Faculty of Electronics, Fotonics and Microsystems (W12N) / Department of Cybernetics and Robotics (K29W12ND02)

SUBJECT CARD

Name of subject in Polish: **Praca dyplomowa**
Name of subject in English: **Master thesis**
Main field of study (if applicable): **Control Engineering and Robotics (AiR)**
Specialization: **Embedded Robotics (AER)**
Profile: **academic**
Level and form of studies: **2nd level, full-time**
Kind of subject: **obligatory**
Subject code: **W12AIR-SM0719D**
Group of courses: **No**

	Lecture	Exercise	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)				150	
Number of hours of total student workload (CNPS)				450	
Form of crediting				Crediting with grade	
For group of courses mark (X) the final course					
Number of ECTS points				15	
including number of ECTS points for practical (P) classes				10.0	
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)				2.0	

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. ECTS credit deficit not exceeded

SUBJECT OBJECTIVES

C1. Independent literature studies, and the implementation of the assigned task under the guidance of the supervisor.

C2. Writing a thesis.

C3. Preparation for professional work in a wide range of tasks related to the field of study, requiring competence and both independence and teamwork skills.

SUBJECT LEARNING OUTCOMES
Relating to skills: PEU_U01 - Can independently perform literature research and, in consultation with the supervisor, apply the methods learned to the assigned task, and write an acceptable thesis.

PROGRAM CONTENT

TEACHING TOOLS USED
N1. Independent study of the literature
N2. Independent work - implementation of the project
N3. Consultation with the thesis supervisor

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation: F — forming (during semester), C — concluding (at semester end)	Learning outcome code	Way of evaluating learning outcome achievement
F1	PEU_U01	Evaluation of the completion of the planned work and the submitted thesis
P = F1		

PRIMARY AND SECONDARY LITERATURE
PRIMARY LITERATURE:
[1] literature specified by the thesis supervisor
SECONDARY LITERATURE:
[1] literature independently selected by the student

SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)
Witold Paluszyński, witold.paluszynski@pwr.edu.pl

Faculty of Electronics, Fotonics and Microsystems (W12N) / Department of Cybernetics and Robotics (K29W12ND02)

SUBJECT CARD

Name of subject in Polish: **Fizyka**

Name of subject in English: **Physics**

Main field of study (if applicable): **Control Engineering and Robotics (AiR)**

Profile: **academic**

Level and form of studies: **2nd level, full-time**

Kind of subject: **obligatory**

Subject code: **W11W12-SM0100W**

Group of courses: **No**

	Lecture	Exercise	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15				
Number of hours of total student workload (CNPS)	30				
Form of crediting	Crediting with grade				
For group of courses mark (X) the final course					
Number of ECTS points	1				
including number of ECTS points for practical (P) classes					
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	0.5				

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

SUBJECT OBJECTIVES

C1. To acquire knowledge of selected fundamental laws of modern physics necessary to understand physical phenomena within the scientific discipline studied

C2. Understanding the need for self-learning

SUBJECT LEARNING OUTCOMES
Relating to knowledge: PEU_W01 - knows and understands what corpuscular-wave duality of light and matter is about PEU_W02 - knows and understands the postulates and basic formalism of quantum mechanics PEU_W03 - knows and understands the physical meaning of Schroedinger's equation and the wave function PEU_W04 - knows and understands the physical meaning of the solution of Schroedinger's equation for the hydrogen atom and multi-electron atoms PEU_W05 - knows and understands the ideas of quantum description of multi-atomic systems, in particular the band structure of crystals PEU_W06 - knows and understands and is aware of the influence of quantum statistics on the properties of matter PEU_W07 - knows and understands how the electro-optical properties of solids can be explained on the basis of the band model of solids PEU_W08 - knows and understands the principle of operation of modern selected semiconductor devices

PROGRAM CONTENT		
Lecture		**Number of hours**
Lec1	Corpuscular-wave duality of light and matter. Planck's law. The de Broglie's postulate.	2
Lec2	Postulates and elements of the formalism of quantum mechanics. The wave function. The Heisenberg indeterminacy principle.	2
Lec3	The Schroedinger equation and its application (well of potential, well systems, tunnel effect). Scanning tunneling microscope.	2
Lec4	Hydrogen atom. Quantum numbers. Spin. Multi-electron atom. Spectrum absorption and emission.	2
Lec5	Multi-atomic systems, types of interatomic bonds. Crystalline structure of solids. Band model of solids.	2
Lec6	Quantum statistics: Fermi-Dirac and Bose-Einstein.	2
Lec7	Electro-optical properties of metals, insulators and semiconductors in the image of the band structure	2
Lec8	Selected modern semiconductor devices (solar cell, photodiode, semiconductor laser).	1
	Total hours:	15

TEACHING TOOLS USED
N1. Traditional lecture with multimedia presentations supplemented by demonstrations of physical phenomena. N2. E-materials for the lecture posted online. N3. Consultation and email contact. N4. Own work - preparation for the final test

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation: F — forming (during semester), C — concluding (at semester end)	Learning outcome code	Way of evaluating learning outcome achievement
F1	PEU_W01-08	lecture activity: oral answers and tests
F2	PEU_W01-08	final test
P(Lect)= F2 (considering F1)		

PRIMARY AND SECONDARY LITERATURE
PRIMARY LITERATURE:
[1] Materiały do wykładu (pliki PPT), dostępne poprzez internet: www.if.pwr.wroc.pl/popko
[2] J. Orear, Fizyka, tom 2, WNT, Warszawa 2008.
[3] K.Sierański, J.Szatkowski, Fizyka. Wzory i Prawa z Objaśnieniami cz.III, Scripta 2008.
SECONDARY LITERATURE:
[1] Paul A. Tipler Fizyka Współczesna; PWN, Warszawa 2011
[2] R R. A. Serway, Physics for Scientists and Engineers, 8th Ed., Brooks/Cole, Belmont 2009

SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)
Pawel Machnikowski, pawel.machnikowski@pwr.edu.pl;Paweł Scharoch, pawel.scharoch@pwr.edu.pl

Faculty of Electronics, Fotonics and Microsystems (W12N) / Department of Cybernetics and Robotics (K29W12ND02)

SUBJECT CARD

Name of subject in Polish: **Komunikacja społeczna**
Name of subject in English: **Social Communication**
Main field of study (if applicable): **Control Engineering and Robotics (AiR)**
Profile: **academic**
Level and form of studies: **2nd level, full-time**
Kind of subject: **obligatory**
Subject code: **W08W12-SM0002S**
Group of courses: **No**

	Lecture	Exercise	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)					15
Number of hours of total student workload (CNPS)					60
Form of crediting					Crediting with grade
For group of courses mark (X) the final course					
Number of ECTS points					2
including number of ECTS points for practical (P) classes					1.0
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)					1.0

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

SUBJECT OBJECTIVES

C1. The student learns about interdisciplinary issues in the field of cultural theory, organisation and management theory and media theory as well as transdisciplinary issues in the humanities and social sciences and engineering with particular reference to the specificity of the field of study

C2. The student receives an introduction to the main theories of culture including the comparative science of civilizations as a basis for orientation in the contemporary process of globalization with an indication of the main areas of application in the context of the professional practice of engineering

C3. The student learns about the main theories of organisation and management with an emphasis on the cultural determinants of organisational systems and using a comparative method

C4. Through the presentation of the main media theories, the student learns about the main areas of application of knowledge from the humanities and social sciences in the work of the professional engineer

SUBJECT LEARNING OUTCOMES

Relating to skills:

PEU_U01 - Can prepare a presentation

PEU_U02 - Students will be able to demonstrate the knowledge required to understand the social, economic, political and legal determinants of engineering activity

PEU_U03 - The student is familiar with the methods of functioning of institutions and mechanisms in the political, legal, economic and social space and their consideration in engineering practice.

