MATH-470

# Martingales in financial mathematics

Schmutz Michael

| Cursus | Sem. | Type |
|---|---|---|
| Financial engineering | MA2, MA4 | Opt. |
| Ing.-math | MA2, MA4 | Opt. |
| Mathématicien | MA2 | Opt. |

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| Language of teaching | English |
| Credits | 5 |
| Session | Summer |
| Semester | Spring |
| Exam | Oral |
| Workload | 150h |
| Weeks | 14 |
| **Hours** | **4 weekly** |
| Courses | 2 weekly |
| Exercises | 2 weekly |
| **Number of positions** | |


## Summary

The aim of the course is to apply the theory of martingales in the context of mathematical finance. The course provides a detailed study of the mathematical ideas that are used in modern financial mathematics. Moreover, the concepts of complete and incomplete markets are discussed.


## Content

• Discrete time models and the Fundamental Theorem of Asset Pricing

- Fundamental results
- Binomial- and trinomial model
- The Snell envelope, optimal stopping, and American options

• Geometric Brownian motion and the Black-Scholes model

- Option pricing and hedging
- Exotic options

• On the theory of (no-)arbitrage in continuous time

• Selected topics on

- Local- and stochastic volatility models
- Stochastic interest rates
- Lévy driven models
- New trends in financial mathematics

## Keywords

martingales, financial mathematics, theory of (no-)arbitrage

## Learning Prerequisites

### Recommended courses

Stochastic calculation

### Important concepts to start the course

Stochastic calculation

## Learning Outcomes

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

- Explore in detail the use of martingales in financial mathematics.
- Prove a criteria for absence of arbitrage in a model based on a finite probability space and state an analogous general result.
- Prove a criteria for completeness of a market model based on a finite probability space and state an analogous general result.
- Explain the difference and the resulting consequences between claims and American options.
- Derive prices for some financial derivatives based on several different models.
- Derive different hedging strategies for some financial derivatives based on several different models.
- Analyze the choice of asset price models according to different criteria.
- Optimize the calibration of chosen asset price models.
- Prove a criteria for completeness of a viable market modeled based on a finite probability space and state an analogous general result.

## Assessment methods

Exam oral
Dans le cas de l'art. 3 al. 5 du Règlement de section, l'enseignant décide de la forme de l'examen qu'il communique aux étudiants concernés.

## Supervision

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| Office hours | Yes |
| Assistants | No |
| Forum | No |
| Others | Office hours: Friday, 13:00-14:00 |

## Resources

### Virtual desktop infrastructure (VDI)

No

### Bibliography


- Lamberton, D. and Lapeyre, B. (2008), Introduction to Stochastic Calculus Applied to Finance, Second Edition, Chapman and Hall, London.
- Shiryaev, A.N. (1999), Essentials of Stochastic Finance: Facts, Models, Theory, World Scientific Publishing, Singapore.
- Barndorff-Nielsen, O.E. and Shiryaev, A.N. (2010), Change of Time and Change of Measure, World Scientific Publishing, Singapore.
- Eberlein, E. and Kallsen, J. (2019), Mathematical Finance, Springer Finance, Cham.


### Ressources en bibliothèque

- Mathematical Finance / Eberlein & Kallsen
- Change of Time and Change of Measure / Barndorff-Nielsen
- Introduction to Stochastic Calculus Applied to Finance / Lamberton
- Essentials of Stochastic Finance / Shiryaev