Technische Universität München

Module Description

MA4405: Stochastic Analysis

Department of Mathematics

Module level:	Language:	Module duration:	Occurrence:
Master	English	one semester	summer semester

Credits*:	Total number of hours:	Self-study hours:	Contact hours:
9	270	180	90

* The number of credits can vary depending on the corresponding SPO version. The valid number is always indicated on the Transcript of Records or the Performance Record.

Description of achievement and assessment methods:
The module examination is based on a written exam (90 minutes).
Students have to know and understand the theoretical foundations of Brownian motion, the theory of continuous martingales and Lévy's representation and characterisation Theorems. They also need to be able to understand the basics of stochastic integration and stochastic differential equations and to apply Itô's formula and change-of-measure techniques.

Possibility of re-taking:
In the next semester: No
At the end of the semester: Yes

(Recommended) requirements:
MA0003 - Analysis 3
MA2409 - Probability Theory

Contents:
Continuous time stochastic processes as a general framework. Brownian motion: construction and path properties. Filtrations, (local) Martingales and stopping times, optional sampling, maximal inequalities and reflection principle. Poisson processes and stable processes. Quadratic and cross variations, Levy's representation and characterization Theorems, Semi-martingales. Stochastic integrals with respect to Brownian motion and general semi-martingales. Integration rules with emphasis on Itô's formula.
Stochastic differential equations, weak and strong solutions. Girsanov's Theorem and applications. Donsker's invariance principle.

Study goals:
After successful completion of the module, students are able to:
- define Brownian motion, prove basic facts about Brownian motion and apply basic calculations involving Brownian motion.
- understand fundamental results such as Lévy's Theorems, Donsker's invariance principle etc, and apply them in calculations as well as in proofs.
- understand the basics of stochastic integration with respect to various processes. Apply Itô's formula and other tools.
- understand the basics of stochastic differential equations, can verify the (in)existence of strong or weak solutions in standard examples.
- understand and apply change-of-measure techniques.

Teaching and learning methods:
lecture, exercise module
The module is offered as lectures with accompanying practice sessions. In the lectures, the contents will be presented

in a talk with demonstrative examples, as well as through discussion with the students. The lectures should motivate the students to carry out their own analysis of the themes presented and to independently study the relevant literature. Corresponding to each lecture, practice sessions will be offered, in which exercise sheets will be available. In this way, students can deepen their understanding of the methods and concepts taught in the lectures and independently check their progress.

Media formats:
blackboard, assignments

Literature:
Karatzas, I. and Shreve, S.E. (1991). Brownian Motion and Stochastic Calculus, New York: Springer.
P. Mörters, Y. Peres (2010): Brownian Motion, Cambridge University Press, New York / Melbourne / Madrid / Cape Town / Singapore / Sao Paulo / Delhi / Dubai / Tokyo
Le Gall, J. F. (2016). Brownian motion, martingales, and stochastic calculus. Springer.
Revuz, D., & Yor, M. (2013). Continuous martingales and Brownian motion (Vol. 293). Springer Science & Business Media.

Responsible for the module:
Berger Steiger, Noam; Prof. Dr.: noam.berger@tum.de

Courses (Type, SH) Lecturer:

0000001832 Stochastic Analysis [MA4405] (4SWS VO, SS 2023/24)
Gantert N

0000001837 Exercises for Stochastic Analysis [MA4405] (2SWS UE, SS 2023/24)
Gantert N, Couillard E

For further information about this module and its allocation to the curriculum see:
https://campus.tum.de/tumonline/wbModHb.wbShowMHBReadOnly?pKnotenNr=2991418

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