MATHEMATICS (MTH)

Mathematics (MTH)
Master of Science

Overview

The program is designed to accommodate students seeking either a terminal master's degree or preparation for PhD work.

Candidates for admission to the Master of Science Program in the Department of Mathematics should have completed at least thirty-three semester hours of mathematics and statistics at an accredited college or university. At least fifteen of these hours should require as a prerequisite two semesters of calculus or a semester of linear algebra. Most successful applicants have taken three semesters of calculus (through multivariable calculus), linear algebra, abstract algebra (or modern algebra), and advanced calculus (or other advanced courses in analysis).

Students in the program have access to state-of-the-art equipment and facilities, including the DEAC Linux cluster (is.wfu.edu/services/high-performance-computing (https://is.wfu.edu/services/high-performance-computing/)).

Programs

- Mathematics, MS (https://bulletin.wfu.edu/graduate/programs/degree-programs/mathematics/mathematics-ms/)
- Data Science, Certificate (https://bulletin.wfu.edu/graduate/programs/certificates/data-science-certificate/)
- Structural and Computational Biophysics (SCB), Certificate (https://bulletin.wfu.edu/graduate/programs/certificates/structural-computational-biophysics-scb-certificate/)

Courses

MTH 605. Introduction to Linear Algebra and Differential Equations. (3 h)
Specific topics covered include: vector algebra, solving linear systems of equations, rank, vector spaces, determinants, eigenvalues, linear transformations, first order differential equations, second order linear ordinary differential equations, and power series solutions to differential equations. May not be used toward any graduate degree offered by the department.

MTH 611. Introductory Real Analysis I. (3 h)
Limits and continuity in metric spaces, sequences and series, differentiation and Riemann-Stieltjes integration, uniform convergence, power series and Fourier series, differentiation of vector functions, implicit and inverse function theorems.

MTH 617. Complex Analysis I. (3 h)
Analytic functions, Caughy's theorem and its consequences, power series, and residue calculus.

MTH 624. Linear Algebra II. (3 h)
A thorough treatment of vector spaces and linear transformations over an arbitrary field, canonical forms. inner product spaces, and linear groups.

MTH 626. Numerical Linear Algebra. (3 h)
An introduction to numerical methods for solving matrix and related problems in science and engineering using a high-level matrix-oriented language such as MATLAB. Topics include systems of linear equations, least squares methods, and eigenvalue computations. Special emphasis is given to applications.

MTH 631. Geometry. (3 h)
An introduction to axiomatic geometry including a comparison of Euclidean and non-Euclidean geometries.

MTH 634. Differential Geometry. (3 h)
Introduction to the theory of curves and surfaces in two and three dimensional space including such topics as curvature, geodesics, and minimal surfaces.

MTH 645. Elementary Number Theory. (3 h)
Course topics include properties of integers, congruences, and prime numbers, with additional topics chosen from arithmetic functions, primitive roots, quadratic residues, Pythagorean triples, and sums of squares.

MTH 646. Modern Number Theory. (3 h)
Course topics include a selection of number-theory topics of recent interest. Some examples include elliptic curves, partitions, modular forms, the Riemann zeta function, and algebraic number theory.

MTH 647. Graph Theory. (3 h)
Paths, circuits, trees, planar graphs, spanning trees, graph coloring, perfect graphs, Ramsey theory, directed graphs, enumeration of graphs and graph theoretic algorithms.

MTH 648. Combinatorial Analysis I. (3 h)
Enumeration techniques, generating functions, recurrence formulas, the principle of inclusion and exclusion, Polya theory, graph theory, combinatorial algorithms, partially ordered sets, designs, Ramsey theory, symmetric functions, and Schur functions.

MTH 649. Combinatorial Analysis II. (3 h)
Enumeration techniques, generating functions, recurrence formulas, the principle of inclusion and exclusion, Polya theory, graph theory, combinatorial algorithms, partially ordered sets, designs, Ramsey theory, symmetric functions, and Schur functions.

