Zał. Nr 1 do ZW 16/2020

PROGRAM OF STUDIES

FACULTY: Fundamental Problems of Technology
MAIN FIELD OF STUDY: Big Data Analytics (BDA)
BRANCH OF SCIENCE: natural sciences
DISCIPLINES: D1 physical sciences, with engineering skills (major discipline)

EDUCATION LEVEL: second-level studies
FORM OF STUDIES: full-time studies
PROFILE: general academic
LANGUAGE OF STUDY: english

Content:

Resolution no. … of the Senate of Wroclaw University of Science and Technology

In effect since 2021/2022

*delete as applicable

Zał. Nr 2 do ZW 16/2020

ASSUMED LEARNING OUTCOMES

FACULTY: **of Fundamental Problems of Technology**

MAIN FIELD OF STUDY: **Big Data Analytics (BDA)**

EDUCATION LEVEL: second-level studies

PROFILE: general academic

Location of the main-field-of study:

Branch of science: **natural sciences**

Discipline / disciplines (for several disciplines, please indicate the major discipline)

physical sciences, with engineering skills

Explanation of the markings:
P6U – universal first degree characteristics corresponding to education at the first-level studies - 6 PRK level *
P7U – universal first degree characteristics corresponding to education at the second-level studies - 7 PRK level *

P6S – second degree characteristics corresponding to education at the first-level studies - 6 PRK level *
P7S – second degree characteristics corresponding to education at the second-level studies - 7 PRK level *

W - category "knowledge"
U - category "skills"
K - category "social competences"
K (*faculty symbol*) _W1, K (*faculty symbol*) _W2, K (*faculty symbol*) _W3, … - main-field-of study learning outcomes related to the category "knowledge"
K (*faculty symbol*) _U1, K (*faculty symbol*) _U2, K (*faculty symbol*) _U3, … - main-field-of study learning outcomes related to the category "skills"
K (*faculty symbol*) _K1, K (*faculty symbol*) _K2, K (*faculty symbol*) _K3, … - main-field-of study learning outcomes related to the category "social competences"
S (*faculty symbol*) _W.., S (*faculty symbol*) _W.., S (*faculty symbol*) _W.., … - specialization learning outcomes related to the category "knowledge"
S (*faculty symbol*) _U.., S (*faculty symbol*) _U.., S (*faculty symbol*) _U.., … - specialization learning outcomes related to the category "skills"
S (*faculty symbol*) _K.., S (*faculty symbol*) _K.., S (*faculty symbol*) _K.., … - specialization learning outcomes related to the category "social competences"
… _inż. – learning outcomes related to the engineer competences

* delete as applicable

Main field of study learning outcomes	**Description of learning outcomes for the main-field-of study** **Big Data Analytics** After completion of studies, the graduate:	Reference to PRK characteristics		
		Universal first degree characteristics (U)	Second degree characteristics typical for qualifications obtained in higher education (S)	
			Characteristics for qualifications on 7 levels of PRK	Characteristics for qualifications on 6 and 7 levels of PRK, enabling acquiring engineering competences
KNOWLEDGE (W)				
BDA2_W01	has taken extended knowledge in physics, computer science and mathematics, that is useful to modeling and solving problems related to analyzing big information resources	P7U_W	P7S_WG	P7S_WG_inż
BDA2_W02	is familiar with the most important directions in the field of the big data analytics, theory of complex systems, and statistical physics	P7U_W	P7S_WG	
BDA2_W03	is familiar with methods of physics and computer science, those are applicable to tracking, modeling, and analyzing big data sets	P7U_W	P7S_WG	P7S_WG_inż
BDA2_W04	is familiar with methods for monitoring online and processing with big data sets	P7U_W	P7S_WG	
BDA2_W05	is familiar with basic techniques of classifying and their computational complexities	P7U_W	P7S_WG	
BDA2_W06	is familiar with methods of modeling and analysis of complex dynamical systems	P7U_W	P7S_WG	
BDA2_W07	is familiar with the definition and usage of the entropy to the analysis of dynamical systems	P7U_W	P7S_WG	
BDA2_W08	is familiar with applications of differential equations to modeling and studying dynamical systems	P7U_W	P7S_WG	
BDA2_W09	is familiar with elements of programming with use of symbolic algebra packages	P7U_W	P7S_WG	
BDA2_W10	is familiar with modeling and generating big structures	P7U_W	P7S_WG	

	of probabilistic data			
BDA2_W11	is familiar with basic rules of safety and hygiene at work with electronic equipment, is familiar with main dangers of using modern information processing and telecommunication technologies	P7U_W	P7S_WK	
BDA2_W12	is familiar with basics of legal and ethical conditions related to data analyzing	P7U_W	P7S_WK	
BDA2_W13	is familiar with general rules of creating and developing individual entrepreneurship using scientific knowledge relevant to the individual educational directions, is familiar with methods of analyzing data for business	P7U_W	P7S_WK	P7S_WK_inż
SKILLS (U)				
BDA2_U01	is able to efficiently use available data sources	P7U_U	P7S_UW	P7S_UW_inż
BDA2_U02	is able to utilize the knowledge in physics to modeling complex systems	P7U_U	P7S_UW	P7S_UW_inż
BDA2_U03	is able to efficiently use specialist literature including the most recent publications	P7U_U	P7S_UU	P7S_UW_inż
BDA2_U04	is able to find an adequate model of observed dynamical phenomenon	P7U_U	P7S_UW	P7S_UW_inż
BDA2_U05	is able to prepare a publication of the scientific character that presents results of a performed study	P7U_U	P7S_UW	
BDA2_U06	is able to apply the mathods of Big Data Analytics to sets of data of scientific observations	P7U_U	P7S_UW	
BDA2_U07	is able to present results of a study in an accessible way	P7U_U	P7S_UK	
BDA2_U08	is able to work in a team for carrying out research projects; is able to lead the teamwork	P7U_U	P7S_UO	
BDA2_U09	is aware of the need for continuous tracking of the specialist literature and is familiar with the major Big-Data conferences, complex systems theory, statistical physics	P7U_U	P7S_UU	
BDA2_U10	is able to speak a foreign language at the B2+ level	P7U_U	P7S_UK	
BDA2_U11	has practical skills in probability theory, statistics, algebra, differential equations, numerical methods and databases	P7U_U	P7S_UW	
SOCIAL COMPETENCES (K)				

BDA2_K01	is able to filter and verify informations taken from different sources	P7U_K	P7S_KK	
BDA2_K02	is able to perform verification of the level of complexity of a studied problem, to divide an analytical task into the stages and is able to control the project implementation	P7U_K	P7S_KK P7S_KR	
BDA2_K03	takes into account ethical and legal problems related to publishing results of data analyses	P7U_K	P7S_KR	
BDA2_K04	undertakes discussions on social issues based on data analysis, being aware of its limitations	P7U_K	P7S_KO	

*delete as applicable

Zał. nr 3 do ZW 16/2020

Attachment no. 2. to the Program of Studies

DESCRIPTION OF THE PROGRAM OF STUDIES

Main field of study Big Data Analytics **Profile general academic**

Level of studies second level studies **Form of studies full-time studies**

1. General description

1.1 Number of semesters: ***3***	*1.2 Total number of ECTS points necessary to complete studies at a given level:* ***90***
*1.3 Total number of hours:****990***	*1.4 Prerequisites (particularly for second-level studies):* *the professional degree: Engineer, MSc Engineer or MSc. The finalized general-academic study in: anstronomy, automatics, electronics and electrical engineering, information engineering and telecommunication, informatics, biomedical engineering, mathematics, physical sciences*
1.5 Upon completion of studies graduate obtains *professional degree of:* ***MSc Engineer*** ***II level competences***	*1.6 Graduate profile, employability:* *The graduate has in-depth knowledge of these areas of physics, computer science and mathematics, that are useful for modeling and solving problems related to the analysis of large information resources. The graduate knows the most*

	important directions of research in the field of analytics of large data sets (Big Data Analytics), complex systems theory and statistical physics and has skills to: (1) use IT tools and technologies to process large amounts of data, (2) use methods of physics of complex systems to study and model the analyzed information resources, (3) find or design an adequate model of the observed dynamic phenomenon and verify it on the basis of empirical data. *The graduate will be prepared to work in a dynamically developing market sector (in particular banking and IT programming sectors) related to the statistical analysis of large data sets, that is aimed to uncover, among others, hidden patterns, market trends, customer preferences, etc.*
1.7 Possibility of continuing studies: ***III level study (PhD study)***	*1.8 Indicate connection with University's mission and its development strategy:* This master program implements the mission of the university, offering technical competences in the field of modeling complex systems and big data analytics, which will be the fundamentals for the modern information technologies in application not only to natural and technical sciences, but also to economic and social systems. It will educate creative specialists prepared to play a leading role in the dynamically developing market segment of big data. The program fits into the implementation of the university's strategic goals through its correlation with the needs of the market, high formal level, interdisciplinary

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical course / group of courses – enter P. For the group of courses – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

	character, students' involvement in research at the highest level and attractiveness for foreign students.

2. Detailed description

2.1 Total number of learning outcomes in the program of study: W (knowledge) = 13, U (skills) = 11, K (competences) = 4, W + U + K = 28

2.2 For the main field of study assigned to more than one discipline - the number of learning outcomes assigned to the discipline:

D1 (major) 28 (this number must be greater than half the total number of learning outcomes)
D2 .....
D3 .....
D4 .....

2.3 For the main field of study assigned to more than one discipline - percentage share of the number of ECTS points for each discipline:

D1 100% ECTS points
D2 .....% ECTS points
D3 .....% ECTS points
D4 .....% ECTS points

2.4a. For the general academic profile of the main field of study – the number of ECTS points assigned to the classes related to the University's academic activity in the discipline or disciplines to which the main field of study is assigned – DN (must be greater than 50% of the total number of ECTS points from 1.2) 62 ECTS points

2.4b. For the practical profile of the main field of study - the number of ECTS points assigned to the classes shaping practical skills (must be greater than 50% of the total number of ECTS points from 1.2)

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical course / group of courses – enter P. For the group of courses – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

2.5 Concise analysis of compliance of the assumed learning outcomes with the needs of the labor market

Over the last years, big data has significant influence to changes in most types of modern industries. Large amount of data are collected everyday by many corporations, including financial, telecommunication, marketing and health companies. However, understanding the value of big data continues to remain a challenge. Analyzing big data could potentially help to discover some hidden patterns and dependencies. In result it should substantially help companies to make different strategic choices. Different surveys show that most of companies are investing or are planning to invest in big data. Therefore, creative specialists, who are not only prepared to use already known tools but also designing new technologies, are of particular high demand.

2.6. The total number of ECTS points that a student must obtain in classes requiring direct participation of academic teachers or other persons conducting classes and students (enter the sum of ECTS points for courses / groups of courses marked with the BU[1] code) **46** ECTS points

2.7. Total number of ECTS points, which student has to obtain from basic sciences classes

Number of ECTS points for obligatory subjects	14
Number of ECTS points for optional subjects	14
Total number of ECTS points	28

2.8. Total number of ECTS points, which student has to obtain from practical classes, including project and laboratory classes (enter total number of ECTS points for courses/group of courses denoted with code P)

Number of ECTS points for obligatory subjects	23
Number of ECTS points for optional subjects	12
Total number of ECTS points	35

2.9. Minimum number of ECTS points, which student has to obtain doing education blocks offered as part of University-wide classes or other main field of study (enter number of ECTS points for courses/groups of courses denoted with code O)

5 ECTS points

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical course / group of courses – enter P. For the group of courses – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

2.10. Total number of ECTS points, which student may obtain doing optional blocks (min. 30% of total number of ECTS points)

28 ECTS points

3. Description of the process leading to learning outcomes acquisition:

The description of the process leading to learning outcomes acquisition is given in the attachment "Assumed learning outcomes", while the details are included into the subject cards, which contain the description of the way of achieving and verifying every detailed result of learning.

4. List of education blocks:

4.1. List of obligatory blocks:

4.1.1 List of general education blocks

4.1.1.1 ***Liberal-managerial subjects*** **block** *(min. ..... ECTS points):NONE*

4.1.1.2 ***Foreign languages*** **block** *(min. 2 ECTS points):*

No.	Course/ group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of course/group of courses	Way[3] of crediting	Course/group of courses			
			lec	cl	Lab	pr	sem		ZZU	CNPS	Total	DN[5] classes	BU[1] classes			University-wide[4]	Concerning scientific activities[5]	Practical[6]	Type[7]
1	JZL100709BK	Foreign Language 2		3				BDA2_U10	45	60	2		1	T,Z	Z	O		P	KO
		Total		3					45	60	2		1						

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical course / group of courses – enter P. For the group of courses – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

4.1.1.3 *Sporting classes* block *(0 ECTS points):NONE*

4.1.1.4 *Information technologies* block *(min. .... ECTS points): NONE*

Altogether for general education blocks

Total number of hours					Total number of ZZU hours	Total number of CNPS hours	Total number of ECTS points	Total number of ECTS points for DN classes[5]	Number of ECTS points for BU classes[1]
lec	cl	lab	pr	sem					
	3				45	60	2		1

4.1.2 List of basic sciences blocks

4.1.2.1 *Mathematics* block

No.	Course/ group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of course/group of courses	Way[3] of crediting	Course/group of courses			
			lec	cl	lab	pr	sem		ZZU	CNPS	Total	DN[5] classes	BU[1] classes			University-wide[4]	Concerning scientific activities[5]	Practical[6]	Type[7]
1		Advanced Topics in Algebra (**GK**)	2	1	1			BDA2_W01 BDA2_U11	60	100	4		2	T	Z(w)				PD
2		Practical Statistics for Data Science(**GK**)	2	1	1			BDA2_W01 BDA2_U11 BDA2_K02	60	100	4		2	T	E(w)			P(2)	PD

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical course / group of courses – enter P. For the group of courses – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

	Total	4	2	2				120	200	8		4						

4.1.2.2 *Physics* block

No.	Course/ group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of course/group of courses	Way[3] of crediting	Course/group of courses			
			lec	cl	lab	pr	sem		ZZU	CNPS	Total	DN[5] classes	BU[1] classes			University-wide[4]	Concerning scientific activities[5]	Practical[6]	Type[7]
1		Elements of Nonlinear Dynamics (**GK**)	1		1			BDA2_W01 BDA2_W06 BDA2_W08 BDA2_W09 BDA2_U04	30	50	2	2	1	T,Z	Z(w)		DN	P(1)	PD
		Total	1		1				30	50	2	2	1						

4.1.2.3 *Chemistry* block: NONE

4.1.2.4 *Information processing* block

No.	Course/ group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of course/group of courses	Way[3] of crediting	Course/group of courses			
			lec	cl	lab	pr	sem		ZZU	CNPS	Total	DN[5] classes	BU[1] classes			University-wide[4]	Concerning scientific activities[5]	Practical[6]	Type[7]
1		Databases and Information Management (**GK**)	2		2			BDA2_W01 BDA2_W03 BDA2_U01 BDA2_U11	60	100	4		2	T	Z(w)			P(2)	PD
		Total	2		2				60	100	4		2						

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical course / group of courses – enter P. For the group of courses – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

Altogether for basic sciences blocks:

Total number of hours					Total number of ZZU hours	Total number of CNPS hours	Total number of ECTS points	Total number of ECTS points for DN classes[5]	Number of ECTS points for BU classes[1]
lec	cl	lab	pr	sem					
7	2	5			210	350	14	2	7

