STATISTICS (STAT)

STAT 101 Introductory Business Statistics
Data summaries and descriptive statistics; introduction to a statistical computer package; Probability: distributions, expectation, variance, covariance, portfolios, central limit theorem; statistical inference of univariate data; Statistical inference for bivariate data: inference for intrinsically linear simple regression models. This course will have a business focus, but is not inappropriate for students in the college.
One-term course offered either term
Prerequisite: MATH 104 or MATH 110 or equivalent; successful completion of STAT 101 is prerequisite to STAT 102
Activity: Lecture
1 Course Unit

STAT 102 Introductory Business Statistics
One-term course offered either term
Prerequisite: STAT 101
Activity: Lecture
1 Course Unit

STAT 111 Introductory Statistics
Introduction to concepts in probability. Basic statistical inference procedures of estimation, confidence intervals and hypothesis testing directed towards applications in science and medicine. The use of the JMP statistical package.
One-term course offered either term
Prerequisites: High school algebra.
Activity: Recitation
1 Course Unit

STAT 112 Introductory Statistics
Further development of the material in STAT 111, in particular the analysis of variance, multiple regression, non-parametric procedures and the analysis of categorical data. Data analysis via statistical packages.
One-term course offered either term
Prerequisite: STAT 111
Activity: Lecture
1 Course Unit

STAT 405 Statistical Computing with R
The goal of this course is to introduce students to the R programming language and related eco-system. This course will provide a skill-set that is in demand in both the research and business environments. In addition, R is a platform that is used and required in other advanced classes taught at Wharton, so that this class will prepare students for these higher level classes and electives.
Taught by: Stine, Waterman, Zhang
One-term course offered either term
Also Offered As: STAT 705
Prerequisite: STAT 102 or STAT 112 or STAT 430
Activity: Lecture
0.5 Course Units

STAT 422 Predictive Analytics for Business
This course follows from the introductory regression classes, STAT 102, STAT 112, and STAT 431 for undergraduates and STAT 613 for MBAs. It extends the ideas from regression modeling, focusing on the core business task of predictive analytics as applied to realistic business related data sets. In particular it introduces automated model selection tools, such as stepwise regression and various current model selection criteria such as AIC and BIC. It delves into classification methodologies such as logistic regression. It also introduces classification and regression trees (CART) and the popular predictive methodology known as the random forest.
One-term course offered either term
Also Offered As: STAT 722
Prerequisite: STAT 102 or STAT 112 or STAT 431
Activity: Lecture
0.5 Course Units

STAT 424 Text Analytics
This course introduces methods for the analysis of unstructured data, focusing on statistical models for text. Techniques include those for sentiment analysis, topic models, and predictive analytics. Course includes topics from natural language processing (NLP), such as identifying parts of speech, parsing sentences (e.g., subject and predicate), and named entity recognition (people and places). Unsupervised techniques suited to feature creation provide variables suited to traditional statistical models (regression) and more recent approaches (regression trees). Examples that span the course illustrate the success of text analytics. Hierarchical generating models often associated with nonparametric Bayesian analysis supply theoretical foundations.
Taught by: Stine
One-term course offered either term
Also Offered As: STAT 724
Prerequisites: Students should be familiar with regression models at the level of STAT 102 and the R statistics language at the level of STAT 405. Familiarity with the R-Studio development environment is presumed, as well as common R packages such as stringr, dplyr and ggplot. Those with more knowledge of Statistics, such as from STAT 422, or computing skills will benefit. The predominant software used in the course is R, with bits of JMP when helpful for interactive illustration. Familiarity with basic probability models is helpful but not presumed.
Activity: Lecture
0.5 Course Units

STAT 430 Probability
Discrete and continuous sample spaces and probability; random variables, distributions, independence; expectation and generating functions; Markov chains and recurrence theory.
One-term course offered either term
Also Offered As: STAT 510
Prerequisite: MATH 114 or MATH 115 or equivalent
Activity: Lecture
1 Course Unit
STAT 431 Statistical Inference
Graphical displays; one- and two-sample confidence intervals; one- and two-sample hypothesis tests; one- and two-way ANOVA; simple and multiple linear least-squares regression; nonlinear regression; variable selection; logistic regression; categorical data analysis; goodness-of-fit tests. A methodology course. This course does not have business applications but has significant overlap with STAT 101 and 102.
One-term course offered either term
Also Offered As: STAT 511
Prerequisite: STAT 430
Activity: Lecture
1 Course Unit

STAT 432 Mathematical Statistics
An introduction to the mathematical theory of statistics. Estimation, with a focus on properties of sufficient statistics and maximum likelihood estimators. Hypothesis testing, with a focus on likelihood ratio tests and the consequent development of "t" tests and hypothesis tests in regression and ANOVA. Nonparametric procedures.
Course usually offered in spring term
Also Offered As: STAT 512
Prerequisite: STAT 430 or 510 or equivalent
Activity: Lecture
1 Course Unit

STAT 433 Stochastic Processes
An introduction to Stochastic Processes. The primary focus is on Markov Chains, Martingales and Gaussian Processes. We will discuss many interesting applications from physics to economics. Topics may include: simulations of path functions, game theory and linear programming, stochastic optimization, Brownian Motion and Black-Scholes.
Taught by: Steele, Mossel
One-term course offered either term
Also Offered As: STAT 533
Prerequisites: STAT 430, or permission of instructor
Activity: Lecture
1 Course Unit

