

# STATISTICS (STAT)

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**Any experimental courses offered by STAT can be found at:**

[registrar.iastate.edu/faculty-staff/courses/explistsings/](http://registrar.iastate.edu/faculty-staff/courses/explistsings/) (<http://www.registrar.iastate.edu/faculty-staff/courses/explistsings/>)

**Courses primarily for undergraduates:**

## **STAT 100: Orientation in Statistics**

(1-0) Cr. R. F.

Opportunities, challenges, and the scope of the curriculum in statistics. For students planning or considering a career in this area.

## **STAT 101: Principles of Statistics**

(3-2) Cr. 4. F.S.SS.

*Prereq: 1 1/2 years of high school algebra*

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. Credit for only one of the following courses may be applied toward graduation: STAT 101, STAT 104, STAT 105, STAT 201, or STAT 226.

## **STAT 104: Introduction to Statistics**

(2-2) Cr. 3. F.S.SS.

*Prereq: 1 1/2 years of high school algebra*

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. Credit for only one of the following courses may be applied toward graduation: STAT 101, STAT 104, STAT 105, STAT 201, or STAT 226.

## **STAT 105: Introduction to Statistics for Engineers**

(3-0) Cr. 3. F.S.SS.

*Prereq: MATH 165*

Statistical concepts with emphasis on engineering applications. Data collection; descriptive statistics; probability distributions and their properties; elements of statistical inference; regression; statistical quality control charts; use of statistical software. Credit for only one of the following courses may be applied toward graduation: STAT 101, STAT 104, STAT 105, STAT 201, or STAT 226. Credit for both STAT 105 and STAT 305 may not be applied toward graduation.

## **STAT 201: Introduction to Statistical Concepts and Methods**

(3-2) Cr. 4. S.

*Prereq: Credit or enrollment in MATH 165*

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. Credit for only one of the following courses may be applied toward graduation: STAT 101, STAT 104, STAT 105, STAT 201, or STAT 226.

## **STAT 202: Career Development in Math and Statistics**

(Cross-listed with MATH). Cr. 1. S.

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.

## **STAT 226: Introduction to Business Statistics I**

(3-0) Cr. 3. F.S.SS.

*Prereq: MATH 150 or MATH 165*

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. Credit for only one of the following courses may be applied toward graduation: STAT 101, STAT 104, STAT 105, STAT 201, or STAT 226.

## **STAT 231: Probability and Statistical Inference for Engineers**

(4-0) Cr. 4. F.S.

*Prereq: Credit or enrollment in MATH 265 (or MATH 265H)*

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.

**STAT 301: Intermediate Statistical Concepts and Methods**

(3-2) Cr. 4. F.S.

*Prereq: STAT 101 or STAT 104 or STAT 105 or STAT 201*

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. Credit for only one of the following courses may be applied toward graduation: STAT 301, STAT 326, or STAT 401

**STAT 305: Engineering Statistics**

(3-0) Cr. 3. F.S.SS.

*Prereq: MATH 165*

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. Credit for both Stat 105 and 305 may not be applied toward graduation.

**STAT 322: Probabilistic Methods for Electrical Engineers**

(Cross-listed with E E). (3-0) Cr. 3. F.S.

*Prereq: E E 224*

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.

**STAT 326: Introduction to Business Statistics II**

(2-2) Cr. 3. F.S.SS.

*Prereq: STAT 226*

Multiple regression analysis; regression diagnostics; model building; applications in analysis of variance and time series; random variables; distributions; conditional probability; statistical process control methods; use of computers to visualize and analyze data. Credit for only one of the following courses may be applied toward graduation: STAT 301, STAT 326 or STAT 401.

**STAT 330: Probability and Statistics for Computer Science**

(3-0) Cr. 3. F.S.SS.

*Prereq: MATH 166*

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.

**STAT 332: Visual Communication of Quantitative Information**

(Cross-listed with ENGL). (3-0) Cr. 3.

*Prereq: STAT 101, STAT 104, STAT 201 or STAT 226; ENGL 250*

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 341: Introduction to the Theory of Probability and Statistics I**

(Cross-listed with MATH). (3-2) Cr. 4. F.S.