4.1.3 List of the main field of study blocks

4.1.3.1 *Obligatory main field of study* blocks

No.	Course/ group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of course/group of courses	Way[3] of crediting	Course/group of courses			
			lec	cl	lab	pr	sem		ZZU	CNPS	Total	DN[5] classes	BU[1] classes			University-wide[4]	Concerning scientific activities[5]	Practical[6]	Type[7]
1		Programming and Classification (**GK**)	2	1	1			BDA2_W01 BDA2_W05 BDA2_W11 BDA2_U06	60	100	4	4	2	T,Z	Z(w)		DN	P(2)	K
2		Stream Programming (**GK**)	2		2			BDA2_W04 BDA2_W11 BDA2_W12 BDA2_U01 BDA2_U08	60	125	5		2	T,Z	Z(w)			P(2)	K
3		Complex Systems (**GK**)	2		2			BDA2_W02 BDA2_W06 BDA2_W07 BDA2_W08	60	125	5	5	3	T	E(w)		DN	P(3)	K

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical course / group of courses – enter P. For the group of courses – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

								BDA2_U02											
4		Big Data Algorithms (**GK**)	2	2	2			BDA2_W02 BDA2_W03 BDA2_W04 BDA2_W10 BDA2_U06	90	150	6	6	3	T	Z(w)		DN	P(4)	K
5		Diploma Seminar 1					1	BDA2_U01 BDA2_U03 BDA2_U07	15	25	1		1	T,Z	Z			P	K
6		Diploma Seminar 2					2	BDA2_U01, BDA2_U03 BDA2_U05 BDA2_U07	30	60	2		1	T	Z			P	K
7		Machine Learning – Applications (**GK**)	2	2				BDA2_W01 BDA2_U09 BDA2_U11	60	75	3	3	2	T	E(w)		DN	P(2)	K
		Total	10	5	7		3		375	660	26	18	14						

Altogether (for main field of study blocks):

Total number of hours					Total number of ZZU hours	Total number of CNPS hours	Total number of ECTS points	Total number of ECTS points for DN classes[5]	Number of ECTS points for BU classes[1]
lec	cl	lab	pr	sem					
10	5	7		3	375	660	26	18	14

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical course / group of courses – enter P. For the group of courses – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

4.2 List of optional blocks

4.2.1 List of general education blocks

4.2.1.1 Liberal-managerial subjects blocks *(min. 5 ECTS points):*

No.	Course/ group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of course/group of courses	Way[3] of crediting	Course/group of courses			
			lec	cl	lab	pr	sem		ZZU	CNPS	Total	DN[5] classes	BU[1] classes			University-wide[4]	Concerning scientific activities[5]	Practical[6]	Type[7]
1	FLP105619BK	Humanities	1					BDA2_W13 BDA2_K01 BDA2_K04	15	60	2		1	T	Z	O			KO
2	EKP105576BK	Social Science	2					BDA2_W13 BDA2_U06 BDA_K03, BDA2_K04	30	90	3		1	T	Z				KO
		Total	3						45	150	5		2						

4.2.1.2 ***Foreign languages*** **block** *(min. 1 ECTS points):*

No.	Course/ group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of course/group of courses	Way[3] of crediting	Course/group of courses			
			lec	cl	lab	pr	sem		ZZU	CNPS	Total	DN[5] classes	BU[1] classes			University-wide[4]	Concerning scientific activities[5]	Practical[6]	Type[7]
1	JZL100709BK	Foreign Language 1		1				BDA2_U10	15	30	1		1	T,Z	Z	O		P	KO

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical course / group of courses – enter P. For the group of courses – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

	Total		1					15	30	1		1						

4.2.1.3 Sporting classes block *(0. ECTS points): NONE*

4.2.1.4 *Information technologies* block *(min. .... ECTS points): NONE*

Altogether for general education blocks:

Total number of hours					Total number of ZZU hours	Total number of CNPS hours	Total number of ECTS points	Total number of ECTS points for DN classes[5]	Number of ECTS points for BU classes[1]
lec	cl	lab	pr	sem					
3	1				60	180	6		3

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical course / group of courses – enter P. For the group of courses – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

4.2.2 List of basic sciences blocks

4.2.2.1 *Mathematics* block *(min. 9 ECTS points):*

No.	Course/ group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of course/group of courses	Way[3] of crediting	Course/group of courses			
			lec	cl	lab	pr	sem		ZZU	CNPS	Total	DN[5] classes	BU[1] classes			University-wide[4]	Concerning scientific activities[5]	Practical[6]	Type[7]
1		Elements of Probability Theory (**GK**) or Probability Theory (**GK**)	3	2				BDA2_W01 BDA2_U11	75	125	5	5	3	T	E(w)		DN	P(2)	PD
1		Elements of Differential Equations (**GK**) or Differential Equations: Physical Applications (**GK**)	2	1				BDA2_W01 BDA2_W03 BDA2_W08 BDA2_U11	45	100	4	4	2	T	E(w)		DN	P(1)	PD
		Total	5	3					120	225	9	9	5						

4.2.2.2 *Physics* block *(min. 5 ECTS points):*

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical course / group of courses – enter P. For the group of courses – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

No.	Course/ group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of course/group of courses	Way[3] of crediting	Course/group of courses			
			lec	cl	lab	pr	sem		ZZU	CNPS	Total	DN[5] classes	BU[1] classes			University -wide[4]	Concerning scientific activities[5]	Practical[6]	Type[7]
1		Statistical Physics for Complex Systems (**GK**) or Quantum Statistical Physics (**GK**)	2		2			BDA2_W01 BDA2_W03 BDA2_U02	60	125	5	5	2	T	Z(w)		DN	P(3)	PD
		Total	2		2				60	125	5	5	2						

4.2.2.3 *Chemistry* block *(min. .... ECTS points):NONE*

Altogether for basic sciences blocks:

Total number of hours					Total number of ZZU hours	Total number of CNPS hours	Total number of ECTS points	Total number of ECTS points for DN classes[5]	Number of ECTS points for BU classes[1]
lec	cl	lab	pr	sem					
7	3	2			180	350	14	14	7

4.2.3 List of main field of study blocks

4.2.3.1 *Optional main field of study* block *(min. 8 ECTS points):*

No.	Course/	Name of course/group of courses (denote group of courses with symbol	Weekly number of hours	Learning effect	Number of	Number of ECTS points	Form[2] of course/group of	Way[3] of crediting	Course/group of courses

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical course / group of courses – enter P. For the group of courses – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

	group of courses code	**GK**)						symbol	hours					courses					
			lec	cl	lab	pr	sem		ZZU	CNPS	Total	DN[5] classes	BU[1] classes			University -wide[4]	Concerning scientific activities[5]	Practical[6]	Type[7]
1		Machine Learning – Introduction (**GK**) or Monographic Lecture 1 (**GK**)	2	2				BDA2_W01 BDA2_U09	60	125	5	5	2	T	Z(w)		DN	P(3)	K
2		Time Series Analysis (**GK**) or Numerical Methods in Physics (**GK**) or Quantum Optics (**GK**) or Stochastic Processes (**GK**)	2	2				BDA2_W01 BDA2_U11	60	75	3	3	2	T	Z(w)		DN	P(2)	K
		Total	4	4					120	200	8	8	4						

Altogether for the main field of study blocks:

Total number of hours					Total number of ZZU hours	Total number of CNPS hours	Total number of ECTS points	Total number of ECTS points for DN classes[5]	Number of ECTS points for BU classes[1]
lec	cl	lab	pr	sem					
4	4				120	200	8	4	4

4.2.4 List of specialization blocks: NONE

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical course / group of courses – enter P. For the group of courses – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

4.3 Training block - concerning principles of training crediting – attachment no. … : NONE

4.4 „Diploma dissertation" block (*if it is foreseen at first level studies)*

Type of diploma dissertation	Licencjat / inżynier / magister / magister inżynier*	
Number of diploma dissertation semesters	**Number of ECTS points**	**Code**
1	**20**	
Character of diploma dissertation		
project, computer program, analysis of data		
Number of BU[1] ECTS points	10	
Number of DN[5] ECTS points	20	

5. Ways of verifying assumed learning outcomes

Type of classes	**Ways of verifying assumed learning outcomes**
lecture	examination, test
class	Short tests, tests, final test

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical course / group of courses – enter P. For the group of courses – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

laboratory	activity, report from laboratory
project	discussion, project defence
seminar	participation in discussion, topic presentation
training	
diploma dissertation	prepared diploma dissertation

6. Range of diploma examination

The range and questions of the diploma examination is determined by the programme commitee for the Big Data Analytics study and it is communicated to the students before the end of the second semester of the studies. At the diploma exam, the student draws three tasks from a prepared list of the examination tasks.

7. Requirements concerning deadlines for crediting courses/groups of courses for all courses in particular blocks: NONE

No.	*Course / group of courses code*	*Name of course / group of courses*	*Crediting by deadline of... (number of semester)*

8. Plan of studies (attachment no. 4)

Approved by faculty student government legislative body:

....

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical course / group of courses – enter P. For the group of courses – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

Date	name and surname, signature of student representative
.....	.....
Date	Dean’s signature

*delete as appropriate

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical course / group of courses – enter P. For the group of courses – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

Zał. nr 4 do ZW 16/2020
Attachment no. 3 to Program of Studies

PLAN OF STUDIES

FACULTY: Faculty of Fundamental Problems of Technology

MAIN FIELD OF STUDY: Big Data Analytics

EDUCATION LEVEL: second-level studies

FORM OF STUDIES: full-time studies

PROFILE: general academic

SPECIALIZATION:

LANGUAGE OF STUDY: english

In effect since 2021/2022

*delete as applicable

Plan of studies structure (optionally)

1) in ECTS point layout

(space for scheme of plan)

2) in hourly layout

(space for scheme of plan)

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical course / group of courses – enter P. For the group of courses – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

1. Set of obligatory and optional courses and groups of courses in semestral arrangement

Semester 1

Obligatory courses / groups of courses Number of ECTS points 13

No.	Course/ group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of course/group of courses	Way[3] of crediting	Course/group of courses			
			lec	cl	lab	pr	sem		ZZU	CNPS	Total	DN[5] classes	BU[1] classes			University-wide[4]	Concerning scientific activities[5]	Practical[6]	Type[7]
1		Programming and Classification (**GK**)	2	1	1			BDA2_W0 BDA2_W0BA2_W11BDA2_U06	60	100	4	4	2	T,Z	Z(w)		DN	P(2)	K
2		Stream Programming (**GK**)	2		2			BDA2_W04 BDA2_W11 BDA2_W12 BDA2_U01BDA2_U08	60	125	5		2	T,Z	Z(w)			P(2)	K
3		Advanced Topics in Algebra (**GK**)	2	1	1			BDA2_W01 BDA2_U11	60	100	4		2	T	Z(w)			P(2)	PD
		Total	6	2	4				180	325	13	4	6						

Optional courses / groups of courses (minimum 210 hours in semester, 17 ECTS points)

No.	Course/ group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of course/group of courses	Way[3] of crediting	Course/group of courses			
			lec	cl	lab	pr	sem		ZZU	CNPS	Total	DN[5] classes	BU[1] classes			University-wide[4]	Concerning scientific activities[5]	Practical[6]	Type[7]

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical course / group of courses – enter P. For the group of courses – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

1	JZL1007 09BK	Foreign Language 1		1				BDA2_U10	15	30	1		1	T,Z	Z	O		P	KO
2	FLP1056 19BK	Humanities	1					BDA2_W13 BDA2_K01 BDA2_K04	15	60	2		1	T	Z	O			KO
3		Elements of Probability Theory (**GK**) or Probability Theory (**GK**)	3	2				BDA2_W01 BDA2_U11	75	125	5	5	3	T	E(w)		DN	P(2)	PD
4		Elements of Differential Equations (**GK**) or Differential Equations: Physical Applications (**GK**)	2	1				BDA2_W01 BDA2_W03 BDA2_W08 BDA2_U11	45	100	4	4	2	T	E(w)		DN	P(1)	PD
5		Statistical Physics for Complex Systems (**GK**) or Quantum Statistical Physics (**GK**)	2		2			BDA2_W01 BDA2_W03 BDA2_U02	60	125	5	5	2	T	Z(w)		DN	P(3)	PD
		Total	8	4	2				210	440	17	14	9						

Altogether in semester

Total number of hours					Total number of ZZU hours	Total number of CNPS hours	Total number of ECTS points	Total number of ECTS points for DN classes[5]	Number of ECTS points for BU classes[1]
lec	cl	lab	pr	sem					
14	6	6			390	765	30	18	15

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical course / group of courses – enter P. For the group of courses – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

Semester 2

Obligatory courses / groups of courses Number of ECTS points 22

No.	Course/ group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of course/group of courses	Way[3] of crediting	Course/group of courses			
			lec	cl	lab	pr	sem		ZZU	CNPS	Total	DN[5] classes	BU[1] classes			University-wide[4]	Concerning scientific activities[5]	Practical[6]	Type[7]
1		Complex Systems (**GK**)	2		2			BDA2_W02 BDA2_W06 BDA2_W07 BDA2_W08 BDA2_U02	60	125	5	5	3	T	E(w)		DN	P(3)	K
2		Big Data Algorithms (**GK**)	2	2	2			BDA2_W02 BDA2_W03 BDA2_W04 BDA_W10 BDA2_U06	90	150	6	6	3	T	Z(w)		DN	P(4)	K
3		Elements of Nonlinear Dynamics (**GK**)	1		1			BDA2_W01 BDA2_W06 BDA2_W08 BDA2_W09 BDA2_U04	30	50	2	2	1	T,Z	Z(w)		DN	P(1)	PD
4		Databases and Information Management (**GK**)	2		2			BDA2_W01 BDA2_W03 BDA2_U01 BDA2_U11	60	100	4		2	T	Z(w)			P(2)	PD
5		Practical Statistics for Data Science (**GK**)	2	1	1			BDA2_W01 BDA2_U11 BDA2_K02	60	100	4		2	T	E(w)			P(2)	PD
6		Diploma Seminar 1					1	BDA2_U01 BDA2_U03 BDA2_U07	15	25	1		1	T,Z	Z			P	K
		Total	9	3	8		1		315	550	22	13	12						

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical course / group of courses – enter P. For the group of courses – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

Optional courses / groups of courses (minimum 90 hours in semester, 8 ECTS points)

No.	Course/ group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of course/group of courses	Way[3] of crediting	Course/group of courses			
			lec	cl	lab	pr	sem		ZZU	CNPS	Total	DN[5] classes	BU[1] classes			University-wide[4]	Concerning scientific activities[5]	Practical[6]	Type[7]
1	EKP105576BK	Social Science	2					BDA2_W13 BDA2_U06 BDA_K03, BDA2_K04	30	90	3		1	T	Z				KO
2		Machine Learning – Introduction (**GK**) or Monographic Lecture 1(**GK**)	2	2				BDA2_W01 BDA2_U09	60	125	5	5	2	T	Z(w)		DN	P(3)	K
		Total	4	2					90	215	8	5	3						

Altogether in semester

Total number of hours					Total number of ZZU hours	Total number of CNPS hours	Total number of ECTS points	Total number of ECTS points for DN classes[5]	Number of ECTS points for BU classes[1]
lec	cl	lab	pr	sem					
13	5	8		1	405	765	30	18	15

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical course / group of courses – enter P. For the group of courses – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

