

## MATHEMATICS AND STATISTICS IN THE COLLEGE OF ARTS AND SCIENCES

<https://www.uvm.edu/cems/mathstat> (<https://www.uvm.edu/cems/mathstat/>)

The Department of Mathematics and Statistics resides in the College of Engineering and Mathematics Sciences. The College of Arts and Sciences offers a B.A. in Mathematics while CEMS offers a B.S. in Mathematics.

### COLLEGE OF ARTS AND SCIENCES MATHEMATICS MAJOR

Mathematics is an independent field of study valued for precision of thought and intrinsic beauty, as well as a rich source of techniques and methods with infinite practical applications. The Department takes great pride in making sure that both of these aspects of mathematics are well represented in the curriculum. Students are encouraged to pursue their talent for finding innovative solutions to complex problems. Many also acquire expertise in other fields, such as physics, chemistry, biology, medicine, engineering, and computer science.

UVM's Mathematics and Statistics Department keeps its classes small, allowing close student-faculty interactions. Talented faculty members teach all levels, from introductory to advanced courses, while also editing major international journals, engaging in research, and writing fundamental textbooks used all over the world. Students go into such diverse fields as computer science, business, law, and government organizations such as the National Security Agency.

Majors may pursue their degrees either through the University's College of Engineering and Mathematical Sciences (B.S.) or the College of Arts and Sciences (B.A.).

### MAJORS

#### MATHEMATICS AND STATISTICS MAJORS

Mathematics B.A. (<http://catalogue.uvm.edu/undergraduate/artsandsciences/mathematicsandstatistics/mathematicsba/>)

### MINORS

#### MATHEMATICS AND STATISTICS MINORS

These minors are administered by the College of Engineering and Mathematical Sciences and are available to all UVM undergraduates.

Mathematics: Pure (<http://catalogue.uvm.edu/undergraduate/engineeringandmathematicalsciences/mathematicsandstatistics/mathematicspureminor/>)

Statistics (<http://catalogue.uvm.edu/undergraduate/engineeringandmathematicalsciences/mathematicsandstatistics/statisticsminor/>)

### GRADUATE

Mathematics AMP

Mathematics M.S.

Mathematics M.S.T.

Mathematical Sciences Ph.D.

Statistics AMP

Statistics M.S.

See the online Graduate Catalogue (<http://catalogue.uvm.edu/graduate/>) for more information.

### Mathematics Courses

#### **MATH 009. QR: College Algebra. 3 Credits.**

Sets, relations, functions with particular attention to properties of algebraic, exponential, logarithmic functions, their graphs and applications in preparation for MATH 019. May not be taken for credit concurrently with, or following receipt of, credit for any mathematics course numbered MATH 019 or above. Pre/co-requisites: Two years of secondary school algebra; one year of secondary school geometry.

#### **MATH 010. QR: Pre-Calculus Mathematics. 3 Credits.**

Skills in working with numerical, algebraic, and trigonometric expressions are developed in preparation for MATH 021. May not be taken for credit concurrently with, or following receipt of, credit for any mathematics course numbered MATH 021 or above. Prerequisite: Two years of secondary school algebra; one year of secondary school geometry.

#### **MATH 015. QR: Elementary School Math. 3 Credits.**

Operations with real numbers: decimals, fractions, percents, integers. Set operations, Venn diagrams, algebra, and problem solving provide background for future instruction in elementary/middle school mathematics. Prerequisite: Three years of secondary school math.

#### **MATH 016. QR: Fund Cncpts Elm School Math. 3 Credits.**

Topics include geometry, measurement, probability, statistics, algebra, number theory, and problem solving to provide background for future instruction in elementary and middle school mathematics. Prerequisite: Three years of secondary school math.

#### **MATH 017. QR: Applications of Finite Math. 3 Credits.**

Introduction to mathematics of finite systems with applications, such as probability, statistics, graph theory, fair division and apportionment problems, voting systems. Prerequisites: Two years of secondary school algebra or MATH 009 or MATH 010.

#### **MATH 018. QR: Basic Mathematics. 3 Credits.**

Data, statistics, modeling, algebra, word problems, calculus. Students who do well in the algebra section may continue with MATH 019 or MATH 021. Prerequisite: three years of high school math. No credit for CEMS students.

**MATH 019. QR: Fundamentals of Calculus I. 3 Credits.**

Introduction to limits and differential/integral calculus with a wide variety of applications. Students interested in intensive use of mathematics should take MATH 021. Credit not given for more than one of the courses MATH 019, MATH 021 unless followed by MATH 022. See MATH 023. Prerequisite: MATH 009 or MATH 010, or sufficiently strong background in secondary school algebra and geometry.

