# STATISTICS (STAT)

**Courses primarily for undergraduates:**

**STAT 1010: Principles of Statistics**
Credits: 4. Contact Hours: Lecture 3, Laboratory 2.
Statistical concepts in modern society; descriptive statistics and graphical displays of data; the normal distribution; data collection (sampling and designing experiments); elementary probability; elements of statistical inference; estimation and hypothesis testing; linear regression and correlation; contingency tables. 1 1/2 years of high school algebra required. Graduation Restriction: Credit for only one of the following courses may be applied toward graduation: STAT 1010, STAT 1040, STAT 1050, STAT 2010, or STAT 2260. (Typically Offered: Fall, Spring, Summer)

**STAT 1040: Introduction to Statistics**
Credits: 3. Contact Hours: Lecture 2, Laboratory 2.
Statistical concepts and their use in science; collecting, organizing and drawing conclusions from data; elementary probability; binomial and normal distributions; regression; estimation and hypothesis testing. For students in the agricultural and biological sciences. 1 1/2 years of high school algebra required. Graduation Restriction: Credit for only one of the following courses may be applied toward graduation: STAT 1010, STAT 1040, STAT 1050, STAT 2010, or STAT 2260. (Typically Offered: Fall, Spring, Summer)

**STAT 1100: Orientation in Statistics**
Credits: 1. Contact Hours: Lecture 1.
Opportunities, challenges, and the scope of the curriculum in statistics. For students planning or considering a career in this area. Offered on a satisfactory-fail basis only. (Typically Offered: Fall)

**STAT 2010: Introduction to Statistical Concepts and Methods**
Credits: 4. Contact Hours: Lecture 3, Laboratory 2.
*Prereq: Credit or Enrollment in* MATH 1650
Statistical thinking and applications of statistical concepts and methods in modern society. Display and summary of categorical and numerical data. Exploring relationships between variables, association, correlation, and regression. Observational studies and experiments. Probability concepts, random variables, discrete and continuous distributions. Elements of statistical inference; estimation and hypothesis testing. Graduation Restriction: Credit for only one of the following courses may be applied toward graduation: STAT 1010, STAT 1040, STAT 1050, STAT 2010, or STAT 2260. Credit for both STAT 1050 and STAT 3050 may not be applied toward graduation. (Typically Offered: Spring)

**STAT 2020: Career Development in Math and Statistics**
(Cross-listed with MATH 2020).
Credits: 1. Contact Hours: Laboratory 2.
Career development in the mathematics and statistics disciplines with an emphasis on contemporary social issues. Presentations by professionals in STEM fields about occupations, decision-making strategies, and career goal implementation; development of job searching, resume writing, negotiating, and interviewing techniques. Offered on a satisfactory-fail basis only. (Typically Offered: Spring)

**STAT 2260: Introduction to Business Statistics I**
Credits: 3. Contact Hours: Lecture 3.
*Prereq:* MATH 1500 *or* MATH 1650
Obtaining, organizing, and presenting statistical data; measures of location and dispersion; the Normal distribution; sampling and sampling distribution of the sample mean; elements of statistical inference; confidence intervals and hypothesis testing for the mean; describing bivariate relationships and inference for simple linear regression analysis; use of computers to visualize and analyze data. Graduation Restriction: Credit for only one of the following courses may be applied toward graduation: STAT 1010, STAT 1040, STAT 1050, STAT 2010, or STAT 2260. (Typically Offered: Fall, Spring, Summer)

**STAT 2310: Probability and Statistical Inference for Engineers**
Credits: 4. Contact Hours: Lecture 4.
*Prereq: Credit or Coenrollment in* MATH 2650
Emphasis on engineering applications. Basic probability; random variables and probability distributions; joint and sampling distributions. Descriptive statistics; confidence intervals; hypothesis testing; simple linear regression; multiple linear regression; one way analysis of variance; use of statistical software. (Typically Offered: Fall, Spring)

**STAT 2610X: Statistics in Sports**
Credits: 3. Contact Hours: Lecture 3.
Introduction the use of statistical, quantitative, and graphical techniques for analysis of sports data. Focus on understanding the types of data that arise in sports and the probability distributions associated with those data types including binomial, Poisson, and normal. Introduction to regression techniques that incorporate variables that affect these distributions. Discussion of head-to-head competitions and the inherent complexities in analyzing data of this type. (Typically Offered: Fall, Spring, Summer)

**STAT 3010: Intermediate Statistical Concepts and Methods**
Credits: 4. Contact Hours: Lecture 3, Laboratory 2.
*Prereq: One of* STAT 1010*, 1040, 1050, 2010, 2260, 2310, 3050, 3220, 3300*
Statistical concepts and methods used in the analysis of observational data. Analysis of single sample, two sample and paired sample data. Simple and multiple linear regression including polynomial regression and use of indicator variables. Model building and analysis of residuals. Introduction to one-way ANOVA, tests of independence for contingency tables, and logistic regression. Graduation Restriction: Credit for only one of the following courses may be applied toward graduation: STAT 3010, STAT 3260, STAT 4010, or STAT 5870. (Typically Offered: Fall, Spring)

**STAT 3050: Engineering Statistics**
Credits: 3. Contact Hours: Lecture 3.
*Prereq:* MATH 1650
Statistics for engineering problem solving. Principles of engineering data collection; descriptive statistics; elementary probability distributions; principles of experimentation; confidence intervals and significance tests; one-, two-, and multi-sample studies; regression analysis; use of statistical software. Graduation Restriction: Credit for both STAT 1050 and STAT 3050 may not be applied toward graduation. (Typically Offered: Fall, Spring, Summer)

**STAT 3220: Probabilistic Methods for Electrical Engineers**
(Cross-listed with EE 3220).
Credits: 3. Contact Hours: Lecture 3.
*Prereq:* EE 2240
Introduction to probability with applications to electrical engineering. Sets and events, probability space, conditional probability, total probability and Bayes' rule. Discrete and continuous random variables, cumulative distribution function, probability mass and density functions, expectation, moments, moment generating functions, multiple random variables, functions of random variables. Elements of statistics, hypothesis testing, confidence intervals, least squares. Introduction to random processes. (Typically Offered: Fall, Spring)

**STAT 3260: Introduction to Business Statistics II**
Credits: 3. Contact Hours: Lecture 2, Laboratory 2.
*Prereq:* STAT 2260
Multiple regression analysis; regression diagnostics; model building; applications in analysis of variance and time series; random variables; distributions; conditional probability; use of computers to visualize and analyze data. Graduation Restriction: Credit for only one of the following courses may be applied toward graduation: STAT 3010, STAT 3260, STAT 4010, or STAT 5870. (Typically Offered: Fall, Spring, Summer)

**STAT 3300: Probability and Statistics for Computer Science**
Credits: 3. Contact Hours: Lecture 3.
*Prereq:* MATH 1660
Topics from probability and statistics applicable to computer science. Basic probability; Random variables and their distributions; Stochastic processes including Markov chains; Queuing models; Basic statistical inference; Introduction to regression. (Typically Offered: Fall, Spring, Summer)

**STAT 3320: Visual Communication of Quantitative Information**
(Cross-listed with ENGL 3320).
Credits: 3. Contact Hours: Lecture 3.
*Prereq:* ENGL 2500*; (*STAT 1010 *or* STAT 1040 *or STAT 1050 or* STAT 2010 *or* STAT 2310 *or* STAT 3050 *or* STAT 3220 *or* STAT 3300*)*
Communicating quantitative information using visual displays; visualizing data; interactive and dynamic data displays; evaluating current examples in the media; color, perception, and representation in graphs; interpreting data displays.

