Wrocław University of Science and Technology
Doctoral School

COURSE CARD

1. Basic information

Course name in English:	Stochastic Processes in Natural Sciences	
Course name in Polish:	Procesy stochastyczne w naukach przyrodniczych	
Number of hours:	30	
Type of course:	Elective course	
Form of course:	lecture	
Code of course:		
Course leader:	Oleksii (Aleksei) Chechkin	
Faculty of the course leader:	W13 Faculty of Pure and Applied Mathematics	
Email address of the course leader:	oleksii.chechkin@pwr.edu.pl	
Scientific discipline(s) assigned to the course (doctoral students representing the marked disciplines can participate in the course):	Architecture and urban planning	☐
	Automation, electronic, electrical engineering and space technologies	☐
	Information and communication technology	☐
	Biomedical engineering	☐
	Chemical engineering	☐
	Civil engineering, geodesy and transport	☐
	Materials engineering	☒
	Mechanical engineering	☐
	Environmental engineering, mining, and energy	☒
	Mathematics	☒
	Chemical sciences	☒
	Physical sciences	☒
	Management and quality studies	☐

2. Objectives

C1. To get new knowledge on the theory of stochastic processes, noises, 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 the the theory of stochastic processes

3. Content

Detailed information about the course content, including topics and form of classes.

No.	Topic	Number of hours	Form of classes

1	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	Select form
2	Brownian Motion, physical view. Underdamped and overdamped Langevin equations. Fokker-Planck and Klein-Kramers kinetic equations.	4	Select form
3	Stochastic differential equations. Ito, Stratonovich and Hänggi-Klimontovich prescriptions. Heterogeneous diffusion processes.	4	Select form
4	Non-Markov processes. Fractional Brownian motion and fractional Langevin equation.	4	Select form
5	Continuous time random walk models, generalized master equation, fractional diffusion and Fokker-Planck equations.	4	Select form
6	First passage and arrival processes.	4	Select form
7	Noises in physical and engineering devices.	4	Select form
8			Select form
9			Select form
10			Select form
11			Select form
12			Select form
13			Select form
14			Select form
15			Select form

4. Prerequisites

List of prerequisites relating to knowledge, skills and other competences for course participants.

1. Basic knowledge of probability theory.

2. Mathematical analysis, in particular, complex analysis, Fourier and Laplace transformations, ordinary and partial differential equations.

5. Learning outcomes

List of learning outcomes at level 8 of the Polish Qualifications Framework assigned to the course (mark the learning outcomes in the last column).

Symbol	Learning outcome	
	KNOWLEDGE. Doctoral student knows and understands:	
SzD_W3	the main trends in the development of the scientific or artistic disciplines covered in the curricula;	☒
SzD_W4	research methodology;	☒
SzD_W5	the rules for the dissemination of scientific results, including in open access mode;	☒
SzD_W6	the fundamental dilemmas of modern civilization;	☐
SzD_W7	the legal and ethical conditions of scientific activity;	☐
SzD_W8	the economic and other relevant conditions of scientific activity;	☐
SzD_W9	basic principles of knowledge transfer to the economic and social spheres and commercialisation of results of scientific activity and know-how related to these results.	☐
	SKILLS. Doctoral student is able to:	
SzD_U2	use knowledge from different fields of science or art to creatively identify, formulate and innovatively solve complex problems or perform research tasks, in particular: - define the purpose and subject of scientific research, formulate a research hypothesis, - develop research methods, techniques and tools, and use them creatively, - draw conclusions on the basis of scientific research; critically analyse and evaluate the results of scientific research, expertise and other creative work and their contribution to knowledge development; transfer the results of scientific activities to the economic and social spheres;	☒
SzD_U3	communicate on specialised topics to the extent that they enable an active participation in the international scientific community;	☒
SzD_U4	disseminate research results, including in popular forms;	☒
SzD_U5	initiate debates and participate in a scientific discourse;	☒
SzD_U6	be able to speak a foreign language at B2 level of the Common European Framework of Reference for Languages to a level that enables them to participate in the international scientific and professional environment;	☐
SzD_U7	plan and implement an individual or collective research or creative activity, including in an international environment;	☐
SzD_U8	independently plan and act for one's own development and inspire and organize the development of others;	☐
SzD_U9	plan classes or groups of classes and implement them using modern methods and tools.	☐
	SOCIAL COMPETENCES. Doctoral student is ready to:	

SzD_K3	fulfilling the social obligations of researchers and creators, initiate public interest activities, thinking and acting in an entrepreneurial way;	☐
SzD_K4	maintaining and developing the ethos of research and creative environments, including: - carrying out scientific activities in an independent manner, - respecting the principle of public ownership of research results, taking into account the principles of intellectual property protection.	☐

6. Evaluation

Short description of the method(s) used to evaluate the learning outcomes assigned to the course, e.g., exam, test, report, presentation, etc.

Written exam

7. Teaching methods

Short description of the teaching methods used during the course, e.g., multimedia presentation, discussion, literature studies, developing written documents, own work, etc.

Lectures on blackboard, multimedia presentations, literature studies

8. Literature

List of primary and secondary literature used to prepare the course and including additional knowledge for participants, e.g., books, textbooks, research papers, standards, web pages, etc.

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.
3. H. RISKEN, THE FOKKER-PLANCK EQUATION. SPRINGER; 1996.
4. W. PAUL, J. BASCHNAGEL, STOCHASTIC PROCESSES. FROM PHYSICS TO FINANCE. SPRINGER, 2013.

SECONDARY LITERATURE:

1. J. KLAFTER, I.M. SOKOLOV, FIRST STEPS IN RANDOM WALKS. FROM TOOLS TO APPLICATIONS. OXFORD UNIV. PRESS, 2011.

9. Other remarks

Additional remarks, comments, (e.g., language of the course)

Language of the course: English