**MATH 020. QR: Fundamentals of Calculus II. 3 Credits.**

Techniques and applications of integration. An introduction to multi-variable calculus: partial derivatives and double integrals. Students completing MATH 020 may be admitted to MATH 022; however, MATH 019 and MATH 023 is preferable to MATH 019. Prerequisite: MATH 019 or MATH 021.

**MATH 021. QR: Calculus I. 4 Credits.**

Introduction to calculus of functions of one variable including: limits, continuity, techniques and applications of differentiation and integration. Prerequisites: MATH 010. Credit not given for more than one course in the pair MATH 019, MATH 021 unless followed by MATH 022 or MATH 023.

**MATH 022. QR: Calculus II. 4 Credits.**

Vectors and vector operations. Techniques and applications of integration. Polar coordinates, Taylor polynomials, sequences and series, power series. Prerequisite: C- or better in MATH 021. Credit will not be given for both MATH 022 and MATH 023.

**MATH 023. QR: Transitional Calculus. 5 Credits.**

Intended to make the transition from a B or better in MATH 019 to MATH 121. Topics are similar to MATH 022 but recognizing different backgrounds of students in MATH 019 versus MATH 021. Prerequisite: B or better in MATH 019. Credit will not be given for both MATH 022 and MATH 023.

**MATH 030. QR: Algebra for Educators. 3 Credits.**

Algebraic concepts and relationships are explored and developed. Linear, quadratic, and exponential functions are featured. Prerequisite: 3 credits of Math numbered 015 or above.

**MATH 040. Geometry for Educators. 3 Credits.**

An examination of geometric relationships using reasoning and proof. Topics include Euclidean, non-Euclidean and finite geometries, affine transformations, constructions, and spatial geometry. Provides background for future instruction in middle and high school geometry. Prerequisites: Three credits of Mathematics at MATH 015 or above, minimum Sophomore standing.

**MATH 052. QR: Fundamentals of Mathematics. 3 Credits.**

Emphasizing proofs, fundamental mathematical concepts and techniques are investigated within the context of number theory and other topics. Prerequisite: MATH 021 or MATH 023. Credit not given for more than one of MATH 052, MATH 054 and CS 064.

**MATH 090. Internship. 1-3 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 092. 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 095. Special Topics. 1-18 Credits.**

Introductory courses or seminars on topics beyond the scope of existing departmental offerings. See Schedule of Courses for specific titles. Prerequisite: Instructor permission.

**MATH 120. Eng Math Linear Algebra Lab. 1 Credit.**

Survey of the fundamental concepts of linear algebra necessary to describe the solution space of a linear differential equation and for solving systems of linear differential equations. May not be taken after MATH 122 or MATH 124. Prerequisite: MATH 021. Co-requisites: MATH 022 or MATH 023.

**MATH 121. QR: Calculus III. 4 Credits.**

Vector-valued functions. Calculus of functions of several variables: partial derivatives, gradient, divergence, curl, multiple integrals, line integrals, Stokes' and Green's theorems. Prerequisite: C- or better in MATH 022 or MATH 023.

**MATH 122. QR: Applied Linear Algebra. 3 Credits.**

Vectors, matrices, linear independence, vector spaces (with focus on real  $n$ -space), determinants, linear transformations, eigenvalues and eigenvectors. Applications from engineering and the sciences incorporated through required computer assignments. Credit not given for both MATH 122 and MATH 124. Prerequisite: MATH 022 or MATH 023.

**MATH 124. QR: Linear Algebra. 3 Credits.**

Vector spaces, linear independence, bases, linear transformations, matrices, determinants, change of basis characteristic equations, eigenvalues and eigenvectors, with applications. Emphasis on understanding and gaining facility with these concepts including proofs. Credit not given for both MATH 122 and MATH 124. Prerequisite: MATH 022 or MATH 023. Co-requisite: MATH 121 or MATH 052.

**MATH 141. QR: Real Anlysis in One Variable. 3 Credits.**

Principles of analysis in one variable. Heine-Borel and Bolzano-Weierstrass theorems; rigorous development of differential and integral calculus; infinite sequences and series of functions. May not be taken concurrently with or after MATH 241. Prerequisite: MATH 052 (preferred) or CS 064.

**MATH 151. QR: Groups and Rings. 3 Credits.**

An introduction to the basic concepts of abstract algebra emphasizing examples, including modular arithmetic, symmetric groups, cyclic groups, polynomial rings, homomorphisms, and isomorphisms. May not be taken concurrently with or after MATH 251. Prerequisite: MATH 052 (preferred) or CS 064.

