EPFL

FIN-415

Probability and stochastic calculus

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Cursus	Sem.	Type
Finance		Opt.
Financial engineering minor	H	Opt.
Financial engineering	MA1, MA3	Obl.
Statistics	MA1, MA3	Opt.

Language of teaching	English
Credits	6
Session	Winter
Semester	Fall
Exam	Written
Workload	180h
Weeks	14
Hours	**5 weekly**
Lecture	3 weekly
Exercises	2 weekly
Number of positions	

Summary

This course gives an introduction to probability theory and stochastic calculus in discrete and continuous time. We study fundamental notions and techniques necessary for applications in finance such as option pricing, hedging, optimal portfolio choice and prediction problems.

Content

Topics include :

- Random variables, characteristic functions, limit theorems
- Markov processes
- Kalman filter
- Ito calculus
- Stochastic differential equations
- Martingale representation
- Girsanov theorem
- Optimal stochastic control
- Jump processes
- Numerical simulation

Keywords

probability, Markov process, Ito formula, diffusion, martingale representation, change of measure, Brownian motion, Poisson process

Learning Prerequisites

Important concepts to start the course

calculus

Learning Outcomes

By the end of the course, the student must be able to:

- Explain the stochastic integral with respect to a Brownian motion
- Explain the notion of an Ito processes with finite activity jumps and its quadratic variation
- Apply Ito's formula to multivariate Ito processes with finite activity jump

- Compute the stochastic exponential of an Ito process with finite activity jumps
- Explain the notion of a stochastic differential equation, the existence, uniqueness, and Markov property of its solution
- Apply the Feynman-Kac theorem on the stochastic representation of solutions to partial differential equations
- Solve a stochastic differential equation formally, for the linear case, and numerically, for the general case
- Derive the HJB equation for some basic stochastic optimal control problems
- Explain the three pillars of stochastic calculus: Ito's formula, Girsanov's theorem, and the martingale representation theorem
- Work out / Determine moment generating functions, conditional moment generating functions, conditional and unconditional moments for multi-dimensional random vectors
- Apply the Law of Large Numbers and the Central Limit Theorem

Transversal skills

- Use a work methodology appropriate to the task.

Teaching methods

Lectures, exercises, homework

Expected student activities

attendance at lectures, completing exercises

Assessment methods

- 40% midterm exam
- 60% final exam

Resources

Bibliography

Björk, T. (2004), "Arbitrage Theory in Continuous Time", Oxford University Press
Glasserman, P. (2004), "Monte Carlo Methods in Financial Engineering", SpringerVerlag
Lamberton, D. and Lapeyre, B. (2000), "Introduction to Stochastic Calculus Applied to Finance", Chapman&Hall/CRC
Oksendal, B. (2007), "Stochastic Differential Equations. An Introduction with Applications", Springer Verlag
Shreve, S. (2004), "Stochastic Calculus for Finance I. The Binomial Asset Pricing Model", Springer Verlag
Shreve, S. (2004), "Stochastic Calculus for Finance II. Continuous-Time Models", Springer Verlag

Ressources en bibliothèque

- Introduction to Stochastic Calculus Applied to Finance / Lamberton
- Stochastic Calculus for Finance II / Shreve
- Arbitrage Theory in Continuous Time / Björk
- Monte Carlo Methods in Financial Engineering / Glasserman
- Stochastic Calculus for Finance I / Shreve
- Stochastic Differential Equations / Oksendal

Moodle Link

- https://go.epfl.ch/FIN-415

Prerequisite for

- Derivatives
- Advanced derivatives
- Interest rate and credit risk models
- Real options and financial structuring