

## Subject card

|                                             |                                                                                                                                                                                  |                                                          |                                         |                                     |                        |            |     |
|---------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------|-----------------------------------------|-------------------------------------|------------------------|------------|-----|
| Subject name and code                       | Introduction to Stochastic Differential Equations, PG_00170283                                                                                                                   |                                                          |                                         |                                     |                        |            |     |
| Field of study                              | Mathematics                                                                                                                                                                      |                                                          |                                         |                                     |                        |            |     |
| Date of commencement of studies             | October 2024                                                                                                                                                                     |                                                          | Academic year of realisation of subject |                                     | 2024/2025              |            |     |
| Education level                             | postgraduate studies                                                                                                                                                             |                                                          | Subject group                           |                                     | Optional subject group |            |     |
| Mode of study                               | full-time studies                                                                                                                                                                |                                                          | Mode of delivery                        |                                     | at the university      |            |     |
| Year of study                               | 1                                                                                                                                                                                |                                                          | Language of instruction                 |                                     | Polish                 |            |     |
| Semester of study                           | 2                                                                                                                                                                                |                                                          | ECTS credits                            |                                     | 6.0                    |            |     |
| Learning profile                            | academic                                                                                                                                                                         |                                                          | Assessment form                         |                                     |                        |            |     |
| Conducting unit                             | Instytut Matematyki -> Faculty of Mathematics, Physics and Informatics -> Rektor                                                                                                 |                                                          |                                         |                                     |                        |            |     |
| Name and surname of lecturer (lecturers)    | Subject supervisor                                                                                                                                                               |                                                          | dr Monika Wrzosek                       |                                     |                        |            |     |
|                                             | Teachers                                                                                                                                                                         |                                                          |                                         |                                     |                        |            |     |
| Lesson types                                | Lesson type                                                                                                                                                                      | Lecture                                                  | Tutorial                                | Laboratory                          | Project                | Seminar    | SUM |
|                                             | Number of study hours                                                                                                                                                            | 30.0                                                     | 30.0                                    | 0.0                                 | 0.0                    | 0.0        | 60  |
|                                             | E-learning hours included: 0.0                                                                                                                                                   |                                                          |                                         |                                     |                        |            |     |
| Learning activity and number of study hours | Learning activity                                                                                                                                                                | Participation in didactic classes included in study plan |                                         | Participation in consultation hours |                        | Self-study | SUM |
|                                             | Number of study hours                                                                                                                                                            | 60                                                       |                                         | 10.0                                |                        | 80.0       | 150 |
| Subject objectives                          | The aim of the course is to familiarize students with the theory of stochastic differential equations and selected properties of solutions to stochastic differential equations. |                                                          |                                         |                                     |                        |            |     |

