STATISTICS AND PROBABILITY   STT

Department of Statistics and Probability
College of Natural Science

180   Introduction to Data Science
Fall, Spring. 4(4-0) Interdepartmental with Computational Mathematics, Science, & Engineering. Administered by Statistics and Probability. P: (MTH 124 or concurrently) or (MTH 132 or concurrently) or (MTH 152H or concurrently) or (LB 118 or concurrently) Not open to students with credit in STT 301.
Pervasiveness and utility of data in modern society. Obtaining and managing data. Summarizing and visualizing data. Ethical issues in data science. Communication with data. Fundamentals of probability and statistics.

191   Selected Topics in Statistics
Fall, Spring. 1 to 4 credits. A student may earn a maximum of 8 credits in all enrollments for this course.
Topics in statistics and probability selected to complement existing courses.

200   Statistical Methods
Fall, Spring, Summer. 3(4-0) P: (MTH 101 or MTH 102 or MTH 103 or MTH 110 or MTH 116 or MTH 124 or MTH 132 or LB 118) or designated score on Mathematics Placement test R: Open to undergraduate students. Not open to students with credit in STT 201 or STT 421.
Data analysis, probability models, random variables, estimation, tests of hypotheses, confidence intervals, and simple linear regression.

201   Statistical Methods
Fall, Spring, Summer. 4(3-2) P: (MTH 101 or MTH 102 or MTH 103 or MTH 110 or MTH 116 or MTH 124 or MTH 132 or LB 118) or designated score on Mathematics Placement test R: Open to undergraduate students. Not open to students with credit in STT 200 or STT 421.
Probability and statistics with computer applications. Data analysis, probability models, random variables, tests of hypotheses, confidence intervals, simple linear regression. Weekly lab using statistical software.

224   Introduction to Probability and Statistics for Ecologists
Spring. 3(2-2) Interdepartmental with Fisheries and Wildlife. Administered by Statistics and Probability. P: MTH 103 or MTH 116 or (MTH 124 or concurrently) or (MTH 132 or concurrently) or (MTH 152H or concurrently) or (LB 118 or concurrently) RB: BS 162 or BS 182H or LB 144 SA: FW 324 Not open to students with credit in STT 231.
Probability and statistics with computer applications for the analysis, interpretation and presentation of ecological data. Data analysis, probability models, random variables, estimation, confidence intervals, test of hypotheses, and simple linear regression with applications to ecology.

231   Statistics for Scientists
Fall, Spring, Summer. 3(4-0) P: MTH 124 or MTH 132 or MTH 152H or LB 118 R: Open to students in the College of Natural Science and open to students in the Lyman Briggs College. SA: STT 331
Calculus-based course in probability and statistics. Probability models, and random variables. Estimation, confidence intervals, tests of hypotheses, and simple linear regression with applications in sciences.

250   Statistics and Probability for K-8 Teachers
Spring. 4(4-0) P: MTH 103 R: Open to undergraduate students in the College of Education or approval of department.
Data collection and analysis. Statistics, probability models. Decision-making in the presence of variability. Computer software relevant for teaching practice.

290   Topics in Statistics and Probability
Fall, Spring, Summer. 1 to 3 credits. RB: MTH 103 R: Approval of department.
Individualized study of selected topics.

301   Computational Methods for Data Science
Fall. 3(3-0) P: (MTH 132 or LB 118 or MTH 152H) and (STT 200 or STT 201 or STT 231 or STT 315 or STT 421 or STT 441)
Obtaining and managing data using statistical software. Data visualization and graphics. Special challenges in working with high-dimensional data.

315   Introduction to Probability and Statistics for Business
Fall, Spring, Summer. 3(4-0) P: MTH 124 or MTH 132 or MTH 152H or LB 118
A first course in probability and statistics primarily for business majors. Data analysis, probability models, random variables, confidence intervals, and tests of hypotheses with business applications.