Semester 3

Obligatory courses / groups of courses Number of ECTS points 27

No.	Course/ group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of course/group of courses	Way[3] of crediting	Course/group of courses			
			lec	cl	lab	pr	sem		ZZU	CNPS	Total	DN[5] classes	BU[1] classes			University-wide[4]	Concerning scientific activities[5]	Practical[6]	Type[7]
1		Diploma Seminar 2					2	BDA2_U01 BDA2_U03 BDA2_U07	30	60	2		1	T	Z			P	K
2	JZL100710BK	Foreign Language 2		3				BDA2_U10	45	60	2		1	T,Z	Z	O		P	KO
3		MSc Thesis						BDA2_U01 BDA2_U05 BDA2_U07		500	20	20	10	T	Z		DN	P	K
4		Machine Learning – Applications (**GK**)	2	2				BDA2_W01 BDA2_U09 BDA2_U11	60	75	3	3	2	T	E(w)		DN	P(2)	K
		Total	2	5			2		135	695	27	23	14						

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical course / group of courses – enter P. For the group of courses – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

Optional courses / groups of courses (minimum 60 hours in semester, 3 ECTS points)

No.	Course/ group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of course/group of courses	Way[3] of crediting	Course/group of courses			
			lec	cl	lab	pr	sem		ZZU	CNPS	Total	DN[5] classes	BU[1] classes			University-wide[4]	Concerning scientific activities[5]	Practical[6]	Type[7]
1		Time Series Analysis (**GK**) or Numerical Methods in Physics (**GK**) or Quantum Optics (**GK**) or Stochastic Processes (**GK**)	2	2				BDA2_W0 BDA2_U11	60	75	3	3	2	T	Z(w)		DN	P(2)	K
		Total	2	2					60	75	3	3	2						

Altogether in semester

Total number of hours					Total number of ZZU hours	Total number of CNPS hours	Total number of ECTS points	Total number of ECTS points for DN classes[5]	Number of ECTS points for BU classes[1]
lec	cl	lab	pr	sem					
4	7			2	195	770	30	26	16

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical course / group of courses – enter P. For the group of courses – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

2. Set of examinations in semestral arrangement

Course / group of courses code	Names of courses / groups of courses ending with examination	Semester
	1. Elements of Probability Theory/Probability Theory 2. Elements of Differential Equations/Differential Equations: Physical Applications	1
	1. Practical Statistics for Data Science 2. Complex Systems	2
	1. Machine Learning – Applications	3

3. Numbers of allowable deficit of ECTS points after particular semesters

Semester	Allowable deficit of ECTS points after semester
1	10
2	8
3	-

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical course / group of courses – enter P. For the group of courses – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

Opinion of student government legislative body

.....	.....
Date	Name and surname, signature of student representative
.....	.....
Date	Dean’s signature

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical course / group of courses – enter P. For the group of courses – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

Zał. nr 5 do ZW 16/2020

FACULTY PPT / DEPARTMENT……

SUBJECT CARD

Name of subject in Polish Zaawansowane Zagadnienia Algebry
Name of subject in English Advanced Topics in Algebra
Main field of study (if applicable): Big Data Analysis
Specialization (if applicable): ……..
Profile: academic / ~~practical~~*
Level and form of studies: 2nd level, full-time
Kind of subject: obligatory ~~/ optional / university-wide~~*
Subject code …….
Group of courses YES / ~~NO~~*

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30	15	15		
Number of hours of total student workload (CNPS)	50	25	25		
Form of crediting	~~Examination~~ / crediting with grade*	~~Examination~~ / crediting with grade*	~~Examination~~ / crediting with grade*	~~Examination / crediting with grade*~~	~~Examination / crediting with grade*~~
For group of courses mark (X) final course	X				
Number of ECTS points	2	1	1		
including number of ECTS points for practical classes (P)		1	1		
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)		1	1		

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. 1. Basic knowledge of programing and basic concepts of linear algebra

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SUBJECT OBJECTIVES

1. C1 Basic knowledge of programing and basic concepts of linear algebra

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:
PEU_W01 – possesses deeper knowledge of linear algebra.

PEU_W02 - knows linear algebraic data analysis algorithms.

relating to skills:

PEU_U01 - can analyse big sets of data using linear algebra tools.

PEU_U02 – can study more advanced study literature based on linear algebr.a

PEU_U03 – can use computer tools for solving linear algebra and data analysis problems.

relating to social competences:

PEU_K01 - can find regularities in large collections of data

PROGRAMME CONTENT

Lecture		**Number of hours**
Lec 1	Linear operators and matrices	2
Lec 2	Eigendecomposition of matrix. Characteristic polynomial, eigenvalue, eigenvector, eigendecomposition - 1.	2
Lec 3	Eigendecomposition of matrix. Characteristic polynomial, eigenvalue, eigenvector, eigendecomposition - 2.	2
Lec 4	Jordan blocks decomposition – 1.	2
Lec 5	Jordan blocks decomposition – 2.	2
Lec 6	Jordan blocks decomposition – 3.	2
Lec 7	Multilinear map. Bilinear form, matrix of bilinear form, dot product, orthogonal set, projections – 1.	2
Lec 8	Multilinear map. Bilinear form, matrix of bilinear form, dot product, orthogonal set, projections – 2.	2
Lec 9	Hermitian matrix - 1.	2
Lec 10	Hermitian matrix - 2.	2
Lec 11	Spectral theorem.	2
Lec 12	Covariance	2
Lec 13	Principal component analysis (PCA) -1	2
Lec 14	Principal component analysis (PCA) -2	2
Lec 15	Singular value decomposition (SVD)	2
	Total hours	30

Classes		**Number of hours**
Cl 1	Linear algebra	7
Cl 2	Covariance	2
Cl 3	PCA data analysis	4
Cl 4	SVD	2
..	Total hours	15

Laboratory		**Number of hours**
Lab 1	Matrix operations	7
Lab 2	Programming PCA and SVD	8
	Total hours	15

TEACHING TOOLS USED
N1. Lecture using board and/or computer presentations. N2. Solving exercises with students. N3. Programming tasks.

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_W02	test
F2	PEU_U03	Solutions of programming tasks
P=(F1+F2)/2		

PRIMARY AND SECONDARY LITERATURE
PRIMARY LITERATURE: [1] Gilbert Strang, Linear Algebra and Its Applications, Cengage Learning, 2005 [2] S.J. Leon. Linear Algebra with Applications. New Jersey: Prentice Hall, 1998. [3] S. Ghahramani. Fundamentals of Probability. Pearson Prentice Hall, 2005. **SECONDARY LITERATURE:** [1] A. Mostowski, M. Stark, Algebra liniowa, PWN, Warszawa 1977 (optional, for Polish speaking students).

SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)
Michał Morayne, michal.morayne@pwr.edu.pl

FACULTY PPT / DEPARTMENT……

SUBJECT CARD

Name of subject in Polish Algorytmy Big Data
Name of subject in English Big Data Algorithms
Main field of study (if applicable): Big Data Analytics
Specialization (if applicable): ……..
Profile: academic
Level and form of studies: 2nd level, full-time
Kind of subject: obligatory
Subject code …….
Group of courses YES /

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30	30	30	0	0
Number of hours of total student workload (CNPS)	50	50	50	0	0
Form of crediting	~~Examination~~ / crediting with grade~~*~~	~~Examination /~~ crediting with grade*	~~Examination /~~ crediting with grade*	~~Examination / crediting with grade*~~	~~Examination / crediting with grade*~~
For group of courses mark (X) final course	X				
Number of ECTS points	2	2	2	0	0
including number of ECTS points for practical classes (P)	0	2	2	0	0
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	1	1	1	0	0

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Basic knowledge of mathematical analysis, linear algebra and programming

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SUBJECT OBJECTIVES

C1 Understanding MapReduce concept

C2 Understanding basic tools of Big Data

C3 Understanding fundamentals of Spark programming

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:

PEK_W01 – knows the MapReduce paradigm

PEK_W02 – knows the notion of Page Rank

PEK_W03 – knows the basic models of random graph and social networks

PEK_W04 – knows algorithms for finding frequent items

relating to skills:

PEK_U01 – can apply MapReduce paradigm

PEK_U02 – can use chosen basic tools for Big Data Analysis

PEK_U03 – can use algorithms for finding frequent items

relating to social competences:

PROGRAMME CONTENT

	Lecture	**Number of hours**
L 1	Basic problems of Big Data	4
L 2	MapReduce model	5
L 3	Link Analysis and Google Page Rank	4
L 4	Advanced recommendation systems	5
L 5	Frequent items	2
L 6	Mining social network graphs	6
L 7	Programming with Spark	4
		30

	Classes	**Number of hours**
C 1	Computational complexity	3
C 2	MapReduce model	6
C 3	Random graphs and network models	5
C 4	Tools for recommendation systems	6
C 5	Tools for finding frequent items	6
C 6	Social networks mining	4
		30

Laboratory		Number of hours
Lab 1	Word – count problem	4
Lab 2	MapReduce with Scala	8
Lab 3	Spark – basic applications	6
Lab 4	Spark – big data transformations	12
		30

TEACHING TOOLS USED
N1. Lecture using board and/or computer presentations N2. Solving exercises with students

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	PEK_W01-W04	Exam
F2	PEK_W01-W04	Solutions of exercises
F3	PEK_U01-U02	Solutions of programming tasks
P = (F1 + F2 + F3)/3		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] J. Leskovec, A. Rajaraman, J. D. Ullman, *Mining of Massive Datasets*, 3rd edition, online, 2016

[2] Tyler Akidau, Slava Chernyak, Reuven Lax, *Streaming Systems. The What, Where, When, and How of Large-Scale Data Processing*, O'Reilly Media, July 2018

SECONDARY LITERATURE:

[1] Martin Odersky, Programming in Scala, Artima Press, 2016

[2] Misra, J., Gries, David, *Finding repeated elements*, Science of Computer Programming. 2 (2): 143–152.

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

Prof. dr hab. inż. Marek Klonowski (marek.klonowski@pwr.edu.pl)

Zał. nr 5 do ZW 16/2020

FACULTY W11 / DEPARTMENT K64W11D11

SUBJECT CARD

Name of subject in Polish Układy Złożone
Name of subject in English Complex Systems
Main field of study (if applicable): Big Data Analytics
Specialization (if applicable): ……..
Profile: academic / ~~practical~~*
Level and form of studies: ~~1st/~~ 2nd level, ~~uniform magister studies~~*, full-time / ~~part-time~~*
Kind of subject: obligatory / ~~optional / university-wide~~*
Subject code …….
Group of courses YES / ~~NO~~*

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30		30		
Number of hours of total student workload (CNPS)	75		50		
Form of crediting	~~Examination~~ / crediting with grade*	Examination / crediting with grade*	Examination / crediting with grade*	Examination / crediting with grade*	Examination / crediting with grade*
For group of courses mark (X) final course	X				
Number of ECTS points	3		2		
including number of ECTS points for practical classes (P)	1		2		
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	1		1		

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Skills in computer programming and Monte Carlo simulations
2. Knowledge and skills in statistical physics
3. Knowledge and skills in probability theory

\

SUBJECT OBJECTIVES

C1 Becoming familiar with the concept of complex systems and relations between different approaches used for complex systems

C2 Acquiring knowledge and skills that allow to design, develop, verify and validate models of complex systems

C3 Acquiring skills to work in the team on the interdisciplinary projects and to present the results of the work to the broad interdisciplinary audience.

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:

PEK_W01 – acquiring knowledge related to concept of complex systems and relations between different approaches used for complex systems

PEK_W02 – acquiring knowledge necessary to design, develop, verify and validate models of complex systems

relating to skills:

PEU_U01 – acquiring skills necessary to design, develop, verify and validate models of complex systems

PEU_U02 – acquiring skills to work in the team on the interdisciplinary projects and to present the results of the work to the broad interdisciplinary audience

relating to social competences:

PEK_K01 – developing skills to critically analyze information related to complex systems from different sources

PEK_K02 - developing skills to analyze the degree of complexity of the examined issue, to divide the task into stages and to implement a project

PEK_K03 - developing skills in social interactions: team work, communication with the society and knowledge transfer

PROGRAMME CONTENT

	Lecture	**Number of hours**
Lec 1	Introduction: What Is a Complex System? Real-life empirical examples and models.	2
Lec 2	Power-laws in complex systems: Zipf analysis of data in literature, music, urban planning, economy, etc., self-organized criticality.	2
Lec 3	Cellular automata: Wolfram's one-dimensional system and universality classes, toy models (e.g. Game of life, Langton's ant) and real-life applications (e.g. modeling traffic jams, etc.).	4
Lec 4	Percolation as a simple model of complexity and criticality – Monte Carlo simulations and analytical methods (exact solution on the Bethe lattice, the mean-field and the renormalization group approaches).	4
Lec 5	Introduction to complex networks – empirical data, basic measures and theoretical models.	4
Lec 6	Spreading phenomena on networks – from virus to opinion.	4
Lec 7	Agent-based vs analytical model. Advantages and disadvantages of both approaches.	4
Lec 8	Tips for building and analyzing model, including a role of: averaging (time	2

	vs. ensemble average), initial conditions (ordered vs disordered), updating schemes (synchronous vs. sequential) and the type of approach (quenched vs. annealed).	
Lec 9	Agent-based modeling in biology, social science and economy- theory and applications.	4
	Total hours	

Laboratory		**Number of hours**
Lab 1	Implementation and visualization of a chosen agent-based model such as the Schelling model of spatial segregation in cities, Reynolds boids, etc.	4
Lab 2	Zipf analysis of selected texts	2
Lab 3	Implementation of the selected cellular automata such as the Wolfram's one dimensional system, Game of Life, Langton Ant, etc.	4
Lab 4	Monte Carlo simulations of the percolation model – clusters, paths and criticality	4
Lab 5	Acquiring empirical data from the internet and representing them in a form of a network	2
Lab 6	Calculating basic properties of complex networks, including: degree distribution, average degree, shortest path, average path length, clustering coefficients, degree correlations, robustness	4
Lab 7	Implementing basic contact processes on graphs	4
Lab 8	Designing, developing, verifying and validating models – the team project	6
	Total hours	30

TEACHING TOOLS USED

N1. lecture with multimedia presentation

N2. team project

N3. discussions, student's presentations

N4. written reports

N5. computer laboratory – programming in C++, Python, Julia or other programming language

N6. digital resources

N7. consultations

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	PEK_W01, PEK_W02, PEU_U0, PEU_U02, PEK_K01-PEK_K03	discussions, progress check in computer lab
F2	PEK_W01, PEK_W02, PEU_U0, PEU_U02, PEK_K01-PEK_K03	final presentation and written report related to the team project
P=(F1+F2)/2		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] J. Ladyman, K.Wiesner, What Is a Complex System?, Yale University Press (2020)
[2] S. Thurner, R. Hanel, and P. Klimek, Introduction to the Theory of Complex Systems, Oxford University Press (2018)
[3] A. L. Barabási, Network Science, Cambridge University Press (2016)
[4] M. Newman, Networks: An Introduction, Oxford University Press (2010)
[5] J. H. Miller, S. E. Page, Complex Adaptive Systems, Princeton University Press (2007)

SECONDARY LITERATURE:

[1] T. M. Cover, J. A. Thomas, Elements of Information Theory, John Wiley & Sons, Inc. (2006)
[2] N. R. Moloney, K. Christensen, Complexity and Criticality, Imperial College Press (2005)
[3] I. Białynicki-Birula, I. Białynicka-Birula, Modeling Reality, Oxford University Press (2004)
[4] Stephen Wolfram, A New Kind of Science, Wolfram Media (2002)
[5] P. Bak, How Nature Works, Springer (1996)
[6] Original articles

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

Prof. dr hab. Katarzyna Weron (katarzyna.weron@pwr.edu.pl)