STAT 434 Financial and Economic Time Series
This course will introduce students to the time series methods and practices which are most relevant to the analysis of financial and economic data. After an introduction to the statistical programming language R the course develops an autoregressive models, moving average models, and their generalizations. The course then develops models that are closely focused on particular features of financial series such as the challenges of time dependent volatility.
Course usually offered in fall term
Prerequisites: STAT 101 and STAT 102 or STAT 431. Familiarity with linear algebra
Activity: Lecture
1 Course Unit

STAT 435 Forecasting Methods for Management
This course provides an introduction to the wide range of techniques available for statistical forecasting. Qualitative techniques, smoothing and decomposition of time series, regression, adaptive methods, autoregressive-moving average modeling, and ARCH and GARCH formulations will be surveyed. The emphasis will be on applications, rather than technical foundations and derivations. The techniques will be studied critically, with examination of their usefulness and limitations.
Taught by: Shaman
One-term course offered either term
Also Offered As: STAT 711
Prerequisite: STAT 102 or 112 or 431
Activity: Lecture
1 Course Unit

STAT 436 Introduction to Large-Scale Data Science
The course will focus on computational approaches to large-scale data analysis. The lectures will introduce the relevant concepts, and students will be asked to work on projects, implementing the methods and experimenting with large-scale datasets. The course will cover various techniques for updating models in an online fashion, as well as subsampling and dimensionality-reduction techniques. The students will experiment with neural network architectures and learn to build predictive models for modern machine learning tasks.
Taught by: Rakhlin
One-term course offered either term
Prerequisites: Linear Algebra and basic R programming
Activity: Lecture
1 Course Unit

STAT 451 Fundamentals of Actuarial Science I
This course is the usual entry point in the actuarial science program. It is required for students who plan to concentrate or minor in actuarial science. It can also be taken by others interested in the mathematics of personal finance and the use of mortality tables. For future actuaries, it provides the necessary knowledge of compound interest and its applications, and basic life contingencies definition to be used throughout their studies. Non-actuaries will be introduced to practical applications of finance mathematics, such as loan amortization and bond pricing, and premium calculation of typical life insurance contracts. Main topics include annuities, loans and bonds; basic principles of life contingencies and determination of annuity and insurance benefits and premiums.
Taught by: Lemaire
Course usually offered in fall term
Also Offered As: BEPP 451, BEPP 851, STAT 851
Prerequisites: MATH 104, STAT 430. STAT 430 can be taken concurrently with BEPP 451 or STAT 451
Activity: Lecture
1 Course Unit
**STAT 452 Fundamentals of Actuarial Science II**
This specialized course is usually only taken by Wharton students who plan to concentrate in actuarial science and Penn students who plan to minor in actuarial mathematics. It provides a comprehensive analysis of advanced life contingencies problems such as reserving, multiple life functions, multiple decrement theory with application to the valuation of pension plans.

Taught by: Lemaire  
Course usually offered in spring term  
Also Offered As: BEPP 452, BEPP 852, STAT 852  
Prerequisite: BEPP 451 or STAT 451  
Activity: Lecture  
1 Course Unit

**STAT 453 Actuarial Statistics**
This course covers models for insurer's losses, and applications of Markov chains. Poisson processes, including extensions such as non-homogeneous, compound, and mixed Poisson processes are studied in detail. The compound model is then used to establish the distribution of losses. An extensive section on Markov chains provides the theory to forecast future states of the process, as well as numerous applications of Markov chains to insurance, finance, and genetics. The course is abundantly illustrated by examples from the insurance and finance literature. While most of the students taking the course are future actuaries, other students interested in applications of statistics may discover in class many fascinating applications of stochastic processes and Markov chains.

Taught by: Lemaire  
Course usually offered in fall term  
Also Offered As: BEPP 453, BEPP 853, STAT 853  
Prerequisite: STAT 430  
Activity: Lecture  
1 Course Unit

**STAT 454 Applied Statistical Methods for Actuaries**
One half of the course is devoted to the study of time series, including ARIMA modeling and forecasting. The other half studies modifications in random variables due to deductibles, co-payments, policy limits, and elements of simulation. This course is a possible entry point into the actuarial science program. The Society of Actuaries has approved STAT 854 for VEE credit on the topic of time series.

Taught by: Lemaire  
Course usually offered in spring term  
Also Offered As: BEPP 454, BEPP 854, STAT 854  
Prerequisites: STAT 430, STAT 431  
Activity: Lecture  
1 Course Unit

**STAT 457 Modern Data Mining**
Modern Data Mining: Statistics or Data Science has been evolving rapidly to keep up with the modern world. While classical multiple regression and logistic regression techniques continue to be the major tools we go beyond to include methods built on top of linear models such as LASSO and Ridge regression. Contemporary methods such as KNN (K nearest neighbor), Random Forest, Support Vector Machines, Principal Component Analyses (PCA), the bootstrap and others are also covered. Text mining especially through PCA is another topic of the course. While learning all the techniques, we keep in mind that our goal is to tackle real problems. Not only do we go through a large collection of interesting, challenging real-life data sets but we also learn how to use the free, powerful software "R" in connection with each of the methods exposed in the class.

