MATHEMATICS AND STATISTICS (MST)

A major in mathematics or in mathematical statistics can be achieved by satisfying the requirements listed for either the bachelor of arts or bachelor of science. Lower division students are urged to consult a member of the departmental faculty before enrolling in courses other than those satisfying Division V requirements.

A minimum grade point average of 2.0 in courses which comprise a major or minor in the department is required for graduation with any major or minor which the department offers. Students may major in the department and minor in statistics, but the only electives that may be counted towards both programs is exactly one of MST 121 or MST 205. Students may not major in the department and minor in mathematics or double-major within the department.

The department regularly schedules activities in mathematics and statistics for students that enhance the course offerings. Examples are:

- participation in the annual Putnam examination
- the COMAP contest in mathematical modeling
- the American Statistical Association DataFest
- data science and hackathon events
- meetings of the mathematics and statistics club
- seminars and courses which build upon the regularly scheduled course offerings
- student research with faculty
- tutoring opportunities

Students who are enrolled at Wake Forest may not take courses in mathematics and statistics at other institutions to satisfy divisional requirements.

Contact Information

Department of Mathematics & Statistics (http://college.wfu.edu/math/)
Manchester Hall 127, Box 7388
Phone 336-758-5300

Programs

Majors

- B.A. in Mathematics (https://bulletin.wfu.edu/courses-instruction/mathematics-statistics/ba-mathematics/)
- B.A. in Mathematical Statistics (https://bulletin.wfu.edu/courses-instruction/mathematics-statistics/ba-mathematical-statistics/)
- B.S. in Mathematics (https://bulletin.wfu.edu/courses-instruction/mathematics-statistics/bs-mathematics/)
- B.S. in Mathematical Statistics (https://bulletin.wfu.edu/courses-instruction/mathematics-statistics/bs-mathematical-statistics/)
- B.S. in Applied Mathematics (https://bulletin.wfu.edu/courses-instruction/mathematics-statistics/bs-applied-mathematics/)
- B.S. in Mathematical Economics (https://bulletin.wfu.edu/courses-instruction/mathematics-statistics/bs-mathematical-economics/)
- B.S. in Mathematical Business (https://bulletin.wfu.edu/courses-instruction/mathematics-statistics/bs-mathematical-business/)

Minors

- Minor in Mathematics (https://bulletin.wfu.edu/courses-instruction/mathematics-statistics/minor-mathematics/)
- Minor in Statistics (https://bulletin.wfu.edu/courses-instruction/mathematics-statistics/minor-statistics/)

Courses

Mathematics (MST)

MST 105. Fundamentals of Algebra and Trigonometry. (1-3 h)
A review of the essentials of algebra and trigonometry. Admission by permission only (generally, a student must have taken fewer than three years of high school mathematics to be eligible for admission). Not to be counted towards any major or minor offered by the department.

MST 105L. Fundamentals of Algebra and Trigonometry Lab. (1-2 h)
A review of the essentails of algebra and trigonometry in a guided laboratory setting. Admission by permission only. Not to be counted towards any major or minor offered by the department. Pass/Fail only.

MST 107. Explorations in Mathematics. (4 h)
An introduction to mathematical reasoning and problem solving. Topics vary by instructor and may include one or more of the following: knot theory, Euclidean and non-Euclidean geometry, set theory, cryptography, discrete models, number theory, discrete mathematics, chaos theory, probability, and MAPLE programming. Lab. (D, QR)

MST 111. Calculus with Analytic Geometry I. (4 h)
Functions, trigonometric functions, limits, continuity, differentiation, applications of derivatives, introduction to integration, the fundamental theorem of calculus. Lab. (D, QR)

MST 112. Calculus with Analytic Geometry II. (4 h)
Techniques of integration, indeterminate forms, improper integrals, transcendental functions, sequences, Taylor's formula, and infinite series, including power series. Lab. (D, QR)

MST 113. Multivariable Calculus. (4 h)
The calculus of vector functions, including geometry of Euclidean space, differentiation, extrema, line integrals, multiple integrals, and Green's, Stokes', and divergence theorems.9 Lab. (D, QR)

MST 117. Discrete Mathematics. (4 h)
Introduction to various topics in discrete mathamatics applicable to computer science including sets, relations, Boolean algebra, propositional logic, functions, computability, proof techniques, graph theory, and elementary combinatorics. Lab. (D, QR)

MST 121. Linear Algebra I. (4 h)
Vectors and vector spaces, linear transformations and matrices, determinants, eigenvalues, and eigenvectors. Credit not allowed for both MST 121 and 205. Credit not allowed for both MST 121 and 206. Lab. (D, QR)

MST 165. Problem-Solving Seminar. (1 h)
Weekly seminar designed for students who wish to participate in mathematical competition such as the annual Putnam examination. Not to be counted toward any major or minor offered by the department. May be repeated for credit. Pass/Fail only.