**STAT 3410: Introduction to the Theory of Probability and Statistics I**
(Cross-listed with MATH 3410).
Credits: 4. Contact Hours: Lecture 3, Laboratory 2.
*Prereq: MATH 2650 or MATH 2650H*
Probability; distribution functions and their properties; classical discrete and continuous distribution functions; multivariate probability distributions and their properties; moment generating functions; transformations of random variables; simulation of random variables and use of the R statistical package. Graduation Restriction: Credit for only one of the following courses may be applied toward graduation: STAT 3410, STAT 3470, STAT 4470, or STAT 5880. (Typically Offered: Fall, Spring)

**STAT 3420: Introduction to the Theory of Probability and Statistics II**
(Cross-listed with MATH 3420).
Credits: 4. Contact Hours: Lecture 3, Laboratory 2.
*Prereq: (*MATH 2070 *or* MATH 3170*); (*STAT 1010 *or* STAT 1040 *or STAT 1050 or* STAT 2010 *or* STAT 2260 *or* STAT 2310 *or* STAT 3050 *or* STAT 3220 *or* STAT 3300*);* STAT 3410
Sampling distributions; confidence intervals and hypothesis testing; theory of estimation and hypothesis tests; linear model theory; resampling methods; introduction to Bayesian inference; use of the R statistical package for simulation and data analysis. (Typically Offered: Fall, Spring)

**STAT 3470: Probability and Statistical Theory for Data Science**
Credits: 4. Contact Hours: Lecture 4.
*Prereq: (*MATH 2070 *or* MATH 3170*);* MATH 2650*; (*STAT 3010 *or* STAT 3260*)*
Introduction to probability; distribution functions and their properties; classical discrete and continuous distributions; sampling distributions; theory of estimation; theory of inference; use of R statistical package for simulation and data analysis. Graduation Restriction: Credit for only one of the following courses may be applied toward graduation: STAT 3410, STAT 3470, STAT 4470, or STAT 5880. (Typically Offered: Fall)

**STAT 3610: Statistical Quality Assurance**
(Cross-listed with IE 3610).
Credits: 3. Contact Hours: Lecture 3.
*Prereq:* STAT 2310*,* STAT 3010*,* STAT 3260*, or* STAT 5870
Statistical methods for process improvement. Simple quality assurance principles and tools. Measurement system precision and accuracy assessment. Control charts. Process capability assessment. Experimental design and analysis for process improvement. Significant external project in process improvement. (Typically Offered: Fall, Spring)

**STAT 3980: Cooperative Education**
Credits: Required. Repeatable.
*Prereq: Department Chair Permission for Course*
Off-campus work periods for undergraduate students in a field of statistics. (Typically Offered: Fall, Spring, Summer)

**STAT 4610X: Sports Analytics**
Credits: 3. Contact Hours: Lecture 3.
Sports analytics refers to the use of statistical, quantitative, and graphical techniques for analysis of sports data. Focus on head-to-head sports and the calculation of relevant statistics, e.g., plus-minus and adjusted plus-minus statistics that attempt to quantify individual contributions to a team's performance. Rating and ranking systems and their relationship to statistical models and estimation of these ratings will be described. (Typically Offered: Fall, Spring, Summer)

**STAT 4710: Introduction to Experimental Design**
(Dual-listed with STAT 5710).
Credits: 3. Contact Hours: Lecture 3.
*Prereq:* STAT 3010 *or* STAT 3260 *or* STAT 5870
The role of statistics in research and the principles of experimental design. Concepts of experimental and observational units, randomization, replication, blocking, subdividing and repeatedly measuring experimental units; factorial treatment designs and confounding; common designs including randomized complete block design, Latin square design, split-plot design, and analysis of data from such common designs; extensions of the analysis of variance to cover variance components. Determining sample size. Graduation Restriction: Credit in only one of STAT 4020, STAT 4710, or STAT 5710 may be applied to graduation. May not be used for graduate credit in the Statistics MS and PhD degree programs. (Typically Offered: Fall, Spring)

**STAT 4720: Introduction to Time Series**
(Dual-listed with STAT 5720).
Credits: 3. Contact Hours: Lecture 3.
*Prereq:* STAT 3010 *or* STAT 3260 *or* STAT 5260 *or* STAT 5870
Methods for analyzing data collected over time; review of multiple regression analysis. Elementary forecasting methods: moving averages and exponential smoothing. Autoregressive-moving average (Box-Jenkins) models: identification, estimation, diagnostic checking, and forecasting. Transfer function models and intervention analysis. Introduction to multivariate time series methods. Graduation Restriction: Credit for only one of STAT 4510, STAT 4720, or STAT 5720 may be applied to graduation. May not be used for graduate credit in the Statistics MS and PhD degree programs. (Typically Offered: Spring)

**STAT 4730: Introduction to Survey Sampling**
(Dual-listed with STAT 5730).
Credits: 3. Contact Hours: Lecture 2, Laboratory 2.
*Prereq: (*STAT 3010 *or* STAT 3260 *or STAT 4010 or* STAT 5870*); (*STAT 3410 *or* STAT 3470 *or STAT 4470 or* STAT 5880*)*
Concepts of sample surveys and the survey process; methods of designing sample surveys, including: simple random, stratified, systematic, probability proportional to size, and multistage sampling designs; methods of analyzing sample surveys including ratio, regression, domain estimation and nonresponse. (Typically Offered: Spring)

**STAT 4740: Introduction to Bayesian Data Analysis**
(Dual-listed with STAT 5740).
Credits: 3. Contact Hours: Lecture 2, Laboratory 2.
*Prereq: (*STAT 3010 *or* STAT 3260 *or STAT 4010 or* STAT 5870*); (*STAT 3410 *or* STAT 3470 *or STAT 4470 or* STAT 5880*)*
Probability models and prior distributions; updating priors through the likelihood function. Computational and simulation-based methods for deriving posterior distributions and for estimating parameters. Basic statistical and hierarchical models. Model adequacy and posterior predictive checks. Markov Chain Monte Carlo methods and introduction to WinBUGS or similar software. Emphasis on applications and examples from the social, biological and physical sciences. Graduation Restriction: Credit for only one of STAT 4440, STAT 4740, or STAT 5740 may be applied to graduation. May not be used for graduate credit in the Statistics MS and PhD degree programs. (Typically Offered: Spring)

**STAT 4750: Introduction to Multivariate Data Analysis**
(Dual-listed with STAT 5750).
Credits: 3. Contact Hours: Lecture 2, Laboratory 2.
*Prereq:* STAT 3010 *or* STAT 3260 *or* STAT 5870
Statistical and graphical methods for displaying and analyzing multivariate data including plotting high-dimensional data using interactive graphics; organizing and summarizing analyses of multivariate data; comparing two group mean vectors; multivariate analysis of variance; reducing variable dimension with principal components; identifying factors with exploratory factor analysis; grouping observations with multidimensional scaling and cluster analysis; classification; R statistical software package and using Rstudio to create reports (RMarkdown and GGplot). Knowledge of linear algebra recommended. Graduation Restriction: Credit for only one of STAT 4070, STAT 4750, or STAT 5750 may be applied to graduation. May not be used for graduate credit in the Statistics MS and PhD degree programs. (Typically Offered: Fall)

**STAT 4760: Introduction to Spatial Data Analysis**
(Dual-listed with STAT 5760).
Credits: 3. Contact Hours: Lecture 3.
*Prereq: (*STAT 3010 *or* STAT 3260 *or STAT 4010 or* STAT 5870*); (*STAT 3410 *or* STAT 3470 *or STAT 4470 or* STAT 5880*)*
The analysis of spatial data; geostatistical methods, mapping and spatial prediction; methods for areal data; models and methods for spatial point processes. Emphasis on application and practical use of spatial statistical analysis. Use of R and R packages for spatial data analysis. Graduation Restriction: Credit for only one of STAT 4060, STAT 4760, or STAT 5760 may be applied to graduation. May not be used for graduate credit in the Statistics MS and PhD degree programs.

