5. FINANCIAL ENGINEERING

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Course description:
The objective of this course is to provide the participants with the necessary skills to value and hedge a wide variety of derivatives contracts; and to enable them to profitably design and structure such contracts. The course presents a systematic, unified approach to the pricing of derivatives and adopts cutting-edge methods throughout. Continuous-time mathematics is developed and employed as the main tool of analysis. In developing the theory, the course will cover stochastic calculus, the valuation of securities via martingale methods and valuation via partial differential equations, as well as the necessary numerical methods.

Course text:

Course assignments and assessments:
The course grade will be based on:

- Two assignments dealing with the valuation of derivatives and associated strategies (30% of grade)
- A final exam (70% of grade)

Detailed Outline
Week 1
INTRODUCTION TO DERIVATIVES MARKETS

Definitions and historical development
Characteristics of forwards, futures and options
Payoff diagrams
Types of traders
Readings (☼ = optional):
Hull, Chapter 1

Week 2
FUTURES BASICS (MARKETS AND HEDGING ISSUES)
The operation of futures markets
Hedging with futures
Hedge ratio
Rolling hedges
Readings:

Hull, Chapters 2, 3


Week 3

FORWARD AND FUTURES PRICES

Stock index futures
Forwards and futures on currencies
Futures on commodities
Cost of carry
Delivery options

Readings:

Hull, Chapter 5, Appendices 3A, 3B

Week 4

INTEREST RATE FUTURES

Preliminaries on interest rate futures
Treasury bond, treasury note and treasury bill futures
Duration and duration based hedging

Readings:

Hull, Chapter 6

Week 5

SWAPS

Interest rate swaps
Currency and other swaps
Valuation
Credit risk
Examples
Readings:

Hull, Chapter 7


Week 6

OPTION BASICS (MARKETS, PRICES, TRADING STRATEGIES)

Description of options and markets
Properties of option prices, limits
Basic trading strategies involving options

Readings:

Hull, Chapters 8, 9, 10


Week 7

BLACK-SCHOLES OPTION PRICING

Asset price random walks
Markov and Wiener processes, geometric Brownian motion
Ito’s lemma
Derivation of the Black-Scholes differential equation
The Black-Scholes model
Risk neutral valuation

Readings:

Hull, Chapters 12, 13, ☼ Appendices 12A, 13A, 13B, 13C
Week 8
OPTIONS ON INDICES, CURRENCIES, FUTURES CONTRACTS

Options on stock indices, currencies, futures contracts
Exchange traded bond options
Interest rate caps

Readings:
Hull, Chapters 14, (emphasise contract descriptions; skim evaluation)

Week 9
DERIVATIVES AND ASSET MANAGEMENT (THE GREEK LETTERS)

Naked and covered positions
Stop-loss and delta hedging strategies
The Greeks: theta, gamma, rho
Portfolio insurance

Readings:
Hull, Chapter 15, ☼Appendix 15A

Week 10
MODELING AND FORECASTING VOLATILITY

Volatility changes, ARCH models
Stochastic volatility models, High frequency empirical evidence
Implied volatility
Option valuation when volatility is stochastic

Readings:
Hull, Chapters 19
☼Engle, R., and Mezrich, J., “Grappling with Garch”, Risk, Vol. 8, No 9, September

**Week 11**

NUMERICAL PROCEDURES

- The Binomial asset pricing model
- Monte Carlo simulation
- Variance reduction
- Finite difference methods

*Readings:*

*Hull, Chapters 11, 17*


**Week 12**

VOLATILITY SMILES AND ALTERNATIVES TO BLACK-SCHOLES

- The volatility term structure
- Volatility matrices
- Alternative models for stock pricing
- Pricing models involving jumps

*Readings:*

*Hull, Chapter 16, 24*


**Week 13**

EXAM