MATHEMATICAL SCIENCES
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 Program 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, algebraic and computational topology, arithmetic geometry, combinatorics/graph theory, complex systems, computational social science, Fourier/harmonic analysis, logic, mathematical cryptography, network science, number theory, topological data analysis, biomathematics, fluid mechanics, numerical methods for, and analytical theories of, partial differential equations, as well as 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
Mathematical Sciences M.S.
Mathematics M.S.T.
Mathematical Sciences Ph.D.

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
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
Patania, Alice; Research Assistant Professor, Department of Mathematics and Statistics; PHD, Politecnico di Torino
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; Assistant Professor, Department of Mathematics and Statistics; PHD, Université Laval
Yu, Jun; Professor, Department of Mathematics and Statistics; PHD, University of Washington Seattle

Mathematics Courses
MATH 5230. 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 3230.

MATH 5360. 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 Mobius transformations. Prerequisites: MATH 2055 or CS 1640; MATH 2248, MATH 2522, or MATH 2544; or Instructor permission.

MATH 5678. 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 2055.

MATH 5737. Gr Intro to Numerical Anyl. 3 Credits.
Error analysis, root-finding, interpolation, least squares, quadrature, linear equations, numerical solution of ordinary differential equations. Prerequisite: Graduate student or Instructor permission. Cross-listed with: CS 5737.

MATH 5766. Gr Chaos,Fractals&Dynmcl Systm. 3 Credits.
Discrete and continuous dynamical systems, Julia sets, the Mandelbrot set, period doubling, renormalization, Henon map, phase plane analysis and Lorenz equations. Prerequisites: Graduate student or Instructor permission. Cross-listed with: CSYS 5766.

MATH 5775. 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 2248; MATH 2522, MATH 2544, MATH 3230, or MATH 3201.
MATH 5788. 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. Prerequisites: MATH 2522 or MATH 2544; MATH 3230 or MATH 3201; or Instructor permission.

MATH 5990. Special Topics. 1-18 Credits.
See Schedule of Courses for specific titles.

MATH 6230. 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 3230.

MATH 6249. 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. Prerequisite: MATH 5230 (or equivalent) or Instructor permission.

MATH 6334. Algebraic Topology. 3 Credits.
Homotopy, Seifert-van Kampen Theorem; simplicial, singular, and Cech homology. Prerequisite: MATH 3468 or MATH 4344.

MATH 6391. Master's Thesis Research. 1-18 Credits.
Research for the Master's Thesis.

MATH 6441. 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 3472.

MATH 6444. 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 3472.

MATH 6551. Abstract Algebra III. 3 Credits.
Advanced group theory and field theory. Prerequisite: MATH 3555 or Graduate student.

MATH 6555. Abstract Algebra IV. 3 Credits.
Ring theory and module theory at the graduate level, with emphasis on commutative algebra. Prerequisite: MATH 6551.

MATH 6678. Topics in Combinatorics. 3 Credits.
Topics will vary each semester and may include combinatorial designs, coding theory, topological graph theory, cryptography. Prerequisite: MATH 3551 or MATH 5678.

MATH 6701. 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 6701.

MATH 6713. 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 6701, CSYS 6701, calculus, and statistics required. Cross-listed with: CSYS 6713.

MATH 6737. 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 2248; MATH 2522 or MATH 2544; MATH 3230, MATH 3201, or MATH 3737 recommended.

MATH 6990. Special Topics. 1-18 Credits.
Subject will vary from year to year. May be repeated for credit.

MATH 6991. 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 6993. 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 6995. Graduate Independent 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 7491. Doctoral Dissertation Research. 1-18 Credits.
Research for the Doctoral Dissertation.

MATH 7990. Special Topics. 1-18 Credits.
See Schedule of Courses for specific titles.

MATH 7991. 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 7995. Graduate Independent 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.
Statistics Courses

STAT 5000. Biostatistics and 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. Understand the relevance of published public health research to clinical practice. Prerequisite: Graduate student or Instructor permission.

STAT 5010. Gr Applied Data Analysis. 3 Credits.
Fundamental data processing, code development, graphing and analysis using statistical software packages. Analysis of data and interpretation of results. Project-based. Prerequisites: Graduate student or Instructor permission; content knowledge of STAT 1410, STAT 2430, or STAT 3210 assumed.

STAT 5210. Advanced Stat Methods & Theory. 3 Credits.
Parametric and non-parametric two-sample tests. Multiple regression and correlation. Matrix representations. Basic experimental design. Analysis of variance (fixed, random, and mixed models). Statistical Software usage. Prerequisites: Graduate student or Instructor permission; content knowledge of STAT 2830 assumed.

STAT 5230. 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 3210, matrix algebra recommended.

STAT 5290. 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: Graduate student or Instructor permission; content knowledge of STAT 3210 or STAT 5210 assumed.

STAT 5310. 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. Prerequisites: Graduate student or Instructor permission; content knowledge of STAT 3210 or STAT 5210 or STAT 5210 assumed; content knowledge of STAT 5010 recommended.

STAT 5350. 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: Graduate student or Instructor permission; content knowledge of STAT 3210 or STAT 5210 assumed.

STAT 5510. 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. Prerequisites: Graduate student or Instructor permission; content knowledge of MATH 2248, STAT 2510 assumed.

STAT 5530. 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 5610. 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 5510.

STAT 5870. Data Science I - Experience. 3 Credits.
Data harvesting, cleaning, and summarizing; working with non-traditional, non-numeric data (social network, natural language textual data, etc.); scientific visualization; advanced data pipelines with a practical focus on real datasets and developing good habits for rigorous and reproducible computational science; Project-based. Prerequisites: Graduate student; Instructor permission; knowledge of CS 1210 and either STAT 1410 or STAT 2430 assumed; knowledge of CS 2100 and MATH 2522 or MATH 2544 strongly recommended. Cross-listed with: CSYS 5870, CS 5870.

STAT 5990. Special Topics. 1-18 Credits.
See Schedule of Courses for specific titles.

STAT 6300. Bayesian Statistics. 3 Credits.

STAT 6391. Master’s Thesis Research. 1-6 Credits.
Research for the Master’s Thesis.

STAT 6600. 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. Prerequisite: Content knowledge of MATH 2522 or MATH 2544 assumed.

STAT 6810. Statistical Research. 1-3 Credits.
Methodologic or data analytic research culminating in oral and written reports to the faculty. Prerequisite: Instructor permission.

STAT 6850. 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 student in Statistics or Biostatistics; permission of Statistics Program Director.
STAT 6870. 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 3870, CS 3870, CSYS 5870, or Instructor permission. Cross-listed with: CS 6870, CSYS 6870.

STAT 6990. 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.

STAT 6993. 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 7980. 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 5230, CS 1210; or Instructor permission. Cross-listed with: CEE 7980, CSYS 7980.