FACULTY WPPT / DEPARTMENT……

SUBJECT CARD

Name of subject in Polish …Bazy danych i zarządzanie informacją…….
Name of subject in English ……Databases and information management …….
Main field of study (if applicable): ……Big Data Analytics…….
Specialization (if applicable): ……..
Profile: academic / ~~practical~~*
Level and form of studies: ~~1st~~/ 2nd level, ~~uniform magister studies*~~, full-time / ~~part-time~~*
Kind of subject: obligatory / ~~optional~~ / ~~university-wide~~*
Subject code …….
Group of courses YES / ~~NO*~~

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30		30		
Number of hours of total student workload (CNPS)	40		60		
Form of crediting	~~Examination~~ / crediting with grade*	~~Examination / crediting with grade*~~	~~Examination /~~ crediting with grade*	~~Examination / crediting with grade*~~	~~Examination / crediting with grade*~~
For group of courses mark (X) final course	X				
Number of ECTS points	2		2		
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)	1		1		

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Knowing the basics of at least one programming language
2. Knowing the basics of Set Theory and set operations

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SUBJECT OBJECTIVES

C1 Showing the value of information and gains of a proper information processing
C2 Showing the practical side of the storing data, data processing and analysis
C3 Pointing out the main differences between relational and non-relational databases

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:
PEK_W01: Knows the syntax of selected SQL and NoSQL dialect

relating to skills:
PEK_U01: Is able to design and implement a database system

relating to social competences:
PEK_K01: Is aware of the importance of data, its processing and preserving its privacy

PROGRAMME CONTENT

	Lecture	**Number of hours**
Lec 1	Introduction to the methods of information processing, the value of information, recall of set theory basics	2
Lec 2	Introduction to SQL and relational data bases	4
Lec 3	Triggers, functions, procedures, creation of databases and database users	2
Lec 4	Designing database systems	2
Lec 5	Security and privacy of the information	2
Lec 6	Functional dependencies and database normalization	4
Lec 7	Database optimization	2
Lec 8	Introduction to non-relational databases	2
Lec 9	Distributed databases	2
Lec 10	Document-oriented databases	4
Lec 11	Graph databases	2
Lec 12	One- and multi-dimensional key-value store databases	2
	Total hours	**30**

	Laboratory	**Number of hours**
Lab 1	Extracting and processing the information using procedural languages	2
Lab 2	Basics of SQL	4
Lab 3	Advanced SQL queries	4
Lab 4	Designing database systems	2
Lab 5	Protecting the integrity and security of the database	4
Lab 6	Database normalization	2
Lab 7	Basics of non-relational databases	2
Lab 8	Document oriented databases	2
Lab 9	Graph databases	2
Lab 10	Designing and implementing database system for large number of users	6

	Total hours	30

TEACHING TOOLS USED

N1. Lecture

N2. Individual problem solving

N3. Group projects

N4. Conversation, posing practical problems by the students and joined solving

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		Short quizzes
F2		Laboratory individual assignments
F3		Group project
P=30%F1+30%F2+40%F3		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] J.D. Ullman, J. Widom A First Course in Database Systems.
[2] J.D. Ullman, Principles of Database Systems.
[3] G. Harrison, Next Generation Databases: NoSQL and Big Data.
[4] E. Redmont, Seven Databases in Seven Weeks: A Guide to Modern Databases and the NoSQL Movement
[5] A. Petrov, Database Internals: A deep-dive into how distributed data systems work
[6] M.J. Hernandez Database Design For Mere Mortals A Hand-on Guide to Relational

SECONDARY LITERATURE:

[1] H. Garcia-Molina, J.D. Ullman, J. Widom, Database Systems The Complete Book
[2] D. Sullivan, NoSQL for Mere Mortals.
[3] T. Hills, NoSQL and SQL Data Modeling: Bringing Together Data, Semantics, and Software.
[4] S Chellappan, D. Ganesan, MongoDB Security.
[5] C. Dwork, A. Roth, The Algorithmic Foundations of Differential Privacy.

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

Piotr Syga

Zał. nr 5 do ZW 16/2020

FACULTY …W11… / DEPARTMENT…-…

SUBJECT CARD

Name of subject in Polish … Równania różniczkowe: zastosowania fizyczne ….
Name of subject in English … Differential Equations: Physical Applications ….
Main field of study (if applicable): … Big Data Analytics …….
Specialization (if applicable): ……-……..
Profile: academic / ~~practical~~*
Level and form of studies: ~~1st~~/ 2nd level, ~~uniform magister studies~~*, full-time / ~~part-time~~*
Kind of subject: ~~obligatory~~ / optional / ~~university-wide~~*
Subject code …….
Group of courses YES / ~~NO~~*

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30	15			
Number of hours of total student workload (CNPS)	60	40			
Form of crediting	Examination / ~~crediting with grade~~*	~~Examination~~ / crediting with grade*	Examination / crediting with grade*	Examination / crediting with grade*	Examination / crediting with grade*
For group of courses mark (X) final course	X				
Number of ECTS points	3	1			
including number of ECTS points for practical classes (P)	0	1			
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	1	1			

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

Knowledge of mathematical analysis and general physics on the level of first-degree studies in technical sciences

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SUBJECT OBJECTIVES

C1 Extending knowledge on the methods of solving ordinary differential equations (ODEs) and partial differential equations (PDEs) of basic types
C2 Become familiar with elementary concepts in analyzing stability of dynamical systems
C3 Gaining basic knowledge on the oscillatory and wave solutions of the generic types of nonlinear differential equations and on their applications to complex systems

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:

PEU_W01 – becoming aware of methods of modeling and analysis of complex dynamical systems

PEU_W02 – becoming aware of methods of reducing phase-space dimensionality

PEU_W03 – becoming aware of specific applications of the differential equations to modeling and studying complex systems

PEU_W04 – taking knowledge on the economic-growth modeling

relating to skills:

PEU_U01 – developing skills in terms of modeling dynamical systems including the application and modification of existing models

PEU_U02 – developing skills in refereeing results of own student calculations

relating to social competences:

PEU_K01 – developing skills in terms of the assessment of the degree of complexity of dynamical problems

PROGRAMME CONTENT

	Lecture	**Number of hours**
Lec. 1	Basic types of ODEs: an overview (separable in variables, exact, homogeneous, linear, and Bernoulli ODEs). Green functions and Laplace transforms.	4
Lec. 2	Systems of linear ODEs with constant coefficients; fundamental matrices, applications	2
Lec. 3	Lyapunov-stability of the systems of the first-order ODEs. Critical points of the autonomous systems	2
Lec. 4	Second-order ODEs reducible to systems of first-order ODEs, elements of the variational calculus and reduction of the Lagrange equations to the Hamilton equations. Phase-portrait analysis	4
Lec. 5	Nonlinear-oscillations example: Duffing oscillator (stability points and bifurcations, oscillator without driving – exact solution, case of weak periodic driving – perturbative solution, nonlinear resonance, phase portraits, transition to chaos)	2
Lec. 6	Lotka-Volterra competitive models (Bernoulli equation as a prototype model of population dynamics, two-species predator-prey model and its analytical trajectories, exact periodic solutions in terms of elliptic functions, stability points, applications to kinetics of chemical processes and epidemy modeling, May extension of the predator-prey model)	3
Lec. 7	Solow's differential model of the macroeconomic growth	2
Lec. 8	Basic types of linear PDEs in 1D, 2D and basic specific solutions: an overview (wave equation, Fick's laws and diffusion equation, Schrodinger equation, Poisson equation). Methods of variable separation, potentials, and Green functions. Euler-Lotka model of the population dynamics.	4

Lec. 9	A solitary-wave equation; nonlinear Schrodinger equation (conservation laws, soliton solutions via “direct” Hirota method, bright-soliton collisions; solution-asymptotics analysis, application; optical fibers, defocusing nonlinear Schrodinger equation and dark solitons)	4
Lec. 10	Stationary and time-dependent Ginzburg-Landau equation (the genesis; phase transitions of the first kind, phase stability and bifurcations, domain-wall solutions, field-driven domain-wall motion, propagating-phase-front solutions)	3
	Total hours	30

Classes		**Number of hours**
Cl. 1	Solving simple differential problems	3
Cl. 2	Solving systems of linear ODEs	2
Cl. 3	Investigating stability and finding first integrals of systems of ODEs	2
Cl. 4	Solving second-order ODEs and/or analyzing the solution stability.	3
Cl. 5	Solving linear PDEs using the potential and Green-function methods	3
Cl. 6	Test	2
	Total hours	15

TEACHING TOOLS USED

N1. Lecture using board and/or computer presentations
N2. Solving exercises with students
N3. Consultations

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	PEK_W01-W04	examination
F2	PEK_U01,U02 PEK_K01	crediting with grade
P=0.25 F1+0.75 F2		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] WA Adkins, MG Davidson, Ordinary Differential Equations, Springer 2012
[2] N Hritonenko, Y Yatsenko, Mathematical Modeling in Economics, Ecology and the Environment, Springer 2013
[3] DG Duffy, Green Functions with Applications, CRC Press 2016

SECONDARY LITERATURE:

[1] JR Taylor, Classical Mechanics, Univ. Science Books 2005
[2] JMT Thompson, HB Steward, Nonlinear dynamics and chaos, Willey 2002
[3] R Hirota, Bilinearization of soliton equations, Journal of the Physical Society of Japan 51 (1982) 323

[4] J Lajzerowicz, JJ Niez, Phase transition in a domain wall, J. Physique Lett. 40 (1979) 165
[5] K Nozaki, N Bekki, Exact solutions of the generalized Ginzburg-Landau equation, Journal of the Physical Society of Japan 53 (1984) 1581

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dr hab. inż. Andrzej Janutka, andrzej.janutka@pwr.edu.pl

Zał. nr 5 do ZW 16/2020

FACULTY W11 / DEPARTMENT K64W11D11

SUBJECT CARD

Name of subject in Polish Seminarium dyplomowe 2
Name of subject in English Diploma Seminar 2
Main field of study (if applicable): Big Data Analytics
Specialization (if applicable): ……..
Profile: academic / ~~practical~~*
Level and form of studies: ~~1st/~~ 2nd level, ~~uniform magister studies~~*, full-time / ~~part-time~~*
Kind of subject: obligatory / ~~optional / university-wide~~*
Subject code …….
Group of courses ~~YES~~ / NO*

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)					30
Number of hours of total student workload (CNPS)					60
Form of crediting	Examination / crediting with grade*	Examination / crediting with grade*	Examination / crediting with grade*	Examination / crediting with grade*	Examination / crediting with grade*
For group of courses mark (X) final course					
Number of ECTS points					2
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)					1

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES SPOŁECZNYCH

1. Basic skills in oral presentation of the scientific results.

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SUBJECT OBJECTIVES

C1 Developing skills in oral presentation of the scientific results and in the scientific discussion

C2 Gaining a broad general knowledge in current subjects related to Big Data

C3 Preparation to the diploma exam

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:
PEK_W01 – Gaining a broad general knowledge in current subjects related to Big Data

relating to skills:
PEU_U01 – Developing skills in oral presentation of the scientific results and in the scientific discussion

relating to social competences:
PEU_K01 – Developing skills to critically analyze information related to the Big Data from different sources

PROGRAMME CONTENT

	Seminae	**Number of hours**
sem1	Introduction: Rules and Tips for the master presentation	2
sem 2-15	Students' presentations on subjects related to their master's theses.	28
	Total hours	

TEACHING TOOLS USED

N1. Oral, enriched with a visual, presentation

N2. discussions

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	PEK_U01 PEK_K01	crediting with grade the presentation
F2	PEK_W01 PEK_U01 PEK_K01	crediting with grade the activity during the scientific discussions
P=(F1+F2)/2		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] Original articles
[2] Jean-Philippe Dionne, Presentation Skills for Scientists and Engineers, Springer Nature Switzerland (2021)

[3] M. Carter, Designing Science Presentations: A Visual Guide to Figures, Papers, Slides, Posters, and More, Academic Press (2021)
[4] E. Zanders, L. MacLeod, Presentation Skills for Scientists. A Practical Guide. Second Edition, Cambridge University Press (2018)
[5] M. Alley, The Craft of Scientific Presentations: Critical Steps to Succeed and Critical Errors to Avoid, Springer-Verlag New York (2013)

SECONDARY LITERATURE:

[1] C. Gallo, Talk Like TED, Palgrave MacMillan (2014)
[2] S. Berkun, Confessions of a Public Speaker, O'Reilly Media (2009)
[3] N. Duarte, Slide:ology, The Art And Science Of Creating Great Presentations, O'Reilly Media (2008)
[4] G. Reynolds, Presentation Zen: Simple Ideas on Presentation Design and Delivery, New Riders (2008)

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

Prof. dr hab. Katarzyna Weron (katarzyna.weron@pwr.edu.pl)

Zał. nr 5 do ZW 16/2020

FACULTY PPT / DEPARTMENT

SUBJECT CARD

Name of subject in Polish Seminarium dyplomowe 1
Name of subject in English Diploma Seminar 1
Main field of study (if applicable): Big Data Analytics
Specialization (if applicable):
Profile: academic
Level and form of studies: 2nd level, full-time
Kind of subject: obligatory
Subject code …….
Group of courses NO

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)					15
Number of hours of total student workload (CNPS)					25
Form of crediting	Examination / crediting with grade*	Examination / crediting with grade*	Examination / crediting with grade*	Examination / crediting with grade*	~~Examination~~ / crediting with grade*
For group of courses mark (X) final course					
Number of ECTS points					1
including number of ECTS points for practical classes (P)					1
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)					1

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

Basic skills in English language.