PROGRAM CONTENT

Seminar		Number of hours
Sem1	The human world as a space of communication. A transdisciplinary orientation in the context of civilisation, organisation and media at the interface of the humanities and social sciences and engineering sciences.	3
Sem2	Civilisations as spaces for the development of humanity (humanitas). What is civilisation and how to explain it? Definitions, fields and theories of civilisation.	2
Sem3	Synergy or clash? Consequences of the affirmation of the plurality of civilisations in the context of the comparative science of civilisations.	2
Sem4	The process of organising society and the multiplicity of civilisations: individualism vs. collectivism, limitationism vs technocratism in the context of a comparative analysis of organisational cultures	2
Sem5	Main theories and practice of organisational management	2
Sem6	Media as the main space and an essential element of social communication with typology of the media taking into account civilisational and technological conditions (globalism vs. technological conditions (globalism vs. regionalism of the media)	2
Sem7	Media pedagogy: socio-media competence. Media ethics: whose responsibility for the media?	2
	Total hours:	15

TEACHING TOOLS USED
N1. Multimedia presentation N2. Problem-based discussion N3. Own work

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation: F — forming (during semester), C — concluding (at semester end)	Learning outcome code	Way of evaluating learning outcome achievement
F1	PEU_U01	Presentation
F2	PEU_U02-U03	seminar discussion
P(Sem) = 0.5*F1 + 0.5*F2 (in order to pass the course, both F1 and F2 must be positive)		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] McQuail, Denis, Teoria komunikowania masowego, PWN, Warszawa 2007
[2] Konersmann, Ralf, Filozofia kultury, Oficyna Naukowa, Warszawa 2009
[3] Huntington, Samuel P., Zderzenie cywilizacji, Muza SA, Warszawa 2003
[4] Kaliszewski, Andrzej, Głłówne nurty w kulturze XX i XXI wieku, Poltext, Warszawa 2012
[5] Hofstede, Geet/ Hofstede, Geet Jan, Kultury i organizacje, Polskie Wydawnictwo Ekonomiczne, Warszawa 2007
[6] Griffin, Ricky W., Podstawy zarządzania organizacjami, PWN, Warszawa 2004
[7] Levinson, Paul, Nowe nowe media, WAM, Kraków 2010
[8] Briggs, Asa/ Burke Peter, Społeczna historia mediów. Od Gutenberga do Internetu, PWN, Warszawa 2010

SECONDARY LITERATURE:

[1] Koźmiński, A.K., Piotrowski, W., Zarządzanie. Teoria i praktyka, PWN, Warszawa 2000
[2] Lepa, Adam, Pedagogika mass-mediów, Archidiecezjalne Wydawnictwo Łódzkie, Łodź 2000
[3] Dusek, Val, Wprowadzenie do filozofii techniki, Wydawnictwo WAM, Kraków 2011
[4] Stępień Tomasz, Kultura, cywilizacja i historia. Geneza pojęć i teorii na kanwie sporu realizm vs. Antyrealizm, [w:] Sikora, Marek (red.), Realizm wobec wyzwań antyrealizmu. Multidyscyplinarny przegląd stanowisk, Oficyna Wydawnicza Politechniki Wrocławskiej, Wrocław 2011

SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)
Tomasz Stępień, tomasz.stepien@pwr.edu.pl

Faculty of Electronics, Fotonics and Microsystems (W12N) / Department of Cybernetics and Robotics (K29W12ND02)

SUBJECT CARD

Name of subject in Polish: **Przedsiębiorczość**

Name of subject in English: **Entrepreneurship**

Main field of study (if applicable): **Control Engineering and Robotics (AiR)**

Profile: **academic**

Level and form of studies: **2nd level, full-time**

Kind of subject: **obligatory**

Subject code: **W08AIR-SM0030**

Group of courses: **No**

	Lecture	Exercise	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15				15
Number of hours of total student workload (CNPS)	60				30
Form of crediting	Crediting with grade				Crediting with grade
For group of courses mark (X) the final course					
Number of ECTS points	2				1
including number of ECTS points for practical (P) classes					1.0
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	1.0				0.8

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

SUBJECT OBJECTIVES

C1. Gain knowledge of entrepreneurship

C2. Learning about selected instruments (strategies, models, methods) to assess entrepreneurship

SUBJECT LEARNING OUTCOMES

Relating to knowledge:

PEU_W01 - Knows the nature of entrepreneurship

PEU_W02 - Knows the basic types of entrepreneurship

PEU_W03 - Is familiar with selected instruments (strategies, models, methods) of entrepreneurial evaluation

Relating to skills:

PEU_U01 - Can retrieve and interpret knowledge related to entrepreneurship

Relating to social competences:
PEU_K01 - Acquires an active entrepreneurial mindset to pursue innovative ventures

PROGRAM CONTENT		
Lecture		**Number of hours**
Lec1	An introduction to entrepreneurship	3
Lec2	Academic entrepreneurship	2
Lec3	Corporate and SME entrepreneurship	2
Lec4	Regional entrepreneurship	2
Lec5	Social entrepreneurship	2
Lec6	Intellectual entrepreneurship	2
Lec7	Test	2
	Total hours:	15

Seminar		**Number of hours**
Sem1	Introduction to the seminar	1
Sem2	Characteristics of an innovative idea	2
Sem3	Customer, client and main competitor characteristics	2
Sem4	Idea / product innovation strategy	2
Sem5	Assessing the success of an idea / intellectual property	2
Sem6	Financing of innovation	2
Sem7	Business model	2
Sem8	Discussion of seminar results	2
	Total hours:	15

TEACHING TOOLS USED
N1. Traditional and/or online lecture using multimedia tools
N2. Multimedia presentations
N3. Selected statistics and reports

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation: F — forming (during semester), C — concluding (at semester end)	Learning outcome code	Way of evaluating learning outcome achievement
F1	PEU_W01-W03, PEU_U01	lecture activity
F2	PEU_W01-W03, PEU_U01	term paper on entrepreneurship

F3	PEU_K01	evaluation of the entrepreneurial mindset through the development of an innovative idea/product
P(Lect)= F2(considering F1), P(Sem) = F3		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] W. Kasprzak, K. Pelc, Innowacje. Strategie techniczne i rozwojowe, Wydawnictwo Politechniki Wrocławskiej, Wrocław, 2012

[2] G. Gierszewska, B. Olszewska, J. Skonieczny, Zarządzanie strategiczne dla inżynierów, PWE, Warszawa 2012

[3] J.Skonieczny (red.), Kształtowanie zachowań innowacyjnych, przedsiębiorczych i twórczych w edukacji inżyniera, Wydawnictwo Indygo Zahir Media, Wrocław, 2011

