**DOCTORAL SCHOOL OF WROCŁAW UNIVERSITY OF SCIENCE AND TECHNOLOGY**

SUPERVISOR/TEAM/ DECLARING/CONDUCTINGCOURSE: …….
DEPARTMENT ……

## COURSE CARD

**Course name in Polish: Elementy wprowadzające do procesów stochochastycznych**
**Course name in English: Introduction elements to stochastic processes**

**Course language Polish / <u>English</u>***
**University-wide general course type*:**
1)basic science course (mathematics, physics, chemistry, computer science or other) :
…….
2) humanities course: …….
3) managementcourse: ……..
4) English language: ……
5) didactics of higher education course: ……

**Specialized courses for PhD students receiving education in discipline*: ……..…….……**
1) <u>specialized course in discipline:</u> ……..
2) interdisciplinary course in the field of several disciplines: ……
3) seminar indiscipline or interdisciplinary: …….

**Subject code:** NFQ100282W

* delete as applicable

| | Lecture | Foreignlanguagecourse | Seminar | Mixedforms |
|---|---|---|---|---|
| Number of hours of organized classes in university (ZZU) | 30 | | | |
| Grading | Exam | Exam | Oralpresentation | Exam, inspection, evaluation classes |

**PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

1. Calculus (from 1st / 2nd level)
2. Sound mastering of basic English language

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**COURSE OBJECTIVES**

C1 Students will learn how to model and analyze statistical properties of chosen well-known physical systems in the presence of additive and multiplicative noise driven by Wiener process
C2 Students will become familiar with basic concepts of Ito's calculus
C3 Students will acquire the skill of solving chosen simple stochastic differential equations

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## PROGRAM CONTENTS

| Form of classes – lecture (Lec) | | Number of hours |
|---|---|---|
| Lec1 | Elementary probability theory, random variables. Stochastic processes in physics | 2 |
| Lec2 | Brownian motion: basic concepts. Monte Carlo simulation of Brownian Motion. | 2 |
| Lec3 | Ornstein-Uhlenbeck process. Simulating the O-U process. Fluctuation-Dissipation Theorem. Johnson noise. | 3 |
| Lec4 | Langevin's Brownian motion: integrating the O-U process, Monte Carlo simulation. Smoluchowski limit. | 2 |
| Lec5 | Brownian projectile. Stochastic damped harmonic oscillator. Stochastic cyclotron motion. | 3 |
| Lec6 | Effusion. Stochastic relaxation of a model polimer (Rouse model). Elastic scattering. | 2 |
| Lec7 | Ito calculus. Ito's formula: changing variables in a Stochastic Differential Equation. Ito stochastic integrals. | 3 |
| Lec8 | Solving the full linear stochastic equation. | 2 |
| Lec9 | System of stochastic differential equations | 2 |
| Lec10 | Wiener-Khinchin Theorem. White noise. | 1 |
| Lec11 | Modeling multiplicative noise in real systems: Stratonovich integrals. | 2 |
| Lec12 | Fokker-Planck equations. Stationary solutions for one dimension. Thermalization of a single particie. Smoluchowski equation. | 4 |
| Lec13 | Poisson process. Master equation. | 2 |
| | Total hours: | **30** |

## TEACHING TOOLS USED

N1. Lecture
N2. Computer lab (during the lecture)
N3. Discussions

## ACHIEVED SUBJECT LEARNING OUTCOMES

| Type of learning outcome | Code of learning outcome | Assessment of learning outcome |
|---|---|---|
| Knowledge<br>Mastering of basic concepts related to Brownian motion | **P8S_WG** | Examination (written), discussions during the lectures |

| | | |
|---|---|---|
| Knowledge<br>Mastering of basic concepts related to Ito's calculus and Stochastic Differential Equations | **P8S_WG** | Examination (written), discussions during the lectures |
| Skills<br>Analysis of Gaussian fluctuations in model physical systems | **P8S_UW** | Examination (written), discussions during the lectures |
| Skills<br>Solving simple Stochastic Differential Equations | **P8S_UW** | Examination (written), discussions during the lectures |
| Skills<br>Monte Carlo simulations of Brownian motion | **P8S_UW** | Computer projects, discussions during the lectures |
| Social competence<br>Awareness of social role of a scientist | **P8U_K** | Discussions during the lectures |

## PRIMARY AND SECONDARY LITERATURE

### PRIMARY LITERATURE:

[1] D.S. Lemons, *An Introduction to Stochastic Processes in Physics*, The Johns Hopkins University Press, 2002.

[2] K. Jacobs, *Stochastic Processes for Physicists: Understanding noisy Systems*, Cambridge University Press, 2010.

### SECONDARY LITERATURE:

[1] O. Calin, *An informal Introduction to Stochastic Calculus with Applications*, World Scientific, 2015.

[2] C. Gardiner, *Stochastic Methods*, Springer, 2009.

[3] A. Janicki, A. Izydorczyk, Komputerowe metody w modelowaniu stochastycznym, WNT, 2001.

[4] Al. Papoulis, *Probability, Random Variables and Stochastic Processes*, Mc Graw-Hill, 1965;
Polskie tłumaczenie: A. Papoulis, *Prawdopodobieństwo, zmienne losowe i procesy stochastyczne*, WNT, 1972.

**SUBJECT SUPERVISOR(NAME AND SURNAME, E-MAIL ADDRESS)**

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