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SUBJECT OBJECTIVES

C1 Developing basic skills in oral presentation of the scientific results

C2 Developing basic skills in the scientific discussion

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:

PEK_W01 – Gaining a broad general knowledge concerning conference presentations

relating to skills:

PEU_U01 – Developing basic skills in oral presentation of the scientific results and in the scientific discussion

relating to social competences:
PEU_K01 – Developing basic skills to critically analyze information from different sources

Seminar		Number of hours
Semin 1	Presentation of scientific results: tips and tricks of the trade	2
Semin 2	Students' presentations on subjects loosely related to science	13
	Total hours	15

TEACHING TOOLS USED

N1. Oral, enriched with a visual, presentation

N2. Discussions

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	PEK_U01 PEK_K01	crediting with grade the presentation
F2	PEK_W01 PEK_U01 PEK_K01	crediting with grade the activity during the scientific discussions
P=(F1+F2)/2		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] Original articles
[2] Jean-Philippe Dionne, Presentation Skills for Scientists and Engineers, Springer Nature Switzerland (2021)
[3] E. Zanders, L. MacLeod, Presentation Skills for Scientists. A Practical Guide. Second Edition, Cambridge University Press (2018)
[4] M. Alley, The Craft of Scientific Presentations: Critical Steps to Succeed and Critical Errors to Avoid, Springer-Verlag New York (2013)

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

prof. dr hab. Antoni C. Mituś antoni.mitus@pwr.edu.pl

FACULTY PPT / DEPARTMENT……

SUBJECT CARD

Name of subject in Polish Elementy Rachunku Prawdopodobieństwa
Name of subject in English Elements of Probability Theory
Main field of study (if applicable): Big Data Analytics
Specialization (if applicable): ……..
Profile: academic
Level and form of studies: 2nd level, full-time
Kind of subject: ~~obligatory /~~ optional ~~/ university-wide*~~
Subject code …….
Group of courses YES / ~~NO*~~

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	45	30	0	0	0
Number of hours of total student workload (CNPS)	80	45	0	0	0
Form of crediting	Examination / ~~crediting with grade*~~	~~Examination /~~ crediting with grade*	~~Examination / crediting with grade*~~	~~Examination / crediting with grade*~~	~~Examination / crediting with grade*~~
For group of courses mark (X) final course	X				
Number of ECTS points	3	2	0	0	0
including number of ECTS points for practical classes (P)	0	2	0	0	0
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	2	1	0	0	0

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Basic knowledge of mathematical analysis

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SUBJECT OBJECTIVES

C1 Understanding the concept of probabilistic space and random variables

C2 Understanding the fundamentals of Bayesian reasoning

C3 Understanding the concept of Markov chains and probabilistic counters

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:

PEK_W01 – knows the notion of independence

PEK_W02 – knows the notion of Bayesian network

PEK_W03 – knows the notion of entropy

PEK_W04 – knows the concept of Markov chain

PEK_W05 – knows the notion of probabilistic counter

relating to skills:
PEK_U01 – can build a simple Bayesian network

PEK_U02 – can model and investigate Markov

relating to social competences:

PROGRAMME CONTENT

	Lecture	**Number of hours**
L 1	Notion of probabilistic space	4
L 2	Events, independence, Bayes' rules	6
L 3	Random variables, expectation, variance, higher moments	6
L 4	Bayes theorem and Bayesian networks [4h]	5
L 5	Basic probabilistic counters	5
L 6	HyperLogLog and other counters used in Big Data	4
L 7	Entropy of discrete random variable	2
L 8	Basic continuous distribution and basic limit theorems	5
L 9	Markov chains	6
L 10	Hidden Markov chains	2
	Total hours	45

	Classes	**Number of hours**
C 1	Elementary discreet probabilistic spaces	6
C 2	Independence, Bayes' rule	4
C 3	Random variables and moments	4
C 4	Bayesian networks	4
C 5	Markov chains	6
C 6	Sums of random variables	6
	Total hours	**30**

TEACHING TOOLS USED
N1. Lecture using board and/or computer presentations N2. Solving exercises with students

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	PEK_W01-W05	Exam
F2	PEK_U01-U02	Solutions of exercises
P = (F1 + F2)/2		

PRIMARY AND SECONDARY LITERATURE
PRIMARY LITERATURE: [1] David F. Anderson, Timo Seppäläinen, Benedek Valkó, Introduction to Probability, Cambridge University Press, 2017 [2] Sheldon Ross, A First Course in Probability, Pearson Education, 2019 **SECONDARY LITERATURE:** [1] Billingsley, P. (1995), Probability and measure, Wiley Series in Probability and Mathematical Statistics. John Wiley & Sons Inc., New York, third edition [1] Timo Koski, John Noble, Bayesian Networks: An Introduction, Wiley, 2009, Wiley Series in Probability and Statistics
SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)
Prof. dr hab. inż. Marek Klonowski (marek.klonowski@pwr.edu.pl)

Zał. nr 5 do ZW 16/2020

FACULTY PPT / DEPARTMENT

SUBJECT CARD

Name of subject in Polish Elementy teorii równań różniczkowych
Name of subject in English Elements of Differential Equations
Main field of study (if applicable): Big Data Analytics
Specialization (if applicable):
Profile: academic
Level and form of studies: 2nd level, full-time
Kind of subject: optional
Subject code
Group of courses YES

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30	15			
Number of hours of total student workload (CNPS)	60	40			
Form of crediting	Examination / ~~crediting with grade~~*	~~Examination~~ / crediting with grade*	~~Examination / crediting with grade~~*	~~Examination / crediting with grade~~*	~~Examination / crediting with grade~~*
For group of courses mark (X) final course	X				
Number of ECTS points	3	1			
including number of ECTS points for practical classes (P)		1			
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	1	1			

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Mathematical analysis (I level studies)

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SUBJECT OBJECTIVES

C1 Becoming familiar with basic methods of solving chosen ordinary and partial differential equations

C2 Practical mastering basic methods of solving chosen ordinary and partial differential equations

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:

PEU_W01 - is familiar with chosen analytical methods of solving first and second order ordinary differential equations

PEU_W02 - is familiar with chosen analytical methods of solving partial differential

equations (first order and mathematical physics)

relating to skills:
PEU_U01 – can solve typical first and second-order ordinary differential equations

PEU_U02 – can use the method of separation of variables for solving partial differential equations

relating to social competences:
PEU_K01 - understands the need for improving one's skills all the time; understands the need for learning by one's own as well as in the group

PROGRAMME CONTENT

Lecture		**Number of hours**
Lec 1	Ordinary differential equations (ODE): examples and basic notions	1
Lec 2	I order ODEs: separable-variable, homogeneous, linear	2
Lec 3	I order ODEs: Bernouli, exact and inexact (integrating factor)	2
Lec 4	II order ODEs: examples and basic notions	1
Lec 5	II order ODEs: linear with constant coefficients, inhomogeneous (method of variation of constants, metod of undefined coefficients)	4
Lec 6	Systems of I order linear ODEs: homogeneous, with constant coefficients	2
Lec 7	Systems of inhomogeneous I order ODEs: method of variation of constants	2
Lec 8	Stability of fixed points for autonomous systems	2
Lec 9	Laplace transform metod	2
Lec 10	Solving ODE using symbolic algebra systems (*Maple, Mathematica*)	2
Lec 11	Partial differential equations (PDE): examples and basic notions	1
Lec 12	I order PDE: method of characteristics	2
Lec 13	Diffusion-type problems: separation of variables, Fourier transform method	3
Lec 14	Hyperbolic-type problems: one-dimensional wave equation, d'Alembert solution, separation of variables	2
Lec 15	Elliptic-type problems: separation of variables	2
	Total hours	30

Classes		**Number of hours**
Cl 1	Solving I order ODEs	2
Cl 2	Solving II order ODEs	2
Cl 3	Solving systems of I order linear ODEs	2
Cl 4	Solving ODEs using symbolic algebra systems (*Maple*, *Mathematica*)	2

Cl 5	Solving I order PDEs	2
Cl 6	II order PDEs: separation of variables	4
Cl 7	Final test	1
	Total hours	15

TEACHING TOOLS USED

N1. Lecture using board and/or computer presentations

N2. Solving exercises with students

N3. Consultations

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_U01, PEU_U02	oral tests, discussions, progress check (classes - solving problems)
F2	PEU_W01, PEU_W02, PEU_U01, PEU_U02, PEU_K01	exam
P= (F1+2 F2)/3		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] W.A. Adkins, M.G. Davidson, *Ordinary Differential Equations,* Springer 2012

[2] N. Hritonenko, Y. Yatsenko, *Mathematical Modeling in Economics, Ecology and the Environment*, Springer 2013

[3] K.F. Riley, M.P. Hobson, S.J. Bence, *Mathematical Methods for Physics and Engineering*, Cambridge, 2006

[4] S.F. Farlow, *Partial Differential Equations for Scientists and Engineers* (Wiley, 1982)

LITERATURA UZUPEŁNIAJĄCA:

[1] M. Gewert, Z. Skoczylas, *Równania różniczkowe zwyczajne*, GiS, Wrocław 2016 (in polish)

[2] F. Leja, *Rachunek różniczkowy i całkowy (ze wstępem do równań różniczkowych),* PWN, Warszawa, 2021 (in polish)

[3] N.M Matwiejew, Metody całkowania równań różniczkowych zwyczajnych, PWN, 1972 (in polish)

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

prof. dr hab. Antoni C. Mituś antoni.mitus@pwr.edu.pl

FACULTY W11 / DEPARTMENT……

SUBJECT CARD

Name of subject in Polish Kwantowa Fizyka Statystyczna
Name of subject in English: Quantum Statistical Physics
Main field of study (if applicable): Big Data Analytics
Specialization (if applicable): ……..
Profile: academic / ~~practical*~~
Level and form of studies: ~~1st/~~ 2nd level, ~~uniform magister studies~~*, full-time / ~~part-time*~~
Kind of subject: ~~obligatory~~ / optional / ~~university-wide*~~
Subject code: ….....
Group of courses YES /~~ NO~~*

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30		30		
Number of hours of total student workload (CNPS)	50		75		
Form of crediting	~~Examination /~~ crediting with grade*	~~Examination / crediting with grade*~~	~~Examination /~~ crediting with grade*	~~Examination / crediting with grade*~~	~~Examination / crediting with grade*~~
For group of courses mark (X) final course	X				
Number of ECTS points	2		3		
including number of ECTS points for practical classes (P)			3		
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	1		1		

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Quantum Mechanics
2. Basic statistical physics

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SUBJECT OBJECTIVES

C1. Student learns basic concepts concerning equilibrium properties of quantum many-body systems, including main tight-binging models
C2. Student learns the basic numerical methods used for quantum many-body systems.

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:

PEU_W01: Student knows the basic concepts of the equilibrium statistical physics
PEU_W02: Student knows the basic microscopic models used in modern statistical physics and solid state physics

relating to skills:

PEU_U01: Student is able to carry out simple analytical calculations concerning quantum many-body systems
PEU_U02: Student is able to carry out basic numerical calculations concerning quantum many-body systems under equilibrium

relating to social competences
PEU_K01: Student is able to critically evaluate her/his knowledge and skills of solving original scientific problems
PEU_K02: Student understands the importance of following recent scientific literature

PROGRAMME CONTENT

Lecture		**Number of hours**
Lec 1	Introduction: Ergodicity of classical systems, Liouville's theorem, Gibbs ensembles for classical and quantum systems.	4
Lec 2	Eigenstate Thermalization Hypothesis	2
Lec 3	Fock space, creation and anihiliation operators	4
Lec 4	Fermi-Dirac and Bose-Einstein distribution functions derived from commutation relations for creation and anihiliation operators	2
Lec 5	Spin operators and their representation in terms of fermion creation and anihiliation operators, Holstein-Primakoff transformation,	4
Lec 6	Selected tight-binging models (Ising, Heisenberg, Hubbard)	2
Lec 7	Spontaneous symmetry breaking within mean-field approaches	2
Lec 8	Magnons in the Heisenberg model, a general concept of quasiparticles	2
Lec 9	Linear response theory and retarded thermodynamic Green's functions	2
Lec 10	Basic properties of thermodynamic Green's functions – spectral function, local density of states	2
Lec 11	Superconductivity and Superfluidity	4
….		
	Total hours	30

Laboratory		**Number of hours**
Lab 1	Building Hamiltonian matrix of the Heisenberg chain	6
Lab 2	Building Hamiltonian matrix of the Hubbard chain	6
Lab 3	Exact diagonalization of the (perturbed) Heisenberg chain and the level statistics	6

Lab 4	Lanczos algorithm	6
Lab 5	Calculating selected susceptibilities for the Heisenberg and Hubbard models	6
…		
	Total hours	30

TEACHING TOOLS USED
N1. Blackboard lecture N2. Computer lab

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_W02 PEU_U01 PEU_K01 PEU_K02	crediting with grade
F2	PEU_W01 PEU_W02 PEU_U01 PEU_K01 PEU_K02	crediting with grade
P=(F1+F2)/2		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] Kerson Huang, *Introduction to Statistical Physics*
[2] L. Lanadu, E. Lifshitz, *Statistical Physics (part 1 & 2)*
[3] G.D. Mahan, *Many-Particle Physics*

SECONDARY LITERATURE:

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

Marcin Mierzejewski, marcin.mierzejewski@pwr.edu.pl

Zał. nr 5 do ZW 16/2020

FACULTY OF FUNDAMENTAL PROBLEMS OF TECHNOLOGY/ DEPARTMENT OF THEORETICAL PHYSICS

SUBJECT CARD

Name of subject in Polish … Nauczanie maszynowe – Wprowadzenie ….
Name of subject in English … Machine Learning – Introduction ….
Main field of study (if applicable): … Big Data Analytics ….
Specialization (if applicable): ……..
Profile: academic / ~~practical~~*
Level and form of studies: ~~1st~~/ 2nd level, ~~uniform magister studies~~*, full-time / ~~part-time~~*
Kind of subject: ~~obligatory~~ / optional / ~~university-wide~~*
Subject code …….
Group of courses YES / ~~NO~~*

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30	30			
Number of hours of total student workload (CNPS)	30	95			
Form of crediting	~~Examination~~ / crediting with grade*	~~Examination~~ / crediting with grade*	~~Examination / crediting with grade*~~	~~Examination / crediting with grade*~~	~~Examination / crediting with grade*~~
For group of courses mark (X) final course	X				
Number of ECTS points	2	3			
including number of ECTS points for practical classes (P)		3			
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	1	1			

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Calculus
2. Linear algebra, mathematical analysis: vectors and matrices, derivatives, integrals
3. Probability and statistics
4. Programming skills in Python

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SUBJECT OBJECTIVES

C1 Develop an appreciation for what is involved in learning models from data
C2 Understand a wide variety of learning algorithms
C3 Understand how to evaluate models generated from data
C4 Apply the algorithms to real problems, optimize the models learned and report on the expected accuracy

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:
PEU_W01 Understanding of the concept of learning in computer and science
PEU_W02 Understanding of the supervised, unsupervised, and reinforcement learning
PEU_W03 Understanding of the training, testing, and validation phases of learning algorithms

relating to skills:
PEU_U01 Design and evaluate machine learning algorithms
PEU_U02 Experiment with machine learning models for simulation and analysis
PEU_U03 Evaluate and interpret the outcome of learning on given problems and compare the outcome for different algorithms

relating to social competences:
PEU_K01 Understanding of the need to undertake lifelong learning
PEU_K02 The ability to work professionally as a member of multi-disciplinary teams

PROGRAMME CONTENT

Lecture		**Number of hours**
Lec 1	Introduction to Machine Learning	2
Lec 2	Artificial neurons, classification and regression	8
Lec 3	Support Vector Machines	6
Lec 4	Kernelization	4
Lec 5	Ridge Regression	2
Lec 6	Clustering Methods	2
Lec 7	Dimensionality reduction	4
Lec 8	Deep Neural Networks	2
	Total hours	30

Classes		**Number of hours**
Cl 1	Computing environment for machine learning	2
Cl 2	Artificial neurons, classification and regression	6
Cl 3	Support Vector Machines	6
Cl 4	Kernelization	4
Cl 5	Ridge Regression	2
Cl 6	Clustering Methods	2
Cl 7	Dimensionality reduction	4
Cl 8	Deep Neural Networks	2

Cl 9	Final test	2
	Total hours	30

TEACHING TOOLS USED

N1. Computer presentation, projector, screen, presenter
N2. Jupyter computational environment
N3. Editors and compilers

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_W02, PEU_W03	Final test
F2	PEU_U01, PEU_U02, PEU_U03	Graded assignments, projects, final test
P = (F1+F2)/2		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] T. Mitchell, *"Machine Learning"*, McGraw Hill (1997)
[2] S. Rogers, M. Girolami, *"A first course in Machine Learning"*, CRC Press (2011)
[3] Y. Abu-Mostafa, M. Magdon-Ismail, H-T Lin, "Learning from Data", AMLBook (2012)
[4] Charu C. Aggarwal "*Neural Networks and Deep Learning. A Textbook"*, Springer (2018) (https://link.springer.com/book/10.1007/978-3-319-94463-0)

SECONDARY LITERATURE:

[1] I. Goodfellow, Y. Bengio, A. Courville, *"Deep Learning"*, MIT Press (2016) (https://www.deeplearningbook.org/)
[2] Aurélien Géron, "Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems", O'Reilly (2019)
[3] François Chollet, *"Deep Learning with Python"*, Manning Publications (2017)

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

Maciej Maśka, maciej.maska@pwr.edu.pl

Zał. nr 5 do ZW 16/2020

FACULTY of Fundamental Problems of Technology

SUBJECT CARD

Name of subject in Polish Machine Learning – applications
Name of subject in English Machine Learning – applications
Main field of study (if applicable): Big Data Analytics
Specialization (if applicable): ……..
Profile: academic / ~~praetical*~~
Level and form of studies: ~~1st~~/ 2nd level, ~~uniform magister studies*~~, full-time / ~~part-time*~~
Kind of subject: obligatory ~~/ optional / university-wide~~*
Subject code …….
Group of courses YES / ~~NO~~*

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30	30			
Number of hours of total student workload (CNPS)	30	45			
Form of crediting	Examination / ~~crediting with grade*~~	~~Examination~~ / crediting with grade*	~~Examination / crediting with grade*~~	~~Examination / crediting with grade*~~	~~Examination / crediting with grade*~~
For group of courses mark (X) final course	x				
Number of ECTS points	**1**	**2**			
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)	1	1			

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Knowledge of basic algebra and mathematical analysis (calculus).
2. Knowledge of basic mathematical statistics.
3. Knowledge of at least one modern programming language: Python, c++
4. familiarity with modern computer architecture: understanding of concepts such as RAM, CPU, GPU.
5. Willingness to gain knowledge in a strongly interdisciplinary (thus difficult to master) area of artificial intelligence.

