NYU TANDON SCHOOL OF ENGINEERING

FRE-GY 6233
Stochastic Calculus and Option Pricing

Instructor Information

- Agnes Tourin, Industry Professor
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- 646 997 3889
- Students hours: Wednesdays: 2:00pm-4:00pm or by appointment
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Course Information

- FRE-GY 6233, sections A and I
- Stochastic Calculus and Option Pricing
- This course provides the mathematical foundations of Option Pricing models and also serves as an introduction to Computational Finance. The techniques covered include arithmetic and geometric Brownian motion, first passage time, the reflection principle, the stochastic Ito integral, Ito differential Calculus, change of probability measure, martingales, Stochastic Differential Equations and Partial Differential Equations. Some of the pricing models considered are the European, Barrier, Asian and American options. These problems are either solved analytically by the martingale or Partial Differential Equations approach, or numerically, by applying approximation and simulation methods. Since the same techniques allow the treatment of more complex financial products, a few advanced examples will be also presented, time permitting.
- Course prerequisites: FRE-GY 6083
- Section A: Monday 2:00pm-4:30pm, in person
- Section I: Thursday 6pm-8:30pm, in person
- Section A: Jacobs Hall 214
- Section I: Jacobs Hall 300

Course Overview and Goals

The content of this course which builds on the core course on Quantitative methods in Finance FRE-GY 6083 comprises the basic techniques of Ito Stochastic Calculus for martingales and their applications to derivatives pricing as well as some elements of computational Finance. Its primary goal is to teach students to price any type of

derivative security. In addition, it prepares students for more advanced courses in financial engineering such as stochastic optimal control and Computational Finance.

Upon Completion of this Course, students will be able to:

- price any derivative security.
- The material taught is part of the common knowledge shared by Q quants in the Financial industry and taking this course will prepare the students to apply for quantitative positions.
- This course prepares students for more advanced courses, for instance stochastic optimal control and computational Finance.
- This course also prepares students to apply to a Ph.D. program in Financial Engineering, Mathematical Finance, Operations Research, or Finance.

Course structure

The first 8 units of this course will be delivered in a flipped classroom format. The lessons, composed of pre-recorded videos will be posted online. In class, the instructor will explain the most difficult aspects of the material, answer the students' questions about the material, and will also hold active learning activities, such as problem solving sessions. The next 6 units will consist of lectures with examples. Finally, the midterm examination will be held on week 8 and the final examination on week 15.

Course Requirements

Class Participation

This course will be delivered in person. The instructor and students will meet at the designated class times. Students are expected to attend classes and participate actively. They should view the available videos ahead of time and come prepared to ask questions and discuss the material. After each class, students should read the assigned readings from the textbooks.

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Assignments

There will be graded weekly homework assignments that will consist of practice exercises designed to help the students assimilate the techniques and concepts taught in class. At least two of these assignments will require the implementation of a code (students may choose the programming language). The weekly assignments will be posted online.

Tests & Quizzes

- There will be a midterm examination on week 8; students will be required to provide answers using the concepts and techniques taught in class to several questions.
- There will be a final examination on week 15.
- I am primarily assessing
    - the depth of understanding of the concepts, models and methods
    - the fluency in advanced computational skills
    - The ability to choose the most appropriate strategy to solve a problem efficiently
    - The ability to write clearly and correctly in Mathematics

Assigned Readings

There are two required textbooks for this course (see section on course materials below) and assigned reading will be selected from these two texts.

Grading of Assignments

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

Assignments/Activities	% of Final Grade
Viewing the online Content (as recorded on NYU Brightspace under *content progress)*	10%
Average weekly homework assignment grade (the lowest grade will be dropped)	30%
Midterm Examination	30%
Final Examination	30%

Letter Grades' percentage range

Letter grades for the entire course will be assigned as follows:

Letter Grade	Points	Percent
A	4.00	95% and higher
A-	3.67	90.0 – 94.99%
B+	3.33	87% - 89.99%
B	3.00	83% - 86.99%
B-	2.67	80% - 82.49%
C+	2.33	77% - 79.99%
C	2.00	70.0% - 76.99%
F	.00	69.99% and lower

View Grades

- Grades will be posted under grades on the Brightspace site for this course as soon as they are available.