Taught by: Zhao  
One-term course offered either term  
Also Offered As: STAT 571, STAT 701  
Prerequisite: STAT 102 or 112 or 431  
Activity: Lecture  
1 Course Unit

**STAT 458 Decision Making under Uncertainty**
Fundamentals of modern decision analysis with emphasis on managerial decision making under uncertainty and risk. The basic topics of decision analysis are examined. These include payoffs and losses, utility and subjective probability, the value of information, Bayesian analysis, inference and decision making. Examples are presented to illustrate the ideas and methods. Some of these involve: choices among investment alternatives; marketing a new product; health care decisions; and costs, benefits, and sample size in surveys.

Taught by: Stine  
Course not offered every year  
Also Offered As: STAT 712  
Prerequisite: STAT 102 or 112 or 431  
Activity: Lecture  
1 Course Unit

**STAT 471 Modern Data Mining**
Modern Data Mining: Statistics or Data Science has been evolving rapidly to keep up with the modern world. While classical multiple regression and logistic regression techniques continue to be the major tools we go beyond to include methods built on top of linear models such as LASSO and Ridge regression. Contemporary methods such as KNN (K nearest neighbor), Random Forest, Support Vector Machines, Principal Component Analyses (PCA), the bootstrap and others are also covered. Text mining especially through PCA is another topic of the course. While learning all the techniques, we keep in mind that our goal is to tackle real problems. Not only do we go through a large collection of interesting, challenging real-life data sets but we also learn how to use the free, powerful software "R" in connection with each of the methods exposed in the class.

Taught by: Zhao  
One-term course offered either term  
Also Offered As: STAT 571, STAT 701  
Prerequisite: STAT 102 or 112 or 431  
Activity: Lecture  
1 Course Unit

**STAT 472 Decision Making under Uncertainty**
Fundamentals of modern decision analysis with emphasis on managerial decision making under uncertainty and risk. The basic topics of decision analysis are examined. These include payoffs and losses, utility and subjective probability, the value of information, Bayesian analysis, inference and decision making. Examples are presented to illustrate the ideas and methods. Some of these involve: choices among investment alternatives; marketing a new product; health care decisions; and costs, benefits, and sample size in surveys.

Taught by: Stine  
Course not offered every year  
Also Offered As: STAT 712  
Prerequisite: STAT 102 or 112 or 431  
Activity: Lecture  
1 Course Unit

**STAT 473 Bioinformatics**
An introduction to the use of statistical methods in the increasingly important scientific areas of genomics and bioinformatics. The topics to be covered will be decided in detail after the initial class meeting, but will be taken from the following: - background probability theory of one and many random variables and of events; background statistical inference theory, classical and Bayesian, Poisson processes and Markov chain; the analysis of one and many DNA sequences, in particular shotgun sequencing, pattern analysis and motifs; substitution matrices, general random walk theory, advanced statistical inference, the theory of BLAST, hidden Markov models, microarray analysis, evolutionary models.

Taught by: Ewens  
Course usually offered in spring term  
Also Offered As: STAT 953  
Prerequisites: Good background in probability and statistics at the approximate level of STAT 430 and STAT 431  
Activity: Lecture  
1 Course Unit

Notes: The material will follow the class textbook, Ewens and Grant "Statistical Models in Bioinformatics", Springer, second edition, 2005.
STAT 474 Modern Regression for the Social, Behavioral and Biological Sciences
Function estimation and data exploration using extensions of regression analysis: smoothers, semiparametric and nonparametric regression, and supervised machine learning. Conceptual foundations are addressed as well as hands-on use for data analysis.
Taught by: Berk
Course usually offered in spring term
Also Offered As: CRIM 474, STAT 974
Prerequisite: STAT 102 or 112 or equivalent
Activity: Lecture
1 Course Unit

STAT 475 Sample Survey Design
This course will cover the design and analysis of sample surveys. Topics include simple sampling, stratified sampling, cluster sampling, graphics, regression analysis using complex surveys and methods for handling nonresponse bias.
Course not offered every year
Also Offered As: BSTA 775, STAT 920
Prerequisite: STAT 102 or 112 or 431
Activity: Lecture
1 Course Unit

STAT 476 Applied Probability Models in Marketing
This course will expose students to the theoretical and empirical "building blocks" that will allow them to construct, estimate, and interpret powerful models of customer behavior. Over the years, researchers and practitioners have used these models for a wide variety of applications, such as new product sales, forecasting, analyses of media usage, and targeted marketing programs. Other disciplines have seen equally broad utilization of these techniques. The course will be entirely lecture-based with a strong emphasis on real-time problem solving. Most sessions will feature sophisticated numerical investigations using Microsoft Excel. Much of the material is highly technical.
Taught by: Fader
Course usually offered in spring term
Also Offered As: MKTG 476, MKTG 676, MKTG 776, STAT 776
Prerequisites: A high comfort level with basic integral calculus and recent exposure to a formal course in probability and statistics such as STAT 430 is strongly recommended.
Activity: Lecture
1 Course Unit

STAT 500 Applied Regression and Analysis of Variance
An applied graduate level course in multiple regression and analysis of variance for students who have completed an undergraduate course in basic statistical methods. Emphasis is on practical methods of data analysis and their interpretation. Primarily for doctoral students in the managerial, behavioral, social and health sciences. May be taken before STAT 500 with permission of instructor.
Taught by: Rosenbaum
Course usually offered in spring term
Also Offered As: PSYC 612
Prerequisite: STAT 102 or 112 or equivalent
Activity: Lecture
1 Course Unit

