Outline

This course introduces the fields of quantitative finance/financial engineering.

Financial Engineering is a multidisciplinary field involving financial theory, the methods of engineering, the tools of mathematics and the practice of programming.

The objective is to help students develop basic skills in modeling, problem solving and the quantitative analysis of risk-return trade-offs in portfolios of financial securities.

The tools we make use of in this course are statistics, probability, multivariable calculus, Taylor series, differential equations, numerical solutions to differential equations, Monte Carlo simulation, and stochastic calculus. We assume a certain fundamental knowledge of statistics, probability theory and calculus, and will use these to teach numerical solutions and stochastic calculus within the course.

Textbooks.
There are no required textbooks for this course, and I will cover most of the material in class and in my notes.

I don't rely on any single textbook. However I will recommend four that are reasonable, though you may find others that are equally good.

1. [B] Stephen Blyth: *An Introduction to Quantitative Finance*
   A new very short good book that hits most of the essentials in a brief, clear and unfancy way.

2. [H] John Hull. *Options, Futures and Other Derivatives.*
   The standard. Long. Contains lots of information about derivatives models.

   Broad too. Good on optimization and CAPM, and on fixed income cash flows.

   Very practical and no-nonsense. Good taste. Approaches finance as a branch of applied mathematics rather than probability theory, which I think is the right way to do it. Easy to dip into for topics.
Topics
(subject to change)

The nature of finance
   Markets, products, value, uncertainty and risk
   Underlyers and derivatives, forwards, futures, options

Products with deterministic cash flows
   Present value analysis, bond prices, risk measures

Products with risky cash flows (i.e. almost everything)
   A model for risk
   Random walks and stock prices
   Binomial lattices
   Arithmetic Brownian motion
   Geometric Brownian motion

The One Principal of Finance: The Law of One Price/No Riskless Arbitrage
   Deriving A Relation Between Risk and Return
   Sharpe ratios
   The Capital Asset Pricing Model

Markowitz Mean-Variance Optimization
   Revisiting CAPM

Mathematical Tools for Stochastic Processes: Stochastic calculus and Ito’s lemma

Options, Forwards, Futures
   Binomial tree model
   Risk-neutral pricing
   Black-Scholes PDE
   Black-Scholes formula
   Delta hedging and Greeks
   American options

Model Calibration & Implied Volatility

Exotic options

Numerical Methods of Solution

Modeling Interest Rates and the Term Structure of Interest Rates

Revisiting Risk-neutral Pricing: Martingales
   No-arbitrage principle
Martingales
“Fundamental Theorem” of Finance
Changes of measure
Risk Management of Portfolios
Value-at-Risk
etc