MATHEMATICAL SCIENCES

http://www.uvm.edu/cems/mathstat/ (http://www.uvm.edu/~cems/mathstat/)

OVERVIEW

The Department of Mathematics and Statistics offers programs towards the Master of Science, Master of Science for Teachers, and Doctor of Philosophy in Mathematical Sciences. The Ph.D. program has three areas of concentration: Pure Mathematics, Applied Mathematics, and Statistics. The Department also offers a M.S. degrees in Statistics and in Biostatistics and M.S. and Ph.D. degrees in Complex Systems & Data Science. It has Accelerated Master's Programs in Mathematics and in Statistics, which are available to UVM undergraduate students.

Opportunities for research arise from the research interests of the Department faculty, which include: algebraic geometry, arithmetic geometry, combinatorics/graph theory, complex systems, computational social science, Fourier/harmonic analysis, logic, mathematical cryptography, network science, number theory, biomathematics, fluid mechanics, numerical methods for, and analytical theories of, partial differential equations, as well as in bioinformatics, time series analysis, survival analysis, discriminant analysis, classification methods, bootstrap methods, categorical data analysis, measurement error models, and experimental design.

DEGREES

- Mathematical Sciences AMP (http://catalogue.uvm.edu/graduate/mathsciences/mathematicalsciencesamp/)
- Mathematical Sciences M.S. (http://catalogue.uvm.edu/graduate/mathsciences/mathematicalsciencesms/)
- Mathematics M.S.T. (http://catalogue.uvm.edu/graduate/mathsciences/mathematicsmst/)
- Mathematical Sciences Ph.D. (http://catalogue.uvm.edu/graduate/mathsciences/mathematicalsciencesphd/)

FACULTY

Backman, Spencer; Assistant Professor, Department of Mathematics and Statistics, PHD, Georgia Institute of Technology
Bagrow, James; Assistant Professor, Department of Mathematics and Statistics; PHD, Clarkson University
Bentil, Daniel E.; Associate Professor, Department of Mathematics and Statistics; DPHIL, University of Oxford
Buzas, Jeff Sandor; Professor, Department of Mathematics and Statistics; PHD, North Carolina State University Raleigh
Chaudhuri, Paramita Saha; Assistant Professor, Department of Mathematics and Statistics; PHD, University of Washington
Cole, Bernard F.; Professor, Department of Mathematics and Statistics; PHD, Boston University
Danforth, Chris; Associate Professor, Department of Mathematics and Statistics; PHD, University of Maryland College Park
Dupuy, Taylor; Assistant Professor, Department of Mathematics and Statistics; PHD, University of New Mexico
Lakoba, Taras Igorevich; Associate Professor, Department of Mathematics and Statistics; PHD, Clarkson University
Rombach, Puck; Assistant Professor, Department of Mathematics and Statistics; PHD, University of Oxford, Somerville College
Single, Richard M.; Associate Professor, Department of Mathematics and Statistics; PHD, SUNY Stony Brook
Vincent, Christelle; Assistant Professor, Department of Mathematics and Statistics; PHD, University of Wisconsin-Madison
Warrington, Gregory S.; Professor, Department of Mathematics and Statistics; PHD, Harvard University
Wilson, James Michael; Professor, Department of Mathematics and Statistics; PHD, University of California Los Angeles
Yang, Jianke; Professor, Department of Mathematics and Statistics; PHD, Massachusetts Institute of Technology
Young, Jean-Gabriel; Research Assistant Professor, Department of Computer Science, PHD, Université Laval
Yu, Jun; Professor, Department of Mathematics and Statistics; PHD, University of Washington Seattle

Mathematics Courses

MATH 230. QR:Ordinary Diffrntl Equation. 3 Credits.
Solutions of linear ordinary differential equations, the Laplace transformation, and series solutions of differential equations. Prerequisite: MATH 121. Corequisite: MATH 122 or MATH 124. Credit not granted for more than one of the courses MATH 230 or MATH 271.

MATH 235. QR:Mathematical Models&Anlysis. 3 Credits.
Techniques of Calculus and linear algebra are applied for mathematical analysis of models of natural and human-created phenomena. Students are coached to give presentations. Prerequisites: MATH 121; MATH 122 or MATH 124 or MATH 230 or MATH 271.