**STAT 4770: Introduction to Categorical Data Analysis**
(Dual-listed with STAT 5770).
Credits: 3. Contact Hours: Lecture 3.
*Prereq:* STAT 3010 *or* STAT 3260 *or* STAT 5870
Statistical methods for the analysis of categorical data: graphical summaries, estimation and inference for proportions, sample size determination, chi-square tests, measures of relative risk, odds and association, analysis of paired data and measures of agreement, logistic regression models, log-linear models. Graduation Restriction: Credit for only one of STAT 4570, STAT 4770, or STAT 5770 may be applied to graduation. May not be used for graduate credit in the Statistics MS and PhD degree programs. (Typically Offered: Spring)

**STAT 4780: Introduction to Stochastic Process Models**
(Dual-listed with STAT 5780).
Credits: 3. Contact Hours: Lecture 3.
*Prereq:* STAT 2310 *or* STAT 3410 *or* STAT 3470 *or STAT 4470 or* STAT 5880
Probabilistic models in biological, engineering and the physical sciences. Markov chains; Poisson, birth-and-death, renewal, branching and queuing processes; applications to bioinformatics and other quantitative problems. Graduation Restriction: Credit for only one of STAT 4320, STAT 4780, or STAT 5780 may be applied to graduation. May not be used for graduate credit in the Statistics MS and PhD degree programs. Offered even number years. (Typically Offered: Fall)

**STAT 4820: Regression for Social and Behavioral Research**
(Dual-listed with STAT 5820).
Credits: 3. Contact Hours: Lecture 2, Laboratory 2.
*Prereq:* STAT 3010 *or* STAT 3260 *or* STAT 5870
Applications of generalized linear regression models to social science data. Assumptions of regression; diagnostics and transformations; analysis of variance and covariance; logistic, multinomial and Poisson regression. Graduation Restriction: Credit for only one of STAT 4040, STAT 4820, or STAT 5820 may be applied to graduation. May not be used for graduate credit in the Statistics MS and PhD degree programs. (Typically Offered: Fall, Spring)

**STAT 4830: Empirical Methods for the Computational Sciences**
(Dual-listed with STAT 5830).
Credits: 3. Contact Hours: Lecture 3.
*Prereq:* STAT 3300*,* MATH 1660
Statistical methods for research involving computers; exploratory data analysis; selected topics from analysis of designed experiments - analysis of variance, hypothesis testing, interaction among variables; linear regression, logistic regression, Poisson regression; parameter estimation, prediction, confidence regions, dimension reduction techniques, model diagnostics and sensitivity analysis; Markov chains and processes; simulation techniques and bootstrap methods; applications to computer science, bioinformatics, computer engineering - programs, models and systems as objects of empirical study; communicating results of empirical studies. Statistical software: R. Knowledge of linear algebra recommended. Graduation Restriction: Credit for only one of STAT 4300, STAT 4830, or STAT 5830 may be applied to graduation. May not be used for graduate credit in the Statistics MS and PhD degree programs. (Typically Offered: Fall)

**STAT 4840: Computer Processing of Scientific Data**
(Dual-listed with STAT 5840).
Credits: 3. Contact Hours: Lecture 3.
*Prereq:* STAT 3010 *or* STAT 3260 *or* STAT 5870
Structure, content and programming aspects of modern statistical software packages. Advanced techniques for data management, graphics, exploratory data analysis, and generalized linear models.Graduation Restriction: Credit for only one of STAT 4790, STAT 4840, or STAT 5840 may be applied to graduation. May not be used for graduate credit in the Statistics MS and PhD degree programs. (Typically Offered: Fall)

**STAT 4860: Introduction to Statistical Computing**
(Dual-listed with STAT 5860).
Credits: 3. Contact Hours: Lecture 3.
*Prereq:* STAT 3010 *or* STAT 3260 *or* STAT 5870
Modern statistical computing. Topics may include: basic and advanced R programming; data management; spread sheets; verifying data accuracy; transferring data between software packages; data and graphical analysis with statistical software packages; algorithmic programming concepts and applications; simulation studies and resampling methods; software reliability; statistical modeling and machine learning. Graduation Restriction: Credit for only one of STAT 4800, STAT 4860, or STAT 5860 may be applied to graduation. May not be used for graduate credit in the Statistics MS and PhD degree programs. (Typically Offered: Spring)

**STAT 4900: Independent Study**
Credits: 1-30. Repeatable, maximum of 9 credits.
*Prereq: 10 credits in STAT; Permission of Instructor*
Graduation Restriction: No more than 9 credits in STAT 4900 may be counted toward graduation. (Typically Offered: Fall, Spring, Summer)

**STAT 4900H: Independent Study: Honors**
Credits: 1-30. Repeatable, maximum of 9 credits.
*Prereq: 10 credits in STAT; Permission of Instructor*
Graduation Restriction: No more than 9 credits in STAT 4900 may be counted toward graduation. (Typically Offered: Fall, Spring, Summer)

**Courses primarily for graduate students, open to qualified undergraduates:**

**STAT 5000: Statistical Methods I**
Credits: 4. Contact Hours: Lecture 3, Laboratory 2.
*Prereq:* STAT 5880 *or current enrollment in* STAT 5420 *or Graduate Classification*
Analysis of data from designed experiments and observational studies. Randomization-based and model-based inference on group means; pairing/blocking and other uses of restricted randomization. Model assessment and diagnostics; remedial measures; alternative approaches based on ranks. Simple linear regression, multiple linear regression, and model selection criteria. Use of linear models to analyze data; least squares estimation; estimability; sampling distributions of estimators; general linear tests; inference for parameters and contrasts. (Typically Offered: Fall)

**STAT 5010: Multivariate Statistical Methods**
Credits: 3. Contact Hours: Lecture 3.
Statistical methods for analyzing and displaying multivariate data; the multivariate normal distribution; inference in multivariate populations, simultaneous analysis of multiple responses, multivariate analysis of variance; summarizing high dimensional data with principal components, factor analysis, canonical correlations, classification methods, clustering, multidimensional scaling; introduction to basic nonparametric multivariate methods. Statistical software: SAS or R. (Typically Offered: Spring)