| Learning outcomes | Course outcome                                                                                                                                                                                                                                                                               | Subject outcome                                                                                                                                                                            | Method of verification                                  |
|-------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------|
|                   | [MATMU2_U04] is able, at an advanced level and including modern mathematics, to apply and present, orally and in writing, methods of at least one selected branch of mathematics                                                                                                             | The student is able to use the known proof methods and methods of solving tasks, and uses the learned concepts correctly.                                                                  | [SU4] test/exam - oral or written                       |
|                   | [MATMU2_K04] is ready to understand and appreciate the importance of intellectual honesty in one's own and other people's actions; ethical conduct                                                                                                                                           | The student understands the importance of intellectual honesty and ethical conduct.                                                                                                        | [SK8] observation of student's independent or team work |
|                   | [MATMU2_K05] is ready to independently search for information in literature, also in foreign languages                                                                                                                                                                                       | The student is ready to independently search for information in the literature.                                                                                                            | [SK8] observation of student's independent or team work |
|                   | [MATMU2_U06] is able to apply methods and examples from a selected field of mathematics in related fields                                                                                                                                                                                    | The student is able to use the known proof methods and methods of solving tasks, and uses the learned concepts correctly.                                                                  | [SU4] test/exam - oral or written                       |
|                   | [MATMU2_W01] knows and understands in-depth the theory of selected areas of mathematics                                                                                                                                                                                                      | The student knows and understands the elements of stochastic analysis, in particular theorems that are the subject of the lecture along with appropriate definitions, examples and proofs. | [SW4] test/exam - oral or written                       |
|                   | [MATMU2_K01] is willing to acknowledge the limitations of his or her own knowledge and is willing to pursue further education                                                                                                                                                                | The student is ready to recognize the limitations of his or her own knowledge and to pursue further education.                                                                             | [SK8] observation of student's independent or team work |
|                   | [MATMU2_U03] can understand mathematical texts of various types from selected fields of mathematics                                                                                                                                                                                          |                                                                                                                                                                                            |                                                         |
|                   | [MATMU2_U07] is able to define his/her interests and develop them; in particular, is able to establish contact with specialists in his/her field, e.g. understand their lectures intended for young mathematicians                                                                           |                                                                                                                                                                                            |                                                         |
|                   | [MATMU2_K02] is ready to precisely formulate questions to deepen his/her understanding of a given topic or find missing elements of reasoning                                                                                                                                                | The student is ready to precisely formulate questions regarding stochastic differential equations.                                                                                         | [SK8] observation of student's independent or team work |
|                   | [MATMU2_U05] can perform proofs in a selected field and, if necessary, also use tools from other areas of mathematics                                                                                                                                                                        | The student is able to use the known proof methods and methods of solving tasks, and uses the learned concepts correctly.                                                                  | [SU4] test/exam - oral or written                       |
|                   | [MATMU2_W02] knows and understands well the role and importance of the construction of mathematical reasoning                                                                                                                                                                                | The student knows the concept of stochastic differential equation and its integral representation.                                                                                         | [SW4] test/exam - oral or written                       |
|                   | [MATMU2_K06] is ready to formulate opinions on basic mathematical issues                                                                                                                                                                                                                     | The student is able to formulate opinions about stochastic differential equations.                                                                                                         | [SK8] observation of student's independent or team work |
|                   | [MATMU2_W03] knows and understands in-depth a selected field of theoretical or applied mathematics and is able to understand the formulations of issues in this field that are still at the research stage and knows the connections of issues in this field with other areas of mathematics | The student knows the theorem of existence and uniqueness of solutions to stochastic differential equations.                                                                               | [SW4] test/exam - oral or written                       |
|                   | [MATMU2_U01] can construct mathematical reasoning: prove theorems and refute hypotheses through construction and selection of counterexamples                                                                                                                                                | The student is able to use the known proof methods and methods of solving tasks, and uses the learned concepts correctly.                                                                  | [SU4] test/exam - oral or written                       |

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|---------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|
| Subject contents                | <ol style="list-style-type: none"><li>1. The Ito process and Ito's lemmas.</li><li>2. Solution of a linear stochastic differential equation.</li><li>3. Theorem on the existence and uniqueness of a strong solution to the stochastic differential equation in the space of Ito processes.</li><li>4. The concept of a weak solution of a stochastic differential equation.</li><li>5. Properties of solutions of stochastic differential equations.</li><li>6. Diffusion generator, Dynkin formula, Feynman-Kac formula.</li></ol> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                               |
| Prerequisites and co-requisites | Basics of the theory of stochastic processes.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                               |
| Assessment methods and criteria | Subject passing criteria                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Passing threshold                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Percentage of the final grade |
|                                 | tests                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 50.0%                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 45.0%                         |
|                                 | final exam                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 50.0%                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 50.0%                         |
|                                 | student's activity                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 0.0%                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 5.0%                          |
| Recommended reading             | Basic literature                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | <ol style="list-style-type: none"><li>1. F. C. Klebaner, Introduction to Stochastic Calculus with Applications, ICP 2005.</li><li>2. B. Øksendal, "Stochastic Differential Equations: An Introduction with Applications." Springer, 2003.</li></ol>                                                                                                                                                                                                                   |                               |
|                                 | Supplementary literature                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | <ol style="list-style-type: none"><li>1. Z. Brzeźniak, T. Zastawniak, "Basic Stochastic Processes", Springer, 1999.</li><li>2. J. Cyganowski, P. Kloeden, J. Ombach, "From Elementary Probability to Stochastic Differential Equations with Maple", Springer, 2002.</li><li>3. W. Feller, "Wstęp do rachunku prawdopodobieństwa", t. I i II, PWN, Warszawa 1977.</li><li>4. A.D. Wentzell, "Wykłady z teorii procesów stochastycznych", PWN, Warszawa 1980.</li></ol> |                               |
|                                 | eResources addresses                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Adresy na platformie eNauczanie:                                                                                                                                                                                                                                                                                                                                                                                                                                      |                               |
|                                 | Example issues/<br>example questions/<br>tasks being completed                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Not applicable                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                               |
| Work placement                  | Not applicable                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                               |

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