[4] P. Drucker, Natchnienie i fart czyli innowacja i przedsiębiorczość, Wydawnictwo Studia Emka, Warszawa 2004

[5] A. Dereń, Zarządzanie wlasnością intelektualną w transferze technologii, Difin, 2014

SECONDARY LITERATURE:

[1] K. Matusiak (red.), Innowacje i transfer technologii. Slownik pojęć PARP, Warszawa 2005

[2] A. Sosnowska, S. Łobejko, A. Kłopotek, J.Brdulak, A. Rutkowska-Brdulak, K. Żbikowska, Jak wdrażać innowacje technologiczne w firmie, PARP, Warszawa 2005

[3] J. G. Wissema, Technostarterzy. Dlaczego i jak?, PARP, Warszawa 2005

[4] A. Bąkowski, T. Cichocki, G. Gromada, J. Guliński, S. Kmita, T. Krzyżyński, U. Marchlewicz, K. Matusiak, D. Trzmielak, J. Wajda, K. Zasiadły, Innowacyjna przedsiębiorczość akademicka, PARP, Warszawa 2005

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

Jan Skonieczy, jan.skonieczny@pwr.edu.pl

Faculty of Electronics, Fotonics and Microsystems (W12N) / Department of Cybernetics and Robotics (K29W12ND02)

SUBJECT CARD

Name of subject in Polish: **Praca dyplomowa**

Name of subject in English: **Master thesis**

Main field of study (if applicable): **Control Engineering and Robotics (AiR)**

Profile: **academic**

Level and form of studies: **2nd level, full-time**

Kind of subject: **obligatory**

Subject code: **W12AIR-SM0010D**

Group of courses: **No**

	Lecture	Exercise	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)				150	
Number of hours of total student workload (CNPS)				450	
Form of crediting				Crediting with grade	
For group of courses mark (X) the final course					
Number of ECTS points				15	
including number of ECTS points for practical (P) classes				10.0	
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)				2.0	

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. ECTS credit deficit not exceeded

SUBJECT OBJECTIVES

C1. Independent literature studies, and the implementation of the assigned task under the guidance of the supervisor.

C2. Writing a thesis.

C3. Preparation for professional work in a wide range of tasks related to the field of study, requiring competence and both independence and teamwork skills.

SUBJECT LEARNING OUTCOMES
Relating to skills: PEU_U01 - Can independently perform literature research and, in consultation with the supervisor, apply the methods learned to the assigned task, and write an acceptable thesis.

PROGRAM CONTENT

TEACHING TOOLS USED
N1. Independent study of the literature
N2. Independent work - implementation of the project
N3. Consultation with the thesis supervisor

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation: F — forming (during semester), C — concluding (at semester end)	Learning outcome code	Way of evaluating learning outcome achievement
F1	PEU_U01	Evaluation of the completion of the planned work and the submitted thesis
P = F1		

PRIMARY AND SECONDARY LITERATURE
PRIMARY LITERATURE:
[1] literature specified by the thesis supervisor
SECONDARY LITERATURE:
[1] literature independently selected by the student

SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)
Witold Paluszyński, witold.paluszynski@pwr.edu.pl

Faculty of Electronics, Fotonics and Microsystems (W12N) / Department of Cybernetics and Robotics (K29W12ND02)

SUBJECT CARD

Name of subject in Polish: **Metody sztucznej inteligencji**
Name of subject in English: **Artificial Intelligence Methods**
Main field of study (if applicable): **Control Engineering and Robotics (AiR)**
Specialization: **Robotics (ARR)**
Profile: **academic**
Level and form of studies: **2nd level, full-time**
Kind of subject: **facultative**
Subject code: **W12AIR-SM0106**
Group of courses: **No**

	Lecture	Exercise	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30			15	
Number of hours of total student workload (CNPS)	60			60	
Form of crediting	Examination			Crediting with grade	
For group of courses mark (X) the final course					
Number of ECTS points	2			2	
including number of ECTS points for practical (P) classes				2.0	
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	1.2			1.6	

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. knowledge of elementary mathematics (algebra, logics)
2. good programming skills required

SUBJECT OBJECTIVES

C1. General understanding of the knowledge representation and reasoning.
C2. Acquire knowledge of various formal paradigms and related problem-solving algorithms.
C3. Gain a practical ability to use one of the existing formal paradigms to build abstract representations of practical problems, and solve them.

SUBJECT LEARNING OUTCOMES
Relating to knowledge: PEU_W01 - understands the concept of artificial intelligence, knowledge representation, and reasoning PEU_W02 - knows the search methods for different classes of problems, and the use of heuristics in problem solving PEU_W03 - understands the application of mathematical logic to problem representation, and the importance of incompleteness and uncertainty thereof PEU_W04 - understands the application of probability to problem description, the application of bayesian networks, the Markov decision processes, and the basic algorithms for solving them Relating to skills: PEU_U01 - can create abstract descriptions of hard practical problems and implement their solutions using altificial intelligence algorithms

PROGRAM CONTENT		
Lecture		**Number of hours**
Lec1	Introduction: program, requirements, literature. Basic concepts and issues. Definition of artificial intelligence. The Turing test. History of AI. Strong and weak artificial intelligence. Knowledge representation.	2
Lec2	State space representation. Backtracking search. Utilizing heuristic information. Hill-climbing strategies.	2
Lec3	Graph searching. Breadth-first, depth-first, and best-first strategies. The A* algorithm. Properties. Constructing heuristics.	2
Lec4	Constraint satisfaction problems. Arc consistency. Basic algorithms. Searching for games. The Minimax algorithm. Alpha-beta cuts. Generalizations of the minimax.	2
Lec5	Knowledge representation in mathematical logic. First order predicate calculus. Resolution theorem proving. Refutation reasoning.	2
Lec6	Logic programming. Horn clauses. Prolog.	2
Lec7	Representing change in logic. Utilizing incomplete and uncertain information. Nonmonotonic logic. Limitations of the knowledge representation based on mathematical logic.	2
Lec8	Semantic knowledge representation. Semantic Web initiative. Basic XML.	2
Lec9	Semantic networks. Knowledge representation in RDF. The SPARQL query language.	2
Lec10	Description logics. The OWL language.	2
Lec11	Probabilistic representation. Conditional probability. Bayes' rule. Probabilistic belief networks.	2
Lec12	Probabilistic reasoning over time. Hidden Markov models. Dynamic Bayesian networks.	2
Lec13	Simple decision making. Utility functions. The MEU principle. Influence diagrams/decision networks. Value of information.	2
Lec14	Sequential decision problems. Markov decision processes. Dynamic programming. Value and policy iteration.	2
Lec15	Reinforcement learning. Basic algorithms. Exploration. Function approximation.	2
	Total hours:	30

Project		Number of hours
Pr1÷4	A series of four individual projects concerning the topics covered in lectures: heuristic searching, programming in logic, probabilistic knowledge representation and decision making.	15
	Total hours:	15

TEACHING TOOLS USED
N1. traditional lecture using video projector
N2. on-line demonstrations during lecture
N3. project classes
N4. office hours
N5. independent work - self study and preparation for the final exam
N6. independent work - developing the project
N7. distant education portal of the WrUST http://eportal.pwr.edu.pl/