**STAT 5020: Applied Modern Multivariate Statistical Learning**
Credits: 3. Contact Hours: Lecture 3.
A Statistics-MS-level introduction to Modern Multivariate Statistical Learning. Theory-based methods for modern data mining and machine learning, inference and prediction. Variance-bias trade-offs and choice of predictors; linear methods of prediction; basis expansions; smoothing, regularization, kernel smoothing methods; neural networks and radial basis function networks; bootstrapping, model averaging, and stacking; linear and quadratic methods of classification; support vector machines; trees and random forests; boosting; prototype methods; unsupervised learning including clustering, principal components, and multi- dimensional scaling; kernel mechanics. Substantial use of R packages implementing these methods. Offered even-numbered years. (Typically Offered: Spring)

**STAT 5030: Exploratory Methods and Data Mining**
Credits: 3. Contact Hours: Lecture 3.
*Prereq:* STAT 5420 *or 5880 or 5790 or 5860*
Approaches to finding the unexpected in data; exploratory data analysis; pattern recognition; dimension reduction; supervised and unsupervised classification; interactive and dynamic graphical methods; computer-intensive statistical techniques for large or high dimensional data and visual inference. Emphasis is on problem solving, topical problems, and learning how so-called black-box methods actually work. Offered irregularly. (Typically Offered: Spring)

**STAT 5050: Environmental Statistics**
Credits: 3. Contact Hours: Lecture 3.
*Prereq: (*STAT 5420 *or 5880); (*STAT 5000 *or 5870)*
Statistical methods and models for environmental applications. Emphasis on environmental toxicology. Analysis of data with below detection-limit values. Dose-response curve modeling, including overdispersion and estimation of safe doses. Trend analysis; analysis of autocorrelated data. Equivalence testing.

**STAT 5060: Statistical Methods for Spatial Data**
Credits: 3. Contact Hours: Lecture 3.
*Prereq:* STAT 5420 *or 5880*
The analysis of spatial data; geostatistical methods and spatial prediction; discrete index random fields and Markov random field models; models for spatial point processes. Offered even-numbered years. (Typically Offered: Spring)

**STAT 5100: Statistical Methods II**
Credits: 3. Contact Hours: Lecture 3.
Linear models and analysis of variance for multifactor experiments with balanced and unbalanced data. Likelihood analysis for general linear models and models with non-normal random components; linear model results in the context of likelihood; linear mixed models and their application; estimation, inference, and prediction. Introduction to generalized linear models and generalized linear mixed models. Case studies of applications including problem formulation, exploratory analysis, model development, estimation and inference, and model assessment. (Typically Offered: Spring)

**STAT 5120: Design of Experiments**
Credits: 3. Contact Hours: Lecture 3.
Basic techniques of experimental design developed in the context of the general linear model; completely randomized, randomized complete block, and Latin Square designs; factorial experiments, confounding, fractional replication; split-plot and incomplete block designs. (Typically Offered: Fall)

**STAT 5130: Response Surface Methodology**
Credits: 3. Contact Hours: Lecture 3.
*Prereq:* STAT 5120 *or 5710*
Analysis techniques for locating optimum and near-optimum operating conditions: standard experimental designs for first- and second-order response surface models; design performance criteria; use of data transformations; mixture experiments; optimization for multiple-response problems. Requires use of statistical software with matrix functions.

**STAT 5150: Theory and Applications of Nonlinear Models**
Credits: 3. Contact Hours: Lecture 3.
Construction of nonlinear statistical models; random and systematic model components, additive error nonlinear regression with constant and non-constant error variances, generalized linear models, transform both sides models. Iterative algorithms for estimation and asymptotic inference. Basic random parameter models, beta-binomial and gamma-Poisson mixtures. Requires use of instructor-supplied and student-written R functions.

**STAT 5160: Statistical Design and Analysis of Gene Expression Experiments**
Credits: 3. Contact Hours: Lecture 3.
*Prereq:* STAT 5000 *and (*STAT 5420 *or* STAT 5880*)*
Introduction to high-throughput technologies for gene expression studies (especially RNA-sequencing technology): the role of blocking, randomization, and biological and technical replication in the design of gene expression experiments; normalization methods; methods for identifying differentially expressed genes including mixed linear model analysis, generalized linear model analysis, generalized linear mixed model analysis, quasi-likelihood methods, and empirical Bayes analysis; procedures for controlling false discovery rate for multiple testing; clustering problems for gene expression data; testing gene categories; emphasis on current research topics for statistical analysis of high dimensional gene expression data.

**STAT 5200: Statistical Methods III**
Credits: 3. Contact Hours: Lecture 3.
*Prereq:* STAT 5100 *AND (*STAT 5430 *or* STAT 5880*)*
Nonlinear regression; generalized least squares; asymptotic inference. Generalized linear models; exponential dispersion families; maximum likelihood and inference. Designing Monte Carlo studies; bootstrap; cross-validation. Fundamentals of Bayesian analysis; data models, priors and posteriors; posterior prediction; credible intervals; Bayes Factors; types of priors; simulation of posteriors; introduction to hierarchical models and Markov Chain Monte Carlo methods. (Typically Offered: Fall)

**STAT 5210: Theory and Applications of Sample Surveys**
Credits: 3. Contact Hours: Lecture 3.
*Prereq: (*STAT 5420 *or 5880); (*STAT 5000 *or 5870)*
Practical aspects and basic theory of design and estimation in sample surveys for finite populations. Simple random, systematic, stratified, cluster multistage and unequal-probability sampling. Horvitz-Thompson estimation of totals and functions of totals: means, proportions, regression coefficients. Linearization technique for variance estimation. Model-assisted ratio and regression estimation. Two-phase sampling and sampling on two occasions. Non-response effects. Imputation. (Typically Offered: Spring)

**STAT 5220: Advanced Applied Survey Sampling**
Credits: 3. Contact Hours: Lecture 3.
Advanced topics in survey sampling and methodology: clustering and stratification in practice, adjustments and imputation for missing data, variance estimation in complex surveys, methods of panel and/or longitudinal surveys, procedures to increase response rates, and computing. Examples are taken from large, well-known surveys in various subject areas. Offered irregularly. (Typically Offered: Fall)

**STAT 5250: Statistical Methods for Mathematics Teachers**
Credits: 6. Contact Hours: Lecture 6.
Descriptive statistics; data collection through experimentation and sampling; univariate statistical inference; contingency tables; design of experiments and ANOVA; simple linear regression; logistic regression; multiple linear regression; statistics pedagogy. (Offered on a 3-year cycle; offered SS 2020.).

**STAT 5260: Applied Statistical Modeling**
Credits: 3. Contact Hours: Lecture 3.
Probability concepts and distributions used in statistical decision-making for business applications. Least-squares and maximum likelihood estimation, sampling distributions of estimators, formal statistical inference, analysis of variance, multiple regression models and strategies for model selection, logistic regression, and Poisson regression. Applications implemented with the R statistical package. Simulations used to investigate properties of inferential procedures and to assist in data analysis. (Typically Offered: Fall)

**STAT 5280: Visual Business Analytics**
Credits: 3. Contact Hours: Lecture 3.
Types of data displays; numerical and visual summaries of data; data structures for data displays; data vs info graphics; good practices of displaying data; human perception and cognition in data displays; graphics as tools of data exploration; graphical diagnostics of statistical models and machine learning procedures; strategies and techniques for data visualizations; basics of reproducibility and repeatability; web-based interactive applets for visual presentation of data and results; programming in R. (Typically Offered: Fall)

**STAT 5310: Quality Control and Engineering Statistics**
(Cross-listed with IE 5310).
Credits: 3. Contact Hours: Lecture 3.
*Prereq:* STAT 5870 *and* STAT 5880
Statistical methods and theory applicable to problems of industrial process monitoring and improvement. Statistical issues in industrial measurement; Shewhart, CUSUM, and other control charts; feedback control; process characterization studies; estimation of product and process characteristics; acceptance sampling, continuous sampling and sequential sampling; economic and decision theoretic arguments in industrial statistics.

