

# STATISTICS & OPERATIONS RSRCH (STAT-GB)

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## STAT-GB 2202 Forecast Time Series Data (2.5 Credits)

*Typically offered occasionally*

FORECAST TIME SERIES DATA

**Grading:** Grad Stern Graded

**Repeatable for additional credit:** No

## STAT-GB 2219 Quantv Mthds-Fincl Models (2.5 Credits)

*Typically offered occasionally*

This course will cover the use of mathematical techniques in determining value and pricing for fixed income securities. The course will be very applications oriented. Cases and problems will be assigned to enhance the material presented in class. Topics will include a mathematical treatment of annuities with applications to problems in mortgage refinance, bond pricing, and other securities. The topics of duration and convexity and its effect on the volatility of fixed income instruments with respect to interest rate movements will be discussed.

**Grading:** Grad Stern Graded

**Repeatable for additional credit:** No

## STAT-GB 2301 Regression and Multivariate Data Analysis (3 Credits)

*Typically offered occasionally*

This is a datadriven applied statistics course focusing on the analysis of data using regression models. It emphasizes applications to the analysis of business and other data and makes extensive use of computer statistical packages. Topics include simple and multiple linear regression, residual analysis, and other regression diagnostics, multicollinearity, and model selection, autoregression, heteroscedasticity, regression models using categorical predictors, and logistic regression. All topics are illustrated on real data sets obtained from financial markets, market research studies, and other scientific inquiries.

**Grading:** Grad Stern Graded

**Repeatable for additional credit:** No

## STAT-GB 2302 Forecasting Time Series Data (3 Credits)

*Typically offered occasionally*

Presented in this course are practical time series forecasting techniques with emphasis on the Box-Jenkins, ARIMA, autoregressive integrated moving average method, and conditional volatility ARCH, autoregressive conditional heterogeneity, and GARCH generalized autoregressive conditional heterogeneity models. The course gives a mix of practical data analysis along with an introduction to the relevant theory. The ARIMA models are used to forecast series like interest spreads.

**Grading:** Grad Stern Graded

**Repeatable for additional credit:** No

## STAT-GB 2308 Applied Stochastic Processes for Financial Models (3 Credits)

*Typically offered occasionally*

In this class we study stochastic models for the financial markets mostly in a discrete time setting. We shall discuss the concept of martingales and risk-neutral probability measures, and derive the general pricing formula for contingent claims. We shall study the binomial model and derive the price of a European call option on this model, called the binomial Black-Scholes (BS) formula. We study put options using the put-call parity. We shall compare the binomial BS formula to the continuous time BS formula, and analyze the latter via the "Greeks". We shall also look at exotic options such as the lookback and the knockout option. Additionally, American options, forward and future contracts, and fixed income models will be included as well.

**Grading:** Grad Stern Graded

**Repeatable for additional credit:** No

## STAT-GB 2309 Mathematics of Investment (3 Credits)

*Typically offered occasionally*

The course discusses mathematical and technical aspects of investments. Topics include measurement of interest and discount rates, accumulated value and present value, annuities, sinking funds, amortization of debt, and determination of yield rates on securities. Applications include bond evaluation, mortgages, capital budgeting, depreciation methods, and insurance.

**Grading:** Grad Stern Graded

**Repeatable for additional credit:** No

## STAT-GB 3105 Analytics & Machine Learn (1.5 Credits)

*Typically offered occasionally*

ANALYTICS & MACHINE LEARN

**Grading:** Grad Stern Graded

**Repeatable for additional credit:** No

## STAT-GB 3127 Statistical Aspects of Market Risk (1.5 Credits)

*Typically offered occasionally*

The recent financial crisis has raised a lot of awareness as well as criticism of risk management models. One potential problem is that easy access to software and statistical formula can result in a misplaced belief in the generated numbers without a clear understanding of the methodology and without questioning whether the numbers should be trusted. The aim of this course is to introduce statistical concepts, models, methodology, and terminology that are commonly used or referred to in market risk management to raise awareness of both the assumptions that are made in commonly used results and of the time series aspects of relevant data and their potential impact on the models and subsequent calculations.

