DOCTORAL SCHOOL OF WROCŁAW UNIVERSITY OF SCIENCE AND TECHNOLOGY

SUPERVISOR DECLARING/CONDUCTING COURSE: Aleksei (Oleksii) Chechkin
DEPARTMENT: Faculty of Pure and Applied Mathematics
SCIENTIFIC DISCIPLINE: Mathematics

COURSE CARD

Course name in Polish:
Course name in English: Stochastic Processes in Natural Sciences
Course language: ~~polish~~/ english
The course is intended for all PhD students: ~~YES~~ / NO Mathematics, Physical Science, Chemical Science, Chemical Engineering

1) ~~BASIC COURSE~~
2) SPECIALIST COURSE
3) ~~SEMINAR~~
4) ~~HUMANISTIC COURSE~~
5) ~~LANGUAGE~~
6) ~~RESEARCH SKILLS~~

Subject code:

* delete as applicable

	Lecture	Foreign language course	Seminar	Mixed forms
Number of hours of organized classes in university (ZZU)				**30**
Grading	Exam	Exam	Oral presentation	Exam~~, inspection, evaluation classes~~

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Basic knowledge of probability theory.
2. Mathematical analysis, in particular, complex analysis, Fourier and Laplace transformations, and ordinary and partial differential equations.

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COURSE OBJECTIVES

C1. To get new knowledge on the theory of stochastic processes, random walks and their applications in natural sciences.
C2. To obtain information on recent advances in the theory of diffusion processes and kinetic theory.
C3. To acquire skills in solving particular problems that require the use of modern tools of stochastic processes theory.

PROGRAM CONTENTS

Form of classes		Number of hours
1.	(Reminder) Basics of the theory of random processes: stationary processes and ergodicity, processes with independent increments, processes with stationary increments. Ordinary Brownian motion (Wiener process), Ornstein-Uhlenbeck process. Random fractals and self-similarity. Markov processes and Fokker-Planck equation.	6
2.	Generalized Central Limit Theorem and alpha-stable Lévy probability laws. Holtzmark distribution and first passage time statistics in Brownian motion.	4
3.	Alpha-stable Lévy processes, Lévy motion (Lévy flights); ordinary Brownian motion as a limit case of the Lévy family.	2
4.	Stochastic differential equations. Ito, Stratonovich and Hänggi-Klimontovich prescriptions. Heterogeneous diffusion processes.	4
5.	Stochastic point processes	2
6.	Non-Markov processes. Fractional Brownian motion and fractional Langevin equation.	2
7.	Renewal theory, continuous time random walk model, generalized master equation, fractional diffusion and Fokker-Planck equations.	4
8.	Subordination of stochastic processes.	2
9.	First passage and arrival processes.	2
10.	Exam.	2
	Total hours	30

TEACHING TOOLS USED

N1. Presentation on blackboard.
N2. Power Point presentation.
N3. Zoom platform in case of on-line teaching.

ACHIEVED SUBJECT LEARNING OUTCOMES

Type of learning outcome	Code of learning outcome	Assessment of learning outcome

PRIMARY AND SECONDARY LITERATURE
PRIMARY LITERATURE: 1. C.W. GARDINER, HANDBOOK OF STOCHASTIC METHODS FOR PHYSICS, CHEMISTRY AND THE NATURAL SCIENCES. SPRINGER-VERLAG, 1997. 2. N.G. VAN KAMPEN, STOCHASTIC PROCESSES IN PHYSICS AND CHEMISTRY. ELSEVIER, 2007. **SECONDARY LITERATURE:** 1. W. PAUL, J. BASCHNAGEL, STOCHASTIC PROCESSES. FROM PHYSICS TO FINANCE. SPRINGER, 2013. 2. J. KLAFETR, I.M. SOKOLOV, FIRST STEPS IN RANDOM WALKS. FROM TOOLS TO APPLICATIONS. OXFORD UNIV. PRESS, 2011.
SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)
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Abstract.
Nowadays the area of applications of stochastic processes is expanding drastically. Novel classes of stochastic phenomena have recently been observed in a wide variety of complex systems such as amorphous semiconductors, glassy and nano-materials, fusion plasma, biological cells and epidemic spreading. The coherent description of such and many other phenomena poses a fundamental challenge to a modern statistical physics of non-equilibrium state and requires going beyond the “traditional” university courses on the theory of probability, stochastic processes and kinetic theory. This short lecture series aims to provide an introductory overview of some basic modern concepts in the theory of stochastic processes and random walk phenomena. The course is based on the previous courses taught by the lecturer to physicists and engineers. The presentation will be given at a “physical” level of rigour, with the use of exercises and particular examples.