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SUBJECT OBJECTIVES

1. Familiarize the student with traditional machine learning techniques, supervised and unsupervised.
2. Introduce currently developed deep learning algorithms.
3. Indicate the enormous potential of applications of these methods in science and technology.

SUBJECT EDUCATIONAL EFFECTS

Relating to knowledge:

- PEU_W01 Has a cross-sectional knowledge of contemporary machine learning techniques, especially deep learning.
- PEU_W02 Is able to well define a data analysis problem (e.g. regression/classification or clustering/segmentation) and to select an appropriate method/model.

Relating to skills:

- PEU_U01 Has basic knowledge of applied machine learning and deep learning libraries/frameworks.

Relating to social competences:

- PEU_K01 Is aware of the potential applications of machine learning techniques in science and technology.

PROGRAMME CONTENT

	Lecture	**Number of hours**
Lec 1	Fundamentals of machine learning: definition, types of learning, bias and variance, application areas, and limitations.	2
Lec 2	Classifiers, traditional methods: SVM, decision trees, bagging and boosting techniques.	2
Lec 3	Dimensionality reduction and clustering.	2
Lec 4	Deep neural networks: backpropagation, activation functions, regularization.	2
Lec 5	Convolutional neural networks: definition, contemporary architectures, applications.	4
Lec 6	Fundamentals of image processing (classical methods), feature vectors.	2
Lec 7	Image recognition using deep networks, detection, segmentation, data augmentation.	2
Lec 8	Recurrent neural networks and their applications, attention mechanism. Natural language processing	4
Lec 9	Encoder-decoder and generative models. Reality gap and domain adaptation techniques.	3
Lec 10	Examples of advanced architectures: Siamese networks, graph networks.	2
Lec 11	Minipresentations	5
	Total hours	**30**

	Classes	**Number of hours**
Cl 1	Popular databases in machine learning (ML). Software repositories. Frameworks: scikit, Pytorch. Building a simple classifier based on traditional methods.	6
Cl 2	Comparison of simple neural network architectures: perceptron, deep networks, convolutional networks.	6
Cl 3	Signal processing, feature vectors, construction of an ECG or EEG signal analyzer.	6
Cl 4	Familiarization with generative models. Model implementation for style transfer between images.	6

Cl 5	Selected applications of ML models: object detection, face recognition, speech recognition/analysis, or others.	6
	Total hours	**30**

TEACHING TOOLS USED

N1. Lecture using multimedia tools

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	colloquium
F2	PEU_W02	mini-presentation for the developed topic
F3	PEU_U01	reports for 3 selected projects
P=(F1+F2+2*F3)/4		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] Ian Goodfellow et al., Deep learning, Cambridge: MIT Press, Cambridge 2016.
[2] Christopher M. Bishop, Pattern recognition and machine learning, Springer, 2006.
[3] Charu C. Aggarwal, Neural networks and deep learning, Springer, 2018.
[4] Michael Nielsen, Neural Networks and Deep Learning, available online only: http://neuralnetworksanddeeplearning.com

SECONDARY LITERATURE:

[1] https://scikit-learn.org/stable/user_guide.html (online)
[2] https://stanford.edu/~shervine/teaching/ (online resource)

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

Jarosław Pawłowski, jaroslaw.pawlowski@pwr.edu.pl

Zał. nr 5 do ZW 16/2020

FACULTY OF FUNDAMENTAL PROBLEMS OF TECHNOLOGY /DEPARTMENT OF THEORETICAL PHYSICS

SUBJECT CARD

Name of subject in Polish Elementy dynamiki nieliniowej
Name of subject in English Elements of Nonlinear Dynamics
Main field of study (if applicable): Big Data Analytics
Specialization (if applicable):
Profile: academic
Level and form of studies: 2nd level, full-time
Kind of subject: obligatory
Subject code
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		25		
Form of crediting	~~Examination~~ / crediting with grade*	~~Examination / crediting with grade~~*	~~Examination~~ / crediting with grade*	~~Examination / crediting with grade~~*	~~Examination / crediting with grade~~*
For group of courses mark (X) final course	X				
Number of ECTS points	1		1		
including number of ECTS points for practical classes (P)			1		
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)			1		

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

Knowledge of mathematical analysis and general physics on the level of first-degree studies in technical sciences

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SUBJECT OBJECTIVES

C1. Becoming familiar with basic concepts of nonlinear dynamics: flows, fixed points, linear stability analysis, phase portraits, limit cycles, bifurcations, chaos, strange attractors, Lyapunov exponent.

C2. Becoming familiar with important equations leading to nonlinear behavior

C3. Becoming familiar with modeling of nonlinear phenomena with Computer Algebra System *Maple.*

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:

PEU_W01 - to acquire knowledge related to basic concepts of nonlinear dynamics

PEU_W02 - to acquire knowledge related to construction of models of nonlinear dynamics

PEU_W03 - become familiar with important models leading to nonlinear dynamical behavior

relating to skills:

PEU_U01 - developing basic skills to model nonlinear dynamics phenomena with *Maple*

PEU_U02 - developing skills to use existing *Maple* worksheets to analyze nonlinear effects in physical, chemical and biological systems

relating to social competences:

PEU_K01 - developing skills to critically analyze information related to nonlinear dynamics

PROGRAMME CONTENT

	Lecture	**Number of hours**
Lec 1-2	Nonlinear systems – an overview (models and diagnostics tools). Phase plane portraits: autonomous system of first-order ODE's, examples of fixed points	3
Lec 3	Phase plane analysis: Simple fixe points and their classification. Geometric interpretation. Higher order fixed points	4
Lec 4	Lorenz's model	3
Lec 5-6	The period-doubling route to chaos: Duffing's equation. One-dimensional maps and Liapunov exponent	2
Lec 7	Approximate analytic methods for nonlinear harmonic oscillators (Poisson's and Lindstedt's perturbation methods)	2
Lec 8	Final test	1
	Total hours	15

	Laboratory	**Number of hours**
Lab 1	First steps with *Maple*: equations, plotting, elements of linear algebra, basic mathematical analysis, ordinary differential equations	3
Lab 2	Phase-plane portraits and analysis (stationary points, "famous phaseportraits)	3
Lab 3	Linear and nonlinear oscillators	3
Lab 4	Deterministic chaos and Poincare section	2
Lab 5	Logistic map	2
Lab 6	Reconstructing an attractor	2
	Total hours	15

TEACHING TOOLS USED

N1. Traditional lecture – computer presentation

N2. Computer laboratory – PC computer with Computer Algebra System *Maple*

N3. Digital resources

N4. Consultations

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-W03	oral tests, discussions, progress check in computer lab
F2	PEU_U01-U02, PEU_K01	crediting with grade (lecture), crediting with grade (computer lab)
P=(F1+F2)/2		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] A.C. Mitus, Nonlinear Dynamics – Lecture Notes (teaching materials for BDA students).

[2] A.C. Mitus, Nonlinear Dynamics - Computer Lab Projects (teaching materials for BDA students).

[3] S.H. Strogatz, *Nonlinear Dynamics and Chaos*, Perseus Books, 1994.

[4] R.H. Enns, G.C. McGuire, *Nonlinear Physics with Maple for Scientists and Engineers*, Birkhauser, 2000.

[5] A.C. Mitus, R. Orlik, G. Pawlik, *Wstęp do pakietu algebry komputerowej Maple, Polkowice, 2010 (in polish)*

SECONDARY LITERATURE:

[1] R.H. Enns, G.C. McGuire, *Computer Algebra Recipes. An Advanced Giude to Scientific Modeling*, Birkhauser, 2007.

[2] R.H. Enns, *Computer Algebra Recipes for Mathematical Physics*, Birkhauser, 2005.

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

prof. dr hab. Antoni C. Mituś antoni. mitus@pwr.edu.pl

Zał. nr 5 do ZW 16/2020

FACULTY OF FUNDAMENTAL PROBLEMS OF TECHNOLOGY/ DEPARTMENT OF THEORETICAL PHYSICS

SUBJECT CARD

Name of subject in Polish … Metody numeryczne w fizyce ….
Name of subject in English … Numerical Methods in Physics ….
Main field of study (if applicable): … Big Data Analytics ….
Specialization (if applicable): ……..
Profile: academic / ~~practical~~*
Level and form of studies: ~~1st~~/ 2nd level, ~~uniform magister studies~~*, full-time / ~~part-time~~*
Kind of subject: ~~obligatory~~ / optional / ~~university-wide~~*
Subject code …….
Group of courses YES / ~~NO~~*

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30	30			
Number of hours of total student workload (CNPS)	30	45			
Form of crediting	~~Examination~~ / crediting with grade*	~~Examination~~ / crediting with grade*	~~Examination / crediting with grade*~~	~~Examination / crediting with grade*~~	~~Examination / crediting with grade*~~
For group of courses mark (X) final course	X				
Number of ECTS points	1	2			
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)	1	1			

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Calculus
2. Mathematical analysis: derivatives, integrals, differential equations
3. Linear algebra: vectors and matrices
4. Classical mechanics, in particular Newton's equations
5. Programming skills in arbitrary high-level language

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SUBJECT OBJECTIVES

C1 Understand the implications of digital number representation and digital arithmetic for computational science and engineering
C2 Develop and implement numerically stable and accurate algorithms for numerical differentiation and integration, finding roots of non-linear equations, solving ordinary and partial differential equations

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:
PEU_W01 Understanding of the fundamental principles of digital computing, including

number representation and arithmetic operations
PEU_W02 Understanding of common numerical methods with application to integration, differentiation, differential equations and algebraic equations
PEU_W03 Understanding of accuracy, stability, convergence, and the propagation of errors through complex numerical algorithms

relating to skills:
PEU_U01 Capability to apply a range of numerical techniques to solve problems in areas of integration, differentiation, differential equations and algebraic equations
PEU_U02 Capability to write computer code to solve problems numerically
PEU_U03 Capability to choose appropriate algorithms to solve various computational problems from science and engineering and interpret the results
PEU_U04 Capability to perform numerical error and stability analyses

relating to social competences:
PEU_K01 Understanding of the need to undertake lifelong learning
PEU_K02 The ability to work professionally as a member of multi-disciplinary teams

PROGRAMME CONTENT

	Lecture	**Number of hours**
Lec 1	Numerical Differentiation and Integration	2
Lec 2	Ordinary Differential Equations (ODE) - Initial Value Problem	6
Lec 3	Nonlinear Equations and Systems of Nonlinear Equations	4
Lec 4	Ordinary Differential Equations – Boundary Value Problem	6
Lec 5	Partial Differential Equations (PDE)	6
Lec 6	Applications of ODE and PDE – Molecular Dynamics	4
Lec 7	Optimization	2
	Total hours	30

	Classes	**Number of hours**
Cl 1	Numerical Differentiation and Integration	2
Cl 2	Ordinary Differential Equations (ODE) - Initial Value Problem	6
Cl 3	Nonlinear Equations and Systems of Nonlinear Equations	4
Cl 4	Ordinary Differential Equations – Boundary Value Problem	6
Cl 5	Partial Differential Equations (PDE)	6
Cl 6	Applications of ODE and PDE – Molecular Dynamics	4
Cl 7	Optimization	2
	Total hours	30

TEACHING TOOLS USED
N1. Computer presentation, projector, screen, presenter N2. Jupyter computational environment N3. Editors and compilers

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_W02, PEU_W03	Final test
F2	PEU_U01, PEU_U02, PEU_U03, PEU_U04	Graded assignments, projects, final test
P = (F1+F2)/2		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] William H. Press, Brian P. Flannery, Saul A. Teukolsky, William T. Vetterling, *"Numerical Recipes: The Art of Scientific Computing"*, Cambridge University Press (2007)

[2] John H. Mathews, *"Numerical methods for mathematics, science and engineering"*, Prentice Hall (1994)

[3] Curtis F. Gerald, Patrick O. Wheatley, *"Applied Numerical Analysis"*, Pearson (2003)

[4] Anne Greenbaum, Tim P. Chartier, *"Numerical Methods: Design, Analysis, and Computer Implementation of Algorithms"*, Princeton University Press (2012)

SECONDARY LITERATURE:

[1] E. Ward Cheney, David R. Kincaid, *"Numerical Mathematics and Computing"*, Cengage Learning (2012)

[2] Dianne P. O'Leary, *"Scientific Computing with Case Studies"*, Society for Industrial and Applied Mathematics (2009)

[3] Alex Gezerlis, *"Numerical Methods in Physics with Python"*, Cambridge University Press (2020)

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

Maciej Maśka, maciej.maska@pwr.edu.pl

FACULTY PPT / DEPARTMENT……

SUBJECT CARD

Name of subject in Polish Statystyka praktyczna w Big Data
Name of subject in English Practical Statistics for Data Science
Main field of study (if applicable): Big Data Analytics
Specialization (if applicable): ……..
Profile: academic
Level and form of studies: 2nd level, full-time
Kind of subject: obligatory
Subject code …….
Group of courses YES

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30	15	15	0	0
Number of hours of total student workload (CNPS)	40	30	30	0	0
Form of crediting	Examination / ~~crediting with grade*~~	~~Examination /~~ crediting with grade*	~~Examination /~~ crediting with grade*	~~Examination / crediting with grade*~~	~~Examination / crediting with grade*~~
For group of courses mark (X) final course	X				
Number of ECTS points	2	1	1	0	0
including number of ECTS points for practical classes (P)	0	1	1	0	0
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	1	1	0	0	0

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. 1. Knowledge of the fundamentals of probability theory and mathematical analysis
2. Knowledge of basic programming

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SUBJECT OBJECTIVES

C1 Understanding principles of statistics

C2 Understanding fundamentals of statistical modelling

C3 Understanding fundamentals of testing hypothesis

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:

PEK_W01 – knows principles of statistics

PEK_W02 – knows the basic regression methods

PEK_W03 – knows the basic testing hypothesis methods

relating to skills:

PEK_U01 – can apply simple model to the data

PEK_U02 – can write a simple procedure using R language

PEK_U03 – can test typical statistical hypothesis

relating to social competences:

PROGRAMME CONTENT

	Lecture	**Number of hours**
L 1	R environment	2
L 2	Basic concepts of practical statistics	2
L 3	Distributions and basic statistics	3
L 4	Relationship between variables	3
L 5	Estimation	6
L 6	Hypothesis testing	8
L 7	Regression	6
	Total hours	30

	Classes	**Number of hours**
C 1	Fundamentals of probability theory	2
C 2	Basic statistics	2
C 3	Correlation	2
C 4	Estimation	2
C 5	Hypothesis testing	4
C 6	Regression	3
	Total hours	15

	Laboratory	**Number of hours**
Lab 1	R environment	2
Lab 2	Basic statistics	3

Lab 3	Estimation	6
Lab 4	Hypothesis testing	6
	Total hours	15

TEACHING TOOLS USED

N1. Lecture using board and/or computer presentations

N2. Solving exercises with students

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	PEK_W01-W03	Exam
F2	PEK_W01-W03	Solutions of exercises
F3	PEK_U01-U03	Solutions of programming tasks
P = (F1 + F2 + F3)/3		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] Sheldon M. Ross, Introductory Statistics 3rd edition, Academic Press, 2010

[2] Allen B. Downey, *Think Stats 2nd Edition*, O'Reilly, 2014

SECONDARY LITERATURE:

[1] Andy Field et al., *Discovering Statistics using R*, Science of Computer Programming, Sage 2012

[2] Peter C. Bruce and Andrew G. Bruce, *Statistics for Data Scientists 50 Essential Concepts*, O'Reilly, 2017

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

Prof. dr hab. inż. Marek Klonowski (marek.klonowski@pwr.edu.pl)

FACULTY PPT / DEPARTMENT……

SUBJECT CARD

Name of subject in Polish ……Rachunek Prawdopodobieństwa
Name of subject in English… Probability Theory
Main field of study (if applicable): Big Data Analysis
Specialization (if applicable): ……..
Profile: academic / ~~practical~~*
Level and form of studies: 2nd level, full-time
Kind of subject: ~~obligatory~~ / optional / ~~university-wide~~*
Subject code …….
Group of courses YES / ~~NO~~*

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	45	30	0	0	0
Number of hours of total student workload (CNPS)	60	65			
Form of crediting	Examination	crediting with grade			
For group of courses mark (X) final course	X				
Number of ECTS points	3	2			
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			

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

Basic knowledge of mathematical analysis and basic concepts of probability.

