

## **Math 440 Mathematical Theory of Financial Economics** **Bouillon 106, 8:00 – 8:50 (M-F)**

**Instructor:** Dr. Yvonne Chueh

**Office and Contact:** Bouillon 107G, Phone: 963-2124, e-mail: [chueh@cwu.edu](mailto:chueh@cwu.edu)

**Office Hours:** 10:00-10:50 Monday to Friday, or e-mail to make appointment or ask questions. Students are welcome to come in anytime when I am in my office. Check out <http://www.cwu.edu/~chueh> or my office door for my daily schedule.

**Prerequisite:** MATH 418C and Permission.

**Text:** Derivatives Markets, 2<sup>nd</sup> Edition, Robert L. McDonald, Pearson  
Actex MFE/3F Study Manual, Johnny Li, Actex, 2011 Edition

### **Course Objectives:**

**This 5-credit one-quarter new course is offered to cover the syllabus from Exam MFE Models for Financial Economics. It comes alongside students to help them prepare for this challenging and advanced professional exam. Given the large amount of material and topics to cover and practice thoroughly before our bi-weekly quiz assessments, students will assume the largest responsibility of reading the textbooks regularly. It's advised that students taking this course have their diligent reading before and after our daily lectures, discussions, and problem solving training.**

The Models for Financial Economics (MFE) Exam is a three hour multiple-choice examination. Exam MFE is offered via computer-based testing (CBT). It is called Exam MFE by the Society of Actuaries and Exam 3F by the CAS.

The syllabus for Exam MFE develops the candidate's **knowledge of the theoretical basis of certain actuarial models and the application of those models to insurance and other financial risks**. A thorough knowledge of calculus, probability and interest theory is assumed. Knowledge of risk management at the level of Exam 1/P is also assumed. In addition, for Exam MFE/3F, **candidates are assumed to be familiar with the earlier chapters of the McDonald text, which are in the syllabus of Exam 2/FM.**

### **Learning Objectives:**

#### **LEARNING OUTCOMES – MODELS FOR FINANCIAL ECONOMICS**

##### **A. Interest rate models (10-15%)**

1. Evaluate features of the Vasicek and Cox-Ingersoll-Ross bond price models.

2. Explain why the time-zero yield curve in the Vasicek and Cox-Ingersoll-Ross bond price models cannot be exogenously prescribed.
3. Construct a Black-Derman-Toy binomial model matching a given time-zero yield curve and a set of volatilities.

**B. Rational valuation of derivative securities (65-75%)**

1. Use put-call parity to determine the relationship between prices of European put and call options and to identify arbitrage opportunities.
2. Calculate the value of European and American options using the binomial model.
3. Calculate the value of European and American options using the Black-Scholes option-pricing model.
4. Identify the situations where the values of European and American options are the same.
5. Interpret the option Greeks.
6. Explain the cash flow characteristics of the following exotic options: Asian, barrier, compound, gap, and exchange.
7. Explain the properties of a lognormal distribution and explain the Black-Scholes formula as a limited expected value for a lognormal distribution.
8. Explain what it means to say that stock prices follow a diffusion process.
9. Apply Itô's lemma in the one-dimensional case.

**C. Simulation (10-15%)**

1. Simulate lognormal stock prices.
2. Use variance reduction techniques to accelerate convergence.

**D. Risk management techniques (5-10%)**

1. Explain and demonstrate how to control risk using the method of delta-hedging.

**Note:** Concepts, principles and techniques needed for Exam MFE/3F are covered in the reference listed below. Candidates and professional educators may use other references, but candidates should be very familiar with the notation and terminology used in the listed references.

**Texts – Models for Financial Economics**

*Derivatives Markets* (Second Edition), 2006, by McDonald, R.L.,

Errata in McDonald's Derivatives Markets

<http://www.kellogg.northwestern.edu/faculty/mcdonald/htm/typos2e.html>

Chapter 9,

Chapter 10, (excluding "Options on Commodities" on page 334),

Chapter 11, Sections 11.1 – 11.4, Appendices 11.A and 11.B,

Chapter 12, Sections 12.1–12.5, Appendix 12.A,

Chapter 13, including Appendix 13.B,

Chapter 14,

Chapter 18,

Chapter 19, Sections 19.1–19.5

Chapter 20, Sections 20.1–20.6 (up to but excluding “Multivariate Itô’s Lemma” on pages 665-666) and 20.7 (up to but excluding “Valuing a Claim on  $S_a Q_b$  on pages 670-672 and excluding “Finding the lease rate” on top one-half of page 669),

Chapter 21, Sections 21.1 – 21.2 (excluding “What If the Underlying Asset Is Not an Investment Asset” on pages 688-690) and 21.3 ( excluding “The Backward Equation” on pages 691-692, and excluding the paragraph on page 692 that begins “If a probability...” and through the end of the section),

Chapter 22, Section 22.1 (but with only those definitions in Tables 22.1 and 22.2 that are relevant to Section 22.1),

Chapter 23, Sections 23.1 – 23.2 (pp.744 thru the middle of p.746 only),

Chapter 24, Sections 24.1–24.5 (up to but excluding “Forward rate agreements” on pages 806-808),

Appendix B.1, Appendix C and including relevant Errata (see below).