MTH 651. Introduction to Mathematical Modeling. (3 h)
Introduction to the mathematical modeling, analysis and simulation of continuous processes using MATLAB, Mathematica or Maple. Topics include dimensional analysis, stability analysis, bifurcation theory, one-dimensional flows, phase plane analysis, index theory, limit cycles, chaotic dynamics, hyperbolic conservation laws and traveling waves.

MTH 652. Partial Differential Equations. (3 h)
A detailed study of partial differential equations, including the heat, wave, and Laplace equations, using methods such as separation of variables, characteristics, Green's functions, and the maximum principle.

MTH 654. Discrete Dynamical Systems. (3 h)
Introduction to the theory of discrete dynamical systems as applied to disciplines such as biology and economics. Includes methods for finding explicit solutions, equilibrium and stability analysis, phase plane analysis, analysis of Markov chains and bifurcation theory.

MTH 655. Introduction to Numerical Methods. (3 h)
An introduction to numerical computations on modern computer architectures; floating point arithmetic and round-off error including programming in a scientific/engineering language such as MATLAB, Cor Fortran. Topics include algorithms and computer techniques for the solution of problems such as roots of functions, approximations, integration, systems of linear equations and least squares methods. Also listed as CSC 655.

MTH 657. Probability. (3 h)
Distributions of discrete and continuous random variables, sampling distributions. Covers much of the material on the syllabus for the first actuarial exam. This course is cross-listed as STA 610.

MTH 658. Mathematical Statistics. (3 h)
This course will cover derivation of point estimators, hypothesis testing, and confidence intervals using both maximum likelihood and Bayesian approaches. P-MTH 657 or POI.

MTH 681. Individual Study. (1-2 h)
A course of independent study directed by a faculty advisor. By prearrangement. May be repeated for credit.

MTH 682. Reading in Mathematics. (1-3 h)
Reading in mathematical topics to provide a foundational basis for more advanced study in a particular area. May not be used to satisfy any requirement in the MS degree with thesis. No more than three hours may be applied to the requirements for the MS degree without thesis. May be repeated for credit for a total of 3 hours.

MTH 683. Advanced Topics in Mathematics. (1-3 h)
Topics in mathematics that are not considered in regular courses. Content varies.

MTH 691. Research Exploration in Mathematics. (1-3 h)
Students will participate in introductory research projects while developing skills for success. May not be used towards any degree offered by the department. Pass/Fail only. POI only.

MTH 711. Real Analysis. (3 h)
An introduction to analysis on metric spaces and to calculus on Banach spaces with applications.

MTH 712. Real Analysis. (3 h)
Measure and integration theory, elementary functional analysis, selected advanced topics in analysis.

MTH 715. Seminar in Analysis. (1 h)

MTH 716. Seminar in Analysis. (1 h)

MTH 717. Optimization in Banach Spaces. (3 h)
Banach and Hilbert spaces, best approximations, linear operators and adjoints, Frechet derivatives and nonlinear optimization, fixed points and iterative methods. Applications to control theory, mathematical programming, and numerical analysis.

MTH 718. Topics in Analysis. (3 h)
Selected topics from functional analysis or analytic function theory.

MTH 721. Abstract Algebra. (3 h)
Groups, rings, fields, extensions, Euclidean domains, polynomials, vector spaces, Galois theory.

MTH 722. Abstract Algebra. (3 h)
Groups, rings, fields, extensions, Euclidean domains, polynomials, vector spaces, Galois theory.

MTH 724. Seminar on Theory of Matrices. (1 h)

MTH 725. Seminar in Algebra. (1 h)

MTH 726. Seminar in Algebra. (1 h)

MTH 728. Topics in Algebra. (3 h)
Topics vary and may include algebraic coding theory, algebraic number theory, matrix theory, representation theory, non-commutative ring theory.

MTH 731. Topology. (3 h)
Point-set topology including topological spaces, continuity, connectedness, compactness, and metric spaces. Additional topics in topology may include classification of surface, algebraic topology, and knot theory.

MTH 732. Topics in Topology and Geometry. (3 h)
Topics vary and may include knot theory, algebraic topology, differential topology, manifolds, and Riemannian geometry. May be repeated for credit. P - 731 or POI.