Some familiarity with mathematical methods like proofs, basic operations on sets (unions, intersections, Cartesian products, etc).

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SUBJECT OBJECTIVES

C1 Providing students with knowledge of Probability Theory.

C2 Providing students with deeper theoretic tools related to Probability Theory enabling them to develop their knowledge in various directions.

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:

PEU_W01 – knows fundamental facts in topology and measure theory

PEU_W02 – knows measure-theoretic probability theory

…
relating to skills:
PEU_U01 – can use probabilistic tools to solve real world problems
PEU_U02 – can read literature in probability theory and study stochastic processes

relating to social competences:
PEU_K01 – can work in teams sharing his knowledge

PROGRAMME CONTENT

Lecture		**Number of hours**
Lec 1	Metric spaces – basic notions and facts. Product spaces.	3
Lec 2	Complete metric spaces, Compact metric spaces.	3
Lec 3	Cantor set.	2
Lec 4	Continuous mappings on metric spaces.	2
Lec 5	Sigma-algebras of sets. Monotone classes. Borel sets in metric spaces	3
Lec 6	Measurable spaces. Measurable functions.	3
Lec 7	Measure. Finitely additive measure. Measure space.	2
Lec 8	Outer measure. Caratheodory's construction of measure. Metric outer measure. Lebesgue measure.	3
Lec 9	Integral.	4
Lec 10	Almost everywhere convergence, convergence with respect to measure.Lebesgue convergence theorems.	2
Lec 11	Product measures, Fubini's theorem.	4
Lec 12	Probabilistic terminology. Independence. Conditional probability. Total law of probability.	3
Lec 13	Random variable. Expected value. Variance. Distribution function. Density function. Laws of probabilty.	4
Lec 14	Characteristic functions	4
Lec 15	Central Limit Theorem, Strong Law of Large Numbers.	5
	Total hours	**45**

Classes		**Number of hours**
Cl 1	Solving basic topological problems	8
Cl 2	Solving basic problems in measure theory.	10
Cl 3	Solving basic problems in probability theory.	12
	Total hours	**30**

TEACHING TOOLS USED

N1. Lecture at the board/on-line.

N2. Solving problems with students.

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, W02	exam
F2	PEU_U01, U02 PEU_K01	Test, solution of exercises
P=(F1+F2)/2		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] Billingsley, P, Probability and measure, Wiley Series in Probability and Mathematical Statistics. John Wiley & Sons Inc., New York 1995, third edition

SECONDARY LITERATURE:

[1] David F. Anderson, Timo Seppäläinen, Benedek Valkó, Introduction to Probability, Cambridge University Press, 2017

[2] Jolanta K. Misiewicz, Wykłady z rachunku prawdopodobieństwa z zadaniami, Script, Warszawa 2013 (optional, for Polish speaking students).

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

Michał Morayne, michal,morayne@pwr.edu.pl

FACULTY PPT / DEPARTMENT……

SUBJECT CARD

Name of subject in Polish Programowanie i Klasyfikacja
Name of subject in English Programming and Classification
Main field of study (if applicable): Big Data Analytics
Specialization (if applicable): ……..
Profile: academic
Level and form of studies: 2nd level, full-time
Kind of subject: obligatory / ~~**optional / university-wide***~~
Subject code
Group of courses YES / ~~**NO***~~

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30	15	15	0	0
Number of hours of total student workload (CNPS)	40	30	30	0	0
Form of crediting	~~Examination~~ / crediting with grade*	~~Examination /~~ crediting with grade*	~~Examination /~~ crediting with grade*	~~Examination / crediting with grade*~~	~~Examination / crediting with grade*~~
For group of courses mark (X) final course	X				
Number of ECTS points	2	1	1	0	0
including number of ECTS points for practical classes (P)	0	1	1	0	0
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	1	1	0	0	0

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Basic knowledge of mathematical analysis, linear algebra and programming

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SUBJECT OBJECTIVES

C1 Understanding the concept of similarity

C2 Understanding the k-mean algorithm

C3 Understanding the concept of hierarchical clustering

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:

PEK_W01 – knows the notion of metric space and similarity

PEK_W02 – knows the notion of sketches

PEK_W03 – knows the k-mean algorithm

PEK_W04 – knows basic hierarchical clustering techniques

relating to skills:

PEK_U01 – can write simple programs in Python Language

PEK_U02 – can build sketches of collection of documents

PEK_U03 – can apply basic clustering algorithms

relating to social competences:

PROGRAMME CONTENT

	Lecture	**Number of hours**
L 1	Introduction to Python programming language	4
L 2	Basic methods of text analysis (TF.IDF)	2
L 3	Notion of metric spaces;	2
L 4	Jaccard Similarity	4
L 5	Locality-Sensitive Hashing for Documents	2
L 6	Sketches and random hyperplanes	4
L 7	The curse of dimensionality	2
L 8	Classification: overview	2
L 9	k-mean Algorithms	4
L 10	Hierarchical clustering	4
		30

	Classes	**Number of hours**
C 1	Elements of functional programming	3
C 2	Metric spaces and similarity	2
C 3	Similarity of documents	2
C 4	Pathological properties of highly dimensional spaces	3

C 5	Properties of k-mean algorithm	3
C 6	Hierarchical clustering	2
		15

Laboratory		**Number of hours**
Lab 1	Word count and related problems	4
Lab 2	Implementation of sketches of documents	4
Lab 3	Implementation of k-mean algorithms	3
Lab 4	Hierarchical classification	4
		15

TEACHING TOOLS USED

N1. Lecture using board and/or computer presentations

N2. Solving exercises with students

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	PEK_W01-W04	Exam
F2	PEK_U01-U02	Solutions of programming tasks
P = (F1 + F2)/2		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] Jure Leskovec, Anand Rajaraman, Jeffrey D. Ullman, Mining of Massive Datasets, online, 2016

[2] Stephen Marsland, Machine Learning: An Algorithmic Perspective, 1st Edition, Chapman and Hall/CRC, 2011

[3] Jiawei Han, Micheline Kamber, Jian Pei, Data Mining: Concepts and Techniques (3rd ed), Morgan Kaufmann, 2011

SECONDARY LITERATURE:

[1] Allen B. Downey, Think Python, Green Tea Press, Needham, Massachusetts, 2015

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

Prof. dr hab. inż. Marek Klonowski (marek.klonowski@pwr.edu.pl)

Zał. nr 5 do ZW 16/2020

FACULTY Fundamental problems of technology

SUBJECT CARD

Name of subject in Polish Optyka kwantowa
Name of subject in English Quantum Optics
Main field of study (if applicable): Big Data Algorithms
Specialization (if applicable):
Profile: academic
Level and form of studies: 2nd level, full-time
Kind of subject: optional
Subject code
Group of courses YES

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30	30			
Number of hours of total student workload (CNPS)	35	40			
Form of crediting	crediting with grade*	crediting with grade*			
For group of courses mark (X) final course	X				
Number of ECTS points	1	2			
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)	1	1			

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Good knowledge of quantum mechanics

2. Knowledge of mathematical analysis and algebra

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SUBJECT OBJECTIVES

C1 To allow the students to learn the formalism of quantum optics

C2 To acquaint the students with selected applications of quantum optics

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:

PEK_W01 Knows the basic formalism of quantum optics

PEK_W02 Knows the applications of quantum optics in science and technology

relating to skills:

PEK_U01 Can apply the formalism of quantum optics to solve simple problems

relating to social competences:

PEK_K01 Understands the broad scientific and social importance of the achievements of quantum optics

PEK_K02 Has the attitude of continuous learning

PROGRAMME CONTENT

Lecture		Number of hours
Lec 1	Quantization of the electromagnetic field	4
Lec 2	Coherent and squeezed states	4
Lec 3	Phase operators	4
Lec 4	Quantum distribution functions	4
Lec 5	Quantum coherence functions and interferometry	6
Lect 6	Light-matter intreraction: quantum description	6
Lect 7	Evaluation	2
	Total hours	30

Classes		Number of hours
Cl 1	Semiclassical description of light-matter interaction: two-level atom driven by classical light	4
Cl 2	Quantization of the electromagnetic field	4
Cl 3	Coherent and squeezed states	4
Cl 4	Phase operators	4
Cl5	Quantum distribution functions	4
Cl6	Quantum coherence functions and interferometry	4
Cl7	Light-matter intreraction: quantum description	4
Cl8	Optical spectroscopy. Resonance fluorescence	2
	Total hours	30

TEACHING TOOLS USED

N1. Lecture supported by graphical material/slides

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	U01	Homeworks, activity during classes
P1	U01	Evaluation test
P = 0.4*F1 + 0.6*P1		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

1. M. O. Scully, M. S. Zubairy Quantum Optics (Cambridge 1997)
2. Y. Yamamoto, A. Imamoglu, *Mesoscopic Quantum Optics*

SUPPLEMTARY LITERATURE:

Stanisław Kryszewski, Quantum Optics, http://iftia9.univ.gda.pl/~sjk/QO-SK.pdf

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

Paweł Machnikowski, Pawel.Machnikowski@pwr.wroc.pl

Zał. nr 5 do ZW 16/2020

FACULTY W11 / DEPARTMENT K64W11D11

SUBJECT CARD

Name of subject in Polish Fizyka Statystyczna Układów Złożonych
Name of subject in English Statistical Physics for Complex Systems
Main field of study (if applicable): Big Data Analytics
Specialization (if applicable): ……..
Profile: academic / practical*
Level and form of studies: ~~1st~~/ 2nd level, ~~uniform magister studies*, full-time / part-time~~*
Kind of subject: ~~obligatory~~ / optional / ~~university-wide~~*
Subject code …….
Group of courses YES / ~~NO~~*

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30		30		
Number of hours of total student workload (CNPS)	50		75		
Form of crediting	Examination / ~~crediting with grade*~~	Examination / crediting with grade*	Examination / crediting with grade*	Examination / crediting with grade*	Examination / crediting with grade*
For group of courses mark (X) final course	X				
Number of ECTS points	3		2		
including number of ECTS points for practical classes (P)	1		2		
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	1		1		

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Knowledge of mathematical analysis, algebra and general physics on the level of first-degree studies in technical sciences
2. Skills in computer programming

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SUBJECT OBJECTIVES

C1 Becoming familiar with basic concepts of macroscopic and microscopic description of large systems composed of interacting objects

C2 Becoming familiar with Monte Carlo simulations in statistical physics

C3 Becoming familiar with basic concepts and methods of the theory of critical phenomena and phase transitions

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:

PEK_W01 – to acquire knowledge related to basic concepts of thermodynamics and statistical physics

PEK_W02 – to acquire knowledge related to Monte Carlo simulations in statistical physics

PEK_W03 – to acquire knowledge related to concepts and methods of the theory of critical phenomena and phase transitions

PEK_W04 – to acquire knowledge related to concepts and methods of statistical physics used to model and analyze Complex Systems

relating to skills:

PEU_U01 – developing skills to model complex systems using statistical mechanics methods

PEU_U02 – developing skills to analyze models of complex systems within Monte Carlo simulations

relating to social competences:

PEU_K01 – developing skills to critically analyze information related to statistical physics from different sources

3		
Lecture		**Number of hours**
Lec 1	Introduction – the statistical physics for complex systems and big data	2
Lec 2	From the microscale to the macroscale: Ehrenfest model, Mark Kac's ring model and H-Boltzmann theorem.	4
Lec 3	Entropy in statistical physics and information theory.	4
Lec 4	Statistical ensembles – theory and examples.	4
Lec 5	The Ising model – Monte Carlo simulations, analytical approach (exact and the mean-field approximation), and interdisciplinary applications.	6
Lec 6	Validation of the model – elements of thermodynamics, relation between thermodynamics and statistical physics.	4
Lec 7	Elements of the theory of the phase transitions and critical phenomena: Landau theory, critical exponents, universality, scaling.	4
Lec 8	Real-life applications of statistical physics to model and analyze various phenomena (in biology, economy and sociology).	2
	Total hours	
Laboratory		**Number of hours**

Lab 1	Pseudo Random Number Generators – comparison and basic tests	4
Lab 2	Simulations the simple microscopic model, such as the Ehrenfest model, Mark Kac's ring model, etc.	4
Lab 3	Calculating the entropy	4
Lab 4	Monte Carlo simulations of the Ising model in one dimension in temperature $T \geq 0$: space-time diagram, the role of initial conditions and the type of updating	4
Lab 5	Monte Carlo simulations of the Ising model in two dimensions – trajectories and the time evolution of the probability density function of magnetization.	4
Lab 6	Monte Carlo simulations of the Ising model in two dimensions – temperature dependence of magnetization, susceptibility, phase transition.	4
Lab 7	Continuous and discontinuous phase transitions in the selected models – simulations and analytical calculations.	6
	Total hours	30

TEACHING TOOLS USED

N1. lecture with multimedia presentation

N2. discussions, problems' solutions

N3. computer laboratory – programming in C++, Python, Julia or other programming language

N4. digital resources

N5. consultations

N6. homework

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	PEK_W01- PEK_W04	oral tests, discussions, progress check in computer lab
F2	PEK_W01- PEK_W04, PEU_U01- PEU_U02,	homework with grade
F3	PEU_U01- PEU_U02, PEU_K01	crediting with grade (lecture), crediting with grade (computer lab)

P=(F1+F2+F3)/3

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] J. P. Sethna, Statistical Mechanics, Entropy, Order Parameters, and Complexity
[2] H. Gould, J. Tobochnik, Statistical and Thermal Physics: With Computer Applications, Princeton University Press (2010)
[3] M. Plischke i B. Bergersen, Equilibrium Statistical Physics, 3rd Edition, Prentice-Hall Inc. (2006)
[4] D. P. Landau, K. Binder, A Guide to Monte Carlo Simulations in Statistical Physics, 4th Edition, Cambridge University Press (2014)
[5] M. E. J. Newman, G. T. Barkema, Monte Carlo Methods in Statistical Physics, Clarendon Press, Oxford (2001)

SECONDARY LITERATURE:

[1] S. Thurner, R. Hanel, and P. Klimek, Introduction to the Theory of Complex Systems, Oxford University Press (2018)
[2] T. M. Cover, J. A. Thomas, Elements of Information Theory, John Wiley & Sons, Inc. (2006)
[3] Nicholas R. Moloney, Kim Christensen, Complexity and Criticality, Imperial College Press (2005)
[4] J. M. Yeomans, Statistical mechanics of phase transitions, Clarendon Press (1992)
[5] Original articles

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

Prof. dr hab. Katarzyna Weron (katarzyna.weron@pwr.edu.pl)

Zał. nr 5 do ZW 16/2020

FACULTY PPT / DEPARTMENT……

SUBJECT CARD

Name of subject in Polish Procesy Stochastyczne……
Name of subject in English Stochastic Processes……
Main field of study (if applicable): Big Data Analytics
Specialization (if applicable): ……..
Profile: academic / ~~practical~~*
Level and form of studies: ~~1st~~/ 2nd level, ~~uniform magister studies~~*, full-time / ~~part-time~~*
Kind of subject: ~~obligatory~~ / optional / ~~university-wide~~*
Subject code …….
Group of courses YES / ~~NO~~*

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30	30			
Number of hours of total student workload (CNPS)	30	45			
Form of crediting	~~Examination~~ / crediting with grade*	~~Examination~~ / crediting with grade*	~~Examination / crediting with grade~~*	~~Examination / crediting with grade~~*	~~Examination / crediting with grade~~*
For group of courses mark (X) final course	X				
Number of ECTS points	1	2			
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)	1	1			

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Mathematical Analysis.
2. Measure Theory.
3. Probability Theory.

