

# STAT - STATISTICS

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## STAT 600 Statistical Computations I

**Credits 3. 3 Lecture Hours.**

Version control and code profiling; code vectorization and k-means algorithm; convex optimization and duality; gradient methods and iterative reweighted least squares, coordinate-descent method and sparse regression with Least Absolute Shrinkage and Selection Operator (LASSO); cross-validation and splitting techniques for model selection; efficient sparse matrix representations; parallel simulations on the cluster.

**Prerequisites:** STAT 612 or concurrent enrollment; familiarity with R programming or approval of instructor.

## STAT 601 Statistical Analysis

**Credits 4. 3 Lecture Hours. 2 Lab Hours.**

For students in engineering, physical and mathematical sciences. Introduction to probability, probability distributions and statistical inference; hypotheses testing; introduction to methods of analysis such as tests of independence, regression, analysis of variance with some consideration of planned experimentation.

**Prerequisite:** MATH 152 or MATH 172.

## STAT 604 Topics in Statistical Computations

**Credits 3. 3 Lecture Hours.**

Efficient uses of existing statistical computer programs (SAS, R, etc.); generation of random numbers; using and creating functions and subroutines; statistical graphics; programming of simulation studies; and data management issues.

**Prerequisite:** MATH 221, MATH 251, or MATH 253.

## STAT 605 Advanced Statistical Computations

**Credits 3. 3 Lecture Hours.**

Programming languages, statistical software and computing environments; development of programming skills using modern methodologies; data extraction and code management; interfacing lower-level languages with data analysis software; simulation; MC integration; MC-MC procedures; permutation tests; bootstrapping.

**Prerequisite:** STAT 612 and STAT 648.

## STAT 607 Sampling

**Credits 3. 3 Lecture Hours.**

Planning, execution and analysis of sampling from finite populations; simple, stratified, multistage and systematic sampling; ratio estimates.

**Prerequisite:** STAT 601 or STAT 652 or concurrent enrollment in STAT 641.

## STAT 608 Regression Analysis

**Credits 3. 3 Lecture Hours.**

Multiple, curvilinear, nonlinear, robust, logistic and principal components regression analysis; regression diagnostics, transformations, analysis of covariance.

**Prerequisite:** STAT 601 or STAT 641.

## STAT 610 Theory of Statistics - Distribution Theory

**Credits 3. 3 Lecture Hours.**

Brief introduction to probability theory; distributions and expectations of random variables, transformations of random variables and order statistics; generating functions and basic limit concepts.

**Prerequisite:** MATH 409 or concurrent enrollment in MATH 409.

## STAT 611 Theory of Statistics - Inference

**Credits 3. 3 Lecture Hours.**

Theory of estimation and hypothesis testing; point estimation, interval estimation, sufficient statistics, decision theory, most powerful tests, likelihood ratio tests, chi-square tests.

**Prerequisite:** STAT 610 or equivalent.

## STAT 612 Theory of Linear Models

**Credits 3. 3 Lecture Hours.**

Matrix algebra for statisticians; Gauss-Markov theorem; estimability; estimation subject to linear restrictions; multivariate normal distribution; distribution of quadratic forms; inferences for linear models; theory of multiple regression and AOV; random-and mixed-effects models.

**Prerequisite:** Course in linear algebra.

## STAT 613 Statistical Methodology I

**Credits 3. 3 Lecture Hours.**

Elements of likelihood inference; exponential family models; group transformation models; survival data; missing data; estimation and hypotheses testing; nonlinear regression models; conditional and marginal inferences; complex models-Markov chains, Markov random fields, time series, and point processes.

**Prerequisite:** STAT 612.

## STAT 614 Probability for Statistics

**Credits 3. 3 Lecture Hours.**

Probability and measures; expectation and integrals, Kolmogorov's extension theorem; Fubini's theorem; inequalities; uniform integrability; conditional expectation; laws of large numbers; central limit theorems

**Prerequisite:** STAT 610 or its equivalent.

## STAT 615 Stochastic Processes

**Credits 3. 3 Lecture Hours.**

Survey of the theory of stochastic processes; includes countable-state Markov processes, birth-death processes, Poisson point processes, renewal processes, Brownian motion and diffusion processes and covariance-stationary processes; theoretical development and applications to real world problems.

**Prerequisites:** STAT 610; MATH 409.

## STAT 616 Statistical Aspects of Machine Learning I: Classical Multivariate Methods

**Credits 3. 3 Lecture Hours.**

Core methods from traditional multivariate analysis and various extensions; probability distributions of random vectors and matrices, multivariate normal distributions, model assessment and selection in multiple regression, multivariate regression, dimension reduction, linear discriminant analysis, logistic discriminant analysis, cluster analysis, multidimensional scaling and distance geometry, and correspondence analysis.