MATH 237. QR:Intro to Numerical Analysis. 3 Credits.
Error analysis, root-finding, interpolation, least squares, quadrature, linear equations, numerical solution of ordinary differential equations. Prerequisites: MATH 121; MATH 122 or MATH 124 or MATH 271; CS 020 or CS 021. Cross-listed with: CS 237.

MATH 241. QR:Anyl in Several Real Vars I. 3 Credits.
Properties of the real numbers, basic topology of metric spaces, infinite sequences and series, continuity. Prerequisites:MATH 141 or MATH 151 or C- or better in Math 052; MATH 121; MATH 122 or MATH 124.

MATH 242. QR:Anyl Several Real Vrbes II. 3 Credits.
Differentiation and integration in n-space, uniform convergence of functions, fundamental theorem of calculus, inverse and implicit function theorems. Prerequisite: MATH 241.

MATH 247. QR:Complex Analysis. 3 Credits.
An introduction to the theory of analytic functions of one complex variable, covering the techniques of complex analysis useful in science and engineering as well as the theory. Topics include complex numbers, analytic and holomorphic functions, power and Laurent series expansions, and Cauchy's theorems on integration. Prerequisites: MATH 052 or CS 064; MATH 121.

MATH 251. QR: Abstract Algebra I. 3 Credits.
Basic theory of groups, rings, fields, homomorphisms, and isomorphisms. Prerequisites: MATH 141 or MATH 151 or C- or better in MATH 052; MATH 122 or MATH 124.

MATH 252. QR: Abstract Algebra II. 3 Credits.
Modules, vector spaces, linear transformations, rational and Jordan canonical forms. Finite fields, field extensions, and Galois theory leading to the insolvability of quintic equations. Prerequisite: MATH 251.

MATH 254. QR: Topology. 3 Credits.
An introduction to point set topology. Topics include open and closed sets, continuous functions, compactness, connectedness, metric and Hausdorff spaces. If time permits, introduction to algebraic topology through topics such as the fundamental group. Provides background for analysis and graduate topology courses as well as for topological data science. Prerequisites: MATH 052 or CS 064; MATH 121 or MATH 122 or MATH 124.

MATH 255. QR:Elementary Number Theory. 3 Credits.
Divisibility, prime numbers, Diophantine equations, congruence of numbers, and methods of solving congruences. A significant portion of the course devoted to individual and/or team projects. Prerequisite: MATH 052; MATH 121 or MATH 122 or MATH 124.

MATH 259. QR: Cryptography. 3 Credits.
A survey of classical and modern cryptography. The strengths and weaknesses of various cryptosystems are discussed. Topics include specific public-key and private-key cryptosystems such as RSA, ElGamal, and elliptic curve cryptosystems, as well as digital signatures and key exchange. Prerequisite: MATH 052 or CS 064; MATH 121 or MATH 122 or MATH 124.

MATH 260. QR: Foundations of Geometry. 3 Credits.
Complex numbers as tool to solve problems in Euclidean geometry. Two models of hyperbolic (non-Euclidean) geometry: Poincare and upper-half plane. Invariants and Moebius transformations. Prerequisite: MATH 052 or CS 064; MATH 121, MATH 122, or MATH 124; or Instructor permission.

MATH 266. QR:Chaos,Fractals&Dynmcal Syst. 3 Credits.
Discrete and continuous dynamical systems, Julia sets, the Mandelbrot set, period doubling, renormalization, Henon map, phase plane analysis and Lorenz equations. Prerequisite: MATH 122 or MATH 124. CS 020 or CS 021 recommended. Cross-listed with: CSYS 266.

MATH 268. QR:Mathematical Biology&Ecol. 3 Credits.
Mathematical modeling in the life sciences. Topics include population modeling, dynamics of infectious diseases, reaction kinetics, wave phenomena in biology, and biological pattern formation. Prerequisite: MATH 122 or MATH 124; MATH 230 or MATH 271; or Instructor permission.

MATH 271. QR:Adv Engineering Mathematics. 3 Credits.
Differential equations, Laplace transforms, and systems of differential equations; brief introduction to Fourier series. Examples from engineering and physical sciences. Credit not granted for both MATH 230 and MATH 271. No credit for Mathematics majors. Prerequisite: MATH 121. Co-requisites: Preferred: MATH 122 or MATH 124; or MATH 120.

