

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** W08IZZ-SM8027**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)	25		50		
Form of crediting	crediting with grade				
For group of courses mark (X) final course	X				
Number of ECTS points	3				
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)	0,68		0,68		

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

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.

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 mikro to makro: Equilibrium, Entropy, Ehrenfest model	2
Lec 3	Percolation model	2
Lec 4	Ising Model	2
Lec 5	Elements of phase transitions theory	2
Lec 6	Complex networks: models and processes on networks	2
Lec 7	Power laws around us and models of self-organized criticality	2
Lec 8	Social complex systems: models of opinion dynamics and diffusion of innovation	2
	Total hours	15

Laboratory		Number of hours
Lab 1	Presentation of the requirements and grading.	1
Lab 2	Monte Carlo Simulations	3
Lab 3	Simulation of the Percolation model	4
Lab 4	Metropolis Monte Carlo simulation of the Ising model	4
Lab 5	Complex networks: models and visualization (NetworkX package for Python)	3
	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 semester), P – concluding (at semester end)	Learning outcomes code	Way of evaluating learning outcomes achievement
F1	PEU_W01, PEU_U01	The final grade from the project
F2	PEU_W01, PEU_U01 PEU_K01	The average grade from labs
$P=0,5 \cdot F1 + 0,5 \cdot F2$		

PRIMARY AND SECONDARY LITERATURE
<u>PRIMARY LITERATURE:</u> 1. Albert-László Barabási, “Network Science”, Cambridge University Press 2016 2. Nino Boccara, “Modeling Complex Systems”, 2nd Edition, Springer-Verlag New York Inc. 2010 3. Nicholas R. Moloney, Kim Christensen, “Complexity and Criticality”, Imperial College Press 2005 <u>SECONDARY LITERATURE:</u> 1. David P. Landau, Kurt Binder, “A Guide to Monte Carlo Simulations in Statistical Physics”, 4th Edition, Cambridge University Press 2014 2. Mark Newman, “Networks: An Introduction”, Oxford University Press 2010 3. Stefan Thurner, Rudolf Hanel, and Peter Klimek, “Introduction to the Theory of Complex Systems”, Oxford University Press 2018 4. Mark E. J. Newman, G. T. Barkema, “Monte Carlo Methods in Statistical Physics”, Oxford University Press 1999 SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS) dr hab. Katarzyna Weron, katarzyna.weron@pwr.edu.pl dr Pratik Mullick, pratik.mullick@pwr.edu.pl