**Prerequisites:** STAT 612, STAT 613.

## STAT 618 Statistical Aspect of Machine Learning II: Modern Techniques

**Credits 3. 3 Lecture Hours.**

Second course in statistical machine learning; recursive partition and tree-based methods, artificial neural networks, support vector machines, reproducing kernels, committee machines, latent variable methods, component analysis, nonlinear dimensionality reduction and manifold learning, matrix factorization and matrix completion, statistical analysis of tensors and multi-indexed data.

**Prerequisites:** STAT 612, STAT 613, and STAT 616.

**STAT 620 Asymptotic Statistics****Credits 3. 3 Lecture Hours.**

Review of basic concepts and important convergence theorems; elements of decision theory; delta method; Bahadur representation theorem; asymptotic distribution of MLE and the LRT statistics; asymptotic efficiency; limit theory for U-statistics and differential statistical functionals with illustrations from M-,L-,R-estimation; multiple testing.

**Prerequisite:** STAT 614.**STAT 621 Advanced Stochastic Processes****Credits 3. 3 Lecture Hours.**

Conditional expectation; stopping times; discrete Markov processes; birth-death processes; queuing models; discrete semi-Markov processes; Brownian motion; diffusion processes, Ito integrals, theorem and limit distributions; differential statistical functions and their limit distributions; M-,L-,R-estimation.

**Prerequisite:** STAT 614 or STAT 615.**STAT 623 Statistical Methods for Chemistry****Credits 3. 3 Lecture Hours.**

Chemometrics topics of process optimization, precision and accuracy; curve fitting; chi-squared tests; multivariate calibration; errors in calibration standards; statistics of instrumentation.

**Prerequisite:** STAT 601, STAT 641 or STAT 652 or approval of instructor.**STAT 624 Databases and Computational Tools Used in Big Data****Credits 3. 3 Lecture Hours.**

Survey of common tools used by statisticians for high performance computing and big data type problems; shell scripting; HPC clusters; code optimization and vectorization; parallelizing applications using numerical libraries; open MP, MPI and parallel R; data management and revision control using Git; exploration of SQL, survey NOSQL databases; introduction to Python.

**Prerequisites:** Knowledge of R, Fortran, or C.**STAT 626 Methods in Time Series Analysis****Credits 3. 3 Lecture Hours.**

Introduction to statistical time series analysis; autocorrelation and spectral characteristics of univariate, autoregressive, moving average models; identification, estimation and forecasting.

**Prerequisite:** STAT 601 or STAT 642 or approval of instructor.**STAT 627 Nonparametric Function Estimation****Credits 3. 3 Lecture Hours.**

Nonparametric function estimation; kernel, local polynomials, Fourier series and spline methods; automated smoothing methods including cross-validation; large sample distributional properties of estimators; recent advances in function estimation.

**Prerequisite:** STAT 611.**STAT 630 Overview of Mathematical Statistics****Credits 3. 3 Lecture Hours.**

Basic probability theory including distributions of random variables and expectations. Introduction to the theory of statistical inference from the likelihood point of view including maximum likelihood estimation, confidence intervals, and likelihood ratio tests. Introduction to Bayesian methods.

**Prerequisites:** MATH 221, MATH 251, and MATH 253.**STAT 631 Statistical Methods in Finance****Credits 3. 3 Lecture Hours.**

Regression and the capital asset pricing model, statistics for portfolio analysis, resampling, time series models, volatility models, option pricing and Monte Carlo methods, copulas, extreme value theory, value at risk, spline smoothing of term structure.

**Prerequisites:** STAT 610, STAT 611, STAT 608.**STAT 632 Statistical Methodology II-Bayesian Modeling and Inference****Credits 3. 3 Lecture Hours.**

Decision theory; fundamentals of Bayesian inference; single and multi-parameter models; Gaussian model; linear and generalized linear models; Bayesian computations; asymptotic methods; non-iterative MC; MCMC; hierarchical models; nonlinear models; random effect models; survival analysis; spatial models.

**Prerequisite:** STAT 613.**STAT 633 Advanced Bayesian Modeling and Computation****Credits 3. 3 Lecture Hours.**

Bayesian methods in their research; methodology, and applications of Bayesian methods in bioinformatics, biostatistics, signal processing, machine learning, and related fields.

**Prerequisite:** STAT 608, STAT 613, STAT 632.**STAT 636 Applied Multivariate Analysis and Statistical Learning****Credits 3. 3 Lecture Hours.**

Exploratory analysis of multivariate data using ordination and clustering techniques; supervised learning methods of predictive modeling; regression and classification; model selection and regularization; resampling methods; nonlinear and tree-based models; error rate estimation; use of R software.

