

## **MFIN 7003 – Module 2/3**

### **Mathematical Techniques of Finance I**

**Session A: Oct 20, 08 - Dec 7, 08**

**Session B: Dec 8, 08 - Feb 7, 09**

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### **Course Description**

There are three main approaches to mathematical finance: the tree approach, the martingale approach and the partial differential equation approach. This course will present these three approaches and their applications to pricing and hedging financial derivatives. The corresponding numerical methods of the three approaches are lattice method, Monte Carlo simulation method, and finite difference method. We might briefly introduce them. Along the lectures, we will also review necessary mathematics, such as calculus, partial differential equation, applied probability and stochastic calculus. After taking this course, students should be able to fully understand no-arbitrage theory, risk-neutral probability, martingale, and Black-Scholes equation. The purpose of this course is to lay down a solid mathematical foundation for students to learn more advanced topics in financial engineering and risk management, such as exotic options, interest rate derivatives and credit risk models.

### **Prerequisites**

- MFIN 6002 Spreadsheet Modeling in Finance
- MFIN 6003 Derivative Securities

### **Reference books**

- Baxter, Martin, and Andrew Rennie, 1996, Financial calculus: an introduction to derivative pricing, Cambridge University Press.  
Call #: [332.63221 B3](#)
- Hull, John, 2006, Options, Futures, & Other Derivatives, 6<sup>th</sup> edition, Prentice Hall.  
Call #: [LB 332.632 H91](#)

- Ross, Sheldon M., 2003, An elementary introduction to mathematical finance: options and other topics, 2nd edition, Cambridge University Press.  
Call #: [332.60151 R826 e](#)

## Grading

- Four Homework (individual) 56%
- One final exam 40%
- Course participation 4%

## Course Topics

Class meets on Monday and Wednesday evenings, 6:45pm-9:45pm, at United Conference Center.

### Tentative Course Outline (subject to change)

Lecture 1 Oct 20, 2008 Mon.	A: Introduction <a href="#">Level Test</a> <hr/> B: The Tree Approach I -- Binomial Branch: Construction of a replicating portfolio; The law of one price; No arbitrage; True probability measure; Risk-neutral probability measure; Martingale <a href="#">Lecture Note 1</a>  Reference: chapter 2.1 of the book by Baxter, Martin, and Andrew Rennie  <a href="#">Homework 1</a> It is due on Wed. Oct. 29, 2008.  Handwritten notes. You need to click shift+ctrl+minus to rotate the view.
Lecture 2 Oct 22, 2008 Wed.	<a href="#">In-class Exercise 1</a>  The Tree Approach II -- Binomial Tree: Binomial/trinomial tree model; Recombinant and non-recombinant trees; Backwards induction; Path probability; General rule of derivatives pricing by binomial tree (risk neutral valuation); Pricing European options, American options and exotic options (lookback and Asian options) by binomial tree; Early exercise; Monte Carlo simulation; Kolmogorov's strong law of large numbers  <a href="#">Lecture Note 2</a>  Reference: chapter 2.2 of the book by Baxter, Martin, and Andrew Rennie
Lecture 3 Oct 27, 2008 Mon.	Normal distribution; Lognormal distribution; Taylor Expansion; Review of Calculus; Review of probability  <a href="#">Lecture Note 3</a> <a href="#">Math Review 1</a> <a href="#">Math Review 2</a>  <a href="#">Homework 2</a> It is due on Wed. Nov. 5, 2008.