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation: F — forming (during semester), C — concluding (at semester end)	Learning outcome code	Way of evaluating learning outcome achievement
F1	PEU_W01 ÷ PEU_W04	exam
F2	PEU_U01	evaluation of the project assignments
P(lecture) = F1; P(project)=F2		

PRIMARY AND SECONDARY LITERATURE
PRIMARY LITERATURE:
[1] S.J.Russell, P.Norvig, Artificial Intelligence A Modern Approach (4th Ed.), Prentice-Hall, 2021
SECONDARY LITERATURE:
[1] Lecture notes
[2] Internet resources

SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)
Witold Paluszyński, witold.paluszynski@pwr.edu.pl

Faculty of Electronics, Fotonics and Microsystems (W12N) / Department of Cybernetics and Robotics (K29W12ND02)

SUBJECT CARD

Name of subject in Polish: **Przedsiębiorczość**

Name of subject in English: **Entrepreneurship**

Main field of study (if applicable): **Control Engineering and Robotics (AiR)**

Profile: **academic**

Level and form of studies: **2nd level, full-time**

Kind of subject: **obligatory**

Subject code: **W08AIR-SM0010**

Group of courses: **No**

	Lecture	Exercise	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15				15
Number of hours of total student workload (CNPS)	60				30
Form of crediting	Crediting with grade				Crediting with grade
For group of courses mark (X) the final course					
Number of ECTS points	2				1
including number of ECTS points for practical (P) classes					1.0
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	1.0				0.8

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

SUBJECT OBJECTIVES

C1. Gain knowledge of entrepreneurship

C2. Learning about selected instruments (strategies, models, methods) to assess entrepreneurship

SUBJECT LEARNING OUTCOMES

Relating to knowledge:

PEU_W01 - Knows the nature of entrepreneurship

PEU_W02 - Knows the basic types of entrepreneurship

PEU_W03 - Is familiar with selected instruments (strategies, models, methods) of entrepreneurial evaluation

Relating to skills:

PEU_U01 - Can retrieve and interpret knowledge related to entrepreneurship

Relating to social competences:
PEU_K01 - Acquires an active entrepreneurial mindset to pursue innovative ventures

PROGRAM CONTENT		
Lecture		**Number of hours**
Lec1	An introduction to entrepreneurship	3
Lec2	Academic entrepreneurship	2
Lec3	Corporate and SME entrepreneurship	2
Lec4	Regional entrepreneurship	2
Lec5	Social entrepreneurship	2
Lec6	Intellectual entrepreneurship	2
Lec7	Test	2
	Total hours:	15

Seminar		**Number of hours**
Sem1	Introduction to the seminar	1
Sem2	Characteristics of an innovative idea	2
Sem3	Customer, client and main competitor characteristics	2
Sem4	Idea / product innovation strategy	2
Sem5	Assessing the success of an idea / intellectual property	2
Sem6	Financing of innovation	2
Sem7	Business model	2
Sem8	Discussion of seminar results	2
	Total hours:	15

TEACHING TOOLS USED
N1. Traditional and/or online lecture using multimedia tools
N2. Multimedia presentations
N3. Selected statistics and reports

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation: F — forming (during semester), C — concluding (at semester end)	Learning outcome code	Way of evaluating learning outcome achievement
F1	PEU_W01-W03, PEU_U01	lecture activity
F2	PEU_W01-W03, PEU_U01	term paper on entrepreneurship

F3	PEU_K01	evaluation of the entrepreneurial mindset through the development of an innovative idea/product
P(Lect)= F2(considering F1), P(Sem) = F3		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] W. Kasprzak, K. Pelc, Innowacje. Strategie techniczne i rozwojowe, Wydawnictwo Politechniki Wrocławskiej, Wrocław, 2012

[2] G. Gierszewska, B. Olszewska, J. Skonieczny, Zarządzanie strategiczne dla inżynierów, PWE, Warszawa 2012

[3] J.Skonieczny (red.), Kształtowanie zachowań innowacyjnych, przedsiębiorczych i twórczych w edukacji inżyniera, Wydawnictwo Indygo Zahir Media, Wrocław, 2011

[4] P. Drucker, Natchnienie i fart czyli innowacja i przedsiębiorczość, Wydawnictwo Studia Emka, Warszawa 2004

[5] A. Dereń, Zarządzanie wlasnością intelektualną w transferze technologii, Difin, 2014

SECONDARY LITERATURE:

[1] K. Matusiak (red.), Innowacje i transfer technologii. Slownik pojęć PARP, Warszawa 2005

[2] A. Sosnowska, S. Łobejko, A. Kłopotek, J.Brdulak, A. Rutkowska-Brdulak, K. Żbikowska, Jak wdrażać innowacje technologiczne w firmie, PARP, Warszawa 2005

[3] J. G. Wissema, Technostarterzy. Dlaczego i jak?, PARP, Warszawa 2005

[4] A. Bąkowski, T. Cichocki, G. Gromada, J. Guliński, S. Kmita, T. Krzyżyński, U. Marchlewicz, K. Matusiak, D. Trzmielak, J. Wajda, K. Zasiadły, Innowacyjna przedsiębiorczość akademicka, PARP, Warszawa 2005

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

Jan Skonieczy, jan.skonieczny@pwr.edu.pl

Faculty of Electronics, Fotonics and Microsystems (W12N) / Department of Cybernetics and Robotics (K29W12ND02)

SUBJECT CARD

Name of subject in Polish: **Komunikacja społeczna**
Name of subject in English: **Social Communication**
Main field of study (if applicable): **Control Engineering and Robotics (AiR)**
Profile: **academic**
Level and form of studies: **2nd level, full-time**
Kind of subject: **obligatory**
Subject code: **W08W12-SM0001S**
Group of courses: **No**

	Lecture	Exercise	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)					15
Number of hours of total student workload (CNPS)					60
Form of crediting					Crediting with grade
For group of courses mark (X) the final course					
Number of ECTS points					2
including number of ECTS points for practical (P) classes					1.0
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)					1.0

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

SUBJECT OBJECTIVES

C1. The student learns about interdisciplinary issues in the field of cultural theory, organisation and management theory and media theory as well as transdisciplinary issues in the humanities and social sciences and engineering with particular reference to the specificity of the field of study

C2. The student receives an introduction to the main theories of culture including the comparative science of civilizations as a basis for orientation in the contemporary process of globalization with an indication of the main areas of application in the context of the professional practice of engineering

C3. The student learns about the main theories of organisation and management with an emphasis on the cultural determinants of organisational systems and using a comparative method

C4. Through the presentation of the main media theories, the student learns about the main areas of application of knowledge from the humanities and social sciences in the work of the professional engineer

SUBJECT LEARNING OUTCOMES

Relating to skills:

PEU_U01 - Can prepare a presentation

PEU_U02 - Students will be able to demonstrate the knowledge required to understand the social, economic, political and legal determinants of engineering activity

PEU_U03 - The student is familiar with the methods of functioning of institutions and mechanisms in the political, legal, economic and social space and their consideration in engineering practice.