**MATH 161. Development of Mathematics. 3 Credits.**

Project-based course. Historical development of mathematical sciences emphasizing interrelations among them. Individual assignments correspond to background and interests of students. Prerequisite: Nine hours of college mathematics.

**MATH 166. QR: Intro to Complex Systems. 3 Credits.**

Discrete dynamical systems, continuous time models, chaos, cobweb plots, cellular automata, agent based models, fractals, and introductory network science (including dynamic network models). May not be taken for credit concurrently with, or following receipt of, credit for any of MATH/CSYS 266/300/302/303. Prerequisites: MATH 021 and familiarity with a programming language.

**MATH 173. QR: Basic Combinatorial Theory. 3 Credits.**

Introduction to basic combinatorial principles emphasizing problem-solving techniques. Enumeration, generating functions, Fibonacci numbers, pigeonhole principle, inclusion-exclusion, and graph theory. Prerequisites: MATH 052 (preferred) or CS 064.

**MATH 183. QR: Fundamentals of Financial Math. 3 Credits.**

Students will be introduced to the basic ideas and algebraic structures of interest theory, time-value of money, annuities, loans, bonds, cash-flows and portfolios. Prerequisites: MATH 020, MATH 022 or MATH 023.

**MATH 190. 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 192. 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. Prerequisite: Junior/Senior standing; approval of Department Chair.

**MATH 193. College Honors. 1-3 Credits.**

Honors studies leading to thesis. Prerequisite: CEMS 101.

**MATH 194. College Honors. 1-3 Credits.****MATH 195. Special Topics. 1-18 Credits.**

See Schedule of Courses for specific titles.

**MATH 197. Teaching Assistantship. 1-3 Credits.**

Undergraduate student service as a teaching assistant, usually in an introductory level course in the discipline, for which credit is awarded. Offered at department discretion.

**MATH 198. Undergraduate Research. 1-18 Credits.**

Undergraduate 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 230. QR: Ordinary Differential 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 & Analysis. 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: Analysis in Several Real Variables 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: Analysis in Several Real Variables 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&Dynamical 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 284. Capstone Experience. 1-3 Credits.**

Focused exploration of topics from all areas of mathematics through individual/team projects including a major paper and presentation. Prerequisites: MATH 052; MATH 122 or MATH 124; Junior standing; Mathematics major.

**MATH 290. 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 292. 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 293. Undergraduate Honors Thesis. 3-4 Credits.**

Program of reading and research culminating in written thesis and oral presentation. Honors notation appears on transcript and Commencement Program. Contact department chairperson for procedures. Prerequisite: CEMS 101.

**MATH 294. Undergraduate Honors Thesis. 3-4 Credits.**

Program of reading and research culminating in written thesis and oral presentation. Honors notation appears on transcript and Commencement Program. Contact department chairperson for procedures.

**MATH 295. Special Topics. 1-18 Credits.**

For advanced students in the indicated fields. Lectures, reports, and directed readings on advanced topics. Credit as arranged. Offered as occasion warrants.

**MATH 297. Teaching Assistantship. 1-3 Credits.**

Undergraduate student service as a teaching assistant, usually in an introductory level course in the discipline, for which credit is awarded. Offered at department discretion.

**MATH 298. Undergraduate Research. 1-18 Credits.**

Undergraduate 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 051. QR:Probability With Statistics. 3 Credits.**

Introduction to probabilistic and statistical reasoning, including probability distribution models and applications to current scientific/social issues. Roles of probability, study design, and exploratory/confirmatory data analysis. Prerequisite: Two years high school algebra. No credit for Sophomores, Juniors, or Seniors in the mathematical and engineering sciences.

**STAT 052. D2:QR: Stat & Social Justice. 3 Credits.**

Introduction to probabilistic and statistical reasoning, including applications to current scientific/social issues, with special focus on issues of poverty, criminal justice, environmental justice, and voting, and impact on diverse and disadvantaged populations. Prerequisites: Two years High School algebra; no credit for Sophomores, Juniors, or Seniors in the mathematical and engineering sciences; credit for only one of STAT 051 and STAT 052.

**STAT 087. QR: Intro to Data Science. 3 Credits.**

Basic techniques of data harvesting and cleaning; association rules, classification, clustering; analyze, manipulate, visualize data using programming languages. Basic principles of probability and statistical modeling/inference to make meaning out of large datasets. No credit given after STAT 200 or greater. Cross-listed with: CS 087.

