Zał. nr 5 do ZW 16/2020

FACULTY OF MANAGEMENT

SUBJECT CARD

Name of subject in Polish: Fizyka układów złożonych
Name of subject in English: Physics of complex systems
Main field of study (if applicable): Business Engineering
Specialization (if applicable): Business Intelligence
Profile: academic
Level and form of studies: 2nd level full-time
Kind of subject: obligatory
Subject code FZZ2515
Group of courses YES

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	**15**		**15**		
Number of hours of total student workload (CNPS)	**60**		**60**		
Form of crediting	**crediting with grade**				
For group of courses mark (X) final course	**X**				
Number of ECTS points	**4**				
including number of ECTS points for practical classes (P)			**2**		
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	**2,1**				

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Programming skills for example in Python
2. Knowledge of elements of physics, probability and statistics, and skills related to this subject

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SUBJECT OBJECTIVES

C1 The purpose of this introductory course is to give an overview of the basic concepts, models and tools, used in the field of the Complex Systems, i.e. systems of many interacting components. After this course students should understand the essence of complexity and relations between different approaches used for complex systems.

SUBJECT EDUCATIONAL EFFECTS

Related to knowledge:

PEU_W01: He knows and understands advanced models, methods and IT tools, especially simulation tools used to solve management decision-making problems, as well as the interactions that occur in selected physical systems between their various components.

In the field of skills:
PEU_U01: Can describe selected issues encountered in everyday and professional life using mathematical and physical formalism and draw conclusions

In the field of social competences: PEU_K01: Is able to take an active part in discussions and work in a group

PROGRAMME CONTENT

Lecture		Number of hours
Lec 1	Presentation of the requirements and grading. Introduction: what is a Complex system and how it can be modeled?	1
Lec 2	From micro to macro: equilibrium and entropy; Ehrenfest model	2
Lec 3	Percolation model on regular networks - from forest fires to traffic; about criticality for the first time	2
Lec 4	Ising model as a prototype of an agent-based model - its applications in the social sciences; about criticality for the second time	2
Lec 5	Elements of the theory of phase transitions and critical phenomena; criticality as an example of emergence in complex systems	2
Lec 6	Complex networks: models and processes on networks	2
Lec 7	Power laws, scaling and self-organizing criticality	2
Lec 8	Final test	2
	Total hours	15

Laboratory		Number of hours
Lab 1	Presentation of the requirements and grading.	1
Lab 2	Simulation of the Ehrenfest model - observation of the system reaching equilibrium	2
Lab 3	Monte Carlo simulation of the percolation model - determining percolation threshold (probability of flow, the largest cluster); observation of criticality in complex systems for the first time	4
Lab 4	Monte Carlo simulation of the Ising model using the Metropolis algorithm - trajectories and stationary states; observation of criticality in complex systems for the second time	4
Lab 5	Complex networks: models and visualization (NetworkX package for Python)	4
	Total hours	15

TEACHING TOOLS USED

N1. Traditional lecture
N2. Multimedia presentation
N3. Computer laboratory – PC computer with Python.

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

Evaluation (F – forming during	Learning outcomes code	Way of evaluating learning outcomes achievement

semester), P – concluding (at semester end)		
F1	PEU_W01, PEU_U01	The final grade from the test (lecture)
F2	PEU_W01, PEU_U01 PEU_K01	The average grade from labs
P=0,5*F1+0,5*F2		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

1. Białynicka-Birula, I. and Białynicki-Birula, I. "Modeling Reality: How Computers Mirror Life", Oxford University Press 2004
2. Moloney, N. R. and Christensen K, "Complexity and Criticality", Imperial College Press 2005
2. Newman, M. E. J. and Barkema, G. T.   "Monte Carlo Methods in Statistical Physics", Oxford University Press 1999
4. Thurner, S. , Hanel, R. and Klimek, P. "Introduction to the Theory of Complex Systems", Oxford University Press 2018

SECONDARY LITERATURE:

1. Bak, P. "How Nature Works: the science of self-organized criticality", Springer 1996
2. Barabási, A-L "Network Science", Cambridge University Press 2016
3. Boccara, N. "Modeling Complex Systems", Second Edition, Springer 2010
4. Gros, C. "Complex and Adaptive Dynamical Systems. A Primer", Third Edition, Springer 2013
5. Landau, D. P. and Binder, K. "A Guide to Monte Carlo Simulations in Statistical Physics", 4th Edition, Cambridge University Press 2014
6. Newman, M. "Networks: An Introduction", Oxford University Press 2010
7. Stauffer, D. and Aharony, A. "Introduction To Percolation Theory", Second Revised Edition, Taylor & Francis 2003
8. Original articles

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

Katarzyna Weron, katarzyna.weron@pwr.edu.pl
Piotr Nyczka, piotr.nyczka@pwr.edu.pl
Pratik Mullick, pratik.mullick@pwr.edu.pl