We will use McDonald's Derivatives Markets for general reading to develop your knowledge of the definitions and applications of financial derivatives and their valuation models. However, the exercises and problem sets in this text are either too easy or too hard in computations (with incorrect answers sometimes) for SOA/CAS MFE exam. To more effectively use your time and get early exposure to the exam-style problems, we will use Actex MFE/3F study manual 2011 edition throughout this course. This manual is the only supplemental textbook needed in addition to the official McDonald's for the purpose of taking SOA MFE exam. For advanced students, feel free to use McDonald's as a reference/introduction and focus on the reading of the self-contained Actex manual.

My plan is to have the class read the assigned chapter sections from McDonald **before** each class period and review your reading by slides presentations at home. Students are urged to comment on the slides and raise questions by email and in class. A great portion of class time will be devoted to go over in-detail technical and conceptual notes (following Actex manual) for exam problem solving purpose.

My test questions will be similar to the homework problems and perhaps problems drawn from the following sample question bank. However, students shouldn't memorize these problems and solutions without developing adequate knowledge and skills to apply to problem solving.

Sample questions Posted at <http://www.cwu.edu/~chueh/Math440.htm>

### **Class format**

Lecture followed by problem solving and group work. Instructor and students discuss their solutions of the assigned problems and answer questions raised by the instructor and the class. This is a very fast-paced class so be sure that you follow our schedule consistently by reading and coming to the class everyday.

### **Attendance**

To achieve success in *any* mathematics class, **regular attendance is almost imperative**. Unlike most subjects, new topics in Mathematical Theory of Financial Economics often build on previous knowledge; failure to learn something early may haunt you throughout the course. We will do work in class occasionally, so if you missed a class you missed in-class credit.

**IF YOU MISS CLASS, IT IS YOUR RESPONSIBILITY TO FIND OUT THE MATERIAL COVERED, MEMORABLE, OR ASSIGNED, AND TO ARRANGE TO PICK UP ANY ASSIGNMENTS THAT MAY BE HANDED OUT OR RETURNED!**

### Homework

Homework will be assigned in class and the due date will be every Friday. Working on homework is the only way most of us learn to critically analyze and “solve” problems.

Some class time will be devoted to questions on the homework. Office hours are also scheduled to provide opportunities for more in-depth discussion and solving of homework problems.

### Grading policy

- Assignments and in-class problem solving/presentation (150 points; at least 15 points per week)
- Five Quizzes (250 points)
- Final Exam (100 points)
- Total 500 points

**Weekly Schedule** (Any change of coverage and quiz schedule will be announced in class.)

#### Week

#### Reading Assignment

0. 9/19-9/21	Sections from McDonald's 1.4, 5.2(page 132 only) 5.1-5.3, 2.2, 9.1 10.1-10.5, 11.2, 11.3, 11.B
1. 9/24-9/28	Risk-Neutral Valuation in Discrete Time Actex Module 0 and Module 1
2. 10/1-10/5	Review; <b>Quiz 1 Friday</b>
3. 10/8-10/12	Sections from McDonald's 11.3, 12.1, 18.1-18.4, 20.1-20.20.7(skip

backward equation, lease  
Rate, valuing a claim, multivariate Ito's  
lemma)

Risk-Neutral Valuation in Continuous Time  
Actex Module 2

4. 10/15-10/19

Review; **Quiz 2 Friday**

5. 10/22-10/26

Sections from McDonald's  
11.4, 12.1-12.3, 12.5, 13.B, 13.2-13.5, 18.5,  
18.6, 22.1, 23.1, 23.2

The Black-Scholes Formula  
Actex Module 3

6. 10/29-11/2

Review; **Quiz 3 Friday**

7. 11/5-11/9

Sections from McDonald's  
9.2, 9.3, 14.2-14.6, 19.2-19.5

Further Topics on Option Pricing  
Actex Module 4

8. 11/12-11/16

Review; **Quiz 4 Friday**

9. 11/19- 11/23

Sections from McDonald's  
9.1, 12.2, 24.1-24.5 (Skip forward rate  
agreements)

Interest Rate Models  
Actex Module 5

*THANKSGIVING!!*

10. 11/26-11/30

Review; **Quiz 5 Friday**

11. 12/03-12/7

**Final Exam, accumulative Quiz 1-Quiz 5**