317   Market Analytics
Fall, Spring, Summer. 3(3-0) Interdepartmental with Marketing. Administered by Marketing. P: STT 200 or STT 201 or STT 315 or STT 351 R: Open to sophomores or juniors or seniors in the Accounting major or in the Business - Admitted major or in the Finance Major or in the Human Resource Management Major or in the Management Major or in the Supply Chain Management Major or in the Marketing Major or in the Applied Engineering Sciences Major. SA: MSC 317
Descriptive and predictive market analytics. Applications of analytics to real-world business decisions. Assessment and manipulation of large datasets. Application of statistical techniques to convert data into useable information. Communication of findings in a meaningful way.

351   Probability and Statistics for Engineering
Fall, Spring, Summer. 3(3-0) P: MTH 234 or MTH 254H or LB 220 Not open to students with credit in STT 430.
Probability models and random variables. Estimation, confidence intervals, tests of hypotheses, simple linear regression. Applications to engineering.

380   Probability and Statistics for Data Science
Fall, Spring. 4(4-0) P: ((MTH 234 or concurrently) or (MTH 254H or concurrently) or (LB 220 or concurrently)) and (MTH 314 or concurrently) and STT 180
Fundamental concepts and methods in probability and statistics from a data science perspective.

381   Fundamentals of Data Science Methods
Fall, Spring. 4(4-0) Interdepartmental with Computational Mathematics, Science, & Engineering. Administered by Computational Mathematics, Science, & Engineering. P: (STT 180 and MTH 314 and CMSE 201 and STT 380) or (STT 180 and MTH 314 and CMSE 201 and STT 441 and STT 442)
Data science methods, including unsupervised learning and supervised learning, feature extraction, dimension reduction, clustering, regression and classification.

404   Introduction to Machine Learning
Fall. 3(3-0) Interdepartmental with Computational Mathematics, Science, & Engineering and Computer Science and Engineering. Administered by Computer Science and Engineering. P: (CSE 331) and (STT 351 or STT 380 or STT 430 or STT 441) and MTH 314 RB: Basic linear algebra R: Open to juniors or seniors in the College of Engineering or in the Computer Science Minor or in the Lyman Briggs Computer Science Coordinate Major or in the Lyman Briggs Computer Science Major or in the Data Science Major.
Core principles and techniques for machine learning including algorithms, model design, and programming.

421   Statistics I
Fall, Spring, Summer. 3(3-0) P: MTH 103 or MTH 110 or MTH 116 Not open to students with credit in STT 200 or STT 201.
Basic probability, random variables, and common distributions. Estimation and tests for one-, two-, and paired sample problems. Introduction to simple linear regression and correlation, one-way ANOVA.

422   Statistics II
Fall, Spring, Summer. 3(3-0) P: STT 421 or STT 441 Not open to students with credit in STT 464.
Goodness of fit and other non-parametric methods. Linear models including multiple regression and ANOVA for simple experimental designs.

STT—Statistics and Probability

430   Introduction to Probability and Statistics
Fall, Spring, Summer. 3(3-0) P: (MTH 234 or concurrently) or (MTH 254H or concurrently) or (LB 220 or concurrently) Not open to students with credit in STT 351.
Calculus-based probability and statistics with applications. Discrete and continuous random variables and their expectations. Point and interval estimation, tests of hypotheses, and simple linear regression.

441   Probability and Statistics I: Probability
Fall, Spring, Summer. 3(3-0) P: MTH 234 or MTH 254H or LB 220 or approval of college
Probability, conditional probability and independence. Random variables. Discrete, continuous, univariate, and multivariate distributions. Expectation and its properties, moment generating functions. Law of large numbers, central limit theorem.