**Grading:** Graded

**Repeatable for additional credit:** No

**STAT-GB 3205 Analytics and Machine Learning for Managers (2.5 Credits)***Typically offered occasionally*

There are a variety of statistical methods, old and new, that are used nowadays to analyze datasets, which can range in size from the small to the enormous. This course gives an introduction to, an overview of and a comparison between these various methods and the attendant terminology and the different kinds of questions they can help answer. Methods that will be discussed include Regression, the Lasso, Discriminant Analysis, Logistic regression, Regression and Classification Trees, etc. This course is not meant for the people doing the analysis but will be geared more towards helping managers understand the material and aid them in having meaningful conversations with the analytics groups in their firms. However, due to its very nature, there will be a mathematical aspect to the course (i.e. there will be formulae), though the aim is to try to understand the intuition behind them.

**Grading:** Grad Stern Pass/Fail Executive MBA**Repeatable for additional credit:** No**STAT-GB 3301 Introduction to the Theory of Probability (3 Credits)***Typically offered occasionally*

This course covers the basic concepts of probability. Topics include the axiomatic definition of probability; combinatorial theorems; conditional probability and independent events; random variables and probability distributions; expectation of functions of random variables; special discrete and continuous distributions, including the chi-square, t, and F distributions; joint distributions with emphasis on the bivariate normal distribution; law of large numbers, central limit theorem; and moment generating functions. The theory of statistical estimation is introduced with a discussion on maximum likelihood estimation.

**Grading:** Grad Stern Graded**Repeatable for additional credit:** No**STAT-GB 3302 Statistical Inference and Regression Analysis (3 Credits)***Typically offered occasionally*

The course has two distinct components: statistical inference and regression analysis. Topics included in statistical inference are principles of statistical estimation and inference, Neyman-Pearson Lemma, testing of means, variances, tests of independence, and nonparametric methods. Regression analysis focuses on the general linear regression model least squares estimation, departures from standard assumptions, autocorrelation, multicollinearity, analysis of residuals, choice of variables, and nonlinear models.

**Grading:** Grad Stern Graded**Repeatable for additional credit:** No**STAT-GB 3303 Multivariate Statist Anal (3 Credits)***Typically offered occasionally*

This course covers multivariate distributions It focuses on the multivariate normal geometric principle of sampling multivariate asymptotics principles of multivariate inference tests of the mean vector for one and several populations leading to Hotellings T2 statistic and MANOVA multiple analysis of variance techniques of multiple comparisons multivariate linear regression models principal components factor analysis canonical correlations discrimination and classification clustering and graphical displays of multivariate data

**Grading:** Grad Stern Graded**Repeatable for additional credit:** No**STAT-GB 3306 Time Series Analysis (3 Credits)***Typically offered occasionally*

This course presents the Fourier analysis of time series The frequency domain approach covered here provides a complementary outlook on time series to the usual time domain Box-Jenkins approach Topics include periodicity cycles in time series data the periodogram and its distribution linear filters and transfer functions spectral density spectral representations of autocovariances and stationary processes ARMA autoregressive moving average models and their spectra model selection the linear forecasting problem and spectral estimation We also discuss long memory models including fractional ARIMA autoregressive integrated moving average and nonlinear time series including ARCH autoregressive conditional heterogeneity models and chaos as time permits

**Grading:** Grad Stern Graded**Repeatable for additional credit:** No**STAT-GB 3310 Applications of Statistical Models to Business, Politics and Policy (3 Credits)***Typically offered occasionally*

This course is intended to provide students with a basic understanding of how statistical models can be applied to the areas of business, politics, and public policy as well as common pitfalls, limitations with different approaches, and lessons learned from recent events. The goal is to give students an understanding of what techniques are used in contemporary statistical analyses of these topics and with the tools to carry out their own empirical analyses and to evaluate the work of others. The course covers techniques used to forecast economic, financial, and political events as well as econometric approaches used to identify causal relationships and to evaluate business and government policies. Much of the instruction is motivated by empirical examples that are assigned as readings for each class. Prerequisites: any introductory Statistics course

**Grading:** Grad Stern Graded**Repeatable for additional credit:** No**STAT-GB 3311 Regression & Multivar Anal (3 Credits)***Typically offered occasionally*

