Department of Finance

340 Wohlers Hall

University of Illinois at Urbana‑Champaign

**Professor Widdicks** **Finance 514**

##### Spring 2018

# FINANCIAL ENGINEERING II

***OFFICE HOURS:***

Monday 11:00 – 12:00

Tuesday 2:00 – 3:00

Wednesday 11:00 – 12:00

OR by appointment

330 Wohlers Hall

Office phone: 244-6856

Email: widdicks@illinois.edu

## COURSE DESCRIPTION:

Financial Engineering II provides an introduction to modern option pricing theory and continuous time finance at a level appropriate to well prepared MSF/MBA students. The course will focus on the three principal models for Financial Engineering: the binomial tree (or state pricing) approach, the Black-Scholes (or PDE) approach, and the probabilistic (or Monte-Carlo) approach. Each of these three techniques will be developed theoretically at first, next we will look in detail at the numerical approach and how we can use or adapt it to deal with practical derivative pricing problems. For each of the three techniques students will have a chance to value a real world product either given to them or of their choice. We will finish up the course by looking at interest rate term structure models.

The intended audience for the course is a limited number of MSF students who are interested in financial derivatives and either have undergraduate degrees in a quantitative subject (math, engineering, physics etc.) or have taken the math courses typically taken by undergraduate engineering students. In addition, many of the problem sets will require the students to write straightforward computer code to compute the prices of various instruments, it is assumed that all students are comfortable with at least one programming language (this can be VBA but also C/C++, Fortran, matlab etc) or programmable package (Matlab,etc.) and have access to the appropriate hardware and software.

Students with less preparation are welcome to enroll in the course and will probably succeed. However, if you have less preparation, you should expect to work harder than the other students. Also it is assumed that students should have had some exposure to options and other financial derivatives. For example they have taken FIN 512 or equivalent.

There are two, complementary, goals to this course. The first is to prepare the students with adequate quantitative methodologies for working as quants or risk-managers. The second is to obtain a good grasp of the financial principles underlying the models and the economic justifications behind the mathematical methodologies.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

## REQUIRED MATERIAL:

### Text:

Joshi, M., The Concepts and Practice of Mathematical Finance, Cambridge University Press: Cambridge, UK. ISBN: 0521514088

*The second or first edition would be fine. This book is very string on intuition but has good derivations and is very up to date covering important practical applications such as the LIBOR market model.*

## RECOMMENDED MATERIAL:

### Text:

Bjork, T., 2004, Arbitrage Theory in Continuous Time, Oxford University Press: Oxford, UK. ISBN: 0199271267

This is comprehensive but a little dry. It is good on the financial theory, especially the stochastic calculus, martingale and risk-neutral sections. However, the notation can be confusing and it is not very strong on intuition.

Paul Wilmott Introduces Quantitative Finance, 2001, Wiley: NY. ISBN 0-471-49862-9 (Paperback).

This is the slightly reduced form version of Wilmott’s excellent, but now out of print, Derivatives book. Sadly, there seem to be more cartoon pictures of the author than his trademark crisp, intuitive explanations. This is a shame.

## OTHER SOURCES:

Hull, J., 2005, Options, Futures and other Derivatives (6th edition), Prentice-Hall ISBN: 0131499084

This is one of the classic derivative textbooks and is very popular amongst quants. However, it does read a little like a recipe book providing the reader with all the practical tools for valuing a whole range of derivatives. The drawback is that the theoretical explanations aren’t that detailed.

Baxter, M, Rennie, A, Financial Calculus: An Introduction to Derivative Pricing, Cambridge University Press. ISBN: 0521552893

A comprehensive treatment of stochastic calculus as applied to financial problems. This is a theory book and does not really offer much in the way of practical applications.

Joshi, M., More Mathematical Finance, Pilot Whale Press. ISBN: 0987122803

More advanced material from Joshi, concentrating more on numerical methods and term structure models. Useful for those of you who want to find more material.

Rendleman, Richard J., 2002, Applied Derivatives, Blackwell: Oxford. ISBN: 0-631-21590-5

One of the most readable books on derivatives. However, this does not mean that the subject matter is trivial. Rendleman was initially a trader and is now a world renowned academic (he was one of the first academics to introduce binomial tree valuation). This shows up in his treatment of derivatives, which is an excellent mix of theory and practice.

Paul Wilmott on Quantitative Finance, 2000, Wiley: NY. ISBN: 0471874388.

Wilmott’s two volume extravaganza is as comprehensive as his Derivatives book but again contains the annoying cartoons and is expensive.