**STAT 5330: Reliability**
(Cross-listed with IE 5330).
Credits: 3. Contact Hours: Lecture 3.
Probabilistic modeling and inference in engineering reliability; lifetime models, product limit estimator, probability plotting, maximum likelihood estimation for censored data, Bayesian methods in reliability, system reliability models, competing risk analysis, acceleration models and analysis of accelerated test data; analysis of recurrent events and degradation data; planning studies to obtain reliability data. Offered even-numbered years. (Typically Offered: Spring)

**STAT 5340: Ecological Statistics**
Credits: 3. Contact Hours: Lecture 3.
*Prereq:* STAT 5420 *or 5880*
Statistical methods for non-standard problems, illustrated using questions and data from ecological field studies. Estimation of abundance and survival from mark-recapture studies, deterministic and stochastic matrix models of population trends, integral projection models, and hierarchical modeling, especially of population dynamics. Additional topics vary based on student interest. Offered odd-numbered years. (Typically Offered: Fall)

**STAT 5360: Statistical Genetics**
(Cross-listed with GDCB 5360).
Credits: 3. Contact Hours: Lecture 3.
Statistical models and methods for genetics covering models of population processes: selection, mutation, migration, population structure, and linkage disequilibrium, and inference techniques: genetic mapping, linkage analysis, and quantitative trait analysis. Applications include genetic map construction, gene mapping, genome-wide association studies (GWAS), inference about population structure, phylogenetic tree construction, and forensic and paternity identification.

**STAT 5420: Theory of Probability and Statistics I**
Credits: 4. Contact Hours: Lecture 4.
Sample spaces, basic probability results, conditional probability. Random variables, univariate distributions, moment generating functions. Joint distributions, conditional distributions and independence, correlation and covariance. Probability laws and transformations. Introduction to the multivariate normal distribution. Sampling distributions, normal theory, sums and order statistics. Convergence concepts, the law of large numbers, the central limit theorem and delta method. Basics of stochastic simulation. (Typically Offered: Fall)

**STAT 5430: Theory of Probability and Statistics II**
Credits: 3. Contact Hours: Lecture 3.
Point estimation including method of moments, maximum likelihood and Bayes. Properties of point estimators, mean squared error, unbiasedness, consistency, loss functions. Large sample properties of maximum likelihood estimators. Exponential families, sufficiency, completeness, ancilarity, Basu's theorem. Hypothesis tests, Neyman-Pearson lemma, uniformly most powerful tests, likelihood ratio tests, Bayes tests. Interval estimation, inverting tests, pivotal quantities. Nonparametric theory, bootstrap. (Typically Offered: Spring)

**STAT 5440: Bayesian Statistics**
Credits: 3. Contact Hours: Lecture 3.
Specification of probability models; subjective, conjugate, and noninformative prior distributions; hierarchical models; analytical and computational techniques for obtaining posterior distributions; model checking, model selection, diagnostics; comparison of Bayesian and traditional methods. (Typically Offered: Spring)

**STAT 5460: Nonparametric Methods in Statistics**
Credits: 3. Contact Hours: Lecture 3.
Overview of parametric versus nonparametric methods of inference; introduction to rank-based tests and/or nonparametric smoothing methods for estimating density and regression functions; smoothing parameter selection. Offered odd-numbered years. (Typically Offered: Fall)

**STAT 5470: Functional Data Analysis**
Credits: 3. Contact Hours: Lecture 3.
Theory and methods for analyzing functional data, which are data that take the forms of trajectories and images, possibly highly discretized and contaminated with noise. Topics include basic operations on functional data, necessary theoretical foundations, functional principal component analysis, kernel and spline smoothing, covariance modeling and estimation, dynamics modeling, concurrent regression models, functional linear models, inference for functional data, classification, and other optional topics. Offered even-numbered years. (Typically Offered: Spring)

**STAT 5510: Time Series Analysis**
Credits: 3. Contact Hours: Lecture 3.
*Prereq:* STAT 5420 *or 5880*
Concepts of trend and dependence in time series data; stationarity and basic model structures for temporal dependence; moving average and autoregressive error structures; analysis in time domain and in frequency domain; parameter estimation, prediction and forecasting; identification of appropriate model structure and model assessment techniques. Possible extended topics including non-linear models, dynamic models, state-space models. (Typically Offered: Fall)

**STAT 5540: Stochastic Process Models**
(Cross-listed with MATH 5540).
Credits: 3. Contact Hours: Lecture 3.
Markov chains on discrete spaces in discrete and continuous time (random walks, Poisson processes, birth and death processes) and their long-term behavior. Optional topics may include branching processes, renewal theory, introduction to Brownian motion. (Typically Offered: Fall)

**STAT 5570: Statistical Methods for Counts and Proportions**
Credits: 3. Contact Hours: Lecture 3.
Statistical methods for analyzing simple random samples when outcomes are counts or proportions; measures of association and relative risk, chi-squared tests, loglinear models, logistic regression and other generalized linear models, tree-based methods. Maximum likelihood estimation and large sample theory. Extensions to longitudinal studies and complex survey designs, models with fixed and random effects. Use of statistical software: SAS or R. Offered odd-numbered years. (Typically Offered: Fall)

**STAT 5590: Item Response Theory**
Credits: 3. Contact Hours: Lecture 3.
*Prereq:* STAT 5000 *or 5870*
Statistical methods for analysis of binary and polytomous data using latent trait models. Application and theory of model selection and fit, dimensionality, differential item functioning and test development. Use of appropriate statistical software. Offered even-numbered years. (Typically Offered: Fall)

**STAT 5650: Methods in Biostatistics and Epidemiology**
(Cross-listed with TOX 5650).
Credits: 3. Contact Hours: Lecture 3.
Statistical methods commonly used in epidemiology and human and animal health studies. Overview of cohort studies, case-control studies and randomized clinical trials. Topics include inference procedures for disease risk factors, analysis of time-to-event and survival data, analysis of longitudinal studies of disease progression and health status, diagnostic test evaluation, and meta-analysis. Examples will come from recent studies of physical and mental health, nutrition and disease progression in human and animal populations. Use of statistical software: SAS or R. Offered even-numbered years. (Typically Offered: Fall)

**STAT 5680: Statistical Bioinformatics**
(Cross-listed with COMS 5680/ GDCB 5680/ BCB 5680).
Credits: 3. Contact Hours: Lecture 3.
Statistical models for sequence data, including applications in genome annotation, motif discovery, variant discovery, molecular phylogeny, gene expression analysis, and metagenomics. Statistical topics include model building, inference, hypothesis testing, and simple experimental design, including for big data/complex models. (Typically Offered: Spring)

