Quantitative methods have become fundamental tools in the analysis and planning of financial operations. There are many reasons for this development: the emergence of a whole range of new and complex financial instruments, innovations in securitization, the volatility of fixed-income markets since interest rate deregulation, the increased globalization of the financial markets, the proliferation of information technology, and so on.

In this course, models for hedging, asset allocation, and multi-period portfolio planning are developed, implemented, and tested. In addition, pricing models for options, bonds, mortgage-backed securities, and swaps are discussed. The models typically require the tools of statistics, optimization, and/or simulation, and they are implemented in spreadsheets or a high-level modeling environment, MATLAB. A student version of Matlab is available at the University Bookstore; details will be discussed in class.

Optional readings in the course bulkpack will focus on the applications and will include recent publications by investment and commercial banks.

The grade for the course will be based on homework assignments and a take-home final exam. The homework will count for 60% of the final grade. There will be about six-seven homework assignments during the term. The final exam will count for 40% of the final grade. Students may work on the homeworks in groups of three or less. Details of the final exam will be discussed later in the term.

This course is quantitative and will require extensive computer use. The course is intended for students who have a strong interest in finance. Prospective students of this course should be comfortable with quantitative methods, such as basic statistics and the methodologies (mathematical programming and simulation) taught in OPIM 621 (Decision Models and Uncertainty).
Course Syllabus

Tentative Schedule

Lecture 0,
Mathematical Review. Review of basic probability, statistics, and regression. Financial data analysis, time series analysis, volatility measurement.

Readings: BP sections on Background material and Data Analysis

1 Course Overview & Hedging.
The course begins with an introduction to hedging. A hedged portfolio is one that is insulated from market forces. In this section, we discuss some basic concepts in hedging. The issue of hedging will be addressed later in the course when pricing models are developed for specific securities.

Topics: Formulation of the hedging problem, Regression hedging. Examples and applications; in-sample versus out-of-sample performance.

Readings: BP section on Hedging and Value at Risk (VAR).

2-6 Numerical Option Pricing – Overview
We first give some brief background on option pricing theory and then present the main numerical methods for pricing complex options – the binomial method and Monte-Carlo simulation. We start with simple European calls and puts, then extend to American and exotic options. Exotics include options with path-dependent payoffs and options on multiple underlying assets.

Topics: Review of the Black & Scholes Model; Geometric Brownian process and the lognormal distribution of stock prices; the discrete approximation (CRR model).

Readings: BP section on Numerical Option Pricing.

2 Numerical Option Pricing I – Option Pricing Theory
We first give some brief background on option pricing theory and then present the binomial method.

Topics: Review of the Black & Scholes Model; Geometric Brownian process and the lognormal distribution of stock prices; the discrete approximation (CRR model).

Readings: BP section on Numerical Option Pricing.

3-5 Numerical Option Pricing II – The Binomial Method.
We start with the binomial pricing method for simple European calls and puts, and then extend it to American options. We continue with binomial pricing methods for exotic options; Exotics include options with path-dependent payoffs and options on multiple underlying assets (rainbow options).

Topics: European and American options. Path independent and path dependent securities: caps, barrier and lookback options. Options on multiple assets.

Readings: BP section on Numerical Option Pricing.

5-6 Numerical Option Pricing III – Monte Carlo Simulation.
We discuss Monte Carlo Simulation. Pricing path independent and dependent options.
Course Syllabus

Variance Reduction Techniques.

Topics: Random number generator; Pricing path independent and dependent securities by simulation; Variance reduction techniques: antithetic and control variate techniques, stratified sampling and Latin Hypercube.

Readings: BP section on Numerical Option Pricing.

Option Pricing IV – Back to the Real World
We apply the B&S models to traded securities and observe the volatility smile.

Topics: Historical simulation, stress test, stochastic volatility, jump diffusion process.

7 Delta Hedging
Black&Scholes meet the real world: We challenge the model's assumptions and partially investigate (via simulation) why observed market prices differ from theoretical values......

Topics: Static hedging versus dynamic hedging, Naked/Covered positions; Stop-Loss strategy.

Structured Option Portfolios
Finally, we investigate the problem of forming a portfolio of short-term options to create a synthetic long-term option. This approach is called structured option portfolio and is motivated by possible difficulties with a standard replication approach for a long-term option.

Topics: Application to long-term option replication. Portfolio option replication.

Readings: BP section on Structured Option Portfolio

8 Portfolio Optimization
In this part of the course, the risk-reward tradeoff is explored for a portfolio with multiple securities. First, we study the standard mean-variance quadratic programming model, variations of the model based on alternative definition of risk, and several applications and extensions.


Readings: BP section on Portfolio Optimization.

9 Multiperiod Portfolio Analysis.
Finally, we address the multiperiod investment problem and the problem of choosing among efficient portfolios.

Course Syllabus

Readings: BP section on Multiperiod Portfolio Analysis.

10  **Bond Analytics.**
We give a brief background on bond mathematics. We study the pricing of U.S. Treasury bonds and introduce some of the taxonomy used for fixed-income securities such as yield and duration.

*Topics:* Review of discounting, present value and yield. Duration and convexity measures. Immunization and hedging applications. The discount factor and the spot yield curve.

Readings: BP section on Bond Analytics.

11  **Yield Curve Fluctuations.**
We investigate changes in the Treasury yield curve and its implication for bond portfolio management.


Readings: BP section on Yield Curve Analysis.

12-13  **Interest Rate Models and Pricing Interest Rate Sensitive Securities.**
Finally, using a simple interest-rate model, we look at pricing of bonds and callable bonds, swaps and swaptions, caps and floors, and mortgage-backed securities.


Readings: BP section on Interest Rate Models.

Course Readings
Most of the reading for the course will be in the form of lecture handouts that will be distributed in class and material from the course bulkpack.
Course Syllabus

Course-Related Books

“Industry” Books
The following books are widely read on Wall Street. Some books are edited compilations of research reports from the major investment banks.


Derivatives Trading and Option Pricing, Nicholas Dunbar (Editor), Risk Books, 2005.


Course Syllabus

My Life as a Quant: Reflections on Physics and Finance, Emanuel Derman, Wiley, 2004
Over the Rainbow, RISK Publications/Fuji, London, 1996,

Fortune’s Formula: The Untold Story of the Scientific Betting System that Beat the Casinos and Wall Street, William Poundstone, Hill and Wang, 2006

Journals


Finance Textbooks

Elton and Gruber, Modern Portfolio Theory and Investment Analysis, 5th edition, Wiley, New
**Course Syllabus**


**Statistics Textbooks**


**Time Series and Multivariate Statistics Textbooks**


**Operations Research Textbooks**