PROGRAM CONTENT

Seminar		Number of hours
Sem1	The human world as a space of communication. A transdisciplinary orientation in the context of civilisation, organisation and media at the interface of the humanities and social sciences and engineering sciences.	3
Sem2	Civilisations as spaces for the development of humanity (humanitas). What is civilisation and how to explain it? Definitions, fields and theories of civilisation.	2
Sem3	Synergy or clash? Consequences of the affirmation of the plurality of civilisations in the context of the comparative science of civilisations.	2
Sem4	The process of organising society and the multiplicity of civilisations: individualism vs. collectivism, limitationism vs technocratism in the context of a comparative analysis of organisational cultures	2
Sem5	Main theories and practice of organisational management	2
Sem6	Media as the main space and an essential element of social communication with typology of the media taking into account civilisational and technological conditions (globalism vs. technological conditions (globalism vs. regionalism of the media)	2
Sem7	Media pedagogy: socio-media competence. Media ethics: whose responsibility for the media?	2
	Total hours:	15

TEACHING TOOLS USED
N1. Multimedia presentation N2. Problem-based discussion N3. Own work

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation: F — forming (during semester), C — concluding (at semester end)	Learning outcome code	Way of evaluating learning outcome achievement
F1	PEU_U01	Presentation
F2	PEU_U02-U03	seminar discussion
P(Sem) = 0.5*F1 + 0.5*F2 (in order to pass the course, both F1 and F2 must be positive)		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] McQuail, Denis, Teoria komunikowania masowego, PWN, Warszawa 2007
[2] Konersmann, Ralf, Filozofia kultury, Oficyna Naukowa, Warszawa 2009
[3] Huntington, Samuel P., Zderzenie cywilizacji, Muza SA, Warszawa 2003
[4] Kaliszewski, Andrzej, Głłówne nurty w kulturze XX i XXI wieku, Poltext, Warszawa 2012
[5] Hofstede, Geet/ Hofstede, Geet Jan, Kultury i organizacje, Polskie Wydawnictwo Ekonomiczne, Warszawa 2007
[6] Griffin, Ricky W., Podstawy zarządzania organizacjami, PWN, Warszawa 2004
[7] Levinson, Paul, Nowe nowe media, WAM, Kraków 2010
[8] Briggs, Asa/ Burke Peter, Społeczna historia mediów. Od Gutenberga do Internetu, PWN, Warszawa 2010

SECONDARY LITERATURE:

[1] Koźmiński, A.K., Piotrowski, W., Zarządzanie. Teoria i praktyka, PWN, Warszawa 2000
[2] Lepa, Adam, Pedagogika mass-mediów, Archidiecezjalne Wydawnictwo Łódzkie, Łodź 2000
[3] Dusek, Val, Wprowadzenie do filozofii techniki, Wydawnictwo WAM, Kraków 2011
[4] Stępień Tomasz, Kultura, cywilizacja i historia. Geneza pojęć i teorii na kanwie sporu realizm vs. Antyrealizm, [w:] Sikora, Marek (red.), Realizm wobec wyzwań antyrealizmu. Multidyscyplinarny przegląd stanowisk, Oficyna Wydawnicza Politechniki Wrocławskiej, Wrocław 2011

SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)
Tomasz Stępień, tomasz.stepien@pwr.edu.pl

Faculty of Electronics, Fotonics and Microsystems (W12N) / Department of Cybernetics and Robotics (K29W12ND02)

SUBJECT CARD

Name of subject in Polish: **Matematyka**

Name of subject in English: **Mathematics**

Main field of study (if applicable): **Control Engineering and Robotics (AiR)**

Profile: **academic**

Level and form of studies: **2nd level, full-time**

Kind of subject: **obligatory**

Subject code: **W13AIR-SM1440W**

Group of courses: **No**

	Lecture	Exercise	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15				
Number of hours of total student workload (CNPS)	30				
Form of crediting	Crediting with grade				
For group of courses mark (X) the final course					
Number of ECTS points	1				
including number of ECTS points for practical (P) classes					
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	0.5				

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Knowledge of differential and integral calculus of functions of one variable.
2. Knowledge of the properties and applications of complex numbers and matrices.
3. Knowledge of the theory and applications of numerical series and power series.
4. Knowledge of the theory of random variables and their probability distributions.

SUBJECT OBJECTIVES

C1. To learn the basic concepts, theorems, methods and applications concerning linear spaces and linear transformations in vector spaces.

C2. To learn the basic concepts, theorems and methods for Banach spaces and Hilbert spaces.

C3. To learn the basic concepts and theorems of measure theory and the Lebesgue integral.

C4. Apply acquired knowledge to create and analyse mathematical models to solve theoretical and practical issues in technology.

SUBJECT LEARNING OUTCOMES
Relating to knowledge: PEU_W01 - knows the basic concepts and properties of linear spaces and linear transformations. PEU_W02 - knows the basic concepts and properties of the scalar product, Banach space and Hilbert space. PEU_W03 - knows the basic facts of measure theory and the construction of the integral in the Lebesgue sense. Relating to skills: PEU_U01 - can determine the basis and dimension of a linear space of finite dimension and the coordinates of a vector in a given basis. PEU_U02 - can determine the matrix of a linear transformation in given bases, can use the properties of linear transformations to determine the powers of a matrix. PEU_U03 - is able to construct an orthogonal system in Hilbert space and to expand into an orthogonal series a vector from Hilbert space with a given orthogonal system. PEU_U04 - can calculate the Lebesgue integral of a function with respect to a given measure and test the convergence of a sequence of integrals using an appropriate convergence theorem.

PROGRAM CONTENT		
Lecture		**Number of hours**
Lec1	Linear vector spaces, definition, examples. Linear vector subspaces.	1
Lec2	Linear independence, basis of a linear vector space, dimension of a linear vector space, finite dimensional vector spaces, examples.	1
Lec3	Linear representations in linear vector spaces, linear representations in finite-dimensional spaces and matrices, operations in space of linear representations and in matrix space.	2
Lec4	Normed linear vector spaces, convergence in normed linear vector spaces, Banach spaces, examples.	2
Lec5	Unitary spaces, orthogonal vectors, Hilbert spaces. Examples.	2
Lec6	Orthogonal systems, orthogonal series. Expansion into an orthogonal series. Orthonormal basis in Hilbert space, examples.	2
Lec7	Orthogonal projection, orthogonal projection theorem.	1
Lec8	Measurable functions of one and many variables. Definition of measure. Probabilistic measure. Lebesgue measure. An integral with respect to a measure. The integral against probabilistic measure, Lebesgue integral (against Lebesgue measure). Integrability. L2 and Lp spaces of random variables . Compactness of spaces Lp.	2
Lec9	Application of the orthogonal projection theorem to the construction of a linear optimal mean-square predictor. Conditional expected value.	1
Lec10	The linear function. Riesz theorem on the form of a linear function in a Hilbert space.	1
	Total hours:	15

TEACHING TOOLS USED
N1. A traditional lecture. N2. Lists of tasks N3. Consultations N4. Student's own work

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation: F — forming (during semester), C — concluding (at semester end)	Learning outcome code	Way of evaluating learning outcome achievement
F1	PEU_W01-W03 PEU_U01-U04	colloquium
P(Lect) = F1		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] D. Mc Quarrie, Matematyka dla przyrodników i inżynierów, T. 2, PWN, Warszawa 2005.

