MAFS5030 – Quantitative Modeling of Derivative Securities

Course objective
This course is directed to those students who would like to acquire an introduction to the pricing theory of financial derivatives. The course starts with the exposition of basic derivative instruments. We then discuss the fundamental concepts of financial economics, like the fundamental theorem of asset pricing, risk neutral valuation principle. The renowned Black-Scholes pricing theory and martingale pricing theory are introduced. Extended option pricing models, like exchange options, quanto options, risky debt models, transaction costs models are considered. We also discuss the notion of implied volatility and volatility smile, trading of volatility via various volatility instruments.

Prerequisite and exclusion
A course on stochastic calculus (MAFS501) should be taken concurrently or earlier. No prior knowledge in finance is required.

Instructor
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Textbook

Course content
1. Introduction to derivative instruments
   1.1 Basic instruments: bonds, forward contracts and futures
   1.2 Exotic swap products
   1.3 Options: Rational boundaries of option values
   1.4 American options: Optimal early exercise policies

2. Discrete securities model
   2.1 Single-period models: Dominant trading strategies and linear pricing measure
   2.2 No-arbitrage theory and risk neutral probability measure: Fundamental Theorem of asset Pricing
   2.3 Valuation of contingent claims and complete markets
   2.4 Information structures and filtrations in multi-period models
   2.5 Notion of martingales: Discounted gain process and self-financing strategy
   2.6 No-arbitrage principle and martingale measure
   2.7 Binomial option pricing models

3. Black-Scholes-Merton framework and Martingale Pricing Theory
   3.1 Review of stochastic processes and Ito calculus
   3.2 Change of measure – Girsanov’s Theorem
   3.3 Riskless hedging principle and dynamic replication strategy
   3.4 Martingale pricing approach
   3.5 European option pricing formulas and their greeks
4. Extended option models
   4.1 Continuous dividend yield models: Time dependent parameters
   4.2 Exchange options
   4.3 Quanto options – equity options with exchange rate risk exposure
   4.4 Implied volatility and volatility smiles
   4.5 Volatility trading: variance and volatility swaps, VIX
   4.6 Merton’s models of risky debts
   4.7 Transaction costs models

Grading policies
   90-minute mid-term: Topic 1 and Topics 2.1-2.4  40%
   135-minute final examination: Topics 2.5-2.6, Topics 3 and 4  60%