442   Probability and Statistics II: Statistics
Fall, Spring. 3(3-0) P: STT 441 and (MTH 309 or MTH 314 or MTH 317H or MTH 415)
Parameter estimation, sampling distributions, confidence intervals, hypothesis testing, simple and multiple regression, analysis of variance. Time series models, data analysis and forecasting

455   Actuarial Models I
Fall. 3(3-0) Interdepartmental with Mathematics. Administered by Statistics and Probability. P: STT 441 and MTH 360
Stochastic models used in insurance. Survival distributions, life insurance, life annuities, benefit premiums, benefit reserves, and analysis of benefit reserves.

456   Actuarial Models II
Spring. 3(3-0) Interdepartmental with Mathematics. Administered by Statistics and Probability. P: STT 455
Continuation of STT 455. Benefit reserves. Multiple life functions. Multiple decrement models and their applications. Elements of stochastic processes for actuaries including Markov chains and Poisson processes

458   Financial Mathematics for Actuaries II
Fall. 3(3-0) Interdepartmental with Mathematics. P: MTH 361 and STT 441 RB: MTH 235 or MTH 340 or MTH 347H
Evaluate and construct interest rate models. Rational valuation of derivative securities using put-call parity and calculation of European and American options. Risk management techniques using the method of delta-hedging.

459   Construction and Evaluation of Actuarial Models
Spring. 3(3-0) Interdepartmental with Mathematics. Administered by Statistics and Probability. P: STT 442
Severity, frequency, and aggregate models. Construction of empirical models. Parametric statistical methods. Credibility analysis. Simulation methods.

461   Computations in Probability and Statistics
Spring. 3(3-0) P: (STT 441 and CSE 231) and (MTH 309 or MTH 314 or MTH 317H or MTH 415)
Computer algorithms for evaluation, simulation and visualization. Sampling and prescribed distributions. Robustness and error analysis of procedures used by statistical packages. Graphics for data display, computation of probabilities and percentiles.

464   Statistics for Biologists
Fall. 3(3-0) Interdepartmental with Animal Science and Crop and Soil Sciences. Administered by Statistics and Probability. P: MTH 103 or MTH 110 or MTH 116 or MTH 132 RB: STT 421
Biological random variables. Estimation of population parameters. Testing hypotheses. Linear correlation and regression. Analyses of counted and measured data to compare several biological groups including contingency tables and analysis of variance.

465   Bayesian Statistical Methods
Fall. 3(3-0) A student may earn a maximum of 0 credits none Interdepartmental with Epidemiology. Administered by Statistics and Probability. P: STT 442
Probability, belief, and exchangeability. Objective, subjective, and empirical Bayes approaches. Applications to one-parameter models, linear regression models, and multivariate normal models. Hierarchical modeling. Computational methods.

467   Insurance Operations
Spring. 3(3-0) Interdepartmental with Mathematics. Administered by Statistics and Probability. P: (ACC 230 and FI 321 and MTH 360) and completion of Tier I writing requirement RB: STT 441
Regulation, marketing and distribution, underwriting, risk control, premium auditing, the claim function, actuarial operations, and reinsurance.

468   Predictive Analytics
Spring. 3(3-0) Interdepartmental with Mathematics. Administered by Mathematics. P: (CSE 231) and (MTH 235 or MTH 340) and MTH 360 and STT 442
Predictive analytics for insurance business and risk management with an emphasis on the use of machine learning tools.

481   Capstone in Statistics (W)
Spring. 3(3-0) P: (STT 442 or approval of department) and completion of Tier I writing requirement R: Open to seniors in the Department of Statistics and Probability or approval of department.
Selected readings and projects illustrating special problems encountered by statisticians in their roles as consultants, educators, researchers and analysts.

490   Directed Study of Statistical Problems
Fall, Spring, Summer. 1 to 3 credits. A student may earn a maximum of 9 credits in all enrollments for this course. R: Open to seniors in the Department of Statistics and Probability. Approval of department.
Individualized study of selected topics.

492   Selected Topics in Data Science
Fall, Spring. 1 to 4 credits. A student may earn a maximum of 12 credits in all enrollments for this course. Interdepartmental with Computational Mathematics, Science, & Engineering and Computer Science and Engineering. Administered by Computational Mathematics, Science, & Engineering. R: Approval of department.
Topics selected to supplement and enrich existing courses in Data Science.