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SUBJECT OBJECTIVES

C1 Providing students with knowledge on stochastic process with emphasis on Markov chains.
C2 Enabling students to apply stochastic processes in practice.

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:
PEK_W01 – knows stochastic processes

PEK_W02 – knows some applications of stochastic processes

relating to skills:
PEU_U01 – can use stochastic processes to model real world phenomena

PEU_U02 – can read further literature in probability theory and study stochastic processes

relating to social competences:
PEU_K01 – can work in multi-discipline teams sharing his knowledge

PROGRAMME CONTENT

Lecture		**Number of hours**
Lec 1	General notion of stochastic process and filtration – discrete and continuous time.	2
Lec 2	Markov chains – definition and basic notions:, states, state space, transition probability, "memorylessness". Transition matrix.	2
Lec 3	Classification of states.	2
Lec 4	Periodic chains.	2
Lec 5	Recurrent and transient states.	2
Lec 6	Random walks.	2
Lec 7	Stationary distributions for Markov chains. Stationary Markov chains. Ergodic states. Ergodic Markov chains.	2
Lec 8	Applications of Markov chains 1.	2
Lec 9	Applications of Markov chains 2.	2
Lec 10	Markov processes with continuous time.	2
Lec 11	Poisson process 1.	2
Lec 12	Poisson process 2.	2
Lec 13	Birth-and-death process.	2
Lec 14	Wiener process (Bownian motion) 1.	2
Lec 15	Wiener process 2.	2
	Total hours	30

Classes		**Number of hours**
C1	Solving basic problems about Markov chains.	15
C 2	Solving basic problems about continuous time Markov processes.	15
	Total hours	30

TEACHING TOOLS USED

N1 Lecture using board and/or computer presentations
N2 Solving problems in class

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	PEK_W01, W02, PEU_U01, U02 PEU_K01	In-class short test, solutions of problems
F2	PEK_W01, W02, PEU_U01, U02 PEU_K01	In-class short test, solutions of problems
F3	PEK_W01, W02, PEU_U01, U02 PEU_K01	Final test
P= (F1+F2+F3)/3		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] [1] Billingsley, P, Probability and measure, Wiley Series in Probability and Mathematical Statistics. John Wiley & Sons Inc., New York 1995, third edition

SECONDARY LITERATURE:

[1] Anzelm Iwanik, Jolanta K. Misiewicz, Wykłady z procesów stochastycznych z zadaniami, Script, Warszawa 2015 (optional, for Polish speaking students).

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

Michał Morayne, michal.morayne@pwr.edu.pl

Zał. nr 5 do ZW 16/2020

FACULTY W11 / DEPARTMENT K64W11D11

SUBJECT CARD

Name of subject in Polish Obsługa strumieni danych
Name of subject in English Stream programming
Main field of study (if applicable): Big Data Analytics
Specialization (if applicable): ……..
Profile: academic / ~~practical~~*
Level and form of studies: ~~1st/~~ 2nd level, ~~uniform magister studies~~*, full-time / ~~part-time~~*
Kind of subject: obligatory / ~~optional / university-wide~~*
Subject code …….
Group of courses YES / ~~NO~~*

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30		30		
Number of hours of total student workload (CNPS)	50		75		
Form of crediting	~~Examination~~ / crediting with grade*	Examination / crediting with grade*	Examination / crediting with grade*	Examination / crediting with grade*	Examination / crediting with grade*
For group of courses mark (X) final course	X				
Number of ECTS points	2		3		
including number of ECTS points for practical classes (P)	0		2		
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	1		1		

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Basic knowledge of programing and basic concepts of linear algebra

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SUBJECT OBJECTIVES

C1 Understanding basic techniques of stream programming

C2 Knowledge of basic parameters of streams of data

C3 Understanding random sampling

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:
PEK_W01 – knows the notion of stream of data

PEK_W02 – knows the notion of aggregates

PEK_W03 – knows basic counting algorithms

PEK_W04 – knows sampling techniques

relating to skills:
PEK_U01 – can build tools for observation of data stream

PEK_U02 – knows how to extract basic properties of a stream

PEK_U03 – can build random samples in on-line regime

relating to social competences:
PEK_K01 – can observe basic properties of observed stream of dataof data

PROGRAMME CONTENT

Lecture		**Number of hours**
Lec 1	Introduction to Scala programming language	6
Lec 2	Reactive programming	2
Lec 3	Scala and Python libraries for observation of streams	2
Lec 4	Basic statistics of stream	4
Lec 5	Hash tables and bloom filters	2
Lec 6	Majority and Misra-Gries summaries	2
Lec 7	Counting Distinct Elements in a Stream	4
Lec 8	Estimating Moments	4
Lec 9	Counting Ones in a Window	2
Lec 10	Random samples from streams	2
	Total hours	

Laboratory		**Number of hours**
Lab 1	Introduction to Scala	10
Lab 2	Building tools for observations of streams	4
Lab 3	Bloom filters	4
Lab 4	Heavy hitters	4
Lab 5	Implementation of HyperLogLog	4
Lab 6	Random samples	4
	Total hours	30

TEACHING TOOLS USED

N1. Lecture using board and computer presentations

N2. Solving exercises with students

N3. Solving programming tasks

N4. Consultations

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	PEK_W01-W04 PEK_K01	Test
F2	PEK_U01-U03	Solutions of programming tasks
P=(F1+F2)/2		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] J. Leskovec, A. Rajaraman, J. D. Ullman, *Mining of Massive Datasets*, book.pdf, 2016

[2] Tyler Akidau, Slava Chernyak, Reuven Lax, *Streaming Systems. The What, Where, When, and How of Large-Scale Data Processing*, O'Reilly Media, July 2018

SECONDARY LITERATURE:

[1] Martin Odersky, Programming in Scala, Artima Press, 2016

[2] Misra, J.; Gries, David, *Finding repeated elements*, Science of Computer Programming. 2 (2): 143–152.

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

dr hab. Yaroslav Pavlyuk (yaroslav.pavlyuk @pwr.edu.pl)

Zał. nr 5 do ZW 16/2020

FACULTY OF FUNDAMENTAL PROBLEMS OF TECHNOLOGY

SUBJECT CARD

Name of subject in Polish Analiza szeregów czasowych
Name of subject in English Time Series Analysis
Main field of study (if applicable): Big Data Analytics
Specialization (if applicable): ……..
Profile: academic / ~~practical~~*
Level and form of studies: 2nd level, full time
Kind of subject: optional
Subject code …….
Group of courses YES

*delete as not necessary

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30	30			
Number of hours of total student workload (CNPS)	30	45			
Form of crediting	~~Examination~~ / crediting with grade*	~~Examination~~ / crediting with grade*	Examination / crediting with grade*	Examination / crediting with grade*	Examination / crediting with grade*
For group of courses mark (X) final course	X				
Number of ECTS points	1	2			
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)	1	1			

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

Basic knowledge of programing in Python, machine learning and statistics.

SUBJECT OBJECTIVES

C1 Knowledge of basic analysis of time series data
C2 Knowledge of forecasting and modelling of time series

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:
PEU_W01 has deeper knowledge of statistical theory and methods particularly common in time series modelling and forecasting
PEU_W02 understands time-dependent seasonal components

PEU_W03 is able to interpret the results of an implemented analysis
PEU_W04 is aware of limitations and possible sources of errors in the analysis

relating to skills:
PEU_U01 can use Python in time series analysis
PEU_U02 can apply auto-regressive and model averaging models
PEU_U03 can forecast time series using Deep Learning methods
PEU_U04 can extract time series' features using Wavelet transform

relating to social competences:
PEU_K01 know one's limitations of knowledge and understands need for further development
PEU_K02 can present and discuss problems in the forum

PROGRAMME CONTENT

Lecture		**Number of hours**
Lec 1	Course requirements, Python Pandas Overview	2
Lec 2	Time series visualization	2
Lec 3-4	Forecasting with smoothing models	4
Lec 5-6	ARMA, ARIMA, and SARIMA models	6
Lec 7	Vector autoregression and Granger causality	2
Lec 8	Time series forecasting using Prophet library	2
Lec 9-11	Deep Learning for Time Series Forecasting	6
Lec 12-13	Wavelet analysis in feature extraction	4
Lec14	Time series clustering using k-shape algorithm	2
Lec15	Final test	2
	Total hours	30

Classes		**Number of hours**
Cl 1	Python Pandas Overview	2
Cl 2	Time series visualization	2
Cl 3	Forecasting with smoothing models	3
Cl 4-5	ARMA models	4
Cl 6-7	ARIMA and SARIMA models	4
Cl 8	Vector autoregression and Granger causality	
Cl 9	Time series forecasting using Prophet library	
Cl 10-11	Deep Learning for Time Series Forecasting	4
Cl 12-13	Wavelet analysis in feature extraction	4

Cl 14	Time series clustering using k-shape algorithm	2
Cl 15	Final project presentation	2
	Total hours	30

TEACHING TOOLS USED

N1. Lecture using board and/or computer presentations
N2. Exercises reports
N3. E-learning (ePortal PWr)
N4. Unassisted student's work (quizzes)
N5. Consultation during office hours
N6. Final project (chosen topic)
N7. Final test

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_W02 PEU_W03 PEU_W04	Final test
F2	PEU_U01 PEU_U02 PEU_U03 PEU_U04	Lab reports
F3	PEU_U01 PEU_U02 PEU_U03 PEU_U04	Quizzes
F4	PEU_U01 PEU_U02 PEU_U03 PEU_U04	Final project
P = 0.3%*F1 + 0.3*F2 + 0.1*F3 + 0.4*F4		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] Hyndman, Rob J., and George Athanasopoulos. Forecasting: principles and practice. OTexts, 2018.
[2] Nielsen, Aileen. Practical time series analysis: Prediction with statistics and machine learning. O'Reilly Media, 2019.
[3] Addison, Paul S. The illustrated wavelet transform handbook: introductory theory and applications in science, engineering, medicine and finance. CRC press, 2017.
[4]

SECONDARY LITERATURE:

[1] Taylor, Sean J., and Benjamin Letham. "Forecasting at scale." The American Statistician 72.1 (2018): 37-45.
[2] Torrence, Christopher, and Gilbert P. Compo. "A practical guide to wavelet analysis." Bulletin of the American Meteorological society 79.1 (1998): 61-78.
[3] Patel, Ankur A. Hands-on unsupervised learning using Python: how to build applied machine learning solutions from unlabeled data. O'Reilly Media, 2019.

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

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Zał. nr 5 do ZW 16/2020

FACULTY OF FUNDAMENTAL PROBLEMS OF TECHNOLOGY / DEPARTMENT OF THEORETICAL PHYSICS

SUBJECT CARD

Name of subject in Polish Wykład monograficzny 1
Name of subject in English Monographic Lecture 1
Main field of study (if applicable): Big Data Analytics
Specialization (if applicable): ……..
Profile: academic
Level and form of studies: 2nd level, full-time
Kind of subject: optional
Subject code …….
Group of courses YES

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30	30			
Number of hours of total student workload (CNPS)	60	65			
Form of crediting	~~Examination~~ / crediting with grade*	~~Examination~~ / crediting with grade*	~~Examination / crediting with grade~~*	~~Examination / crediting with grade~~*	~~Examination / crediting with grade~~*
For group of courses mark (X) final course	X				
Number of ECTS points	2	3			
including number of ECTS points for practical classes (P)		3			
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	1	1			

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Programming skills acquired in first semester
2. Mathematical skills (differential equation and probability theory) acquired in first semester
3. Skills in statistical physics

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SUBJECT OBJECTIVES

C1. Presentation of new trends in computer science, physics and mathematics

C2. Practical mastery of the tools and concepts discussed during the lecture

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:
PEU_W01 - Getting to know new ideas in computer science, physics and mathematics

relating to skills:
PEU_U01 - Student can apply new solutions in computer science, physics and mathematics

relating to social competences:
PEU_K01 - Understands the need to track new developments in computer science, physics and mathematics

PROGRAMME CONTENT

	Lecture	**Number of hours**
Lec 1-2	Emerging new concepts in computer science/physics/mathematics: short characterization	4
Lec 3-5	Ideas and concepts preceding current state of knowledge – historical sketch	6
Lec 6-8	Presentation of corresponding programming/physical/mathematical tools	6
Lec 9-12	Detailed presentation of emerging new concepts	8
Lec 13-14	Perspectives for future development based on current emerging concepts	4
Lec 15	Final test	2
	Total hours	30

	Classes	**Number of hours**
Cl 1-2	Getting familiar with programming/physics/mathematics tools related to emerging concepts	4
Cl 3-5	Introductory exercises with new programming/physics/mathematics tools	6
Cl 6-9	Solving simple problems related to new emerging concepts	8
Cl 10-14	Solving challenging problems motivated by new emerging concepts	10
Cl 15	Final test	2
	Total hours	30

TEACHING TOOLS USED

N1. Lecture using board and computer presentations

N2. Solving exercises with students

N3. Solving programming tasks

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

Evaluation (F – forming during semester), P – concluding (at	Learning outcomes code	Way of evaluating learning outcomes achievement

semester end)		
F1	PEK_W01, PEK_K01	Test
F2	PEK_U01	Solutions of practical tasks
P=(F1+F2)/2		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

Detailed list of the literature will be provided during the first lecture. It will cover:

1. Literature review of concepts and ideas preceding current state of knowledge
2. Current papers related to new emerging trends (both traditional and electronic sources)
3. Papers/textbooks written by the lecturer/lecturers

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

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