FE 710 Applied Stochastic Differential Equations

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Objectives

This course is designed for graduate students who took FE 610 and have a good grasp of understanding Probability and Stochastic Calculus. The objective is to understand Stochastic Differential Equations (SDE's) both from theoretical and practical perspective.

Textbook(s):

We will provide notes additional to the textbook material. The main textbook used is:

- *Stochastic Differential Equation*, by Bernt Øksendal, 6th edition, 2010, ISBN-10: 3540047581, ISBN-13: 978-3540047582

In addition the following textbooks provide additional references:

- *Stochastic Calculus for Finance* vol I and II, by Steven E. Shreve, Springer Finance, 2004, ISBN-13: 978-0387249681 (vol I) and 978-1441923110 (vol II) (used in FE610).

- Eckhard Platen and Nicola Bruti-Liberati, Numerical Solutions of Stochastic Differential Equations with Jumps in Finance, Springer 2010, ISBN: 978-3-642-12057-2
- *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
- *Introduction to the Mathemtics of Financial Derivatives*, by Salih N Neftci, 2nd ed, Associated Press, 2000, ISBN 0125153929.
- *Handbook of Probability*, by I. Florescu and C. Tudor, ISBN: 978-0-470-64727-1, Oct. 2013. (for probability background)

Course topics

Topics include Ito calculus review, linear stochastic differential equations (SDE's), examples of solvable SDE's, weak and strong solutions, existence and uniqueness of strong solutions, Ito-Taylor expansions, SDE for Markov processes with jumps, Levy processes, forward and backward equtions and the Feynman-Kac representation formula, and introduction to stochastic control. Applications are mostly from fianncial engineering but applications in areas such as population dynamics, energy, climatology and seismology may also be presented.

Grading Policy

We will have several assignments throughout the course. We may have a midterm and/or final in the course. The percentage for all components will be decided and announced throughout the class.

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.

Collaboration versus Academic Misconduct

Generally in my classes, I encourage students to work together on the homework problems, review problems, studying, and projects. However, there is good collaboration, and then there is academic misconduct. To help clarify what the university considers good collaboration, I will give you the following two lists:

Good Collaboration

- Try all of the homework problems yourself, on your own.
- After working on every problem yourself, then get together with a small group of other students who have also worked on every problem themselves. Discuss ideas for how to do the more di?cult problems.
- Finish the homework problems on your own so that what you turn in truly represents your own understanding of the material.

- Work the review problems individually, and then use the group for discussion.
- Discuss concepts or practice problems in the group
- Explain concepts or practice problems to each other.
- If the assignment involves writing a long worded explanation (like an essay question), you may proofread somebody's completed written work and allow them to proofread your work. Do this only after you have both completed your own assignments, though.
- If you are working on a group quiz, everyone should work all of the problems themselves before getting together to talk through their reasoning and decide on the best ?nal answers.
- Asking a tutor for help on a problem related to a homework problem but then working the actual homework problem yourself.

Academic Misconduct

- Sitting in a group and dividing up the problems. (You do problem 1, Ill do problem 2, and hell do problem 3: then well share our work to get the assignment done more quickly.)
- Attending a group work session without having ?rst worked all of the problems yourself.
- Starting the problem yourself but then just copying somebody else's solution for the rest of the problem after you got stuck.
- Reading someone else's answers before you have completed your work (especially for an essay-type question).
- Having a tutor work though all (or some) of your homework problems for you to copy down.