MATH 273. QR:Combinatorial Graph Theory. 3 Credits.
Paths and trees, connectivity, Eulerian and Hamiltonian cycles, matchings, edge and vertex colorings, planar graphs, Euler's formula and the Four Color Theorem, networks. Prerequisite: MATH 052.

MATH 300. Principles of Complex Systems. 3 Credits.
Introduction to fundamental concepts of complex systems. Topics include: emergence, scaling phenomena, and mechanisms, multi-scale systems, failure, robustness, collective social phenomena, complex networks. Students from all disciplines welcomed. Pre/co-requisites: Calculus and statistics required; Linear Algebra, Differential Equations, and Computer programming recommended but not required. Cross-listed with: CSYS 300.

MATH 303. Complex Networks. 3 Credits.
Detailed exploration of distribution, transportation, small-world, scale-free, social, biological, organizational networks; generative mechanisms; measurement and statistics of network properties; network dynamics; contagion processes. Students from all disciplines welcomed. Pre/co-requisites: MATH 300/CSYS 300, Calculus, and Statistics required. Cross-listed with: CSYS 303.

MATH 330. Adv Ordinary Diff Equations. 3 Credits.
Linear and nonlinear systems, approximate solutions, existence, uniqueness, dependence on initial conditions, stability, asymptotic behavior, singularities, self-adjoint problems. Prerequisite: MATH 230.

MATH 331. Theory of Func of Complex Var. 3 Credits.
Complex functions, differentiation and the Cauchy-Riemann equations, power and Laurent series, integration, calculus of residues, contour integration, isolated singularities, conformal mapping, harmonic functions. Prerequisite: MATH 242.

MATH 333. Thry Functions Real Variables. 3 Credits.
Lebesgue measure and integration theory, Monotone and Dominated Convergence Theorems and applications, product measures, basic theory of LP-spaces. Prerequisite: MATH 242.

MATH 337. Numerical Diff Equations. 3 Credits.
Numerical solution and analysis of differential equations: initial-value and boundary-value problems; finite difference and finite element methods. Prerequisites: MATH 121; MATH 122 or MATH 124; MATH 230 or MATH 271 or MATH 237 recommended.

MATH 339. Partial Differential Equations. 3 Credits.
Classification of equations, linear equations, first order equations, second order elliptic, parabolic, and hyperbolic equations, uniqueness and existence of solutions. Prerequisite: MATH 230.

MATH 349. Nonlinear Partial Diff Eqs. 3 Credits.
This course covers modern mathematical theories and numerical methods for nonlinear partial differential equations. Topics include: inverse scattering transform; solitons; bilinear method; Darboux transformation; solitary waves; Vakhitov-Kolokolov stability criterion; transverse instability; virial theorem; wave collapse; pseudo-spectral method; split-step method. Prerequisites: MATH 330 (or equivalent) or Instructor permission.

MATH 350. Abstract Algebra III. 3 Credits.
Advanced group theory and field theory. Prerequisites: MATH 252 or Graduate standing.

MATH 351. Topics in Algebra. 3 Credits.
Topics will vary each semester and may include algebraic number theory, algebraic geometry, and the arithmetic of elliptic curves. Repeatable for credit with Instructor permission. Topics vary by offering; periodic offering at intervals that may exceed four years. Prerequisite: MATH 252.

MATH 352. Abstract Algebra IV. 3 Credits.
Ring theory and module theory at the graduate level, with emphasis on commutative algebra. Prerequisite: MATH 350.

MATH 354. Algebraic Topology. 3 Credits.
Homotopy, Seifert-van Kampen Theorem; simplicial, singular, and Cech homology. Prerequisite: MATH 241 or MATH 254.

MATH 373. Topics in Combinatorics. 3 Credits.
Topics will vary each semester and may include combinatorial designs, coding theory, topological graph theory, cryptography. Topics vary by offering; periodic offering at intervals that may exceed four years. Prerequisite: MATH 251 or MATH 273.