STAT 501 Introduction to Nonparametric Methods and Log-linear Models
An applied graduate level course for students who have completed an undergraduate course in basic statistical methods. Covers two unrelated topics: loglinear and logit models for discrete data and nonparametric methods for nonnormal data. Emphasis is on practical methods of data analysis and their interpretation. Primarily for doctoral students in the managerial, behavioral, social and health sciences. May be taken before STAT 500 with permission of instructor.
Taught by: Rosenbaum
Course usually offered in spring term
Also Offered As: PSYC 612
Prerequisite: STAT 102 or 112 or equivalent
Activity: Lecture
1 Course Unit

STAT 502 Survey Methods and Design
Methods and design of field surveys in education, the social sciences, criminal justice research, and other areas. It treats methods of eliciting information through household, mail, telephone surveys, methods of assuring privacy, enhancing cooperation rates and related matters. Fundamentals of statistical sampling and sample design are covered. Much of the course is based on contemporary surveys sponsored by the National Center for Education Statistics and other federal, state, and local agencies.
Taught by: Boruch
Course usually offered in spring term
Also Offered As: EDUC 683
Prerequisite: STAT 520 or equivalent
Activity: Lecture
1 Course Unit

STAT 503 Data Analytics and Statistical Computing
This course will introduce a high-level programming language, called R, that is widely used for statistical data analysis. Using R, we will study and practice the following methodologies: data cleaning, feature extraction; web scrubbing, text analysis; data visualization; fitting statistical models; simulation of probability distributions and statistical models; statistical inference methods that use simulations (bootstrap, permutation tests).
Taught by: Buja
One-term course offered either term
Also Offered As: STAT 470, STAT 770
Prerequisites: Two courses at the statistics 400 or 500 level.
Activity: Lecture
1 Course Unit

STAT 510 Probability
Taught by: Brown
One-term course offered either term
Also Offered As: STAT 430
Prerequisite: A one year course in calculus
Activity: Lecture
1 Course Unit
STAT 511 Statistical Inference
Graphical displays; one- and two-sample confidence intervals; one- and two-sample hypothesis tests; one- and two-way ANOVA; simple and multiple linear least-squares regression; nonlinear regression; variable selection; logistic regression; categorical data analysis; goodness-of-fit tests. A methodology course. One-term course offered either term
Prerequisite: STAT 510 or equivalent
Activity: Lecture
1 Course Unit

STAT 512 Mathematical Statistics
An introduction to the mathematical theory of statistics. Estimation, with a focus on properties of sufficient statistics and maximum likelihood estimators. Hypothesis testing, with a focus on likelihood ratio tests and the consequent development of ‘t’ tests and hypothesis tests in regression and ANOVA. Nonparametric procedures.
Course usually offered in spring term
Also Offered As: STAT 431
Prerequisite: STAT 510 or equivalent
Activity: Lecture
1 Course Unit

STAT 520 Applied Econometrics I
This is a course in econometrics for graduate students. The goal is to prepare students for empirical research by studying econometric methodology and its theoretical foundations. Students taking the course should be familiar with elementary statistical methodology and basic linear algebra, and should have some programming experience. Topics include conditional expectation and linear projection, asymptotic statistical theory, ordinary least squares estimation, the bootstrap and jackknife, instrumental variables and two-stage least squares, specification tests, systems of equations, generalized least squares, and introduction to use of linear panel data models.
Taught by: Shaman
Course usually offered in fall term
Prerequisites: MATH 114 and MATH 312 or equivalents, and an undergraduate introduction to probability and statistics
Activity: Lecture
1 Course Unit

STAT 521 Applied Econometrics II
Topics include system estimation with instrumental variables, fixed effects and random effects estimation, M-estimation, nonlinear regression, quantile regression, maximum likelihood estimation, generalized method of moments estimation, minimum distance estimation, and binary and multinomial response models. Both theory and applications will be stressed.
Taught by: Shaman
Course usually offered in spring term
Prerequisites: STAT 520. This is a continuation of STAT 520
Activity: Lecture
1 Course Unit

STAT 533 Stochastic Processes
An introduction to Stochastic Processes. The primary focus is on Markov Chains, Martingales and Gaussian Processes. We will discuss many interesting applications from physics to economics. Topics may include: simulations of path functions, game theory and linear programming, stochastic optimization, Brownian Motion and Black-Scholes.
Taught by: Steel, Mossel
One-term course offered either term
Also Offered As: STAT 433
Prerequisite: STAT 510 or equivalent
Activity: Lecture
1 Course Unit

STAT 542 Bayesian Methods and Computation
Sophisticated tools for probability modeling and data analysis from the Bayesian perspective. Hierarchical models, mixture models and Monte Carlo simulation techniques.
Taught by: Jensen
Course usually offered in spring term
Prerequisite: STAT 430 or 510 or equivalent or permission of instructor
Activity: Lecture
1 Course Unit

STAT 553 Machine Learning
This course gives a broad overview of the machine learning and statistical pattern recognition. Some topics will be rather glanced over while others will be considered in-depth. Topics include supervised learning (generative/discriminative models, parametric/nonparametric, neural networks, support vector machines, boosting, bagging, random forests), online learning (prediction with expert advice), learning theory (VC dimension, generalization bounds, bias/variance trade-off), unsupervised learning (clustering, k-means, PCA, ICA). Most of the course concentrates on the supervised and online learning.
Course usually offered in spring term
Prerequisites: STAT 510 and 512 or equivalent
Activity: Lecture
1 Course Unit