	<p><a href="#">Handwritten notes</a>. You need to click shift+ctrl+minus to rotate the view.</p>
<p>Lecture 4 Oct 29, 2008 Wed.</p>	<p><b>Homework 1 is due today.</b></p> <p><a href="#">In-class Exercise 2 Exercises on Differentiation Rules</a></p> <p>Stochastic Differential Equations: The quantitative finance timeline; Brownian motion; Geometric Brownian motion; Ito's lemma; Ito's integration; Modeling Stock Prices</p> <p><a href="#">Lecture Note 4</a> <a href="#">Article: The quantitative finance timeline by Paul Wilmott</a> <a href="#">Supplement to Lecture 4</a></p> <p><a href="#">Handwritten notes</a>. You need to click shift+ctrl+minus to rotate the view.</p>
<p>Lecture 5 Nov 3, 2008 Mon.</p>	<p>The Martingale Approach (Risk-neutral Pricing Method) I: Black-Scholes economy; Martingale revisit; Change of measure; General rule of derivatives pricing by martingale approach</p> <p><a href="#">Lecture Note 5A</a></p> <p><a href="#">Article: The quantitative finance timeline by Paul Wilmott</a></p> <p><a href="#">Handwritten notes</a>. You need to click shift+ctrl+minus to rotate the view.</p>
<p>Lecture 6 Nov 5, 2008 Wed.</p>	<p><b>Homework 2 is due today.</b></p> <p>Tradable and non-tradable; Pricing Foreign Exchange; Pricing Equities with Dividends</p> <p><a href="#">Lecture Note 5B</a></p> <p><b>Homework 3 It is due on Mon. Nov. 17, 2008.</b></p> <p><a href="#">Handwritten notes</a>. You need to click shift+ctrl+minus to rotate the view.</p>
<p>Lecture 7 Nov 10, 2008 Mon.</p>	<p>For those that are not familiar with ordinary integration, please try to read Section 4.1 – Section 4.2 (from pages 52 to 56) of <a href="#">Math Review 3</a> and try to do <a href="#">Exercise on Integration Rules</a> before class if you have time. <a href="#">Answers to Exercise on Integration Rules</a></p> <p>The Martingale Approach II -- Deriving Black-Scholes Formula by Martingale Approach: BS formula for vanilla call and vanilla put; Put-call</p>

	<p>parity; Review of Riemann Integration</p> <p><a href="#">Lecture Note 6</a></p> <p><a href="#">Handwritten notes</a>. You need to click shift+ctrl+minus to rotate the view.</p>
<p>Lecture 8 Nov 12, 2008 Wed.</p>	<p><a href="#">In-class Exercise 3</a></p> <p>The Black-Scholes and Merton Approach (The Partial Differential Equation (PDE) Approach) I -- Deriving Black-Scholes Partial Differential Equation: Market price of risk; Delta-neutral portfolio; Correlation; Perfect hedging; Portfolio analysis; Capital Asset Pricing Model (CAPM)</p> <p><a href="#">Lecture Note 7</a> <a href="#">An Article by Black</a></p> <p><a href="#">Summary of risk neutral valuation</a></p> <p><a href="#">Homework 4</a> <b>It is due on Mon. Nov. 24, 2008.</b></p> <p><a href="#">Handwritten notes</a>. You need to click shift+ctrl+minus to rotate the view.</p>
<p>Lecture 9 Nov 17, 2007 Mon.</p>	<p><b>Homework 3 is due today.</b></p> <p>PDE Approach II -- Deriving Black-Scholes Formula from Black-Scholes PDE: Heat equation; Delta function; Green's function; Transformation method in solving PDE</p> <p><a href="#">Lecture Note 8</a> <a href="#">LUO Xingguo's PPT</a></p> <p><a href="#">Handwritten notes</a>. You need to click shift+ctrl+minus to rotate the view.</p>
<p>Lecture 10 Nov 19, 2007 Wed.</p>	<p>Asymptotic Analysis of the Black-Scholes Formula and Implied Volatility; A brief discussion on the question of butterfly spread in Group Project 2.</p> <p><a href="#">Lecture Note 9</a></p> <p><a href="#">Handwritten notes</a>. You need to click shift+ctrl+minus to rotate the view.</p>
<p>Lecture 11 Nov 24, 2007 Mon.</p>	<p><b>Homework 4 is due today.</b></p> <p>Deriving Greeks and hedging with Greeks</p> <p><a href="#">Lecture Note 10</a></p> <p><a href="#">Handwritten notes</a>. You need to click shift+ctrl+minus to rotate the view.</p>

Lecture 12  
Nov 26,  
2007  
Wed.

Exam Review and Q&A

**Good Luck on Exams!**

[Handwritten notes](#). You need to click shift+ctrl+minus to rotate the view.

## **Final exam**

- **B13**
- **4:00 – 6:00 pm on Dec 6, 2008 Saturday for session A and Feb 6, 2009 Saturday for session B**
- **Open books and open notes**