MATH 390. Internship. 1-18 Credits.
On-site supervised work experience combined with a structured academic learning plan directed by a faculty member or a faculty-staff team in which a faculty member is the instructor of record, for which academic credit is awarded. Offered at department discretion.

MATH 391. Master's Thesis Research. 1-18 Credits.

MATH 392. Independent Study. 1-18 Credits.
A course which is tailored to fit the interests of a specific student, which occurs outside the traditional classroom/laboratory setting under the supervision of a faculty member, for which credit is awarded. Offered at department discretion.

MATH 394. Independent Graduate Research. 1-18 Credits.
Graduate student work on individual or small team research projects under the supervision of a faculty member, for which credit is awarded. Offered at department discretion.

MATH 395. Advanced Special Topics. 1-18 Credits.
Subject will vary from year to year. May be repeated for credit.

MATH 490. Internship. 1-18 Credits.
On-site supervised work experience combined with a structured academic learning plan directed by a faculty member or a faculty-staff team in which a faculty member is the instructor of record, for which academic credit is awarded. Offered at department discretion.

MATH 491. Doctoral Dissertation Research. 1-18 Credits.

MATH 494. Independent Graduate Research. 1-18 Credits.
Graduate student work on individual or small team research projects under the supervision of a faculty member, for which credit is awarded. Offered at department discretion.

MATH 496. Advanced Special Topics. 1-18 Credits.
See Schedule of Courses for specific titles.

Statistics Courses

STAT 200. QR: Med Biostat&Epidemiology. 3 Credits.
Introductory design and analysis of medical studies. Epidemiological concepts, case-control and cohort studies. Clinical trials. Students evaluate statistical aspects of published health science studies. Prerequisite: STAT 111, STAT 141, STAT 143, or STAT 211.

STAT 201. QR:Stat Computing&Data Anlysis. 3 Credits.
Fundamental data processing, code development, graphing and analysis using statistical software packages, including SAS and R. Analysis of data and interpretation of results. Project-based. Prerequisite: STAT 141 or STAT 143 or STAT 211; or STAT 111 with Instructor permission.

STAT 211. QR: Statistical Methods I. 3 Credits.
Fundamental concepts for data analysis and experimental design. Descriptive and inferential statistics, including classical and nonparametric methods, regression, correlation, and analysis of variance. Statistical software. Prerequisite: Minimum Junior standing or STAT 141 or STAT 143 and Instructor permission.

STAT 221. QR: Statistical Methods II. 3 Credits.
Multiple regression and correlation. Basic experimental design. Analysis of variance (fixed, random, and mixed models). Analysis of covariance. Computer software usage. Prerequisite: STAT 143 or STAT 211 with a grade of C or better; or STAT 141 and Instructor permission.

STAT 223. QR:Appld Multivariate Analysis. 3 Credits.
Multivariate normal distribution. Inference for mean vectors and covariance matrices. Multivariate analysis of variance (MANOVA), discrimination and classification, principal components, factor and cluster analysis. Prerequisite: STAT 221, matrix algebra recommended.

STAT 224. QR:Stats for Qualty&Productvty. 3 Credits.
Statistical process control; Shewhart, cusum and other control charts; process capability studies. Total Quality Management. Acceptance, continuous, sequential sampling. Process design and improvement. Case studies. Prerequisite: STAT 141, STAT 143, or STAT 211.

STAT 229. QR:Survivl/Logistic Regression. 3 Credits.
Models and inference for time-to-event and binary data. Censored data, life tables, Kaplan-Meier estimation, logrank tests, proportional hazards models. Logistic regression-interpretation, assessment, model building, special topics. Prerequisite: STAT 221.

STAT 231. QR: Experimental Design. 3 Credits.
Randomization, complete and incomplete blocks, cross-overs, Latin squares, covariance analysis, factorial experiments, confounding, fractional factorials, nesting, split plots, repeated measures, mixed models, response surface optimization. Prerequisite: STAT 221; or STAT 211 and STAT 201.

STAT 235. QR: Categorical Data Analysis. 3 Credits.
Measures of association and inference for categorical and ordinal data in multiway contingency tables. Log linear and logistic regression models. Prerequisite: STAT 211.