**Prerequisites:** STAT 630, or STAT 610 and STAT 611; MATH 304.**STAT 638 Introduction to Applied Bayesian Methods****Credits 3. 3 Lecture Hours.**

Uncertainty regarding parameters and how they can be explicitly described as a posterior distribution which blends information from a sampling model and prior distribution; emphasis on modeling and computations under the Bayesian paradigm; includes prior distributions, Bayes Theorem, conjugate and non-conjugate models, posterior simulation via the Gibbs sampler and MCMC, hierarchical modeling.

**Prerequisites:** STAT 630, or equivalent or approval of instructor.**STAT 639 Data Mining and Analysis****Credits 3. 3 Lecture Hours.**

Broad overview of data mining, integrating related concepts from machine learning and statistics; exploratory data analysis, pattern mining, clustering and classification; applications to scientific and online data.

**Cross Listing:** ECEN 758 and CSCE 676.**STAT 641 The Methods of Statistics I****Credits 3. 3 Lecture Hours.**

An application of the various disciplines in statistics to data analysis, introduction to statistical software; demonstration of interplay between probability models and statistical inference.

**Prerequisite:** Concurrent enrollment in STAT 610 or approval of instructor.**STAT 642 The Methods of Statistics II****Credits 3. 3 Lecture Hours.**

Design and analysis of experiments; scientific method; graphical displays; analysis of nonconventional designs and experiments involving categorical data.

**Prerequisite:** STAT 641.

**STAT 645 Applied Biostatistics and Data Analysis****Credits 3. 3 Lecture Hours.**

Survey of crucial topics in biostatistics; application of regression in biostatistics; analysis of correlated data; logistic and Poisson regression for binary or count data; survival analysis for censored outcomes; design and analysis of clinical trials; sample size calculation by simulation; bootstrap techniques for assessing statistical significance; data analysis using R.

**Prerequisites:** STAT 630, STAT 652, STAT 641, STAT 642, or STAT 611; prior knowledge of matrices and R programming.

**STAT 646 Statistical Bioinformatics****Credits 3. 3 Lecture Hours.**

An overview of relevant biological concepts and technologies of genomic/proteomic applications; methods to handle, visualize, analyze, and interpret genomic/proteomic data; exploratory data analysis for genomic/proteomic data; data preprocessing and normalization; hypotheses testing; classification and prediction techniques for using genomic/proteomic data to predict disease status.

**Prerequisites:** STAT 604, STAT 651, STAT 652 or equivalent or prior approval of instructor.

**STAT 647 Spatial Statistics****Credits 3. 3 Lecture Hours.**

Spatial correlation and its effects; spatial prediction (kriging); spatial regression; analysis of point patterns (tests for randomness and modelling patterns); subsampling methods for spatial data.

**Prerequisite:** STAT 630 or STAT 611 or equivalent.

**STAT 648 Applied Statistics and Data Analysis****Credits 3. 3 Lecture Hours.**

Background to conduct research in the development of new methodology in applied statistics. Topics covered will include: exploratory data analysis; sampling; testing; smoothing; classification; time series; and spatial data analysis.

**Prerequisite:** Approval of instructor.

**STAT 649 Communication Skills in Statistical Research, Teaching and Consulting****Credits 3. 3 Lecture Hours.**

Develop communication skills in teaching, research and statistical consulting; classroom and group exercises, teaching best practices; using simulations in the classroom, techniques to foster active learning environments; developing consulting techniques; communicating research dissemination.

**Prerequisites:** Graduate classification in statistics or approval of instructor.

**STAT 650 Statistical Foundation For Data Science****Credits 3. 3 Lecture Hours.**

Introduction to both probability and statistics with emphasis on applications in data science; topics include basic probability concepts, sample space, conditional probability, random variables, as well as statistical inference.

**Prerequisites:** MATH 411 or STAT 414 and basic knowledge of R.

**STAT 651 Statistics in Research I****Credits 3. 3 Lecture Hours.**

For graduate students in other disciplines; non-calculus exposition of the concepts, methods and usage of statistical data analysis; T-tests, analysis of variance and linear regression.

**Prerequisite:** MATH 102 or equivalent.

**STAT 652 Statistics in Research II****Credits 3. 3 Lecture Hours.**

Continuation of STAT 651. Concepts of experimental design, individual treatment comparisons, randomized blocks and factorial experiments, multiple regression, Chi-squared tests and a brief introduction to covariance, non-parametric methods and sample surveys.

**Prerequisite:** STAT 651.

**STAT 653 Statistics in Research III****Credits 3. 3 Lecture Hours.**

Advanced topics in ANOVA; analysis of covariance; and regression analysis including analysis of messy data; non-linear regression; logistic and weighted regression; diagnostics and model building; emphasis on concepts; computing and interpretation.