**STAT 090. Internship. 1-3 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.

**STAT 092. 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 095. Special Topics. 1-18 Credits.**

Lectures, reports, and directed readings at an introductory level. Prerequisite: As listed in schedule of courses.

**STAT 111. QR: Elements of Statistics. 3 Credits.**

Basic statistical concepts, methods, and applications, including correlation, regression, confidence intervals, and hypothesis tests. Prerequisites: Two years of high school algebra.

**STAT 141. QR:Basic Statistical Methods 1. 3 Credits.**

Foundational course for students taking further quantitative courses. Exploratory data analysis, probability distributions, estimation, hypothesis testing. Introductory regression, experimentation, contingency tables, and nonparametrics. Computer software used. Credit not awarded for more than one of STAT 141 or STAT 143.

**STAT 143. QR: Statistics for Engineering. 3 Credits.**

Data analysis, probability models, parameter estimation, hypothesis testing. Multi-factor experimental design and regression analysis. Quality control, SPC, reliability. Engineering cases and project. Statistical analysis software. Credit not given for more than one of STAT 141 or STAT 143. Prerequisites: MATH 020 or MATH 022; Sophomore standing.

**STAT 151. QR: Applied Probability. 3 Credits.**

Foundations of probability, conditioning, and independence. Business, computing, biological, engineering reliability, and quality control applications. Classical discrete and continuous models. Pseudo-random number generation. Prerequisites: MATH 020 or MATH 022 or MATH 023.

**STAT 181. Introduction to Coding in R. 1 Credit.**

Fundamentals of coding in the R programming language, including base package and other packages, for the purpose of data wrangling, data visualization, data analysis and modeling. Prerequisite: Any introductory-level or intermediate-level Statistics course. Pre/Co-requisite: Minimum Sophomore standing.

**STAT 183. QR:Basic Statistical Methods 2. 3 Credits.**

Quantitative statistical methodologies useful across disciplines. Analysis of variance, multiple and logistic regression, time series analysis, non-parametric methods, Bayesian statistics and decision analysis. Prerequisite: A grade of C or better in any of STAT 141, STAT 143, STAT 211, or EC 170.

**STAT 187. QR: Basics of Data Science. 3 Credits.**

Basic data science techniques, from import to cleaning to visualizing and modeling, using the R language. Machine learning methods include regression, classification and clustering algorithms. Programming methods include user-defined functions. Prerequisite: STAT 111 or STAT 141 or STAT 143 or STAT 211. Cross-listed with: CS 187.

**STAT 190. 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.

**STAT 191. 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. Prerequisites: Junior standing; permission of Program Director.

**STAT 195. Intermediate Special Topics. 1-18 Credits.**

Lectures, reports, and directed readings. Prerequisite: As listed in schedule of courses.

**STAT 197. Teaching Assistantship. 1-3 Credits.**

Undergraduate student service as a teaching assistant, usually in an introductory level course in the discipline, for which credit is awarded. Offered at department discretion.

**STAT 198. Undergraduate Research. 1-18 Credits.**

Undergraduate 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.

**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 Analysis. 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: Applied 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 Quality & Productivity. 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: Survival/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: Applied Time Series & Forecasting. 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 281. Capstone Experience. 1-3 Credits.**

Intensive experience in carrying out a complete statistical analysis for a research project in substantive area with close consultation with a project investigator. Project-based. Prerequisite: STAT 200 or STAT 201 or STAT 221 through STAT 237 or STAT 253; some statistical software experience; Instructor permission.

**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 290. 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.

**STAT 291. 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 293. Undergrad Honors Thesis. 1-18 Credits.**

A program of reading, research, design, and analysis culminating in a written thesis and oral defense. Honors notation appears on transcript and Commencement Program. Contact Statistics Program Director for procedures. Prerequisite: CEMS 101.

**STAT 294. Undergrad Honors Thesis. 1-8 Credits.**

A program of reading, research, design, and analysis culminating in a written thesis and oral defense. Honors notation appears on transcript and Commencement Program. Contact Statistics Program Director for procedures.

**STAT 295. Advanced Special Topics. 1-18 Credits.**

For advanced students. Lectures, reports, and directed readings on advanced topics. Prerequisite: As listed in schedule of courses.

**STAT 297. Teaching Assistantship. 1-3 Credits.**

Undergraduate student service as a teaching assistant, usually in an introductory level course in the discipline, for which credit is awarded. Offered at department discretion.

**STAT 298. Undergraduate Research. 1-18 Credits.**

Undergraduate 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.