MST 205. Introduction to Linear Algebra and Differential Equations. (4 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. Credit not allowed for both MST 205 and MST 251 or for both MST 205 and MST 121 or for both MST 205 and MST 206. P-MST 112 or POI.

MST 206. Applied Matrix Algebra and Selected Topics. (2 h)
Matrices, determinants, solutions of linear equations, special matrices, eigenvalues and eigenvectors of matrices. Additional topics will be covered as time permits. Not to be counted toward any major offered by the department except for the major in mathematical business. Credit not allowed for both MST 206 and 121. Credit not allowed for both MST 206 and 205. P-MST 111 or POI.

MST 214. Multivariable Analysis. (3 h)
Functions between Euclidean spaces, multivariable limits, differentiation, change of variables, line and surface integrals, vector fields, integration theorems for vector fields, Implicit & Inverse Function Theorems, Contraction Mapping Theorem, applications, other selected topics from analysis in multiple dimensions. P-MST 113 and MST 121, or MST 205.

MST 225. Linear Algebra II. (3 h)
A continuation of the study of linear algebra and its applications over the real and complex numbers. Topics may include the spectral theorem, quadratic forms, the singular value decomposition, Gershgorin's circle theorem, analytic functions of matrices, pseudoinverses, and other topics chosen by the instructor. P-MST 112 and 121 or POI.

MST 243. Codes and Cryptography. (3 h)
Essential concepts in coding theory and cryptography. Congruences, cryptosystems, public key, Huffman codes, information theory, and other coding methods. P - MST 117 or POI. (D)

MST 251. Ordinary Differential Equations. (3 h)
Linear equations with constant coefficients, linear equations with variable coefficients, and existence and uniqueness theorems for first order equations. Credit not allowed for both MST 251 and MST 205. P-MST 112 or POI. (D, QR)

MST 253. Operations Research. (3 h)
Mathematical models and optimization techniques. Studies in linear programming, simplex method, duality, sensitivity analysis, and other selected topics. P-MST 111 and MST 121, 205, or 206 or POI. (D, QR)

MST 254. Optimization Theory. (3 h)
Unconstrained and constrained optimization problems; Lagrange multiplier methods; second-order sufficient conditions; inequality constraints; and Karush-Kuhn-Tucker conditions. P - MST 113 and 121 or POI.

MST 283. Topics in Mathematics. (1-3 h)
Topics in mathematics not considered in regular courses or which continue study begun in regular courses. Content varies.

MST 306. Advanced Mathematics for the Physical Sciences. (3 h)
Advanced topics in linear algebra, special functions, integral transforms and partial differential equations. Not to be counted toward any major offered by the department except for the major in mathematical business. P - MST 205 or POI.

MST 311. 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. P - MST 117 or POI. (D)

MST 312. Introductory Real Analysis II. (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. P - MST 117 or POI. (D)

MST 317. Complex Analysis I. (3 h)
Analytic functions, Cauchy's theorem and its consequences, power series, and residue calculus. P - MST 113 or POI. (D)

MST 321. Modern Algebra I. (3 h)
Introduction to modern abstract algebra through the study of groups, rings, integral domains, and fields. P - MST 121 or POI. (D)

MST 322. Modern Algebra II. (3 h)
A continuation of modern abstract algebra through the study of additional properties of groups, rings, and fields. P - MST 117 and 321 or POI. (D)

MST 324. Advanced Linear Algebra. (3 h)
Thorough treatment of vector spaces and linear transformations over an arbitrary field, canonical forms, inner product spaces, and linear groups. P - MST 121 and 321 or POI. (D)

MST 326. Numerical Linear Algebra. (3 h)
Numerical methods for solving matrix and related problems in science and engineering using a high-level matrix-oriented language such as MATLAB. Topics will include systems of linear equations, least squares methods, and eigenvalue computations. Special emphasis given to applications. Also listed as CSC 352. P-MST 112 and MST 121, 205 or 206 or POI. (D)

MST 331. Geometry. (3 h)
An introduction to axiomatic geometry including a comparison of Euclidean and non-Euclidean geometries. P - MST 117 or POI. (D)

MST 333. Introductory Topology. (3 h)
Topics vary and may include knot theory, topological spaces, homemorphisms, classification of surfaces, manifolds, Euler characteristic, and the fundamental group. P - MST 117 or POI.

