381 Computational Finance

Course Objectives

Computational finance course will

- bring a level of confidence to students to the finance field,
- provide an experience of formulating finance problems into computational problems,
- introduce the computational issues in financial problems,
- provide an illustration of the role of optimisation in computational finance such as single and multi-period mean-variance portfolio management,
- introduce numerical techniques for valuation, pricing and hedging of financial investment instruments such as options.

COURSE OUTLINE

Part I

Introduction to Computational Methods in Finance

1-Quick Review of Matrices and Functions (2 Hours, IM)

- Terminology and definitions – vectors, matrices.
- Functions of a single variable; differentiability; convexity, concavity; determining minimum or maximum.
- Functions of several variables; partial differentiation; gradient; Hessian; Taylor expansion; Newton's method.
- Partial differential equations; finite difference method.

2. Probability and Optimisation (2 Hours, IM)

- Random variables, probability; distribution, moments.
- Optimisation.
- Linear and quadratic programming; feasible set; Lagrangean function; optimality conditions.

Part II

Portfolio Theory and Risk Management

3-Introduction to Investment Theory (2 Hours, NG)

- basic terminology and definitions – investment, financial markets, cash flows, risk aversion, pricing, hedging
- fundamental theorems and principals
- interest rate theory – present value, future value

4-Bonds, Stocks and Their Valuation (2 Hours, NG)

- Valuation of bonds, bond prices, yield to maturity, duration, convexity, term structure, spot and forward rates
- Valuation of common stocks, stock prices, stock returns and dividend yields

5-Single-period Markowitz Model (2 Hours, BR)

- asset return, portfolio return and uncertainty
- maximum expected value
- minimum risk – variance, downside risk and may be credit risk, value at risk

- Markowitz model – various versions with different constraints
- the efficient frontier

6-The Asset Pricing Models (2 Hours, NG)

- capital asset pricing model
- factor models – single and multi factor models
- simple and multiple linear and nonlinear regression
- arbitrage pricing model

Part III

Derivative Securities

7-Introduction to Derivatives (2 Hours, NG)

- financial derivatives – futures, swaps, option contracts (Vanilla, Exotic)
- time values of derivatives – arbitrage and risk-neutral valuation

8-Introduction to Option Theory (2 Hours, NG)

- models of asset dynamics – binomial lattice, stochastic process, Brownian motion
- Ito calculus

9-Option Pricing Models (2 Hours, NG)

- Black-Scholes equation and its applications to valuation
- binomial pricing models

10-Hedging and Risk Management (2 Hours, NG)

- financial risk management
- dynamic and static hedging strategies, bucket hedging
- measuring risk – risk sensitivities (greeks), value-at-risk, scenario analysis
- managing risk for vanilla and exotic options

Recommended Books

There are many specific references from both academic and practitioners journals that will be given in the lecture notes. General books that cover parts of the material are summarised as follows;

References

[1] J. Hull, *Options, Futures, and Other Derivative Securities*, Prentice Hall, 2000.

[2] D. Duffie, *Dynamic Asset Pricing Theory*, Princeton University Press, 1996.

[3] D. G. Luenberger, *Investment Science*, 1998.

[4] P. Wilmott, *Derivatives: The Theory and Practice of Financial Engineering*, 1998.

[5] P. Wilmott, *Option Pricing: Mathematical Models and Computation*, 1993.

[6] S. Pliska, *Discrete Time Models in Finance*, 1998.

[7] E.J., Elton, M.J. Gruber, *Modern Portfolio Theory and Investment Analysis*, 1995.