**STAT 5700: Systems Biology**
(Cross-listed with COMS 5700/ CPRE 5700/ GDCB 5700/ BCB 5700).
Credits: 3. Contact Hours: Lecture 3.
Algorithmic and statistical approaches in computational functional genomics and systems biology. Analysis of high throughput biological data obtained using system-wide measurements. Topological analysis, module discovery, and comparative analysis of gene and protein networks. Modeling, analysis, and inference of transcriptional regulatory networks, protein-protein interaction networks, and metabolic networks. Dynamic systems and whole-cell models. Ontology-driven, network based, and probabilistic approaches to information integration. (Typically Offered: Spring)

**STAT 5710: Introduction to Experimental Design**
(Dual-listed with STAT 4710).
Credits: 3. Contact Hours: Lecture 3.
The role of statistics in research and the principles of experimental design. Concepts of experimental and observational units, randomization, replication, blocking, subdividing and repeatedly measuring experimental units; factorial treatment designs and confounding; common designs including randomized complete block design, Latin square design, split-plot design, and analysis of data from such common designs; extensions of the analysis of variance to cover variance components. Determining sample size. Graduation Restriction: Credit in only one of STAT 4020, STAT 4710, or STAT 5710 may be applied to graduation. May not be used for graduate credit in the Statistics MS and PhD degree programs. (Typically Offered: Fall, Spring)

**STAT 5720: Introduction to Time Series**
(Dual-listed with STAT 4720).
Credits: 3. Contact Hours: Lecture 3.
Methods for analyzing data collected over time; review of multiple regression analysis. Elementary forecasting methods: moving averages and exponential smoothing. Autoregressive-moving average (Box-Jenkins) models: identification, estimation, diagnostic checking, and forecasting. Transfer function models and intervention analysis. Introduction to multivariate time series methods. Graduation Restriction: Credit for only one of STAT 4510, STAT 4720, or STAT 5720 may be applied to graduation. May not be used for graduate credit in the Statistics MS and PhD degree programs. (Typically Offered: Spring)

**STAT 5730: Introduction to Survey Sampling**
(Dual-listed with STAT 4730).
Credits: 3. Contact Hours: Lecture 2, Laboratory 2.
*Prereq:* STAT 5870 *and* STAT 5880
Concepts of sample surveys and the survey process; methods of designing sample surveys, including: simple random, stratified, systematic, probability proportional to size, and multistage sampling designs; methods of analyzing sample surveys including ratio, regression, domain estimation and nonresponse. (Typically Offered: Spring)

**STAT 5740: Introduction to Bayesian Data Analysis**
(Dual-listed with STAT 4740).
Credits: 3. Contact Hours: Lecture 2, Laboratory 2.
*Prereq:* STAT 5870 *and* STAT 5880
Probability models and prior distributions; updating priors through the likelihood function. Computational and simulation-based methods for deriving posterior distributions and for estimating parameters. Basic statistical and hierarchical models. Model adequacy and posterior predictive checks. Markov Chain Monte Carlo methods and introduction to WinBUGS or similar software. Emphasis on applications and examples from the social, biological and physical sciences. Graduation Restriction: Credit for only one of STAT 4440, STAT 4740, or STAT 5740 may be applied to graduation. May not be used for graduate credit in the Statistics MS and PhD degree programs. (Typically Offered: Spring)

**STAT 5750: Introduction to Multivariate Data Analysis**
(Dual-listed with STAT 4750).
Credits: 3. Contact Hours: Lecture 2, Laboratory 2.
Statistical and graphical methods for displaying and analyzing multivariate data including plotting high-dimensional data using interactive graphics; organizing and summarizing analyses of multivariate data; comparing two group mean vectors; multivariate analysis of variance; reducing variable dimension with principal components; identifying factors with exploratory factor analysis; grouping observations with multidimensional scaling and cluster analysis; classification; R statistical software package and using Rstudio to create reports (RMarkdown and GGplot). Knowledge of linear algebra recommended. Graduation Restriction: Credit for only one of STAT 4070, STAT 4750, or STAT 5750 may be applied to graduation. May not be used for graduate credit in the Statistics MS and PhD degree programs. (Typically Offered: Fall)

**STAT 5760: Introduction to Spatial Data Analysis**
(Dual-listed with STAT 4760).
Credits: 3. Contact Hours: Lecture 3.
*Prereq: (*STAT 5870 *and* STAT 5880*) or Permission of Instructor*
The analysis of spatial data; geostatistical methods, mapping and spatial prediction; methods for areal data; models and methods for spatial point processes. Emphasis on application and practical use of spatial statistical analysis. Use of R and R packages for spatial data analysis. Graduation Restriction: Credit for only one of STAT 4060, STAT 4760, or STAT 5760 may be applied to graduation. May not be used for graduate credit in the Statistics MS and PhD degree programs.

**STAT 5770: Introduction to Categorical Data Analysis**
(Dual-listed with STAT 4770).
Credits: 3. Contact Hours: Lecture 3.
Statistical methods for the analysis of categorical data: graphical summaries, estimation and inference for proportions, sample size determination, chi-square tests, measures of relative risk, odds and association, analysis of paired data and measures of agreement, logistic regression models, log-linear models. Graduation Restriction: Credit for only one of STAT 4570, STAT 4770, or STAT 5770 may be applied to graduation. May not be used for graduate credit in the Statistics MS and PhD degree programs. (Typically Offered: Spring)

**STAT 5780: Introduction to Stochastic Process Models**
(Dual-listed with STAT 4780).
Credits: 3. Contact Hours: Lecture 3.
*Prereq:* STAT 5880
Probabilistic models in biological, engineering and the physical sciences. Markov chains; Poisson, birth-and-death, renewal, branching and queuing processes; applications to bioinformatics and other quantitative problems. Graduation Restriction: Credit for only one of STAT 4320, STAT 4780, or STAT 5780 may be applied to graduation. May not be used for graduate credit in the Statistics MS and PhD degree programs. Offered even number years. (Typically Offered: Fall)

**STAT 5790: An Introduction to R**
Credits: 1. Contact Hours: Laboratory 2.
*Prereq: Credit or concurrent enrollment* STAT 5000
An introduction to the logic of programming, numerical algorithms, and graphics. The R statistical programming environment will be used to demonstrate how data can be stored, manipulated, plotted, and analyzed using both built-in functions and user extensions. Concepts of modularization, looping, vectorization, conditional execution, and function construction will be emphasized. (Typically Offered: Fall)

**STAT 5800: Statistical Computing**
Credits: 3. Contact Hours: Lecture 3.
Introduction to scientific computing for statistics using C: Introduction to C for computing and memory efficiency; design of statistical algorithms; use of algorithms in modern libraries, parallel computing. Interfacing R with C. Building statistical libraries. Statistical computing: solving nonlinear equations; optimization; integration; simulation methods, inversion of probability integral transformations, rejection sampling, importance sampling. (Typically Offered: Spring)

**STAT 5810: Analysis of Gene Expression Data for the Biological Sciences**
Credits: 3. Contact Hours: Lecture 3.
Introduction to high-throughput technologies for gene expression studies (especially R-sequencing technology): the role of blocking, randomization, and biological and technical replication in the design of gene expression experiments; normalization methods; methods for identifying differentially expressed genes including mixed linear model analysis, generalized linear model analysis, generalized linear mixed model analysis, quasi-likelihood methods, empirical Bayes analysis, and resampling based approaches; procedures for controlling false discovery rate for multiple testing; clustering and classification problems for gene expression data; testing gene categories; emphasis on practical use of methods. Graduation Restriction: May not be used for graduate credit in the Statistics MS and PhD degree programs. Credit in STAT 4160 or STAT 5810, but not both, may be applied toward graduation. (Typically Offered: Spring)

