NYU TANDON SCHOOL OF ENGINEERING

Finance & Risk Engineering

FRE-GY 6233,
Option Pricing and Stochastic Calculus

Instructor Information

- Nathan Sauldubois
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- Office hours : By Appointment
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Course Information

- FRE6233
- Option Pricing and Stochastic Calculus
- This is a first course in Mathematical Finance and is a building block for more advanced courses. The material taught is part of the common knowledge shared by quants in the Financial industry. This course provides the first steps for a Ph.D. program in Financial Engineering, Mathematical Finance, Operations Research, or Finance.
- Prerequisite : FRE 6083
- Wednesday 11:00-1:30
- Jacobs-Hall Room 216

Course Overview and Goals

This course provides the mathematical foundations of Option Pricing models. The techniques covered include the properties of the Brownian motion and the corresponding stochastic calculus, Ito differential Calculus, change of probability measure, martingales, Stochastic Differential Equations, Partial Differential Equations as the heat equation and the Fokker-Planck equation. Some of the pricing models considered are the European, Barrier, Asian and American options. These problems are either solved analytically by the martingale and the change of numéraire technique, the Partial Differential Equations approach, or numerically, by applying approximation and simulation methods. Since the same techniques allow the treatment of more complex financial products, several advanced examples will be also presented.

Upon completion of this course, students will be able to:

- Price any derivative security.

Course Requirements

Class Participation

Students are expected to attend classes and participate actively. They should view the videos and read the textbooks ahead of time and come prepared to ask questions and discuss the weekly assignment.

Assignments

There will be two types of homework assignments. The first type will consist of practice exercises designed to help the students assimilate the techniques taught in class and prepare them for the examinations. The second type will consist of implementing numerical or simulation techniques, to compute option prices that cannot be computed analytically

Tests & Quizzes

There will be a take home midterm examination, a take home final examination and weekly homework assignments. The Midterm examination will be due on week 7: students will be required to solve four or five problems by using the computational techniques taught during the first 6 weeks.

Grading of Assignments

The grade for this course will be determined according to the following formula:

Assignments/Activities	% of Final Grade
Average weekly homework assignment score (the worst grade will be dropped)	50%
Midterm exam	20%
Final exam	20%

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Course Schedule

Topics and Assignments

Week/Date	Topic	Assignment Due
Week 1 : 01/21	Brownian Motion	Numerical exercises due 02/04
Week 2 : 01/28	Brownian Motion	Practice Exercises due 02/11
Week 3 : 02/04	Stochastic Integral and Itô's formula	Numerical exercises due 02/18
Week 4 : 02/11	Stochastic Integral and Itô's formula	Practice Exercises due 02/25
Week 5 : 02/18	Risk neutral pricing and the Black-Scholes model	Numerical exercises due 03/04
Week 6 : 02/25	Risk neutral pricing and the Black-Scholes model	Practice Exercises due 03/11
Week 7 : 03/04	Connection with PDEs and martingale representation	Numerical exercises due 03/18
[Week 8 : 03/11	Connection with PDEs and martingale representation + Midterm Exam	
SPRING BREAK		
Week 9 : 03/25	Change of measure and Martingale derivatives pricing	Practice Exercises due 03/25

Week 10 : 04/01	Change of measure and Martingale derivatives pricing	Numerical exercises due 04/15
Week 11 : 04/08	Fokker-Planck equation and implied volatility surface	Practice Exercises due 04/22
Week 12 : 04/15	Stochastic interest rates	Numerical exercises due 04/29
Week 13 : 04/22	Asian and Barrier options	Practice Exercises due 05/15
Week 14 : 04/29	American options	
Week 15 :	Final exam	

Required Textbooks & Materials

- Tomas Bjork, *Arbitrage Theory in continuous time*, Oxford University press, Reprint, ISBN-0191525103, 9780191525100.
- Steve E. Shreve, *Stochastic Calculus for Finance II: continuous-time models*, 2nd edition, 2004, Springer
- Ioannis Karatzas & Steve E. Shreve, *Brownian Motion and Stochastic Calculus*, Graduate Texts in Mathematics, 113, 2nd edition, 2004, Springer. (More advanced)

Resources

- **Access your course materials**: NYU Brightspace
- **Databases, journal articles, and more**: Bern Dibner Library (library.nyu.edu)
  NYU Virtual Business Library (guides.nyu.edu/vbl)
- **Obtain 24/7 technology assistance:** Tandon IT Help Desk (soehelpdesk@nyu.edu, 646.997.3123)
  NYU IT Service Desk (AskIT@nyu.edu, 212-998-3333)

Policies

Academic Misconduct

A. Introduction: The School of Engineering encourages academic excellence in an environment that promotes honesty, integrity, and fairness, and students at the School of Engineering are expected to exhibit those qualities in their academic work. It is through the process of submitting their own work and receiving honest feedback on that work that students may progress academically. Any act of academic dishonesty is seen as an attack upon the School and will not be tolerated. Furthermore, those who breach the School's rules on academic integrity will be sanctioned under this Policy. Students are responsible for familiarizing themselves with the School's Policy on Academic Misconduct.

B. Definition: Academic dishonesty may include misrepresentation, deception, dishonesty, or any act of falsification committed by a student to influence a grade or other academic evaluation. Academic dishonesty also includes intentionally damaging the academic work of others or assisting other students in acts of dishonesty. Common examples of academically dishonest behavior include, but are not limited to, the following:
    1. Cheating: intentionally using or attempting to use unauthorized notes, books, electronic media, or electronic communications in an exam; talking with fellow students or looking at another person's work during an exam; submitting work prepared in advance for an in-class examination; having someone take an exam for you or taking an exam for someone else; violating other rules governing the administration of examinations.
    2. Fabrication: including but not limited to, falsifying experimental data and/or citations.
    3. Plagiarism: Intentionally or knowingly representing the words or ideas of another as one's own in any academic exercise; failure to attribute direct quotations, paraphrases, or borrowed facts or information.
    4. Unauthorized collaboration: working together on work that was meant to be done individually.
    5. Duplicating work: presenting for grading the same work for more than one project or in more than one class, unless express and prior permission have been received from the course instructor(s) or research adviser involved.
    6. Forgery: altering any academic document, including, but not limited to, academic records, admissions materials, or medical excuses.

Disability Disclosure Statement

Academic accommodations are available for students with disabilities. Please contact the **Moses Center for Students with Disabilities** (212-998-4980 or mosescsd@nyu.edu) for further information. Students who are requesting academic accommodations are advised to reach out to the Moses Center as early as possible in the semester for assistance.

Inclusion Statement

The NYU Tandon School values an inclusive and equitable environment for all our students. I hope to foster a sense of community in this class and consider it a place where individuals of all backgrounds, beliefs, ethnicities, national origins, gender identities, sexual orientations, religious and political affiliations, and abilities will be treated with respect. It is my intent that all students' learning needs be addressed both in and out of class and that the diversity that students bring to this class be viewed as a resource, strength, and benefit. If this standard is not being upheld, please feel free to speak with me.

Using Generative AI

Please refer to the Adapting Assignments to Generative AI page to craft a statement that is either Integrating, Avoiding, or Forbidding.