There are many more books on Derivatives so feel free to ask me about any other textbooks or to find one which best suits your background or style of learning.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

## REQUIREMENTS AND GRADES:

Your grade will be based on problem sets, valuation projects, a midterm and a final exam. Most of the problems on the midterms and final will be similar to the problem sets and projects. The final will be cumulative.

### Grading Weights:

Problem Sets 20%

Valuation Projects 30%

Midterm 20%

Final Exam (cumulative) 30%

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

## ADDITIONAL NOTES:

### 1) Lecture Notes:

There will be lecture notes for each class. Each week, copies of these lecture notes will be available on COMPASS. Lecture notes and *any other reading materials* will be distributed in the form of \*.pdf (Adobe Acrobat) files.

### 2) Problem Sets:

There will be **seven problem sets** that will comprise either individual or group work. Unless otherwise stated in class, problem sets will be due in one week after they are handed out. The valuation projects will typically be completed in groups.

### 3) Grading Scale:

I will use the standard grading scale, including + (plus) and – (minus) and will grade on a curve.

### 4) Academic Integrity:

You are expected to follow the University's Code of Academic Integrity. The relevant section may be found at <http://www.uiuc.edu/admin_manual/code/rule_33.html>.

## SYLLABUS:

A *tentative* syllabus follows. Students are strongly urged to read the appropriate chapters BEFORE the lecture so as to learn more during the lectures.

|  |  |  |
| --- | --- | --- |
| Date | Subject | Reading |
| Tuesday 1/16 | Introduction to course |  |
| Wednesday 1/17 | Option payoffs and recap | Joshi 2, Bjork 2.1, Wilmott 1, 2 |
| Wednesday 1/24 | Binomial: One period Pricing | Joshi 2, Bjork 2.1, Wilmott 1, 2 |
| Monday 1/29 | Binomial: Implementing the model | Joshi 3, Bjork 2.2, WIlmott 3 |
| Wednesday 1/31 | Binomial: Fundamental Theorems of Finance | Bjork 3 |
| Monday 2/5 | Binomial: Accuracy of methods | Additional readings |
| Wednesday 2/7 | Binomial: calibration and improvements | Additional readings |
| Monday 2/12 | Binomial: adaptations for specific problems, | Additional readings |
| Wednesday 2/14 | PDE: Brownian motion | Joshi 5, Wilmott 4, Bjork 5.2 |
| Monday 2/19 | PDE: Stochastic integrals | Joshi 5, Wilmott 5 |
| Wednesday 2/21 | PDE: Ito’s lemma | Joshi 5 ,Wilmott 5 |
| Monday 2/26 | PDE: Black-Scholes-Merton (BSM) analysis | Bjork 7, Joshi 5.6, 6.8, 6.10 + Carr article |
| Wednesday 2/28 | PDE: BSM analysis | Bjork 7, Joshi 5.6, 6.8, 6.10 + Carr article |
| Monday 3/5 | PDE: PDE solutions | Wilmott 7 |
| Wednesday 3/7 | PDE: Generalizations | Wilmott 8 |
| Monday 3/12 | PDE: Volatility | Joshi 16, Wilmott 9, 10 |
| Wednesday 3/14 | MIDTERM |  |
| Monday 3/19 | SPRING BREAK |  |
| Wednesday 3/21 | SPRING BREAK |  |
| Monday 3/26 | PDE: Finite Difference Methods | Joshi 7.6, Wilmott 25 + additional readings |
| Wednesday 3/28 | PDE: Using finite difference methods for option pricing | Joshi 7.6, Wilmott 25 |
| Monday 4/2 | PDE: Improving finite-difference methods | Additional readings |
| Wednesday 4/4 | Monte Carlo: The probabilistic solution | Bjork 5.3 – 5.5, Joshi 6 |
| Monday 4/9 | Monte Carlo: The probabilistic solution | Bjork 5.3 – 5.5, Joshi 6 |
| Wednesday 4/11 | Monte Carlo: Applications of the probabilistic solution | Bjork 5.3 – 5.5, Joshi 6 |
| Monday 4/16 | Monte Carlo: Monte Carlo techniques for option pricing | Joshi 7.3, Wilmott 26 |
| Wednesday 4/18 | Monte Carlo: Analysis and improvement on Monte Carlo techniques | Wilmott 26 + additional readings |
| Monday 4/23 | Swaps, FRAs, Swaptions and Black’s formula | Joshi 13, Wilmott 17 |
| Wednesday 4/25 | Swaps, FRAs, Swaptions and Black’s formula | Joshi 13, Wilmott 17 |
| Monday 4/30 | Binomial trees for interest rate derivatives, the BDT model | Wilmott 16 |
| Wednesday 5/2 | Binomial trees for interest rate derivatives, the BDT model | Wilmott 16 |