495   Experiential Learning in Data Science (W)
Fall, Spring. 4(2-4) Interdepartmental with Computational Mathematics, Science, & Engineering and Computer Science and Engineering. Administered by Computational Mathematics, Science, & Engineering. P: (CSE 232 and CMSE 382) and completion of Tier I writing requirement R: Open to seniors.
Team-based data science projects on realistic, large-scale data.

800   Quantitative Foundations for Machine Learning
Fall. 3(3-0)
Fall: Lansing. Interdepartmental with Mathematics. Administered by Mathematics. P: MTH 132 and MTH 133 or approval of department
Advanced calculus and linear algebra tools for machine learning algorithms.

801   Design of Experiments
Fall of even years. 3(3-0) RB: STT 422 or STT 442 or STT 471
Blocking and randomization. Split-plot, latin square and factorial designs. Fractional factorial designs, aliasing and confounding of effects. Mixture and central composite designs and response surface exploration. Clinical trials.

802   Statistical Computation
Fall of even years. 3(3-0) RB: (STT 442 and MTH 309) or (mathematical statistics and linear algebra)
Computational techniques commonly used in Statistics. Matrix decompositions. Least squares and Least Absolute Deviations. Solution of nonlinear equations. Optimization techniques including the EM algorithm and constrained optimization. Numerical integration. Generation of random numbers and stochastic simulation. Implementation in statistical software.

804   Statistical Consulting and Practice
Fall. 3(3-0) R: Open to master's students in the College of Natural Science. Approval of department.
Statistical consulting and the practical aspects of the consulting environment. Ethics. Communication skills. Data management, and statistical methods.

805   Statistical Modeling for Business Analytics
Summer. 3(3-0) RB: STT 442 R: Open to master's students in the Business Analytics Major.
Low dimensional data visualization. Simple linear regression. Regression diagnostics. Analysis of variance. Multiple linear regression. Regression model building. Variable selection. Categorical data. Logistic regression. Proportional odds model. Introduction to time series.

808   Biostatistics I
Fall. 3(3-0) Interdepartmental with Epidemiology. Administered by Epidemiology. RB: College-level algebra. R: Open to master's students or doctoral students in the Epidemiology major or approval of department. SA: STT 425
Applications of probability and statistics in the applied health sciences. Probability distributions, estimation and tests for one-, two-, and paired samples, linear regression, correlation, and ANOVA. Use of statistical software. Critical appraisal of statistical methods in the biomedical literature.

809   Biostatistics II
Spring. 3(3-0) Interdepartmental with Epidemiology. P: EPI 808 RB: MTH 103 or MTH 110 or MTH 116 R: Open to master's students or doctoral students in the Epidemiology major or approval of department. SA: STT 426
Analysis of categorical data in epidemiologic studies. Contingency tables and logistic regression.

814   Advanced Statistics for Biologists
Spring. 4(3-2) Interdepartmental with Animal Science and Crop and Soil Sciences. Administered by Statistics and Probability. RB: STT 464
Concepts of reducing experimental error for biological and agricultural research. Covariance, randomized block designs, latin squares, split plots, repeated-measures designs, regression applications, and response surface designs. Analyses using statistical software.

820A   Econometrics IA
Fall. 3(3-0) Interdepartmental with Economics. Administered by Economics. R: Open only to doctoral students in the Economics major or the Department of Agricultural Economics or the Business Administration major or approval of department.
Statistical tools for econometrics. Applications of statistical tools, including probability distributions, estimation, hypothesis testing, and maximum likelihood to econometric problems.

825   Sample Surveys
Fall. 3(3-0) RB: STT 422 or STT 442 or STT 862
Application of statistical sampling theory to survey designs. Simple random, stratified, and systematic samples. Sub-sampling, double sampling. Ratio and regression estimators.