[2] E. Piegat, Elementy analizy funkcjonalnej oraz teorii miary i całki Lebesgue'a, Wydawnictwo Politechniki Wrocławskiej, 1975

[3] M. Gewert, Z. Skoczylas, Algebra liniowa 2, Definicje, twierdzenia, wzory. Oficyna Wydawnicza GiS, Wrocław 2005.

[4] M. Gewert, Z. Skoczylas, Algebra liniowa 2, Przykłady i zadania. Oficyna Wydawnicza GiS, Wrocław 2005.

SECONDARY LITERATURE:

[1] W. Rudin, Analiza rzeczywista i zespolona, PWN, Warszawa 1986

[2] J. Górniak, T. Pytlik, Analiza funkcjonalna w zadaniach, Wydawnictwo Politechniki Wroclawskiej, Wrocław 1992.

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SUBJECT CARD

Name of subject in Polish: **Fizyka**

Name of subject in English: **Physics**

Main field of study (if applicable): **Control Engineering and Robotics (AiR)**

Profile: **academic**

Level and form of studies: **2nd level, full-time**

Kind of subject: **obligatory**

Subject code: **W11W12-SM4901W**

Group of courses: **No**

	Lecture	Exercise	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15				
Number of hours of total student workload (CNPS)	30				
Form of crediting	Crediting with grade				
For group of courses mark (X) the final course					
Number of ECTS points	1				
including number of ECTS points for practical (P) classes					
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	0.5				

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

SUBJECT OBJECTIVES

C1. To acquire knowledge of selected fundamental laws of modern physics necessary to understand physical phenomena within the scientific discipline studied

C2. Understanding the need for self-learning

SUBJECT LEARNING OUTCOMES
Relating to knowledge: PEU_W01 - knows and understands what corpuscular-wave duality of light and matter is about PEU_W02 - knows and understands the postulates and basic formalism of quantum mechanics PEU_W03 - knows and understands the physical meaning of Schroedinger's equation and the wave function PEU_W04 - knows and understands the physical meaning of the solution of Schroedinger's equation for the hydrogen atom and multi-electron atoms PEU_W05 - knows and understands the ideas of quantum description of multi-atomic systems, in particular the band structure of crystals PEU_W06 - knows and understands and is aware of the influence of quantum statistics on the properties of matter PEU_W07 - knows and understands how the electro-optical properties of solids can be explained on the basis of the band model of solids PEU_W08 - knows and understands the principle of operation of modern selected semiconductor devices

PROGRAM CONTENT		
Lecture		**Number of hours**
Lec1	Corpuscular-wave duality of light and matter. Planck's law. The de Broglie's postulate.	2
Lec2	Postulates and elements of the formalism of quantum mechanics. The wave function. The Heisenberg indeterminacy principle.	2
Lec3	The Schroedinger equation and its application (well of potential, well systems, tunnel effect). Scanning tunneling microscope.	2
Lec4	Hydrogen atom. Quantum numbers. Spin. Multi-electron atom. Spectrum absorption and emission.	2
Lec5	Multi-atomic systems, types of interatomic bonds. Crystalline structure of solids. Band model of solids.	2
Lec6	Quantum statistics: Fermi-Dirac and Bose-Einstein.	2
Lec7	Electro-optical properties of metals, insulators and semiconductors in the image of the band structure	2
Lec8	Selected modern semiconductor devices (solar cell, photodiode, semiconductor laser).	1
	Total hours:	15

TEACHING TOOLS USED
N1. Traditional lecture with multimedia presentations supplemented by demonstrations of physical phenomena. N2. E-materials for the lecture posted online. N3. Consultation and email contact. N4. Own work - preparation for the final test

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation: F — forming (during semester), C — concluding (at semester end)	Learning outcome code	Way of evaluating learning outcome achievement
F1	PEU_W01-08	lecture activity: oral answers and tests
F2	PEU_W01-08	final test
P(Lect)= F2 (considering F1)		

PRIMARY AND SECONDARY LITERATURE
PRIMARY LITERATURE:
[1] Materiały do wykładu (pliki PPT), dostępne poprzez internet: www.if.pwr.wroc.pl/popko
[2] J. Orear, Fizyka, tom 2, WNT, Warszawa 2008.
[3] K.Sierański, J.Szatkowski, Fizyka. Wzory i Prawa z Objaśnieniami cz.III, Scripta 2008.
SECONDARY LITERATURE:
[1] Paul A. Tipler Fizyka Współczesna; PWN, Warszawa 2011
[2] R R. A. Serway, Physics for Scientists and Engineers, 8th Ed., Brooks/Cole, Belmont 2009

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Pawel Machnikowski, pawel.machnikowski@pwr.edu.pl;Paweł Scharoch, pawel.scharoch@pwr.edu.pl

Faculty of Electronics, Fotonics and Microsystems (W12N) / Department of Cybernetics and Robotics (K29W12ND02)

SUBJECT CARD

Name of subject in Polish: **Seminarium dyplomowe**
Name of subject in English: **Diploma Seminar**
Main field of study (if applicable): **Control Engineering and Robotics (AiR)**
Specialization: **Electronic Control Systems (AEU)**
Profile: **academic**
Level and form of studies: **2nd level, full-time**
Kind of subject: **facultative**
Subject code: **W12AIR-SM0211S**
Group of courses: **No**

	Lecture	Exercise	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)					30
Number of hours of total student workload (CNPS)					90
Form of crediting					Crediting with grade
For group of courses mark (X) the final course					
Number of ECTS points					3
including number of ECTS points for practical (P) classes					3.0
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)					1.5

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

SUBJECT OBJECTIVES

C1. Acquire the ability to seek the selective knowledge necessary to create their own original solutions.

C2. Gain the ability to prepare a presentation to communicate own original ideas, concepts and solutions to an audience in a communicative manner.

C3. Acquire creative discussion skills in which one can justify and defend one's position in a factual and substantive manner.

C4. Acquire the ability to write a work that presents one's own achievements, including presenting one's own achievements against the background of the subject literature.

