FE 610 Probability and Stochastic Processes for Finance

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Objectives

This course is designed for first year graduate students and advanced undergraduate students in Financial Engineering. The goal is to learn the foundation on which anything and everything in Finance is built upon. The students are supposed to have a strong background in applied mathematics (analysis) and probability at an undergraduate level. This is a core course for all programs in Financial Engineering.

Textbook(s):

I will provide notes additional to the textbook material. As for textbooks, not one textbook is extremely exceptional for this class. The main textbook used is:

- *Introduction to the Mathemtics of Financial Derivatives*, by by Salih N Neftci, 2nd ed, Associated Press, 2000, ISBN 0125153929.

In addition the following textbooks provide additional references:

- *Introduction to Probability Models*, 10th edition, by Sheldon M. Ross, Academic Press, 2009, ISBN-10: 0123756863 ISBN-13: 978-0123756862.
- *Probability and Random Processes* by Geoffrey Grimmett and David Stirzaker, Oxford University Press 2001.
- *Stochastic Calculus and Financial Applications*, by J. Michael Steele, Springer 2000, ISBN-10: 0387950168, ISBN-13: 978-0387950167
- Introduction to Stochastic Calculus With Applications by Fima C. Klebaner, , ISBN-10: 1848168322, ISBN-13: 978-1848168329
- *Financial Calculus: An Introduction to Derivative Pricing* by Martin Baxter, Andrew Rennie, 1996, ISBN-10: 0521552893, ISBN-13: 978-0521552899
- *Stochastic Differential Equation*, by Bernt Øksendal, 6th edition, 2010, ISBN-10: 3540047581, ISBN-13: 978-3540047582

Course outline:

- Calculus review (Ch 3)
- Probability review, (Ch 5).
- Martingales (Ch 6)
- Markov chains and Markov processes
- Brownian Motion (Ch 8)
- Itô integral (Ch 9)
- Itô lemma, Itô process (Ch 10)
- Financial Derivatives (Ch 1)
- Arbitrage Theorem (Fundamental Th of Asset pricing) Ch 2
- Stochastic Differential Equations (Ch 11)

- Partial Differential Equations in Finance (derivative pricing) (Ch 12)
- Black Scholes model (revisited-throughout) (Ch 13)
- Equivalent Martingale Measures and Applications (Ch 14 and 15)

Homework, Exams and Grading:

Proper assignment write-up

To understand the course material and get a good grade it is necessary (though not sufficient) to invest a substantial amount of time working on the assignments. Homework consisting of about 7-8 problems will be assigned in class and posted on the web every other week or so. They will be due on the specified due date at the specified time. *No late homework will be accepted under any circumstances.* The lowest homework grade will be dropped. I will grade two or three problems (selected by me) from each assignment which will count toward 60% of the homework grade, while casually reviewing the other problems for the remaining 40% of the homework grade.

You are encouraged to discuss homework; however, **all written homework must be written by you. Copying solutions from other students in the class, former students, tutors, or any other source is strictly forbidden**. Copying the solution of one or more problems from another source than your own brain is consider academic dishonesty/misconduct and will be dealt with according to the Stevens honor board policy.

Your solutions must be those that you fully understand and can produce again (and solve similar problems) without help. The ideal model to follow is first to work independently, then to discuss **issues** with your fellow students, and then to prepare the final write-up.

There are three stages in the preparation of the solution to a problem in this class:

1. Outline the steps.
2. Identify the mathematical techniques necessary to carry out those steps.
3. Carry out the mathematical techniques correctly.

Comments about the first two steps. It is no surprise that in a mathematical course students spend most time on the final 3rd stage. However, the first two stages are equally important for a successful demonstration of understanding the course concepts. At the beginning of every course the problems are simple enough that the need for the first two stages seem unnecessary but by the end of the class the problems become complicated enough that this will not seem artificial (indeed it will be most helpful).

It is equally important that you do this for the test problems. During a test students have sometime difficulties carrying out all the mathematical analysis to completely solve the problem. If I can see that you know what steps you should be doing, then I can give you more credit than if you just cant carry out the steps and don't tell me anything. Thus, a clearly written plan of your solution method will help you earn a good test grade.

Comments for the third step. As a professional in a quantitative field, you will be expected to be mathematically sophisticated enough to know whether or not you are carrying out a mathematical technique correctly. I expect you to practice that sophistication in all material submitted in this course. For example, do not ever turn in a problem requiring an integration that you did not know how to do completely, so you just did it as far as you could and then wrote the answer you knew it should have, hoping the instructor or grader would not notice that the solution was not complete. Instead, find the help you need to fully carry out the solution correctly before you submit the paper, as you will do in your professional activities.

You must show all of your steps in carrying out the mathematical techniques. Explain what you are doing as if you are teaching it to someone. People who write journal articles often leave out most of the easy steps and just show the hardest steps. That is fine for journal articles, but it is not appropriate for a classroom situation where you need to be convincing the instructor that you understand the reasons for all the steps you are doing.

Exam policy

We will have one midterm and a final exam. Both exams will be in-class, closed-book, closed-notes. You will be allowed to bring a handwritten page containing whatever you think is relevant for the exam. A summary of the distributions (pages 621-627 in your textbook) will be provided for each examination. You will have to show all the work to receive credit for the problems in the exam. The date for the midterm will be agreed on during

the semester. The most weight for the final grade will be coming from the final examination.

There will be no individual make up exams. If you miss one of the exams, you may be allowed to take a *comprehensive* make up exam (location and time to be determined) at the end of the semester. To be allowed to take this make up exam you have to bring valid written documentation that explains the reason for the missed exam. The make up exam will replace at most one missing exam grade.