*Prereq: MATH 265 (or MATH 265H)*

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. Credit for both STAT 341 and STAT 447 may not be applied toward graduation.

**STAT 342: Introduction to the Theory of Probability and Statistics II**

(Cross-listed with MATH). (3-2) Cr. 4. F.S.

*Prereq: STAT 201 or equivalent; STAT 341; MATH 207 or MATH 317*

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.

**STAT 347: Probability and Statistical Theory for Data Science**

Cr. 4. F.

*Prereq: MATH 207 or 317; MATH 265; STAT 301 or 326*

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. Credit for both STAT 341 and STAT 347 may not be applied toward graduation.

**STAT 361: Statistical Quality Assurance**

(Cross-listed with I E). (2-2) Cr. 3. F.S.

*Prereq: STAT 231, STAT 301, STAT 326 or STAT 401*

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.

**STAT 398: Cooperative Education**

Cr. R. F.S.SS.

*Prereq: Permission of department chair*

Off-campus work periods for undergraduate students in a field of statistics.

**STAT 402: Statistical Design and the Analysis of Experiments**

(3-0) Cr. 3. F.S.

*Prereq: STAT 301 or STAT 326 or STAT 401*

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.

**STAT 404: Regression for Social and Behavioral Research**

(2-2) Cr. 3. F.S.

*Prereq: STAT 301 or STAT 326 or STAT 401*

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.

**STAT 406: Statistical Methods for Spatial Data**

(3-0) Cr. 3. Alt. S., offered even-numbered years.

*Prereq: Six hours of statistics at the 400-level*

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.

**STAT 407: Methods of Multivariate Analysis**

(2-2) Cr. 3. F.

*Prereq: STAT 301 or STAT 326 or STAT 401, knowledge of matrix algebra*

Techniques for displaying and analyzing multivariate data including plotting high-dimensional data using interactive graphics; comparing group mean vectors using Hotelling's  $T^2$ ; multivariate analysis of variance; reducing variable dimension with principal components; identifying factors with exploratory factor analysis; grouping observations with multidimensional scaling and cluster analysis; and classification using discriminant analysis, logistic regression, classification trees, and random forests. Introduction to the R statistical software package.

**STAT 421: Survey Sampling Techniques**

(2-2) Cr. 3. S.

*Prereq: STAT 301 or STAT 326 or STAT 401; STAT 341*

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.

**STAT 430: Empirical Methods for the Computational Sciences**

(3-0) Cr. 3. F.

*Prereq: STAT 330 or an equivalent course, MATH 166, knowledge of linear algebra.*

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.

**STAT 432: Applied Probability Models**

(3-0) Cr. 3. Alt. F., offered even-numbered years.

*Prereq: STAT 231 or STAT 341 or STAT 447*

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.

**STAT 444: Bayesian Data Analysis**

(2-2) Cr. 3. S.

*Prereq: STAT 301 or STAT 326 or STAT 401; STAT 342 or STAT 447.*

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.

**STAT 451: Applied Time Series**

(3-0) Cr. 3. S.

*Prereq: STAT 301 or STAT 326 or STAT 401*

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.

**STAT 457: Applied Categorical Data Analysis**

(3-0) Cr. 3. S.

*Prereq: STAT 301 or STAT 326 or STAT 401*

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.

**STAT 479: Computer Processing of Statistical Data**

(3-0) Cr. 3. F.

*Prereq: STAT 301 or STAT 326 or STAT 401*

Structure, content and programming aspects of modern statistical software packages. Advanced techniques for data management, graphics, exploratory data analysis, and generalized linear models.

**STAT 480: Statistical Computing Applications**

(3-0) Cr. 3. S.

*Prereq: STAT 301 or STAT 326 or STAT 401*

Modern statistical computing. Topics may include: 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.

**STAT 490: Independent Study**

Cr. arr. Repeatable, maximum of 9 credits.

*Prereq: 10 credits in statistics*

No more than 9 credits in Stat 490 may be counted toward graduation.