This is a datadriven applied statistics course focusing on the twin subjects of regression and multivariate data analysis It emphasizes applications to the analysis of business data and makes extensive use of computer statistical packages Topics include the analysis and management of data multiple linear and nonlinear regression selection of variables residual analysis model building autoregression and multicollinearity Topics in multivariate data analysis include principal components analysis of variance categorical data analysis factor analysis cluster analysis discriminant analysis and logistic regression All topics are illustrated on data sets obtained from the financial markets market research studies and other scientific inquiries

**Grading:** Grad Stern Graded**Repeatable for additional credit:** No

**STAT-GB 3312 Forecast Time Series Data (3 Credits)**

*Typically offered occasionally*

Presented in this course are practical time series forecasting techniques with emphasis on the Box-Jenkins ARIMA autoregressive integrated moving average method and conditional volatility ARCH autoregressive conditional heterogeneity and GARCH generalized autoregressive conditional heterogeneity models. The course gives a mix of practical data analysis along with an introduction to the relevant theory. The ARIMA models are used to forecast series like interest spreads while ARCH models are used in estimating and forecasting the volatility of series like stock returns and exchange rate returns. Students analyze data sets of their own choice in projects. Additional topics of interest covered in the course are methods of testing for nonstationary Dickey-Fuller tests as well as models for capturing seasonality as seen for example in series of monthly sales figures. The low-cost forecasting method of exponential smoothing is discussed and its connection to the RiskMetrics™ methods of J.P. Morgan and GARCH models is explored. If time permits, we also study methods of forecasting multivariate time series where information from several series is pooled to forecast a single series. The concept of cointegration or comovement of multivariate series is discussed, interest rates being a prime example along with their implications for forecasts. Other potential topics in the course include the use of ARCH models in value at risk VAR analysis and in option pricing.

**Grading:** Grad Stern Graded

**Repeatable for additional credit:** No

**STAT-GB 3314 Stat Comput & Sampl Meth (3 Credits)**

*Typically offered occasionally*

This course covers most of the classical and modern Monte Carlo methods for statistical estimation. In particular, the fast growth of Monte Carlo Markov Chain MCMC methods has enabled the use of Bayesian inference in many applied fields. Methodologies are illustrated with financial applications such as estimation of implied volatility and risk measures. Examples are drawn from published research and survey papers in current literature. Risk magazine J.P. Morgan's Risk Metrics. The course integrates three basic components of statistical analysis in financial areas: 1) modeling and inference with emphasis on Bayesian methodology, 2) computing and sampling methods for statistical estimation with emphasis on MCMC and 3) applications to financial data with emphasis on volatility and risk. The focus is placed on the second component bridging the gap between what can be said in theory, first component and what can be done in practice, third component. The goals of the course are modest so that a full treatment of all major topics can be achieved.

**Grading:** Grad Stern Graded

**Repeatable for additional credit:** No

**STAT-GB 3321 Introduction to Stochastic Processes (3 Credits)**

*Typically offered occasionally*

This is an introductory course in stochastic processes. Its purpose is to introduce students to the classes of stochastic processes, which are widely used as modeling tools in business fields such as finance, marketing and actuarial science as well as in physical and social sciences. The course covers basic theory of discrete and continuous time Markov chains, of Brownian motion and its generalizations, and of martingales. The discussion of Markov chains and Brownian motion includes statistical aspects of these processes. If time permits, the idea of stochastic integration is introduced and the rules of stochastic calculus are developed.

**Grading:** Grad Stern Graded

**Repeatable for additional credit:** No

**STAT-GB 3323 Stochastic Models in Finc (3 Credits)**

*Typically offered occasionally*

This is a course on mathematical methods for modeling financial markets with emphasis on valuation of financial derivatives. Topics include concepts of arbitrage, equivalent martingales measures, price systems with finite and infinite state space, Black-Scholes valuation formula, Girsanov's theorem, general contingent claims pricing, valuation of European and American options and estimation of the volatility of the asset prices.

**Grading:** Grad Stern Graded

**Repeatable for additional credit:** No

**STAT-GB 3352 Adv Theory of Probability (3 Credits)**

*Typically offered occasionally*

The aim of the course is to establish a comprehensive foundation of the theory of probability. The topics covered are basic measure theory, random variables and induced measures and distributions, independence of random variables, integration in a probability space with emphasis on conditional expectation and martingales, modes of convergence of random variables including almost sure convergence, convergence in LP, convergence in probability and convergence in distribution, characteristic functions and the inversion formula and the central limit theorem for independent identically distributed random variables and also for martingale differences. If time permits, additional topics will include functional central limit theorems and their applications.

