-4 Credit Hours.**

Topics will vary at the discretion on faculty. Offering will be by arrangement.

**Components:** THI.

**Grading:** GRD.

**Typically Offered:** Offered by Announcement Only.

**MTH 780. Topics in Analysis. 3 Credit Hours.**

Topics will vary by semester and will be announced in the schedule of course offerings.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Offered by Announcement Only.

**MTH 781. Topics in Analysis. 3 Credit Hours.**

Topics will vary by semester and will be announced in the schedule of course offerings.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Offered by Announcement Only.

**MTH 782. Topics in Topology. 3 Credit Hours.**

Topics will vary by semester and will be announced in the schedule of course offerings.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Offered by Announcement Only.

**MTH 783. Topics in Topology. 3 Credit Hours.**

Topics will vary by semester and will be announced in the schedule of course offerings.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Offered by Announcement Only.

**MTH 785. Topics in Algebra. 3 Credit Hours.**

Topics will vary by semester and will be announced in the schedule of course offerings.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Offered by Announcement Only.

**MTH 786. Topics in Mathematics. 3 Credit Hours.**

Topics will vary by semester and will be announced in the schedule of course offerings.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Offered by Announcement Only.

**MTH 787. Topics in Mathematics. 3 Credit Hours.**

Topics will vary by semester and will be announced in the schedule of course offerings.

**Components:** LEC.

**Grading:** GRD.

**Typically Offered:** Offered by Announcement Only.

**MTH 820. Research in Residence. 1 Credit Hour.**

To establish a residence for non-thesis master's students who are preparing for major examinations. Credit not granted. Regarded as full-time residence.

**Components:** THI.

**Grading:** GRD.

**Typically Offered:** Fall, Spring, & Summer.

**MTH 830. Pre-Candidacy Doctoral Dissertation. 1-12 Credit Hours.**

Credits earned in this course apply towards the 12 credit hour dissertation research requirement of the graduate school. The student will enroll for credit as determined by his/her dissertation advisor. Up to 12 hours may be taken in a regular semester, but not more than six in a summer session.

**Components:** THI.

**Grading:** SUS.

**Typically Offered:** Fall, Spring, & Summer.

**MTH 835. Research Project. 1-6 Credit Hours.**

Directed Research Project as approved by faculty.

**Components:** THI.

**Grading:** GRD.

**Typically Offered:** Fall, Spring, & Summer.

**MTH 840. Post-Candidacy Doctoral Dissertation. 1-6 Credit Hours.**

Credits earned in this course apply towards the 12 credit hour dissertation research requirement of the graduate school. The student will enroll for credit as determined by his/her dissertation advisor. Up to 12 hours may be taken in a regular semester, but not more than six in a summer session.

**Components:** THI.

**Grading:** SUS.

**Typically Offered:** Fall, Spring, & Summer.

**MTH 845. Research in Residence. 1 Credit Hour.**

Research in Residence - establishing full-time status as a student.

**Components:** THI.

**Grading:** GRD.

**Typically Offered:** Fall & Spring.

**MTH 850. Research in Residence. 1 Credit Hour.**

Used to establish research in residence for the Ph.D. after the student has been enrolled for the permissible cumulative total in appropriate doctoral research. Credit not granted. May be regarded as full-time residence as determined by the Dean of the Graduate School.

**Components:** THI.

**Grading:** SUS.

**Typically Offered:** Fall, Spring, & Summer.