MST 334. 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. P - MST 113 or POI. (D)

MST 345. Elementary Number Theory. (3 h)
Properties of integers, congruences, and prime numbers, with additional topics chosen from arithetic functions, primitive roots, quadratic residues, Pythagorean triples, and sums of squares. P-MST 117. (D)

MST 346. Modern Number Theory. (3 h)
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. P - MST 117. (D)

MST 347. 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. P-MST 117 or POI. (D)

MST 348. 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. P - MST 117 or POI. (D)

MST 349. 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. P - MST 117 or POI. (D)

MST 351. Introduction to Mathematical Modeling. (3 h)
Introduction to the mathematical modeling, analysis and simulation of continuous processes using MATLAB, Mathematics 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. P-MST 121 and 251 or POI.

MST 352. 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. P - MST 113 and 251 or POI. (D)

MST 353. Probability Models. (3 h)
Introduction to probability models, Markov chains, Poisson processes and Markov decision processes. Applications will emphasize problems in business and management science. Also listed as STA 353. P-MST 111 and MST 121 or 205 or 206, or POI. (D)

MST 354. 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. P - MST 112 and 121 or POI. (D)

MST 355. Introduction to Numerical Methods. (3 h)
Numerical computations on modern computer architectures; floating point arithmetic and round-off error. Programming in a scientific/engineering language such as MATLAB, C, or FORTRAN. Algorithms and computer techniques for the solution of problems such as roots of functions, approximation, integration, systems of linear equations and least squares methods. Also listed as CSC 355. P-MST 112 and MST 121, 205 or 206, or POI. (D)

MST 357. Probability. (3 h)
Probability distributions, mathematical expectation, and sampling distributions. MST 357 covers much of the material on the syllabus for the first Actuarial exam. Also listed as STA 310. P-MST 112 or 205 or POI. (D)

MST 359. Networks: Models and Analysis. (3 h)
A course in fundamental network theory concepts, including measures of network structure, community detection, clustering, and network modelling and inference. Topics also draw from recent advances in the analysis of networks and network data, as well as applications in economics, sociology, biology, computer science, and other areas. Also listed as STA 352. P-MST 117 or MST 121 or MST 205 or MST 206 and one course in STA at the 200 level or above. (D)

MST 381. Individual Study. (1-3 h)
A course of independent study directed by a faculty adviser. By prearrangement.

MST 383. Advanced Topics in Mathematics. (1-3 h)
Topics in mathematics not considered in regular courses or which continue study begun in regular courses. Content varies.

MST 391. Senior Seminar Preparation. (1 h)
Independent study or research directed by a faculty advisor by prearrangement with the adviser.

MST 392. Senior Seminar Presentation. (1 h)
Preparation of a paper, followed by a one-hour oral presentation based upon work in MST 391.

Statistics (STA)

STA 107. Explorations in Statistics. (3 h)
Introduction to statistical literacy and the role of statistics in settings such as elections, medicine, sports, and the sciences. Topics vary by instructor. (D, QR)

STA 111. Elementary Probability and Statistics. (4 h)
Data collection and visualization, exploratory analysis, introductory probability, inference techniques for one variable, and statistical literacy. Lab. (D, QR)

STA 175. Competitions. (1-3 h)
Seminar designed for students who wish to participate in statistics and/or data analysis competitions. Not to be counted toward any major or minor offered by the department. May be repeated for credit. Pass/Fail only.

STA 212. Statistical Models. (3 h)
A project-oriented course emphasizing data analysis, with introductions to multiple and logistic regression, model selection, design, categorical data, data visualization, and statistical programming. P-A first course in statistics, such as STA 111, ANT 380, BIO 380, BEM 201 or 202, HES 262, PSY 311 or 312, SOC 271, or POI. (D, QR)

STA 247. Design and Sampling. (3 h)
Experimental designs, observational studies, survey design and estimation with stratified, cluster, and other sampling schemes. P-STA 111 or STA 212 or POI. (D)

STA 279. Topics in Statistics. (1-3 h)
Topics in statistics not considered in regular courses, or which continue study begun in regular courses. Content varies.