**STAT 490H: Independent Study: Honors**

Cr. arr. Repeatable, maximum of 9 credits.

*Prereq: 10 credits in statistics*

No more than 9 credits in Stat 490 may be counted toward graduation.

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

**STAT 500: Statistical Methods I**

(3-2) Cr. 4. F.

*Prereq: STAT 447 or current enrollment in STAT 542; knowledge of matrix algebra.*

Analysis of data from designed experiments and observational studies. Randomization-based inference; inference on group means; nonparametric bootstrap; pairing/blocking and other uses of restricted randomization. Use of linear models to analyze data; least squares estimation; estimability; sampling distributions of estimators; general linear tests; inference for parameters and contrasts. Model assessment and diagnostics; remedial measures; alternative approaches based on ranks.

**STAT 501: Multivariate Statistical Methods**

(3-0) Cr. 3. S.

*Prereq: STAT 500; STAT 542; STAT 579 or equivalent; knowledge of matrix algebra.*

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.

**STAT 502: Applied Modern Multivariate Statistical Learning**

(3-0) Cr. 3. Alt. S., offered even-numbered years.

*Prereq: STAT 500, STAT 542, STAT 579.*

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.

**STAT 503: Exploratory Methods and Data Mining**

(2-2) Cr. 3. Alt. S., offered odd-numbered years.

*Prereq: STAT 301 or STAT 326 or STAT 401; STAT 341 or STAT 447 or STAT 542; STAT 480 or STAT 579*

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.

**STAT 505: Environmental Statistics**

(3-0) Cr. 3.

*Prereq: STAT 341 or STAT 447; STAT 401*

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 506: Statistical Methods for Spatial Data**

(3-0) Cr. 3. Alt. S., offered even-numbered years.

*Prereq: STAT 447 or STAT 542*

The analysis of spatial data; geostatistical methods and spatial prediction; discrete index random fields and Markkov random field models; models for spatial point processes.

**STAT 510: Statistical Methods II**

(3-0) Cr. 3. S.

*Prereq: STAT 500, STAT 447 or credit/enrollment in STAT 543*

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.

**STAT 512: Design of Experiments**

(3-0) Cr. 3. F.

*Prereq: STAT 510*

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.

**STAT 513: Response Surface Methodology**

(3-0) Cr. 3.

*Prereq: STAT 402 or STAT 512, knowledge of elementary matrix theory and matrix formulation of regression*

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 515: Theory and Applications of Nonlinear Models**

(3-0) Cr. 3.

*Prereq: STAT 447 or STAT 543; STAT 510*

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 516: Statistical Design and Analysis of Gene Expression****Experiments**

(3-0) Cr. 3.

*Prereq: STAT 500; STAT 447 or STAT 542*

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 520: Statistical Methods III**

(3-0) Cr. 3. F.

*Prereq: STAT 510, STAT 447 or STAT 543*

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.

**STAT 521: Theory and Applications of Sample Surveys**

(3-0) Cr. 3. S.

*Prereq: STAT 401; STAT 447 or STAT 542*

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.

**STAT 522: Advanced Applied Survey Sampling**

(3-0) Cr. 3. Alt. F., offered irregularly.

*Prereq: STAT 521 or both STAT 421 and STAT 447*

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. Prior exposure to mathematical statistics, probability, and at least one course in survey sampling theory is assumed.

**STAT 525: Statistical Methods for Mathematics Teachers**

(6-0) Cr. 6.

*Prereq: STAT 341 or equivalent*

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 2017.). May not be used for graduate credit in the Statistics program. Credit in STAT 410 or STAT 525, but not both, may be applied toward graduation.

**STAT 526: Applied Statistical Modeling**

Cr. 3. F.

*Prereq: Admission to Master of Business Analytics program*

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. May not be used for graduate credit in the Statistics program.

**STAT 528: Visual Business Analytics**

Cr. 3. F.

*Prereq: Admission to the Master of Business Analytics Program*

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. May not be used for graduate credit in the Statistics program.