SUBJECT LEARNING OUTCOMES

Relating to skills:

PEU_U01 - is able to prepare a presentation containing the results of solutions to the problem posed

PEU_U02 - can substantiate his/her original ideas and solutions in a discussion

PEU_U03 - can critically evaluate scientific and technical solutions of others

PROGRAM CONTENT

Seminar		Number of hours
Sem1	Discussing the principles of preparing and writing the diploma work, in particular presenting the editorial principles	2
Sem2	Individual presentations concerning the discussion of the current state of knowledge related to the problems of the realized thesis and relating the anticipated, original own contribution to the achievements of the literature	8
Sem3	Discussion in a seminar group on the state of the literature knowledge and the assumed concept of solving problems constituting the thesis	6
Sem4	Individual presentations of the completed thesis with emphasis on the author's own original work, together with a seminar group discussion	14
Sem5	As time permits, discuss questions from the graduation exam	0
	Total hours:	30

TEACHING TOOLS USED

N1. multimedia presentation

N2. problem-based discussion

N3. personal work

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

Evaluation: F — forming (during semester), C — concluding (at semester end)	Learning outcome code	Way of evaluating learning outcome achievement
F1	PEU_U01	presentation
F2	PEU_U02, PEU_U03	seminar discussion
P = 0.5*F1 + 0.5*F2 (in order to pass the course, both F1 and F2 must be positive)		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

SECONDARY LITERATURE:

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Faculty of Electronics, Fotonics and Microsystems (W12N) / Department of Cybernetics and Robotics (K29W12ND02)

SUBJECT CARD

Name of subject in Polish: **Seminarium specjalnościowe**
Name of subject in English: **Specialization seminar**
Main field of study (if applicable): **Control Engineering and Robotics (AiR)**
Specialization: **Electronic Control Systems (AEU)**
Profile: **academic**
Level and form of studies: **2nd level, full-time**
Kind of subject: **facultative**
Subject code: **W12AIR-SM0207S**
Group of courses: **No**

	Lecture	Exercise	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					Crediting with grade
For group of courses mark (X) the final course					
Number of ECTS points					2
including number of ECTS points for practical (P) classes					1.0
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)					1.0

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Can search for information related to the progress of automation

SUBJECT OBJECTIVES

C1. Gaining knowledge on presentation preparation in order to present own ideas, concepts and solutions in accessible form

SUBJECT LEARNING OUTCOMES

Relating to knowledge:

PEU_W01 - Gains knowledge in a selected area of automation in the field of automation systems' modeling, hardwware and software support of automation, sensory data analysis

Relating to skills:

PEU_U01 - Is able to critically evaluate the scientific and technical solutions of other people

Relating to social competences:
PEU_K01 - Can substantively justify his original ideas and solutions in a discussion

PROGRAM CONTENT

Seminar		Number of hours
Sem1	Discussion of the thematic scope of the seminar and the rules of preparation presentation. Setting topics for individual students.	2
Sem2	Individual presentations	14
Sem3	Discussion in the seminar group on the topic presented in the presentation, with return attention to the state of literature knowledge and the author's own contribution to the concept of solving the problems discussed in the presentation.	14
	Total hours:	30

TEACHING TOOLS USED

N1. multimedia presentation
N2. discussion
N3. individual work

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

Evaluation: F — forming (during semester), C — concluding (at semester end)	Learning outcome code	Way of evaluating learning outcome achievement
F1	PEU_U01, PEU_W01	presentation
F2	PEU_K01, PEU_W01	discussion
P = 0.5*F1 + 0.5*F2 (in order to pass the course, both F1 and F2 must be positive)		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] K. Tchoń et al.: "Manipulatory i roboty mobilne", Akademicka Oficyna Wydawnicza, Warszawa, 2000.

SECONDARY LITERATURE:

[1] czasopisma branżowe:, np. "Pomiary, Automatyka, Kontrola", "Pomiary, Automatyka, Robotyka"
[2] materiały z cyklicznych KKA (Krajowa Konferencja Automatyki)

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Faculty of Electronics, Fotonics and Microsystems (W12N) / Department of Cybernetics and Robotics (K29W12ND02)

SUBJECT CARD

Name of subject in Polish: **Projekt przejściowy**
Name of subject in English: **Intermediate project**
Main field of study (if applicable): **Control Engineering and Robotics (AiR)**
Specialization: **Embedded Robotics (AER)**
Profile: **academic**
Level and form of studies: **2nd level, full-time**
Kind of subject: **facultative**
Subject code: **W12AIR-SM0713P**
Group of courses: **No**

	Lecture	Exercise	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)				30	
Number of hours of total student workload (CNPS)				90	
Form of crediting				Crediting with grade	
For group of courses mark (X) the final course					
Number of ECTS points				3	
including number of ECTS points for practical (P) classes				3.0	
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)				1.5	

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. K2AIR_W04
2. K2AIR_W07
3. K2AIR_U08

SUBJECT OBJECTIVES
C1. Developing skills for researching and constructively analyzing the available literature.
C2. Developing skills for formulating the goals, scope, requirements, and time schedule of the project.
C3. Developing skills for designing the abstract architecture of the system.
C4. Developing skills for implementing the given system structure under the supervision of the instructor, and in cooperation with another student.
C5. Developing skills for writing and presenting the project documentation.

SUBJECT LEARNING OUTCOMES
Relating to skills: PEU_U01 - can locate and research the technical literature for the given problem PEU_U02 - can state the goals, scope, requirements and time schedule for a project PEU_U03 - can creatively implement a project in the broad area of embedded robotics PEU_U04 - can document and present project results

PROGRAM CONTENT

Project		Number of hours
Pr1	Proposal of an individual project in the broad area of embedded robotics systems and applications	6
Pr2	Development of the first milestone of the project	6
Pr3	Development of the second milestone of the project	6
Pr4	Development of the final version of the project	6
Pr5	Preparation of the project report	4
Pr6	Preparation and presentation of the project outcome	2
	Total hours:	30

TEACHING TOOLS USED
N1. project classes
N2. Office Hours
N3. independent work - developing the project
N4. distant education portal of the WrUST http://eportal.pwr.edu.pl/

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation: F — forming (during semester), C — concluding (at semester end)	Learning outcome code	Way of evaluating learning outcome achievement
F1	PEU_U01 ÷ PEU_U03	Evaluation of the project execution and outcome
F2	PEU_U04	Evaluation of the report and project presentation

C = 0.7*F1 + 0.3*F2 (in order to pass the course, both F1 and F2 must be positive)

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] Handbook of robotics, II ed., Springer, 20013
[2] Siciliano, et.al., Robotics - Modeling, Planning and Control, Springer, 2009
[3] Thrun et.al. Probabilistic robotics. MIT, 2006
[4] Bradski, Kaehler: Learning OpenCV, O'Reilly, 2008
[5] Duda, Hart, Stork: Pattern Classification, Second Edition, Wiley 2000
[6] LaValle, Planning Algorithms, Cambridge, 2006
[7] Latombe, Robot motion planning, Kluwer, 1993
[8] Tchoń et.al. Manipulatory i roboty mobilne. OW PLJ, 2000

SECONDARY LITERATURE:

[1] Internet resources

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SUBJECT CARD

Name of subject in Polish: **Sterowanie adaptacyjne i odporne**
Name of subject in English: **Robust and Adaptive Control**
Main field of study (if applicable): **Control Engineering and Robotics (AiR)**
Specialization: **Robotics (ARR)**
Profile: **academic**
Level and form of studies: **2nd level, full-time**
Kind of subject: **facultative**
Subject code: **W12AIR-SM0100**
Group of courses: **No**

	Lecture	Exercise	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30	15	15		
Number of hours of total student workload (CNPS)	60	30	60		
Form of crediting	Examination	Crediting with grade	Crediting with grade		
For group of courses mark (X) the final course					
Number of ECTS points	2	1	2		
including number of ECTS points for practical (P) classes		1.0	2.0		
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	1.2	0.8	1.6		

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Control Theory

SUBJECT OBJECTIVES

C1. Gaining knowledge and skills on selected classical design methods for feedback control systems

C2. Gaining knowledge and skills on including uncertainty concerning a controlled process in a model if its dynamics and analysis methods for feedback control systems based on such a model

C3. Gaining knowledge and skills on H_∞ control algorithm

C4. Gaining knowledge and skills in the scope of design and analysis of adaptive feedback control systems

C5. Gaining knowledge and skills in computer-based techniques for the analysis, synthesis and implementation of robust and adaptive control systems.