STA 310. 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. Also listed as MST 357. P-MST 112 or POI. (D)

STA 311. Statistical Inference. (3 h)
Derivation of point estimators, hypothesis testing, and confidence intervals, using both frequentist and Bayesian approaches. P-STA 310 or MST 357 or POI. (D)

STA 312. Linear Models. (3 h)
Theory of estimation and testing in linear models. Topics include least squares and the normal equations, the Gauss-Markov Theorem, testing general linear hypotheses, model selection, and applications. P-MST 121 or 205 or 206, and STA 310 or MST 357. (D)

STA 352. Networks: Models and Analysis. (3 h)
A course in fundamental network theory concepts, including measures of network structure, community detection, clustering, and network modelling and inference. Topics also draw from recent advances in the analysis of networks and network data, as well as applications in economics, sociology, biology, computer science, and other areas. Also listed as MST 359. P-MST 117 or MST 121 or MST 205 or MST 206 and one course in STA at the 200 level or above. (D)

STA 353. Probability Models. (3 h)
Introduction to probability models, Markov chains, Poisson processes and Markov decision processes. Applications will emphasize problems in business and management science. Also listed as MST 353. P-MST 111, and MST 121 or MST 205 or MST 206. (D)

STA 362. Multivariate Statistics. (3 h)
Multivariate and linear methods for classification, visualization, discrimination, and analysis of high dimensional data. P-STA 212 and one of MST 121 or MST 205 or MST 206, or POI. (D)

STA 363. Introduction to Statistical Learning. (3 h)
An introduction to supervised learning. Topics may include lasso and ridge regression, splines, generalized additive models, random forests, and support vector machines. P-STA 212 and one of MST 121 or MST 205 or MST 206, or POI, experience with statistical computing. (D)

STA 364. Computational and Nonparametric Statistics. (3 h)
Computationally intensive statistical methods. Topics include simulation, Monte Carlo integration and Markov Chain Monte Carlo, sub-sampling, and non-parametric estimation and regression. Students will make extensive use of statistical software throughout the course. P-STA 111 or STA 212, and either STA 310 or MST 357, or POI. (D)

STA 368. Time Series and Forecasting. (3 h)
Methods and models for time series processes and autocorrelated data. Topics include model diagnostics, ARMA models, spectral methods, computational considerations, and forecasting error. P-STA 212, and either STA 310 or MST 357, or POI. (D)

STA 379. Advanced Topics in Statistics. (1-3 h)
Topics in statistics not considered in regular courses or which continue study begun in regular courses. Content varies.

STA 381. Applied Statistics Capstone. (2 h)
Students integrate knowledge acquired throughout their degree program. Topics include developing a research plan, statistical writing, data visualization, and data ethics. Students will communicate statistical results to both technical and non-technical audiences through written reports and oral presentations. Offered fall semester. P-senior STA major.

STA 383. Individual Study. (1-3 h)
A course of independent study directed by a faculty adviser. By prearrangement.

STA 391. Senior Research Capstone I. (1 h)
Independent study or research directed by a faculty adviser by prearrangement with the adviser.

STA 392. Senior Research Capstone II. (1 h)
Preparation of a paper, followed by an oral presentation based upon work completed in STA 391.

Faculty

Chair Sarah Raynor
Associate Chair Robert Erhardt
Wake Forest Taylor Professor Stephen Robinson
Professors Edward Allen, Kenneth Berenhaut, Jennifer Erway Fey, Hugh Howards, Miaohua Jiang, Ellen E. Kirkman, James Norris III, Sarah Raynor
Professor of the Practice Jule Connolly
Sterge Faculty Fellows and Associate Professors Sarah Mason, Jeremy Rouse
Associate Professors Robert Erhardt, W. Frank Moore, R. Jason Parsley
Sterge Faculty Fellows and Assistant Professors Abbey Bourdon, John Gemmer
Assistant Professors Lucy D'Agostino McGowan, Staci Hepler, John Holmes, Emily Huang, Sneha Jadhay, Kyongwon Kim
Assistant Teaching Professor Justin Allman, Nicole Dalzell, Lynne Yengulalp
Visiting Assistant Professors Guillermo Alesandroni, Duff Baker-Jarvis, Qing Liu, Rajan Puri
Teacher-Scholar Postdoctoral Fellows Kaitlin Hill, Marco Lopez, Katherine Moore, Mostafa Rezapour, Lori Watson
Professor Emeritus and Part-time Instructor Richard Carmichael