**STAT 531: Quality Control and Engineering Statistics**

(Cross-listed with I E). (3-0) Cr. 3.

*Prereq: STAT 401; STAT 342 or STAT 447*

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 533: Reliability**

(Cross-listed with I E). (3-0) Cr. 3. Alt. S., offered even-numbered years.

*Prereq:* STAT 342 or STAT 432 or STAT 447

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 recurrence and degradation data; planning studies to obtain reliability data.

**STAT 534: Ecological Statistics**

(3-0) Cr. 3. Alt. F., offered odd-numbered years.

*Prereq:* STAT 447 or STAT 542

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.

**STAT 536: Statistical Genetics**

(Cross-listed with GDCB). (3-0) Cr. 3.

*Prereq:* STAT 401, STAT 447; GEN 320 or BIOL 313

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 542: Theory of Probability and Statistics I**

(4-0) Cr. 4. F.

*Prereq:* MATH 414.

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.

**STAT 543: Theory of Probability and Statistics II**

(3-0) Cr. 3. S.

*Prereq:* STAT 542.

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, ancillarity, 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.

**STAT 544: Bayesian Statistics**

(3-0) Cr. 3. S.

*Prereq:* Credit or concurrent enrollment in STAT 543

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.

**STAT 546: Nonparametric Methods in Statistics**

(3-0) Cr. 3. Alt. F., offered odd-numbered years.

*Prereq:* STAT 510, STAT 542

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; applications to semiparametric models and goodness-of-fit tests of a parametric model.

**STAT 547: Functional Data Analysis**

(3-0) Cr. 3. Alt. S., offered even-numbered years.

*Prereq:* STAT 543, STAT 510

Theory and methods for analyzing functional data, which are high dimensional data resulted from discrete, error-contaminated measurements on smooth curves and images. The topics include kernel and spline smoothing, basis expansion, semiparametric regression, functional analysis of variance, covariance modeling and estimation, functional principal component analysis, functional generalization linear models, joint modeling, dimension reduction, classification and clustering functional data.

**STAT 551: Time Series Analysis**

(3-0) Cr. 3. F.

*Prereq: STAT 447 or STAT 542*

Concepts of trend and dependence in time series data; stationarity and basic model structures for dealing with temporal dependence; moving average and autoregressive error structures; analysis in the time domain and the frequency domain; parameter estimation, prediction and forecasting; identification of appropriate model structure for actual data and model assessment techniques. Possible extended topics include dynamic models and linear filters.

**STAT 554: Introduction to Stochastic Processes**

(Cross-listed with MATH). (3-0) Cr. 3. F.

*Prereq: STAT 542*

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.

**STAT 557: Statistical Methods for Counts and Proportions**

(3-0) Cr. 3. Alt. F., offered odd-numbered years.

*Prereq: STAT 500 or STAT 401; STAT 543 or STAT 447*

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.

**STAT 565: Methods in Biostatistics and Epidemiology**

(Cross-listed with TOX). (3-0) Cr. 3. Alt. F., offered even-numbered years.

*Prereq: STAT 500 or STAT 401; STAT 543 or STAT 447*

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.

**STAT 568: Bioinformatics II (Statistical Bioinformatics)**

(Cross-listed with BCB, COM S, GDCB). (3-0) Cr. 3. S.

*Prereq: BCB 567 or (BIOL 315 and STAT 430), credit or enrollment in GEN 409*

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.

**STAT 570: Bioinformatics IV (Systems Biology)**

(Cross-listed with BCB, COM S, CPR E, GDCB). (3-0) Cr. 3. S.

*Prereq: BCB 567 or COM S 311, COM S 228, GEN 409, STAT 430*

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.

**STAT 579: An Introduction to R**

(0-2) Cr. 1. F.

*Prereq: Enrollment in STAT 500*

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.

**STAT 580: Statistical Computing**

(3-0) Cr. 3. S.

*Prereq: STAT 579; STAT 447 or STAT 542*

Introduction to scientific computing for statistics using tools and concepts in R: programming tools, modern programming methodologies, modularization, design of statistical algorithms. Introduction to C programming for efficiency; interfacing R with C. Building statistical libraries. Use of algorithms in modern subroutine packages, optimization and integration. Implementation of simulation methods; inversion of probability integral transform, rejection sampling, importance sampling. Monte Carlo integration.