843   Multivariate Analysis
Spring of even years. 3(3-0) RB: STT 442 or STT 862 Not open to students with credit in FW 850.
Multivariate normal distribution, tests of hypotheses on means, multivariate analysis of variance. Discriminant analysis. Principal components. Factor analysis. Analysis of frequency data.

844   Time Series Analysis
Spring of odd years. 3(3-0) RB: STT 442 or STT 862
Stationary time series. Autocorrelation and spectra. ARMA and ARIMA processes: estimation and forecasting. Seasonal ARIMA models. Identification and diagnostic techniques. Multivariate time series. Time series software.

847   Analysis of Survival Data
Spring of odd years. 3(3-0) Interdepartmental with Epidemiology. Administered by Statistics and Probability. RB: STT 422 or STT 442 or STT 862
Analysis of lifetime data. Estimation of survival functions for parametric and nonparametric models. Censored data. The Cox proportional hazards model. Accelerated failure time models. Frailty models. Use of statistical software packages.

849   Applied Bayesian Inference using Monte Carlo Methods for Quantitative Biologists
Fall of even years. 3(2-2) Interdepartmental with Animal Science and Fisheries and Wildlife. Administered by Fisheries and Wildlife. RB: (STT 814 and IBIO 851) or equivalent courses. R: Not open to undergraduate students.
Applications of Bayesian inference using software in quantitative biology and genetics. Hierarchical and non-hierarchical models. Model checking, model selection and model comparison. Markov chain Monte Carlo methods.

855   Statistical Genetics
Fall of odd years. 3(3-0) RB: STT 442 or STT 862
Probabilistic and statistical methods for genetic linkage and association studies. Quantitative trait locus mapping.

860   Advanced Inference for Biostatistics
Fall. 3(3-0) Interdepartmental with Epidemiology. Administered by Epidemiology. P: STT 861 and (STT 862 or concurrently) or approval of department RB: Masters in statistics or biostatistics R: Open to doctoral students in the Department of Epidemiology and Biostatistics or approval of department.
Statistical inference problems with biomedical applications.

861   Theory of Probability and Statistics I
Fall. 3(3-0) RB: MTH 234 and MTH 309
Probability models, random variables and vectors. Special distributions including exponential family. Expected values, covariance matrices, moment generating functions. Convergence in probability and distribution. Weak Law of Large Numbers and Lyapunov Central Limit Theorem.

862   Theory of Probability and Statistics II
Spring. 3(3-0) P: STT 861
Statistical inference: sufficiency, estimation, confidence intervals and testing of hypotheses. One and two sample nonparametric tests. Linear models and Gauss-Markov Theorem.

863   Statistical Methods I
Fall. 3(3-0) RB: (STT 442 or STT 862) and MTH 415 SA: STT 841
Introduction to the general theory of linear models. Application of regression models. Interval estimation, prediction and hypothesis testing. Contrasts; model diagnostics; model selection. LASSO type and high dimensional variable selection. Introduction to Linear mixed effect models.

864   Statistical Methods II
Spring. 3(3-0) P: STT 863
Generalized linear models(GLMs). Deviance and residual analysis in GLMs. Analysis of two-way and three-way contingency tables. Logistic regression. Log-linear models. Multicategorical response models. Poisson regression. Introduction to generalized estimating equations. Introduction to longitudinal data. Bayesian analysis using WinBUGS.

866   Spatial Data Analysis
Fall. 4(3-2) Interdepartmental with Geography. Administered by Geography. RB: (GEO 363 or STT 421 or STT 430) or equivalent quantitative methods courses. SA: GEO 466
Theory and techniques for statistical analysis of point patterns, spatially continuous data, and data in spatial zones.