STAT 571 Modern Data Mining
Modern Data Mining: Statistics or Data Science has been evolving rapidly to keep up with the modern world. While classical multiple regression and logistic regression technique continue to be the major tools we go beyond to include methods built on top of linear models such as LASSO and Ridge regression. Contemporary methods such as KNN (K nearest neighbor), Random Forest, Support Vector Machines, Principal Component Analyses (PCA), the bootstrap and others are also covered. Text mining especially through PCA is another topic of the course. While learning all the techniques, we keep in mind that our goal is to tackle real problems. Not only do we go through a large collection of interesting, challenging real-life data sets but we also learn how to use the free, powerful software "R" in connection with each of the methods exposed in the class.
Taught by: Zhao
One-term course offered either term
Also Offered As: STAT 471, STAT 701
Prerequisite: Two courses at the statistics 400 or 500 level or permission from instructor
Activity: Lecture
1 Course Unit
STAT 613 Regression Analysis for Business
This course provides the fundamental methods of statistical analysis, the art and science if extracting information from data. The course will begin with a focus on the basic elements of exploratory data analysis, probability theory and statistical inference. With this as a foundation, it will proceed to explore the use of the key statistical methodology known as regression analysis for solving business problems, such as the prediction of future sales and the response of the market to price changes. The use of regression diagnostics and various graphical displays supplement the basic numerical summaries and provides insight into the validity of the models. Specific important topics covered include least squares estimation, residuals and outliers, tests and confidence intervals, correlation and autocorrelation, collinearity, and randomization. The presentation relies upon computer software for most of the needed calculations, and the resulting style focuses on construction of models, interpretation of results, and critical evaluation of assumptions.
Course usually offered in fall term
Prerequisites: The basic mathematical skills covered in STAT 611, Mathematics for Business Analysis
Activity: Lecture
1 Course Unit
Notes: Lecture and discussion, assigned exercises, data analysis project, quizzes and a final exam.

STAT 701 Modern Data Mining
Modern Data Mining: Statistics or Data Science has been evolving rapidly to keep up with the modern world. While classical multiple regression and logistic regression technique continue to be the major tools we go beyond to include methods built on top of linear models such as LASSO and Ridge regression. Contemporary methods such as KNN (K nearest neighbor), Random Forest, Support Vector Machines, Principal Component Analyses (PCA), the bootstrap and others are also covered. Text mining especially through PCA is another topic of the course. While learning all the techniques, we keep in mind that our goal is to tackle real problems. Not only do we go through a large collection of interesting, challenging real-life data sets but we also learn how to use the free, powerful software "R" in connection with each of the methods exposed in the class.
Taught by: Zhao
One-term course offered either term
Also Offered As: STAT 471, STAT 571
Prerequisite: STAT 613 or equivalent
Activity: Lecture
1 Course Unit

STAT 705 Statistical Computing with R
The goal of this course is to introduce students to the R programming language and related eco-system. This course will provide a skill-set that is in demand in both the research and business environments. In addition, R is a platform that is used and required in other advanced classes taught at Wharton, so that this class will prepare students for these higher level classes and electives.
Taught by: Stine, Waterman, Zhang
One-term course offered either term
Also Offered As: STAT 405
Prerequisites: STAT 613 or STAT 621 or waiving the Statistics Core completely.
Activity: Lecture
0.5 Course Units

STAT 711 Forecasting Methods for Management
This course provides an introduction to the wide range of techniques available for statistical forecasting. Qualitative techniques, smoothing and decomposition of time series, regression, adaptive methods, autoregressive-moving average modeling, and ARCH and GARCH formulations will be surveyed. The emphasis will be on applications, rather than technical foundations and derivations. The techniques will be studied critically, with examination of their usefulness and limitations.
Taught by: Shaman
One-term course offered either term
Also Offered As: STAT 435
Prerequisite: STAT 613 or equivalent
Activity: Lecture
1 Course Unit
STAT 722 Decision Making Under Uncertainty
Fundamentals of modern decision analysis with emphasis on managerial decision making under uncertainty and risk. The basic topics of decision analysis are examined. These include payoffs and losses, utility and subjective probability, the value of information, Bayesian analysis, inference and decision making. Examples are presented to illustrate the ideas and methods. Some of these involve: choices among investment alternatives; marketing a new product; health care decisions; and costs, benefits, and sample size in surveys.
Taught by: Stine
Course not offered every year
Also Offered As: STAT 472
Prerequisite: STAT 520 or STAT 613 or equivalent
Activity: Lecture
1 Course Unit

STAT 724 Text Analytics
This course follows from the introductory regression classes, STAT 102, STAT 112, and STAT 431 for undergraduates and STAT 613 for MBAs. It extends the ideas from regression modeling, focusing on the core business task of predictive analytics as applied to realistic business related data sets. In particular it introduces automated model selection tools, such as stepwise regression and various current model selection criteria such as AIC and BIC. It delves into classification methodologies such as logistic regression. It also introduces classification and regression trees (CART) and the popular predictive methodology known as the random forest.
One-term course offered either term
Also Offered As: STAT 422
Prerequisite: STAT 613 or STAT 621 or having waived the statistics core completely
Activity: Lecture
0.5 Course Units