MTH 733. Topics in Topology and Geometry. (3 h)
Topics vary and may include knot theory, non-Euclidean geometry, combinatorial topology, differential topology, minimal surfaces and algebraic topology.

MTH 735. Seminar on Topology. (1 h)

MTH 736. Seminar on Topology. (1 h)

MTH 737. Seminar on Geometry. (1 h)

MTH 738. Seminar on Geometry. (1 h)

MTH 744. Topics in Number Theory. (3 h)
Topics vary and are chosen from the areas of analytic, algebraic, and elementary number theory. Topics may include Farey fractions, the theory of paritions, Waring's problem, prime number theorem, and Dirichlet's problem.

MTH 745. Seminar on Number Theory. (1 h)

MTH 746. Seminar on Number Theory. (1 h)

MTH 747. Topics in Discrete Mathematics. (3 h)
Topics vary and may include enumerative combinatorics, graph theory, algebraic combinatorics, combinatorial optimization, coding theory, experimental designs, Ramsey theory, Polya theory, representational theory, set theory and mathematical logic.

MTH 748. Seminar on Combinatorial Analysis. (1 h)

MTH 749. Seminar on Combinatorial Analysis. (1 h)

MTH 750. Dynamical Systems. (3 h)
Introduction to modern theory of dynamical systems. Linear and nonlinear autonomous differential equations, invariant sets, closed orbits, Poincare maps, structural stability, center manifolds, normal forms, local bifurcations of equilibria, linear and non-linear maps, hyperbolic sets, attractors, symbolic representation, fractal dimensions. P-MTH 611.

MTH 752. Topics in Applied Mathematics. (3 h)
Topics vary and may include computational methods in differential equations, optimization methods, approximation techniques, eigenvalue problems. May be repeated for credit.

MTH 753. Nonlinear Optimization. (3 h)
The problem of finding global minimums of functions is addressed in the context of problems in which many local minima exist. Numerical techniques are emphasized, including gradient descent and quasi-Newton methods. Current literature is examined and a comparison made of various techniques for both unconstrained and constrained optimization problems. Also listed as CSC 753.

MTH 754. Numerical Methods for Partial Differential Equations. (3 h)
Numerical techniques for solving partial differential equations (including elliptic, parabolic, and hyperbolic) are studied along with applications to science and engineering. Theoretical foundations are described and emphasis is placed on algorithm design and implementation using either C, FORTRAN, or MATLAB. Credit not allowed for both MTH 754 and CSC 754. P-MTH 655 or CSC 655.

MTH 757. Stochastic Processes and Applications. (3 h)
This course includes the axiomatic foundations of probability theory and an introduction to stochastic processes. Applications may include Markov chains, Markov Chain Monte Carlo with Metropolis-Hastings, Gibb sampling, Brownian motion, and related topics, with an emphasis on modern developments. This course is cross-listed as STA 710. P-MTH 657 or STA 610 and MTH 611 or POI.

MTH 791. Thesis Research I. (1-9 h)
May be repeated for credit. Satisfactory/Unsatisfactory.

MTH 792. Thesis Research II. (1-9 h)
May be repeated for credit. Satisfactory/Unsatisfactory.

Faculty

Program Director Jeremy Rouse
Taylor Professor and Chair Stephen Robinson
Sterge Faculty Fellow and Professor Ellen Kirkman
Professors Edward Allen, Jennifer Erway Fey, Hugh Howards, Miaohua Jiang, Sarah Mason, W. Frank Moore, Sarah Raynor, Jeremy Rouse
Associate Professors Abbey Bourdon, John Gemmer, R. Jason Parsley
Associate Teaching Professor and Director of the Math and Stats Center Lynne Yengulalp
Associate Teaching Professor Justin Allman
Assistant Professors Sebastian Bozlee, Claudia Falcon, Leandro Lichtenfelz, Fan Yang, Wenjun Zhao
Teacher-Scholar Postdoctoral Fellows Kyle Celano, Dylan Bruyney Odessa, Shohreh Gholizadeh Siahmazgi, Justin Valletta, Dominic Veconi
Visiting Assistant Professors Pratyush Mishra