867   Linear Model Methodology
Fall. 3(3-0) P: STT 862 R: Open to doctoral students in the Department of Statistics and Probability or approval of department.
Properties of the multivariate normal distribution, Cochran's Theorem, simple and multiple linear regression models, Gauss-Markov Theorem, best linear unbiased prediction, one- and two-way ANOVA models, sums of squares, diagnostics and model selection, contingency tables and multinomial models, generalized linear models, logistic regression.

868   Mixed Models: Theory, Methods and Applications
Spring. 3(3-0) P: STT 867 R: Open to doctoral students in the Statistics major or approval of department.
Maximum likelihood estimation and other estimation methods for linear mixed models. Statistical properties of LME models. Prediction under LME models. Generalized linear mixed models. Quasi-likelihood estimation, generalized estimating equations for GLMM. Nonlinear mixed models. Diagnostics and influence analysis. Bayesian development in mixed linear models. Application of mixed models.

872   Statistical Inference I
Spring. 3(3-0) P: STT 862 and STT 881 R: Open to doctoral students in the Statistics major or approval of department.
Statistical distributions, decision-theoretic formulation of estimation and testing of hypotheses, sufficiency, Rao-Blackwellization, admissibility, Bayes and minimax estimation, maximum likelihood estimation, inference based on order statistics, Neyman-Pearson Lemma and applications, multiple testing.

873   Statistical Learning and Data Mining
Fall of odd years. 3(3-0) P: STT 868 and STT 872 R: Open to doctoral students in the Statistics major or approval of department.
Statistical methods focusing on machine learning and data mining, modern regression and classification techniques, support vector machines, boosting, kernel methods and ensemble methods, clustering dimension reduction, manifold learning, and selected topics.

STT—Statistics and Probability

874 **Introduction to Bayesian Analysis**
Fall of even years. 3(3-0) P: STT 868 and STT 872 R: Open to doctoral students in the Statistics major or approval of department.
Bayesian methods including empirical Bayes, hierarchical Bayes and nonparametric Bayes, computational methods for Bayesian inference including the Gibbs Sampler and Metropolis-Hastings method, and applications.

875 **R Programming for Data Sciences** Summer. 3(3-0) Interdepartmental with Forestry. Administered by Forestry.
Programming in R and use of associated open source tools. Addressing practical issues in documenting workflow, data management, and scientific computing.

881 **Theory of Probability I**
Fall. 3(3-0) P: STT 861 and MTH 421 R: Open to doctoral students in the Statistics major or approval of department.
Measures and their extensions, integration. Lp spaces and Inequalities. Lebesgue decomposition, the Radon-Nikodym theorem. Product measures, Fubini's theorem. Kolmogorov consistency theorem. Independence, Kolmogorov's zero-one law, the Borel-Cantelli lemma. Law of large numbers. Central limit theorems, characteristic functions, the Lindeberg-Feller theorem, asymptotic normality of sample median. Poisson convergence. Conditional expectations.

882 **Theory of Probability II**
Spring. 3(3-0) P: STT 881 R: Open to doctoral students in the Statistics major or approval of department.
Random walks, transience and recurrence. Martingales, martingale convergence theorem, Doob's inequality, optional stopping theorem. Stationary processes and Ergodic theorem. Brownian motion. Kolmogorov's continuity theorem, strong Markov property, the reflection principle, martingales related to Brownian motion. Weak convergence in C([0,1]) and D([0,1]), Donsker's invariance principle, empirical processes.

886 **Stochastic Processes and Applications**
Fall. 3(3-0) RB: STT 441 or STT 861
Markov chains and their applications in both discrete and continuous time, including classification of states, recurrence, limiting probabilities. Queuing theory, Poisson process and renewal theory.

888 **Stochastic Models in Finance**
Spring of even years. 3(3-0) RB: STT 441 or STT 861 SA: STT 887
Stochastic models used in pricing financial derivatives. Discrete-time models. Brownian motion. Stochastic integrals and Ito's formula. Basic Black-Scholes model. Risk neutral distribution. European and American options. Exotic options. Interest rate market, futures, and interest rate options.