STAT 770 Data Analytics and Statistical Computing
This course will introduce a high-level programming language, called R, that is widely used for statistical data analysis. Using R, we will study and practice the following methodologies: data cleaning, feature extraction; web scrubbing, text analysis; data visualization; fitting statistical models; simulation of probability distributions and statistical models; statistical inference methods that use simulations (bootstrap, permutation tests).
Taught by: Buja
One-term course offered either term
Also Offered As: STAT 470, STAT 503
Prerequisites: STAT 613 or STAT 621 or waiving the Statistics Core completely.
Activity: Lecture
1 Course Unit

STAT 776 Applied Probability Models in Marketing
This course will expose students to the theoretical and empirical "building blocks" that will allow them to develop and implement powerful models of customer behavior. Over the years, researchers and practitioners have used these methods for a wide variety of applications, such as new product sales forecasting, analyses of media usage, customer valuation, and targeted marketing programs. These same techniques are also very useful for other types of business (and non-business) problems. The course will be entirely lecture-based with a strong emphasis on real-time problem solving. Most sessions will feature sophisticated numerical investigations using Microsoft Excel. Much of the material is highly technical.
Taught by: Fader
Course usually offered in spring term
Also Offered As: MKTG 476, MKTG 776, STAT 476
Prerequisites: Students must have a high comfort level with basic integral calculus, and recent exposure to a formal course in probability and statistics is strongly recommended.
Activity: Lecture
1 Course Unit
Notes: Format: Lecture, real-time problem solving

STAT 851 Fundamentals of Actuarial Science I
This course is the usual entry point in the actuarial science program. It is required for students who plan to concentrate or minor in actuarial science. It can also be taken by others interested in the mathematics of personal finance and the use of mortality tables. For future actuaries, it provides the necessary knowledge of compound interest and its applications, and basic life contingencies definition to be used throughout their studies. Non-actuaries will be introduced to practical applications of finance mathematics, such as loan amortization and bond pricing, and premium calculation of typical life insurance contracts. Main topics include annuities, loans and bonds; basic principles of life contingencies and determination of annuity and insurance benefits and premiums.
Taught by: Lemaire
Course usually offered in fall term
Also Offered As: BEPP 451, BEPP 851, STAT 451
Prerequisite: One semester of calculus
Activity: Lecture
1 Course Unit
STAT 852 Fundamentals of Actuarial Science II
This specialized course is usually only taken by Wharton students who plan to concentrate in actuarial science and Penn students who plan to minor in actuarial mathematics. It provides a comprehensive analysis of advanced life contingencies problems such as reserving, multiple life functions, multiple decrement theory with application to the valuation of pension plans.
Taught by: Lemaire
Course usually offered in spring term
Also Offered As: BEPP 452, BEPP 852, STAT 452
Prerequisite: STAT 851 or BEPP 851
Activity: Lecture
1 Course Unit

STAT 853 Actuarial Statistics
This course covers models for insurer’s losses, and applications of Markov chains. Poisson processes, including extensions such as non-homogeneous, compound, and mixed Poisson processes are studied in detail. The compound model is then used to establish the distribution of losses. An extensive section on Markov chains provides the theory to forecast future states of the process, as well as numerous applications of Markov chains to insurance, finance, and genetics. The course is abundantly illustrated by examples from the insurance and finance literature. While most of the students taking the course are future actuaries, other students interested in applications of statistics may discover in class many fascinating applications of stochastic processes and Markov chains.
Taught by: Lemaire
Course usually offered in fall term
Also Offered As: BEPP 453, BEPP 853, STAT 453
Prerequisite: Two semesters of Statistics
Activity: Lecture
1 Course Unit

STAT 854 Applied Statistical Methods for Actuaries
One half of the course is devoted to the study of time series, including ARIMA modeling and forecasting. The other half studies modifications in random variables due to deductibles, co-payments, policy limits, and elements of simulation. This course is a possible entry point into the actuarial science program. The Society of Actuaries has approved STAT 854 for VEE credit on the topic of time series.
Taught by: Lemaire
Course usually offered in spring term
Also Offered As: BEPP 454, BEPP 854, STAT 454
Prerequisite: One semester of probability
Activity: Lecture
1 Course Unit

STAT 900 Advanced Probability
The topics covered will change from year to year. Typical topics include the theory of large deviations, percolation theory, particle systems, and probabilistic learning theory.
Course not offered every year
Prerequisite: STAT 931 or equivalent
Activity: Lecture
1 Course Unit

STAT 901 Stochastic Processes II
Martingales, optimal stopping, Wald’s lemma, age-dependent branching processes, stochastic integration, Itô’s lemma.
Course not offered every year
Also Offered As: OIDD 931
Prerequisite: OIDD 930 or equivalent
Activity: Lecture
1 Course Unit

STAT 910 Forecasting and Time Series Analysis
Fourier analysis of data, stationary time series, properties of autoregressive moving average models and estimation of their parameters, spectral analysis, forecasting. Discussion of applications to problems in economics, engineering, physical science, and life science.
Taught by: Stine
Course offered spring; odd-numbered years
Also Offered As: BSTA 852
Prerequisite: STAT 520 or 961 or equivalent
Activity: Lecture
1 Course Unit

STAT 915 Nonparametric Inference
Statistical inference when the functional form of the distribution is not specified. Nonparametric function estimation, density estimation, survival analysis, contingency tables, association, and efficiency.
Course not offered every year
Prerequisite: STAT 520 or equivalent
Activity: Lecture
1 Course Unit