**Grading:** Grad Stern Graded

**Repeatable for additional credit:** No

**STAT-GB 3370 Independent Study (3 Credits)**

*Typically offered occasionally*

Independent Study

**Grading:** Grad Stern Graded

**Repeatable for additional credit:** No

**STAT-GB 3383 Frequency Domain Time Series (3 Credits)**

*Typically offered occasionally*

Frequency Domain Time Series

**Grading:** Grad Stern Graded

**Repeatable for additional credit:** No

**STAT-GB 3385 Foundations of Machine Learning and Deep Learning with Applications to Business (3 Credits)**

*Typically offered occasionally*

This course contains two parts: (1) In the first part, we will cover the basics of supervised (regression and classification) and unsupervised learning (clustering and dimension reduction). We will also discuss modern topics such as deep neural networks, semi-supervised learning, multi-armed bandit learning, and stochastic optimization for training web-scale data. (2) In the second part, we will cover applications relevant to information and operations, including crowdsourcing, dynamic pricing, and choice-model based recommendation. The Ph.D. students should also prepare the course project and present in class how to use machine learning techniques to address challenges in their own domains.

**Grading:** Grad Stern Graded

**Repeatable for additional credit:** No

**STAT-GB 4101 Research Practicum-Stat (1 Credit)**

*Typically offered occasionally*

RESEARCH PRACTICUM-STAT

**Grading:** Grad Stern Pass/Fail

**Repeatable for additional credit:** No

**STAT-GB 4102 Research Practicum (1 Credit)***Typically offered occasionally*

RESEARCH PRACTICUM

**Grading:** Grad Stern Pass/Fail**Repeatable for additional credit:** No**STAT-GB 4103 Research Practicum (1 Credit)***Typically offered occasionally*

RESEARCH PRACTICUM

**Grading:** Grad Stern Pass/Fail**Repeatable for additional credit:** No**STAT-GB 4104 Research Pract IV - Stat (1 Credit)***Typically offered occasionally*

RESEARCH PRACT IV - STAT

**Grading:** Grad Stern Pass/Fail**Repeatable for additional credit:** No**STAT-GB 4105 Research Practicum - 5 (1 Credit)***Typically offered occasionally*

RESEARCH PRACTICUM - 5

**Grading:** Grad Stern Pass/Fail**Repeatable for additional credit:** No**STAT-GB 4150 Teaching Pract-Stat/Or (1 Credit)***Typically offered occasionally*

TEACHING PRACT-STAT/OR

**Grading:** Grad Stern Pass/Fail**Repeatable for additional credit:** No**STAT-GB 4210 Corporate Research Stat (2 Credits)***Typically offered occasionally*

CORPORATE RESEARCH STAT

**Grading:** Grad Stern Graded**Repeatable for additional credit:** No**STAT-GB 4304 Modern Statistics & Causal Inference for Data Science (3 Credits)***Typically offered occasionally*

This course surveys theory and methods addressing important statistical aspects of data science with a focus on high-dimensional data, statistical learning, and causal inference. We will begin with advances in hypothesis testing such as control of the false discovery rate for multiple comparisons. Then we will discuss statistical theory for popular learning and model selection methods such as the lasso, including recent advances in post-selection inference. Finally, after reviewing frameworks for causal inference the course will conclude by reading literature on the application of statistical learning methods to causal inference. Throughout the course we will combine theory, through mathematical understanding, with practice, through empirical understanding and competency with applications such as simulation studies. We assume a working knowledge of probability and linear algebra, familiarity with statistics, and willingness to code in the R statistical programming language, but otherwise the course is self-contained.