890 **Statistical Problems**
Fall, Spring, Summer. 1 to 3 credits. A student may earn a maximum of 24 credits in all enrollments for this course. R: Approval of department.
Individualized study on selected problems.

899 **Master's Thesis Research**
Fall, Spring, Summer. 1 to 6 credits. A student may earn a maximum of 36 credits in all enrollments for this course. R: Approval of department.
Master's thesis research.

914 **Advanced Organizational Research Methods**
Spring. 3(3-0) Interdepartmental with Management. Administered by Management. P: MGT 906
Methods for empirically testing scientific theories in organizational contexts.

920 **Advanced Methods in Epidemiology and Applied Statistics**
Spring. 3(3-0) Interdepartmental with Epidemiology. Administered by Epidemiology. P: (EPI 826B or concurrently) or EPI 826 or approval of department R: Open to graduate students in the Department of Epidemiology and Biostatistics or approval of department.
Pattern recognition and cluster analysis, longitudinal data analysis, path analysis, repeated measures and time-series analysis.

951 **Statistical Inference II**
Spring of odd years. 3(3-0) P: STT 872 and STT 882 R: Open to doctoral students in the Statistics major or approval of department.
Decision theoretic estimation: Minimaxity, admissibility, shrinkage estimators, James-Stein estimators. Advanced estimation theory, maximal invariant tests, multiple testing, FDR, and related methods. Permutation and rank tests, unbiasedness and invariance, Hunt Stein theorem.

953 **Asymptotic Theory**
Spring of even years. 3(3-0) P: STT 872 and STT 882 R: Open to doctoral students in the Statistics major or approval of department.
Locally asymptotic normal models, empirical likelihood, U-statistics, Asymptotically efficient and adaptive procedures

961 **Weak Convergence and Asymptotic Theory**
Fall of odd years. 3(3-0) P: STT 872 and STT 882 R: Open to doctoral students in the Statistics major or approval of department.
Maximal inequalities, covering numbers, symmetrization technique, Glivenko-Cantelli Theorems, Donsker Theorems and some results for Gaussian processes, Vapnik-Chervonenkis classes of sets and functions, applications to M-estimators, bootstrap, delta-method

962 **Fractional Processes and Power Laws**
Spring of even years. 3(3-0) P: STT 872 and STT 882 R: Open to doctoral students in the Statistics major or approval of department.
Self-similar processes. Fractional Brownian motion, fractional stable motions. Fractional calculus, Laplace and Fourier transforms, semigroups and generators. Continuous time random walks. Connections between long range dependence, heavy tails, and fractional calculus. Inference for processes with long range dependence and heavy tails, including fractional ARIMA models, ARCH/GARCH models, and random difference equations.

964 **Stochastic Analysis**
Spring of even years. 3(3-0) RB: STT 882
Stochastic integrals and semi-martingales, Ito formula, stochastic differential equations. Applications.

990 **Problems in Statistics and Probability**
Fall, Spring, Summer. 1 to 3 credits. A student may earn a maximum of 6 credits in all enrollments for this course. RB: STT 872 R: Approval of department.
Individual study on an advanced topic in statistics or probability.

996 **Advanced Topics in Probability**
Fall, Spring, Summer. 3(3-0) A student may earn a maximum of 15 credits in all enrollments for this course. RB: STT 882 R: Approval of department.
Current topics in probability.

997 **Advanced Topics in Statistics**
Fall, Spring, Summer. 3(3-0) A student may earn a maximum of 15 credits in all enrollments for this course. RB: STT 872 R: Approval of department.
Topics selected from non- and semi parametric statistics, multivariate analysis, time series analysis, Bayesian statistics, regression and kernel estimation, and other topics in advanced statistics.

999 **Doctoral Dissertation Research**
Fall, Spring, Summer. 1 to 24 credits. A student may earn a maximum of 36 credits in all enrollments for this course. R: Approval of department.
Doctoral dissertation research.