STAT 241. QR: Statistical Inference. 3 Credits.
Introduction to statistical theory: related probability fundamentals, derivation of statistical principles, and methodology for parameter estimation and hypothesis testing. Prerequisites: A grade of C or better in one of STAT 151, STAT 153, or STAT 251; STAT 141 or equivalent; MATH 121.

STAT 251. QR: Probability Theory. 3 Credits.
Distributions of random variables and functions of random variables. Expectations, stochastic independence, sampling and limiting distributions (central limit theorems). Concepts of random number generation. Prerequisite: MATH 121; STAT 151 or STAT 153 recommended.

STAT 253. QR:Appl Time Series&Forecastng. 3 Credits.
Autoregressive moving average (Box-Jenkins) models, autocorrelation, partial correlation, differencing for nonstationarity, computer modeling. Forecasting, seasonal or cyclic variation, transfer function and intervention analysis, spectral analysis.

STAT 261. QR: Statistical Theory. 3 Credits.
Point and interval estimation, hypothesis testing, and decision theory. Application of general statistical principles to areas such as nonparametric tests, sequential analysis, and linear models. Prerequisite: STAT 251.

STAT 287. QR: Data Science I. 3 Credits.
Data harvesting, cleaning, and summarizing; working with non-traditional, non-numeric data (social network, natural language textual data, etc.); scientific visualization using static and interactive infographics; a practical focus on real datasets, and developing good habits for rigorous and reproducible computational science; Project-based. Prerequisites: CS 020 or CS 021; STAT 141 or STAT 143 or STAT 211; CS 110 and MATH 122/124 recommended. Cross-listed with: CS 287, CSYS 287.

STAT 288. QR: Statistical Learning. 3 Credits.
Statistical learning methods and applications to modern problems in science, industry, and society. Topics include: linear model selection, cross-validation, lasso and ridge regression, tree-based methods, bagging and boosting, support vector machines, and unsupervised learning. Prerequisites: STAT 143, STAT 183 or STAT 211. Cross-listed with: CS 288.

STAT 330. Bayesian Statistics. 3 Credits.
Introduction to Bayesian inference. Posterior inference, predictive distributions, prior distribution selection. MCMC algorithms. Hierarchical models. Model checking and selection. Use of computer software. Pre/co-requisite: STAT 241 or STAT 251 or Instructor permission.

STAT 360. Linear Models. 3 Credits.
Theory of linear models, least squares and maximum likelihood estimation, fixed, random and mixed models, variance component estimation, introduction to generalized linear models, bootstrapping. Prerequisites: STAT 261 and knowledge of matrix algebra or Instructor permission.

STAT 369. Applied Geostatistics. 3 Credits.
Introduction to the theory of regionalized variables, geostatistics (kriging techniques): special topics in multivariate analysis; Applications to real data subject to spatial variation are emphasized. Prerequisites: STAT 223; CS 020 or CS 021; or Instructor permission. Cross-listed with: CE 369, CSYS 369.

STAT 381. Statistical Research. 1-3 Credits.
Methodologic or data analytic research culminating in oral and written reports to the faculty. Prerequisite: Instructor permission.

STAT 385. Consulting Practicum. 1-3 Credits.
Supervised field work in statistical consulting. Experiences may include advising UVM faculty and students or clients in applied settings such as industry and government agencies. Prerequisites: Second year Graduate standing in Statistics or Biostatistics and permission of Statistics Program Director.

STAT 387. Data Science II. 3 Credits.
Advanced data analysis, collection, and filtering; statistical modeling, monte carlo statistical methods, and in particular Bayesian data analysis, including necessary probabilistic background material; a practical focus on real datasets and developing good habits for rigorous and reproducible computational science. Prerequisite: STAT 287 or CS 287 or CSYS 287 or Instructor permission. Cross-listed with: CS 387, CSYS 387.

STAT 391. Master's Thesis Research. 1-6 Credits.

STAT 392. Independent Study. 1-18 Credits.
A course which is tailored to fit the interests of a specific student, which occurs outside the traditional classroom/laboratory setting under the supervision of a faculty member, for which credit is awarded. Offered at department discretion.

STAT 395. Advanced Special Topics. 1-18 Credits.
Lectures or directed readings on advanced and contemporary topics not presently included in other statistics courses. Prerequisites: As listed in schedule of courses.