**STAT 5820: Regression for Social and Behavioral Research**
(Dual-listed with STAT 4820).
Credits: 3. Contact Hours: Lecture 2, Laboratory 2.
Applications of generalized linear regression models to social science data. Assumptions of regression; diagnostics and transformations; analysis of variance and covariance; logistic, multinomial and Poisson regression. Graduation Restriction: Credit for only one of STAT 4040, STAT 4820, or STAT 5820 may be applied to graduation. May not be used for graduate credit in the Statistics MS and PhD degree programs. (Typically Offered: Fall, Spring)

**STAT 5830: Empirical Methods for the Computational Sciences**
(Dual-listed with STAT 4830).
Credits: 3. Contact Hours: Lecture 3.
Statistical methods for research involving computers; exploratory data analysis; selected topics from analysis of designed experiments - analysis of variance, hypothesis testing, interaction among variables; linear regression, logistic regression, Poisson regression; parameter estimation, prediction, confidence regions, dimension reduction techniques, model diagnostics and sensitivity analysis; Markov chains and processes; simulation techniques and bootstrap methods; applications to computer science, bioinformatics, computer engineering - programs, models and systems as objects of empirical study; communicating results of empirical studies. Statistical software: R. Knowledge of linear algebra recommended. Graduation Restriction: Credit for only one of STAT 4300, STAT 4830, or STAT 5830 may be applied to graduation. May not be used for graduate credit in the Statistics MS and PhD degree programs. (Typically Offered: Fall)

**STAT 5840: Computer Processing of Scientific Data**
(Dual-listed with STAT 4840).
Credits: 3. Contact Hours: Lecture 3.
Structure, content and programming aspects of modern statistical software packages. Advanced techniques for data management, graphics, exploratory data analysis, and generalized linear models.Graduation Restriction: Credit for only one of STAT 4790, STAT 4840, or STAT 5840 may be applied to graduation. May not be used for graduate credit in the Statistics MS and PhD degree programs. (Typically Offered: Fall)

**STAT 5850: Data Technologies for Statistical Analysis**
Credits: 3. Contact Hours: Lecture 3.
Introduction to computational methods for data analysis. Accessing and managing data formats: flat files, databases, web technologies based on mark-up languages (SML, KML, HTML), netCDF. Elements of text processing: regular expressions for cleaning data. Working with massive data, handling missing data, scaled computing. Efficient programming, reproducible code. Offered even-numbered years. (Typically Offered: Spring)

**STAT 5860: Introduction to Statistical Computing**
(Dual-listed with STAT 4860).
Credits: 3. Contact Hours: Lecture 3.
Modern statistical computing. Topics may include: basic and advanced R programming; data management; spread sheets; verifying data accuracy; transferring data between software packages; data and graphical analysis with statistical software packages; algorithmic programming concepts and applications; simulation studies and resampling methods; software reliability; statistical modeling and machine learning. Graduation Restriction: Credit for only one of STAT 4800, STAT 4860, or STAT 5860 may be applied to graduation. May not be used for graduate credit in the Statistics MS and PhD degree programs. (Typically Offered: Spring)

**STAT 5870: Statistical Methods for Research Workers**
Credits: 4. Contact Hours: Lecture 3, Laboratory 2.
A first course in statistics for graduate students from the applied sciences. Principles of data analysis and scientific inference, including estimation, hypothesis testing, and the construction of interval estimates. Statistical concepts and models, including group comparison, blocking, and linear regression. Different sections are designed for students in various disciplines, and additional methods covered may depend on the target audience. Topics covered may include basic experimental designs and analysis of variance for those designs, analysis of categorical data, logistic and log-linear regression, likelihood-based inference, and the use of simulation. Equivalent to STAT 4010 in previous catalogs. Graduation Restriction: May not be used for graduate credit in the Statistics MS and PhD degree programs. Credit in STAT 4010 or STAT 5870, but not both, may be applied toward graduation. (Typically Offered: Fall, Spring, Summer)

**STAT 5880: Statistical Theory for Research Workers**
Credits: 4. Contact Hours: Lecture 4.
Provides an introduction to the theoretical basis of fundamental statistical methods for graduate students in the applied sciences. Probability and probability distributions, moments and moment generating functions, conditional expectation, and transformation of random variables. Estimation based on loss functions, maximum likelihood, and properties of estimators. Sampling distributions, exact and asymptotic results, and the development of intervals. Principles of Bayesian analysis, inference from posterior distributions, and optimal prediction. Uses simulation to verify and extend theoretical results. Equivalent to STAT 4470 in previous catalogs. Graduation Restriction: May not be used for graduate credit in the Statistics MS and PhD degree programs. Credit in STAT 4470 or STAT 5880, but not both, may be applied toward graduation. (Typically Offered: Fall, Spring, Summer)

**STAT 5900A: Special Topics: Theory**
Credits: 1-30. Repeatable.

**STAT 5900B: Special Topics: Methods**
Credits: 1-30. Repeatable.

**STAT 5900C: Special Topics: Design of Experiments**
Credits: 1-30. Repeatable.

**STAT 5900D: Special Topics: Sample Surveys**
Credits: 1-30. Repeatable.

**STAT 5900E: Special Topics: Statistics Education**
Credits: 1-30. Repeatable.

**STAT 5900F: Special Topics: Statistical Computing and Graphics**
Credits: 1-30. Repeatable.

**STAT 5980: Cooperative Education**
Credits: Required. Repeatable.
Off-campus work periods for graduate students in a field of statistics. (Typically Offered: Fall, Spring, Summer)

**STAT 5990: Creative Component**
Credits: 1-30. Repeatable.
*Prereq: Instructor Permission for Course*
Offered on a satisfactory-fail basis only.

**Courses for graduate students:**

**STAT 6010: Advanced Statistical Methods**
Credits: 3. Contact Hours: Lecture 3.
Methods of constructing complex models including adding parameters to existing structures, incorporating stochastic processes and latent variables. Use of modified likelihood functions; quasi-likelihoods; profiles; compositelikelihoods. Asymptotic normality as a basis of inference; Godambe information. Sample reuse; block bootstrap; resampling with dependence. Simulation for model assessment. Issues in Bayesian analysis. (Typically Offered: Spring)

**STAT 6020: Modern Multivariate Statistical Learning**
Credits: 3. Contact Hours: Lecture 3.
Statistical theory and methods for modern data mining and machine learning, inference, and prediction. Variance-bias trade-offs and choice of predictors; linear methods of prediction; basis expansions; smoothing, regularization, and reproducing kernel Hilbert spaces; kernel smoothing methods; neural networks and radial basis function networks; bootstrapping, model averaging, and stacking; linear and quadratic methods of classification; support vector machines; trees and random forests; boosting; prototype methods; unsupervised learning including clustering, principal components, and multi- dimensional scaling; kernel mechanics. Offered odd-numbered years. (Typically Offered: Spring)