Course Schedule

Topics and Assignments

Week/Date	Topic	Reading	Assignment Due
Week 1 Th Section : 01/22 Mo Section I: 01/26	**Information and the Brownian motion, part 1:** Information and conditioning	Textbook by Shreve: Chapter 2 Videos 1.1-1.3	NA
Week 2 Th Section : 01/29 Mo Section: 02/02	**Information and the Brownian motion, part 2:** The Brownian motion **Ito Calculus, part 1**	Textbook by Shreve: Chapter 3 Videos 1.4-1.7 and 2.1-2.3	First homework assignment is due On 02/03
Week 3 Th Section: 02/05 Mo Section: 02/09	**Ito Calculus, part 2**	videos 2.4-2.5 Textbook by Shreve, chapter 4 Complements: Textbook by Bjork, chapter 4.	Second homework assignment is due on 02/10
Week 4 Th Section: 02/12 Mo Section: 02/17	**Application of stochastic calculus to the Black-Scholes model**	videos 3.1-3.5 Textbook by Shreve, chapter 4. Complements: Textbook by Bjork, chapters 5,6,7,9.	Third homework assignment is due on 02/18

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Week 5 Th Section: 02/19 Mo Section: 02/23	**The martingale approach**	videos 4.1-4.8 Textbook by Shreve, chapter 5. Complements: Textbook by Bjork, chapters 10, 11,12.	Fourth homework assignment is due on 02/24
Week 6 Th Section: 02/26 Mo Section: 03/02	**The Partial Differential Equations approach**	videos 5.1-5-7 Textbook by Shreve, chapter 6. Textbook by Bjork, chapter 18.	Fifth homework assignment is due on 03/03
Week 7 Th Section: 03/05 Mo Section: 03/09	**The Asian option**	videos 6.1-6.6 Textbook by Shreve, chapter 7.	Sixth homework assignment is due on 03/10
Week 8 Th Section:03/12 Mo Section:03/23	**Midterm Examination**		No homework due
Week 9 Th Section 03/26 Mo Section: 03/30	**The American option: a Finite Difference method**	Lecture notes	Seventh homework Assignment is due on 04/08
Weeks 10-11 Th Section: 04/02,04/09 Mo Section I: 04/06, 04/13	**Multidimensional market models:** stochastic calculus in several dimensions, multi-dimensional asset pricing models	Textbook by Shreve, Chapters 5,9. Complements: Textbook by Bjork, chapter 14,17, 26.	Eight homework Assignment is due on 04/14 No assignment due on 04/21
Week 12 Th Section: 04/16 Mo Section: 04/20	**Stochastic Calculus for jump-diffusion processes**	Textbook by Shreve, chapter 11	Nine homework Assignment is due on 04/28

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Week 13 Th Section: 04/23 Mo Section: 04/27	**Option pricing in a jump-diffusion model**	Textbook by Shreve, Chapter 11	Tenth homework assignment due on 05/05
Week 14 Th Section: 04/30 Monday Section: 05/04	**Review**		Eleventh homework assignment is due on 00/00
Week 15 Th Section: 05/07 Mo Section: 05/11	**Final Examination (in person)**		

Tests and Quizzes

- Midterm Examination
  - Mo Section: 03/12
  - Th Section: 03/23

- Final Examination on week 15:
  - Mo Section: Monday May 11, at the regular class time and location
  - Th Section: Thursday May 07, at the regular class time and location

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Course Materials

Required Textbooks & Materials

- Tomas Bjork, *Arbitrage Theory in continuous time*, Oxford University press, Reprint, ISBN-0191525103, 9780191525100.
- Shreve, *Stochastic Calculus for Finance II: continuous-time models,* 2nd edition, 2004, Springer.

Resources

- **Access your course materials**: nyu-lms-brightspace.html
- **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)
- **Google Gemini** is available in NYU google services: https://www.nyu.edu/life/information-technology/artificial-intelligence-at-nyu/generative-ai-services.html

Policies

Generative AI policy for this course

This policy was adapted from the NYU page **https://www.nyu.edu/faculty/teaching-and-learning-resources/Student-Learning-with-Generative-AI.html)**

- You are encouraged to use Generative AI as a learning tool.
- You must document your process and use of Generative AI if you are using Generative AI
- You must still apply and develop your critical and creative thinking while using AI. You should always **independently verify and check** the output produced by AI.

- You **may not** simply copy and paste the output generated by an AI. Also just rephrasing an AI-generated output is **not enough** for it to be considered your own work!
- It is your responsibility to master the course material, build the understanding and develop the rigorous mathematical skills set by the course goals **without having to rely on AI**!
- You **will not** be allowed to use AI for the examinations

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 has 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.