**Grading:** Grad Stern Graded**Repeatable for additional credit:** No**STAT-GB 4310 Statistics - Social Data (3 Credits)***Typically offered occasionally*

Statistical methods for describing and utilizing nontraditional data modalities arising from social processes. Half of the course will be devoted to network data (communications, recommendations, and transactions) and the other half will be devoted to textual data (words, phrases, and documents). We will survey a broad class of models for dealing with these types of data. Possible topics include the following: word-sense disambiguation; sentiment analysis; Markov and hidden Markov text models; topic discovery; descriptive statistics for networks; community detection; exponential random graph models; latent space models; network sampling; point processes; low-rank matrix approximations; power laws. The course will assume some prior knowledge of linear algebra, probability, and statistical inference.

**Grading:** Grad Stern Graded**Repeatable for additional credit:** No**STAT-GB 6008 Appl Stoch Proc F/Fin Models (3 Credits)**

Presents a mathematical background for the stochastic processes that are widely employed as modeling tools in finance. The emphasis is on an intuitive approach and examples rather than on proofs and mathematical rigor. Topics include random walks, martingales, Markov chains, Poisson process and other continuous time Markov chains, Brownian motion, geometric Brownian motion, and other diffusion processes. The relevance of the considered processes to financial modeling is stressed throughout. In particular, applications to pricing of derivative securities and to modeling of the term structure of interest rates are discussed.

**Grading:** Grad Stern Graded**Repeatable for additional credit:** No**STAT-GB 6014 Intro Theory of Probability (3 Credits)***Typically offered occasionally*

Covers the basic concepts of probability. Topics include the axiomatic definition of probability; combinatorial theorems; conditional probability and independent events; random variables and probability distributions; expectation of functions of random variables; special discrete and continuous distributions, including the chi-square, t, F, and bivariate normal distributions; law of large numbers; central limit theorem; and moment generating functions. The theory of statistical estimation is introduced with a discussion on maximum likelihood estimation.

**Grading:** Grad Stern Graded**Repeatable for additional credit:** No**STAT-GB 6015 Stat Infer/Regress Analy (3 Credits)**

Consists of two distinct components: statistical inference and regression analysis. Statistical inference topics include the principles of statistical estimation and inference, Neyman Pearson Lemma, testing of means, variances, tests of independence, and nonparametric methods. Regression analysis discusses the general linear regression model, least squares estimation, departures from standard assumptions, autocorrelation, multicollinearity, analysis of residuals, choice of variables, and nonlinear models.

**Grading:** Grad Stern Graded**Repeatable for additional credit:** No

**STAT-GB 6017 Regression & Multivariate Data Analysis (3 Credits)**

*Typically offered occasionally*

This is a data-driven, applied statistics course focusing on the analysis of data using regression models. It emphasizes applications to the analysis of business and other data and makes extensive use of computer statistical packages. Topics include simple and multiple linear regression, residual analysis and other regression diagnostics, multicollinearity and model selection, autoregression, heteroscedasticity, regression models using categorical predictors, and logistic regression. All topics are illustrated on real data sets obtained from financial markets, market research studies, and other scientific inquiries.

**Grading:** Grad Stern Graded

**Repeatable for additional credit:** No

**STAT-GB 6018 Forecasting Time Series Data (3 Credits)**

*Typically offered occasionally*

A model-based approach to forecasting time series data, with emphasis on model building, foundations, and applications. Students will use the methodology of the course to analyze data sets of their choice in two projects. Weekly homework assignments on data analysis and theory. Topics of the course include the following: Autocorrelation vs. trend; Mean Squared Error for measuring forecast performance; Conditional distribution of future given present and past; Mean reversion (stationarity) and differencing; ARIMA models, their properties, and the corresponding forecasts; Box-Jenkins approach to statistical modeling: estimation, identification, diagnostic checking; Model Selection using information criteria; Exponential Smoothing; Linear vs. Nonlinear models; Chaos; Best possible forecast vs. best linear forecast; ARCH/GARCH models for forecasting volatility; Fractional ARIMA and long-memory models; Seasonal ARIMA models; Unit root tests and cointegration.

**Grading:** Grad Stern Graded

**Repeatable for additional credit:** No

**STAT-GB 6027 Mathematics of Investment (3 Credits)**

Discusses the mathematical and technical aspects of investments.

Topics include measurement of interest and discount rates, accumulated value and present value, annuities, sinking funds, amortization of debt, and determination of yield rates on securities. Applications include bond evaluation, mortgages, capital budgeting, and depreciation methods.

**Grading:** Grad Stern Graded

**Repeatable for additional credit:** No