**Prerequisite:** STAT 652.

**STAT 654 Statistical Computing with R and Python****Credits 3. 3 Lecture Hours.**

Aspects of numerical analysis for statisticians and data scientists including matrix inversion, splines, function optimization and MCMC; emphasis on implementing methods in R and python; data science skills such as code profiling, web scraping and data visualization.

**Prerequisites:** Basic knowledge of R or Python.

**STAT 656 Applied Analytics Using SAS Enterprise Miner****Credits 3. 3 Lecture Hours.**

Introduction to data mining and will demonstrate the procedures; Optimal prediction decisions; comparing and deploying predictive models; neural networks; constructing and adjusting tree models; the construction and evaluation of multi-stage models.

**Prerequisite:** STAT 657, STAT 659.

**STAT 657 Advanced Programming Using SAS****Credits 3. 3 Lecture Hours.**

Programming with SAS/IML, programming in SAS Data step, advanced use of various SAS procedures.

**Prerequisites:** STAT 604.

**STAT 658 Transportation Statistics****Credits 3. 3 Lecture Hours.**

Design of experiments, estimation, hypothesis testing, modeling, and data mining for transportation specialists.

**Prerequisite:** STAT 211 or STAT 651.

**STAT 659 Applied Categorical Data Analysis****Credits 3. 3 Lecture Hours.**

Introduction to analysis and interpretation of categorical data using ANOVA/regression analogs; includes contingency tables, loglinear models, logistic regression; use of computer software such as SAS, GLIM, SPSSX.

**Prerequisite:** STAT 601, STAT 641 or STAT 652 or equivalent.

**STAT 667 Statistics for Advanced Placement Teachers****Credits 1 to 3. 1 to 3 Lecture Hours.**

Review of the fundamental concepts and techniques of statistics; topics included in Advanced Placement Statistics; exploring data, planning surveys and experiments, exploring models, statistical inference.

**Prerequisite:** Approval of instructor.

**STAT 673 Time Series Analysis I****Credits 3. 3 Lecture Hours.**

Introduction to diverse modes of analysis now available to solve for univariate time series; basic problems of parameter estimation, spectral analysis, forecasting and model identification.

**Prerequisite:** STAT 611 or equivalent.

**STAT 674 Time Series Analysis II**

**Credits 3. 3 Lecture Hours.**

Continuation of STAT 673. Multiple time series, ARMA models, test of hypotheses, estimation of spectral density matrix, transfer function and forecasting.

**Prerequisites:** STAT 673.

**STAT 677 Advanced Spatial Statistics**

**Credits 3. 3 Lecture Hours.**

Spatial statistics from an advanced perspective; Gaussian processes; Gaussian Markov random fields; positive definite functions; nonstationary and multivariate process; hierarchical spatial models; measurement error; change of support; computational approaches for large spatial data sets; spatio-temporal statistics.

**Prerequisites:** STAT 612, STAT 613, and STAT 632.

**STAT 681 Seminar**

**Credit 1. 1 Lecture Hour.**

Oral presentations of special topics and current research in statistics.

May be repeated for credit.

**Prerequisite:** Graduate classification in statistics.

**STAT 683 Data Science Capstone**

**Credits 3. 3 Lecture Hours.**

Application of data science methods including machine learning to research problems; team project-based training for project management, interdisciplinary collaboration and communication skills.

**Prerequisite:** Two or more of ECEN 758, CSCE 676, STAT 639, ECEN 649, ECEN 765, ECEN 760, CSCE 636, CSCE 633, CSCE 666, STAT 616, or STAT 618; Python programming experience is highly recommended.

**Cross Listing:** CSCE 725 and ECEN 725.

**STAT 684 Professional Internship**

**Credits 1 to 3. 1 to 3 Other Hours.**

Practicum in statistical consulting for students in PhD program. Students will be assigned consulting problems brought to the Department of Statistics by researchers in other disciplines.

**Prerequisite:** STAT 642 or its equivalent.

**STAT 685 Directed Studies**

**Credits 1 to 6. 1 to 6 Other Hours.**

Individual instruction in selected fields in statistics; investigation of special topics not within scope of thesis research and not covered by other formal courses.

**Prerequisites:** Graduate classification and approval of department head.

**STAT 689 Special Topics in...**

**Credits 1 to 4. 1 to 4 Lecture Hours.**

Selected topics in an identified area of statistics. Open to non-majors.

May be repeated for credit.

**Prerequisite:** Approval of instructor.

**STAT 691 Research**

**Credits 1 to 23. 1 to 23 Other Hours.**

Research for thesis or dissertation.

**Prerequisite:** Graduate classification.

**STAT 695 Frontiers in Statistical Research**

**Credit 1. 1 Lecture Hour.**

Familiarize the present status of research in a wide variety of new areas of statistical research; content will vary from semester to semester but will always be framed around introducing new research areas. May be taken six times for credit.

**Prerequisites:** Graduate classification in the Department of Statistics or approval of instructor.