Math 581/Econ 673: Mathematical Finance

This course is ideal for students who want a rigorous introduction to finance. The course covers three fundamental areas every modeler in finance should know: security price modeling, portfolio theory, and financial derivatives. We shall dissect financial models by isolating their central assumptions and conceptual building blocks, showing rigorously how their governing equations and relations are derived, and weighing critically their strengths and weaknesses.

Prerequisites: The mathematical prerequisites are Math 212 (or 222), Math 221, and Math 230 (or 340) or consent of instructor.

Assignments: assignments are team based.

Grading: 70% homework and 30% in-class, individual project.

Text: The primary reference for the course will be a manuscript in progress (the instructor will provide more info during the first day of class). The following books can serve as supplemental readings:


Course Outline

- The Time Value of Money
  - Compound interest with fractional compounding
  - NPV, IRR, and Descartes’s Rule of Signs
  - Annuity and amortization theory
  - Valuation of stocks and bonds

- Portfolio Theory
  - Markowitz portfolio model
– Two-security portfolio
– N-security portfolio
– Investor utility
– Diversification and the uniform Dirichlet distribution

• Capital Market Theory and Portfolio Risk Measures
  – The Capital Market Line
  – The CAPM Theorem
  – The Security Market Line
  – The Sharpe ratio
  – The Sortino ratio
  – VaR
  – Linear factor models: alpha, beta, and the Fama-French model

• Modeling the Future Value of Risky Securities
  – Binomial trees
  – Continuous-time limit of the CRR tree
  – Stochastic process: Brownian motion and geometric Brownian motion
  – Itô’s formula

• Options, Forwards, and Futures
  – No arbitrage and the Law of One Price
  – Option type, style, and payoff
  – Put-Call Parity for European options
  – Put-Call Parity bounds for American options
  – Forwards and futures

• The Black-Scholes-Merton Model
  – Black-Scholes-Merton (BSM) formula
  – Binomial-tree approach to the BSM formula
  – Continuous-time, risk-neutral approach to the BSM formula
  – Delta hedging
  – Implied volatility