**STAT 581: Analysis of Gene Expression Data for the Biological Sciences**  
(3-0) Cr. 3. S.

*Prereq: STAT 401 or STAT 587*

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, 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. May not be used for graduate credit in the Statistics MS and PhD degree programs. Credit in STAT 416 or STAT 581, but not both, may be applied toward graduation.

**STAT 585: Data Technologies for Statistical Analysis.**

Cr. 3. Alt. S., offered odd-numbered years.

*Prereq: STAT 579.*

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.

**STAT 587: Statistical Methods for Research Workers**

(3-2) Cr. 4. F.S.SS.

*Prereq: An applied statistics course at the undergraduate level, such as STAT 101, 104, 105, 201, or 226. Students without an equivalent course should contact the department.*

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 401 in previous catalogs. May not be used for graduate credit in the Statistics MS and PhD degree programs. Credit in STAT 401 or STAT 587, but not both, may be applied toward graduation.

**STAT 588: Statistical Theory for Research Workers**

(4-0) Cr. 4. F.S.SS.

*Prereq: MATH 151 and permission of instructor, or MATH 265*

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 447 in previous catalogs. May not be used for graduate credit in the Statistics MS and PhD degree programs. Credit in STAT 447 or STAT 588, but not both, may be applied toward graduation.

**STAT 590: Special Topics**

Cr. arr. Repeatable.

**STAT 590A: Special Topics: Theory**

Cr. arr. Repeatable.

**STAT 590B: Special Topics: Methods**

Cr. arr. Repeatable.

**STAT 590C: Special Topics: Design of Experiments**

Cr. arr. Repeatable.

**STAT 590D: Special Topics: Sample Surveys**

Cr. arr. Repeatable.

**STAT 590E: Special Topics: Statistics Education**

Cr. arr. Repeatable.

**STAT 590F: Special Topics: Statistical Computing and Graphics**

Cr. arr. Repeatable. F.

**STAT 598: Cooperative Education**

Cr. R. F.S.SS.

*Prereq: Permission of the department chair*

Off-campus work periods for graduate students in a field of statistics.

**STAT 599: Creative Component**

Cr. arr.

**Courses for graduate students:**

**STAT 601: Advanced Statistical Methods**

(3-0) Cr. 3. S.

*Prereq: STAT 520, STAT 543 and MATH 414 or enrollment in STAT 641*

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; composite likelihoods. Asymptotic normality as a basis of inference; Godambe information. Sample reuse; block bootstrap; resampling with dependence. Simulation for model assessment. Issues in Bayesian analysis.

**STAT 602: Modern Multivariate Statistical Learning**

(3-0) Cr. 3. Alt. S., offered odd-numbered years.

*Prereq: STAT 520, STAT 543, STAT 579*

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.

**STAT 606: Advanced Spatial Statistics**

(3-0) Cr. 3. Alt. F., offered irregularly.

*Prereq: STAT 506, STAT 543*

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.

**STAT 611: Theory and Applications of Linear Models**

(3-0) Cr. 3. F.

*Prereq: STAT 510; STAT 542 or STAT 447; a course in matrix algebra*

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 models, inference for variance components.

**STAT 612: Advanced Design of Experiments**

(3-0) Cr. 3. Alt. S., offered irregularly.

*Prereq: STAT 512*

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.

**STAT 615: Advanced Bayesian Methods**

(3-0) Cr. 3. Alt. F., offered odd-numbered years.

*Prereq: STAT 544 and STAT 601*

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.

**STAT 621: Advanced Theory of Survey Statistics**

(3-0) Cr. 3. Alt. F., offered irregularly.

*Prereq: STAT 521*

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.

**STAT 641: Foundations of Probability Theory**

(Cross-listed with MATH). (3-0) Cr. 3. F.