**STAT 6060: Advanced Spatial Statistics**
Credits: 3. Contact Hours: Lecture 3.
Consideration of advanced topics in spatial statistics, including areas of recent development in modern spatial statistics. Topics may include spatial sampling design; spatial Markov random fields; non-Gaussian spatial models, including spatial generalized linear mixed effects model; spatial Bayesian hierarchical models, simulation of random fields; spatial-temporal process models; non-stationary process models; multivariate spatial process models; spectral methods for spatial data; computational methods for large spatial data, spatial models for stream networks. Use of R to analyze various real spatial data. Offered irregularly. (Typically Offered: Fall)

**STAT 6110: Theory and Applications of Linear Models**
Credits: 3. Contact Hours: Lecture 3.
Matrix preliminaries, estimability, theory of least squares and of best linear unbiased estimation, analysis of variance and covariance, distribution of quadratic forms, extension of theory to mixed and random effects models, restricted maximum likelihood estimation and inference for variance components. (Typically Offered: Fall)

**STAT 6120: Advanced Design of Experiments**
Credits: 3. Contact Hours: Lecture 3.
General theory of factorial experiments. Design optimality criteria, approximate design and general equivalence theory, computational approaches to constructing optimal designs for linear models, and extensions to nonlinear models. Advanced topics of current interest in the design of experiments, including one or more of: distance based design criteria and construction of spatial process models, screening design strategies for high- dimensional problems, and design problems associated with computational experiments. Offered irregularly. (Typically Offered: Spring)

**STAT 6150: Advanced Bayesian Methods**
Credits: 3. Contact Hours: Lecture 3.
Complex hierarchical and multilevel models, dynamic linear and generalized linear models, spatial models. Bayesian nonparametric methods. Specialized Markov chain Monte Carlo algorithms and practical approaches to increasing mixing and speed convergence. Summarizing posterior distributions, and issues in inference. Model assessment, model selection, and model averaging. Offered odd-numbered years. (Typically Offered: Fall)

**STAT 6210: Advanced Theory of Survey Statistics**
Credits: 3. Contact Hours: Lecture 3.
Advanced topics of current interest in the design of surveys and analysis of survey data, including: asymptotic theory for design and model-based estimators, use of auxiliary information in estimation, variance estimation techniques, small area estimation, non-response modeling and imputation. Offered irregularly. (Typically Offered: Fall)

**STAT 6410: Foundations of Probability Theory**
(Cross-listed with MATH 6410).
Credits: 3. Contact Hours: Lecture 3.
*Prereq: MATH 4140 or MATH 5010 or Graduate Classification*
Sequences and set theory; Lebesgue measure, measurable functions. Absolute continuity of functions, integrability and the fundamental theorem of Lebesgue integration. General measure spaces, probability measure, extension theorem and construction of Lebesgue-Stieljes measures on Euclidean spaces. Measurable transformations and random variables, induced measures and probability distributions. General integration and expectation, Lp-spaces and integral inequalities. Uniform integrability and absolutecontinuity of measures. Probability densities and the Radon-Nikodym theorem. Product spaces and Fubini-Tonelli theorems. (Typically Offered: Fall)

**STAT 6420: Advanced Probability Theory**
(Cross-listed with MATH 6420).
Credits: 3. Contact Hours: Lecture 3.
Probability spaces and random variables. Kolmogorov's consistency theorem. Independence, Borel-Cantelli lemmas and Kolmogorov's 0 - 1 Law. Types and characterizations of convergence for random variables. Sums of independent random variables, empirical distributions, weak and strong laws of large numbers. Convergence in distribution and its formulations, tightness, characteristic functions, central limit theorems and Lindeberg-Feller conditions. Conditional probability and expectation, discrete parameter martingales. (Typically Offered: Spring)

**STAT 6430: Advanced Theory of Statistical Inference**
Credits: 3. Contact Hours: Lecture 3.
Foundational concepts for likelihood, including sufficiency, completeness, exponential families, statistical information. Elements of decision theory, risk management strategies, theoretical properties of decision rules. Large-sample properties of maximum likelihood and Bayesian estimation, consistency, asymptotic normality, efficiency, likelihood ratios. Potential additional topics including M-estimation, U-statistics, nonparametric inference. (Typically Offered: Fall)

**STAT 6440: Advanced Bayesian Theory**
Credits: 3. Contact Hours: Lecture 3.
Exchangeability, parametric models, consistency and asymptotic normality of posterior distributions, posterior robustness, selection of priors using formal rules, improper priors and posterior propriety, Bayes factors, model selection, MCMC theory, irreducibility, Harris recurrence, regeneration, minorization and drift conditions, ergodicity, central limit theorems, Gibbs samplers, Metropolis Hastings samplers, techniques for speeding up convergence of certain MCMC algorithms. Offered even-numbered years. (Typically Offered: Fall)

**STAT 6450: Advanced Stochastic Processes**
(Cross-listed with MATH 6450).
Credits: 3. Contact Hours: Lecture 3.
Weak convergence. Random walks and Brownian motion. Martingales. Stochastic integration and Ito's Formula. Stochastic differential equations and applications. (Typically Offered: Spring)

**STAT 6470: Advanced Multivariate Analysis**
Credits: 3. Contact Hours: Lecture 3.
Classical and high dimensional multivariate methods and their theories; multivariate random vectors and their distributions (multivariate normal, elliptical contour distributions); dependence measures and copulas; Wishart distribution and distributions for quadratic form statistics; Hotelling's T square test and its derivation; high- dimensional inference for mean and covariance, concentration inequalities, random matrix theory, signal detection and identification. Offered even-numbered years. (Typically Offered: Fall)

**STAT 6480: Seminar on Theory of Statistics and Probability**
Credits: 1-30. Contact Hours: Lecture 30.
Repeatable.
Seminar topics change with each offering. Offered irregularly. (Typically Offered: Fall)

**STAT 6510: Advanced Time Series**
Credits: 3. Contact Hours: Lecture 3.
Estimation and distributional theory for time series, generalized estimating functions, M-estimation, frequency domain estimation. Limit theorems under time dependence, mixing, long-memory. Approximations of sampling distributions and standard errors for time series statistics, bootstrap, subsampling. Offered even-numbered years. (Typically Offered: Fall)

**STAT 6800: Advanced Statistical Computing**
Credits: 3. Contact Hours: Lecture 3.
Normal approximations to likelihoods. The delta-method and propagation of errors. Topics in the use of the E-M algorithm including; its use in the exponential family, computation of standard errors, acceleration. Resampling methods: brief theory and application of the jackknife and the bootstrap. Randomization tests. Stochastic simulation: Markov Chain, Monte Carlo, Gibbs' sampling, Hastings-Metropolis algorithms, critical slowing-down and remedies, auxiliary variables, simulated tempering, reversible-jump MCMC and multi-grid methods. Offered even-numbered years. (Typically Offered: Fall)

**STAT 6900A: Advanced Special Topics: Theory**
Credits: 1-30. Repeatable.

**STAT 6900B: Advanced Special Topics: Methods**
Credits: 1-30. Repeatable.

**STAT 6900C: Advanced Special Topics: Design of Experiments**
Credits: 1-30. Repeatable.

**STAT 6900D: Advanced Special Topics: Sample Surveys**
Credits: 1-30. Repeatable.

**STAT 6900E: Advanced Special Topics: Statistical Computing**
Credits: 1-30. Repeatable.

**STAT 6900F: Advanced Special Topics: Graphics**
Credits: 1-30. Repeatable.

**STAT 6990: Research**
Credits: 1-30. Repeatable.
*Prereq: Instructor Permission for Course*