STAT 920 Sample Survey Methods
This course will cover the design and analysis of sample surveys. Topics include simple random sampling, stratified sampling, cluster sampling, graphics, regression analysis using complex surveys and methods for handling nonresponse bias.
Taught by: Small
Course not offered every year
Also Offered As: BSTA 775, STAT 475
Prerequisites: STAT 520, 961 or 970 or permission of instructor
Activity: Lecture
1 Course Unit

STAT 921 Observational Studies
This course will cover statistical methods for the design and analysis of observational studies. Topics will include the potential outcomes framework for causal inference; randomized experiments; matching and propensity score methods for controlling confounding in observational studies; tests of hidden bias; sensitivity analysis; and instrumental variables.
Taught by: Small
Course usually offered in fall term
Prerequisites: STAT 520, 961 or 970 or permission of instructor
Activity: Lecture
1 Course Unit

STAT 924 Advanced Experimental Design
Factorial designs, confounding, incomplete blocks, fractional factorials, random and mixed models, response surfaces.
Course not offered every year
Prerequisite: STAT 972
Activity: Lecture
1 Course Unit
STAT 925 Multivariate Analysis: Theory
This is a course that prepares PhD students in statistics for research in multivariate statistics and high dimensional statistical inference. Topics from classical multivariate statistics include the multivariate normal distribution and the Wishart distribution; estimation and hypothesis testing of mean vectors and covariance matrices; principal component analysis, canonical correlation analysis and discriminant analysis; etc. Topics from modern multivariate statistics include the Marcenko-Pastur law, the Tracy-Widom law, nonparametric estimation and hypothesis testing of high-dimensional covariance matrices, high-dimensional principal component analysis, etc.
Taught by: Ma
Course not offered every year
Prerequisites: STAT 930, 970 and 972 or permission of instructor
Activity: Lecture
1 Course Unit

STAT 926 Multivariate Analysis: Methodology
This is a course that prepares PhD students in statistics for research in multivariate statistics and data visualization. The emphasis will be on a deep conceptual understanding of multivariate methods to the point where students will propose variations and extensions to existing methods or whole new approaches to problems previously solved by classical methods. Topics include: principal component analysis, canonical correlation analysis, generalized canonical analysis; nonlinear extensions of multivariate methods based on optimal transformations of quantitative variables and optimal scaling of categorical variables; shrinkage- and sparsity-based extensions to classical methods; clustering methods of the k-means and hierarchical varieties; multidimensional scaling, graph drawing, and manifold estimation.
Taught by: Buja
Course not offered every year
Prerequisite: STAT 961 or permission of instructor
Activity: Lecture
1 Course Unit

STAT 927 Bayesian Statistical Theory and Methods
A course in Bayesian statistical theory and methods. Axiomatic developments of utility theory and subjective probability, and elements of Bayesian theory.
Taught by: Zhao
Course not offered every year
Also Offered As: BSTA 854
Prerequisite: STAT 971
Activity: Lecture
1 Course Unit

STAT 928 Statistical Learning Theory
Statistical learning theory studies the statistical aspects of machine learning and automated reasoning, through the use of (sampled) data. In particular, the focus is on characterizing the generalization ability of learning algorithms in terms of how well they perform on ”new” data when trained on some given data set. The focus of the course is on: providing the fundamental tools used in this analysis; understanding the performance of widely used learning algorithms; understanding the ”art” of designing good algorithms, both in terms of statistical and computational properties. Potential topics include: empirical process theory; online learning; stochastic optimization; margin based algorithms; feature selection; concentration of measure.
Taught by: Rakhlin
Course usually offered in spring term
Prerequisites: Probability and linear algebra.
Activity: Lecture
1 Course Unit

STAT 930 Probability
Taught by: Steele
Course usually offered in fall term
Also Offered As: MATH 546
Prerequisite: STAT 430 or 510 or equivalent
Activity: Lecture
1 Course Unit

STAT 931 Stochastic Processes
Taught by: Steele
Course usually offered in spring term
Also Offered As: MATH 547
Prerequisite: STAT 930
Activity: Lecture
1 Course Unit

STAT 932 Survival Models and Analysis Methods for Medical and Biological Data
Parametric models, nonparametric methods for one-and two-sample problems, proportional hazards model, inference based on ranks. Problems will be considered from clinical trials, toxicology and tumorigenicity studies, and epidemiological studies.
Taught by: Zhao
Course not offered every year
Also Offered As: BSTA 653
Prerequisite: STAT 971
Activity: Lecture
1 Course Unit
STAT 933 Analysis of Categorical Data
Likelihood equations for log-linear models, properties of maximum likelihood estimates, exact and approximate conditional inference, computing algorithms, weighted least squares methods, and conditional independence and log-linear models. Applied topics, including interpretation of log-linear and logit model parameters, smoothing of tables, goodness-of-fit, and incomplete contingency tables.
Taught by: Rosenbaum
Course not offered every year
Prerequisites: STAT 961 and 971
Activity: Lecture
1 Course Unit

STAT 940 Advanced Inference I
The topics covered will change from year to year. Typical topics include sequential analysis, nonparametric function estimation, robustness, bootstrapping and applications decision theory, likelihood methods, and mixture models.
Course not offered every year
Prerequisite: STAT 971
Activity: Lecture
1 Course Unit

STAT 941 Advanced Inference II
A continuation of STAT 940.
Course not offered every year
Prerequisite: STAT 940
Activity: Lecture
1 Course Unit