*Prereq: MATH 414 or MATH 501 or equivalent course.*

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, L<sub>p</sub>-spaces and integral inequalities. Uniform integrability and absolute continuity of measures. Probability densities and the Radon-Nikodym theorem. Product spaces and Fubini-Tonelli theorems.

**STAT 642: Advanced Probability Theory**

(Cross-listed with MATH). (3-0) Cr. 3. S.

*Prereq:* STAT 641, or STAT 543 and MATH 515.

Probability spaces and random variables. Kolmogorov's consistency theorem. Independence, Borel-Cantelli lemmas and Kolmogorov's 0-1 Law. Comparing types of convergence for random variables. Sums of independent random variables, empirical distributions, weak and strong laws of large numbers. Convergence in distribution and its characterizations, tightness, characteristic functions, central limit theorems and Lindeberg-Feller conditions. Conditional probability and expectation. Discrete parameter martingales and their properties and applications.

**STAT 643: Advanced Theory of Statistical Inference**

(3-0) Cr. 3. F.

*Prereq:* STAT 543, STAT 642

Sufficiency and related concepts, completeness, exponential families and statistical information. Elements of decision theory, decision rules, invariance and Bayes rule. Maximum likelihood and asymptotic inference. Generalized estimating equations and estimating functions, M-estimation, U-statistics. Likelihood ratio tests, simple and composite hypotheses, multiple testing. Bayesian inference. Nonparametric inference, bootstrap, empirical likelihood, and tests for nonparametric models.

**STAT 644: Advanced Bayesian Theory**

(3-0) Cr. 3. Alt. F., offered even-numbered years.

*Prereq:* STAT 544 and STAT 642

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.

**STAT 645: Advanced Stochastic Processes**

(Cross-listed with MATH). (3-0) Cr. 3. S.

Weak convergence. Random walks and Brownian motion. Martingales. Stochastic integration and Ito's Formula. Stochastic differential equations and applications.

**STAT 647: Advanced Multivariate Analysis**

(3-0) Cr. 3. Alt. F., offered even-numbered years.

*Prereq:* STAT 543, knowledge of matrix algebra

Multivariate normal distribution, estimation of the mean vector and the covariance matrix, multiple and partial correlation, Hotelling's T<sup>2</sup> statistic, Wishart distribution, multivariate regression, principle components, discriminant analysis, high dimensional data analysis, latent variables.

**STAT 648: Seminar on Theory of Statistics and Probability**

Cr. arr. Alt. F., offered irregularly.

*Prereq:* STAT 543.

Seminar topics change with each offering.

**STAT 651: Advanced Time Series**

(3-0) Cr. 3. Alt. F., offered even-numbered years.

*Prereq:* STAT 551, STAT 642

Stationary and nonstationary time series models, including ARMA, ARCH, and GARCH. Covariance and spectral representation of time series. Fourier and periodogram analyses. Predictions. CLT for mixing processes. Estimation and distribution theory. Long range dependence.

**STAT 680: Advanced Statistical Computing**

(3-0) Cr. 3. Alt. F., offered even-numbered years.

*Prereq:* STAT 543 and STAT 580

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.

**STAT 690: Advanced Special Topics**

Cr. arr. Repeatable.

*Prereq:* Permission of instructor

**STAT 690A: Advanced Special Topics: Theory**

Cr. arr. Repeatable.

*Prereq:* Permission of instructor

**STAT 690B: Advanced Special Topics: Methods**

Cr. arr. Repeatable.

*Prereq:* Permission of instructor

**STAT 690C: Advanced Special Topics: Design of Experiments**

Cr. arr. Repeatable.

*Prereq:* Permission of instructor

**STAT 690D: Advanced Special Topics: Sample Surveys**

Cr. arr. Repeatable.

*Prereq:* Permission of instructor

**STAT 690E: Advanced Special Topics: Statistical Computing**

Cr. arr. Repeatable.

*Prereq:* Permission of instructor

**STAT 690F: Advanced Special Topics: Graphics**

Cr. arr. Repeatable.

*Prereq:* Permission of instructor

**STAT 699: Research**

Cr. arr. Repeatable.