STAT 950 Quantitative Consulting Seminar
The seminar offers the opportunity for small teams of MBAs to work on "real life" quantitative consulting projects. These projects are drawn from both business and University sources. The emphasis is on providing a relevant and comprehensible solution to the client's problem. In-class brainstorming sessions, client presentations and written reports give students the opportunity to test for the existence of an intersection between their quantitative and communication skills.
Taught by: Waterman
Course usually offered in spring term
Prerequisites: No prerequisites, but please talk to the instructor to determine your fit with the course.
Activity: Seminar
1 Course Unit

STAT 951 Statistical Practice II
A continuation of STAT 950.
Course not offered every year
Prerequisites: STAT 961, 970 and 971
Activity: Seminar
1 Course Unit

STAT 953 Bioinformatics
An introduction to the use of statistical methods in the increasingly important scientific areas of genomics and bioinformatics. The topics to be covered will be decided in detail after the initial class meeting, but will be taken from the following: - background probability theory of one and many random variables and of events; background statistical inference theory, classical and Bayesian; Poisson processes and Markov chain; the analysis of one and many DNA sequences, in particular shotgun sequencing, pattern analysis and motifs; substitution matrices, general random walk theory, advanced statistical inference, the theory of BLAST, hidden Markov models, microarray analysis, evolutionary models.
Taught by: Ewens
Course usually offered in spring term
Also Offered As: STAT 473
Prerequisites: Good background in probability and statistics at the approximate level of STAT 430 and STAT 431
Activity: Lecture
1 Course Unit
Notes: The material will follow the class textbook, Ewens and Grant "Statistical Models in Bioinformatics", Springer, second edition, 2005.

STAT 955 Stochastic Calculus and Financial Applications
Selected topics in the theory of probability and stochastic processes.
Taught by: Steele
Course usually offered in fall term
Prerequisite: STAT 930 or equivalent
Activity: Lecture
1 Course Unit

STAT 956 Financial and Economic Time Series
This graduate course introduces students to the time series methods and practices which are most relevant to the analysis of financial and economic data. The course will address both theoretical and empirical issues. Extensive use will be made of the S-Plus Statistical Language, but no previous experience of S-Plus will be required. The course begins with a quick review of ARIMA models. Most of the course is devoted to ARCH, GARCH, threshold, switching Markov, state space, and nonlinear models.
Taught by: Steele
Course usually offered in spring term
Prerequisites: A graduate course in statistics or econometrics. Familiarity with linear algebra.
Activity: Lecture
1 Course Unit

STAT 957 Seminar in Data Analysis
Survey of methods for the analysis of large unstructured data sets: detection of outliers, Winsorizing, graphical techniques, robust estimators, multivariate problems.
Course not offered every year
Prerequisites: STAT 961, 971, 972, 925, or equivalents; permission of instructor
Activity: Seminar
1 Course Unit
STAT 961 Statistical Methodology
This is a course that prepares 1st year PhD students in statistics for a research career. This is not an applied statistics course. Topics covered include: linear models and their high-dimensional geometry, statistical inference illustrated with linear models, diagnostics for linear models, bootstrap and permutation inference, principal component analysis, smoothing and cross-validation.
Taught by: Buja
Course usually offered in fall term
Prerequisites: STAT 431 or 520 or equivalent; a solid course in linear algebra and a programming language
Activity: Lecture
1 Course Unit

STAT 962 Advanced Methods for Applied Statistics
This course is designed for Ph.D. students in statistics and will cover various advanced methods and models that are useful in applied statistics. Topics for the course will include missing data, measurement error, nonlinear and generalized linear regression models, survival analysis, experimental design, longitudinal studies, building R packages and reproducible research.
Taught by: Small
Course usually offered in spring term
Prerequisite: STAT 961
Activity: Lecture
1 Course Unit

STAT 970 Mathematical Statistics
Decision theory and statistical optimality criteria, sufficiency, point estimation and hypothesis testing methods and theory.
Taught by: Small
Course usually offered in fall term
Prerequisites: STAT 431 or 520 or equivalent; comfort with mathematical proofs (e.g., MATH 360)
Activity: Lecture
1 Course Unit

STAT 971 Introduction to Linear Statistical Models
Taught by: Brown
Course usually offered in spring term
Prerequisite: STAT 970
Activity: Lecture
1 Course Unit

STAT 972 Advanced Topics in Mathematical Statistics
A continuation of STAT 970.
Taught by: Cai
One-term course offered either term
Also Offered As: BSTA 820
Prerequisites: STAT 970 and 971
Activity: Lecture
1 Course Unit

STAT 974 Modern Regression for the Social, Behavioral and Biological Sciences
Function estimation and data exploration using extensions of regression analysis: smoothers, semiparametric and nonparametric regression, and supervised machine learning. Conceptual foundations are addressed as well as hands-on use for data analysis.
Taught by: Berk
Course usually offered in spring term
Also Offered As: CRIM 474, STAT 474
Prerequisites: Two statistics courses at the graduate school level including a solid foundation in the generalized linear model.
Activity: Lecture
1 Course Unit

STAT 991 Seminar in Advanced Application of Statistics
This seminar will be taken by doctoral candidates after the completion of most of their coursework. Topics vary from year to year and are chosen from advance probability, statistical inference, robust methods, and decision theory with principal emphasis on applications.
One-term course offered either term
Activity: Seminar
1 Course Unit