SUBJECT LEARNING OUTCOMES
Relating to knowledge: PEU_W01 - He/She knows methods of modelling systems with uncertainty in dynamics and external disturbances as well as robust and adaptive model based control algorithms in conjunction with methods of their analysis. Relating to skills: PEU_U01 - He/She is able to apply methods of modelling systems with uncertainty in dynamics and external disturbances as well as design and analyse robust and adaptive model based control algorithms.

PROGRAM CONTENT		
Lecture		**Number of hours**
Lec1	General scheme of a feedback control system	2
Lec2	Classisal design methods for compensators	2
Lec3	Analysis methods of a parametric uncertainty	2
Lec4	Signal spaces, systems norms	2
Lec5	Uncertainty models	2
Lec6	Systems algebra	2
Lec7	H_∞ control	4
Lec8	General scheme of an adaptive control system	2
Lec9	Stability	2
Lec10	Recursive identification algorithms	2
Lec11	Robust adaptive laws	2
Lec12	Adaptive Luenberger observer	2
Lec13	Adaptive pole placement and backstepping	4
	Total hours:	30

Exercise		**Number of hours**
Ex1	Selected topics in mathematical methods in automation and robotics	3
Ex2	Classical techniques for compensators design	2
Ex3	Uncertainty models and robustness	2
Ex4	H_∞ control	2
Ex5	Adaptive laws	2
Ex6	Stability of simple adaptive systems	2
Ex7	Final test	2
	Total hours:	15

Laboratory		**Number of hours**
Lab1	Introduction to Laboratory Classes	1
Lab2	Modelling and identification of a pendulum on a cart	2
Lab3	DC motor: modelling and identification	2

Lab4	DC motor: control	2
Lab5	Pendulum on cart: control	2
Lab6	2R Manipulator: control	2
Lab7	2R Manipulator: controller deployment	2
Lab8	Term for Carrying Out an Overdue Exercise	2
	Total hours:	15

TEACHING TOOLS USED
N1. traditional and/or online lecture with use of real/virtual witeboard and multimedia tools
N2. calculus exercises in traditional form
N3. laboratory classes
N4. self-study
N5. office hours

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation: F — forming (during semester), C — concluding (at semester end)	Learning outcome code	Way of evaluating learning outcome achievement
F1	PEU_W01	written or oral final exam
F2	PEU_U01	final test
F3	PEU_U01	laboratory tasks reports
P(Lecture)=F1, P(Exercise)=F2, P(Laboratory)=F3		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] T. Kaczorek, Wektory i macierze w automatyce i elektrotechnice, WNT, 1998

[2] T. Kaczorek, Podstawy teorii sterowania, WNT, 2005

[3] A. Niederliński, J. Mościński, Z. Ogonowski, Regulacja Adaptacyjne, PWN, 1995

[4] P. A. Ioannou, J. Sun, Robust Adaptive Control, Prentice - Hall, 1996 http://www - rcf.usc.edu/ioannou/RobustAdaptiveBook95pdf

[5] Datta, Biswa Nath, Numerical Methods for Linear Control Systems - Design and Analysis, 2004 Elsevier http://www.knovel.com/web/portal/browse/display? EXT KNOVEL DISPLAY bookid=1920

SECONDARY LITERATURE:

[1] F. W. Fairman, Linear Control Theory. The State Space Approach. John Willey and Sons, 1998

[2] K. Zhou, J. C. Doyle, K. Glover, Robust and Optimal Control, Prentice Hall, 1996

[3] R. Marino, P. Tomei, Nonlinear Control Design. Geometric, Adaptive and Robust, Prentice Hall, 1995

[4] R. A. Freeman, P. A. Kokotović, Robust Nonlinear Control Design, State - Space and Lyapunov Techniques, Birkhauser, 1996

[5] I. Mareels, J.W.Polderman, Adaptive Systems An Introduction, Birkhauser, 1996

[6] I. D. Landau, R. Lozano, M. M'Saad, Adaptive Control, Springer - Verlag London, 1998.

[7] G. Tao, Adaptive Control Design and Analysis, John Willey and Sons, 2003

[8] B. Shahian, M. Hassul, Control System Design Using Matlab, Englewood Cliffs, 1993

[9] The Mathworks. Dokumentacja oprogramowania Matlab/Simulink

[10] B. Mrozek, Z. Mrozek, Matlab i Simulink. Poradnik U˙zytkownika, Helion 2004

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SUBJECT CARD

Name of subject in Polish: **Roboty społeczne**
Name of subject in English: **Social Robots**
Main field of study (if applicable): **Control Engineering and Robotics (AiR)**
Specialization: **Robotics (ARR)**
Profile: **academic**
Level and form of studies: **2nd level, full-time**
Kind of subject: **facultative**
Subject code: **W12AIR-SM0109**
Group of courses: **No**

	Lecture	Exercise	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15		15		
Number of hours of total student workload (CNPS)	30		30		
Form of crediting	Crediting with grade		Crediting with grade		
For group of courses mark (X) the final course					
Number of ECTS points	1		1		
including number of ECTS points for practical (P) classes			1.0		
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	0.6		0.8		

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. None

SUBJECT OBJECTIVES

C1. Gaining ability to create a common social space of robots and humans
C2. Gaining basic knowledge on technology of social robots

SUBJECT LEARNING OUTCOMES

Relating to knowledge:

PEU_W01 - Knowledge of the fundamental features of a social robot, in particular on a socially intelligent agent and an ebodiment, and on Human-Robot Interactions

Relating to skills:

PEU_U01 - The ability of programming of a humanoid robot NAO, designing and programming of socially interactive behaviours for NAO as well as implementation of short-term scenarios of multimodal human-robot interactions involving NAO

PROGRAM CONTENT		
Lecture		**Number of hours**
Lec1	Introduction to Social Robots	2
Lec2	Computational Models of Emotion, Personality	3
Lec3	User Models, Intentionality	2
Lec4	Embodiment	2
Lec5	Human - Robot Communication	2
Lec6	Human - Robot Interactions	2
Lec7	Selected topics in social robotics and Human-Robot Interactions	2
	Total hours:	15

Laboratory		**Number of hours**
Lab1	Introduction to Laboratory Classes	1
Lab2	Basics of Graphical Programming of NAO in Choreographe	2
Lab3	Perception of Human and Environment by NAO	2
Lab4	Motion, Action, Expressive Behavior	2
Lab5	Voice Communication Between Human and Robot, Dialog System in NAO	2
Lab6	Programming of Interactive Behaviour of Nao with use of Python	2
Lab7	Human – Robot Interactions, Animation of Social Behaviours of a Robot	2
Lab8	Socially Intelligent Agent	2
	Total hours:	15

TEACHING TOOLS USED
N1. traditional and/or online lecture with use of real/virtual witeboard and multimedia tools
N2. laboratory classes
N3. office hours
N4. self-study

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation: F — forming (during semester), C — concluding (at semester end)	Learning outcome code	Way of evaluating learning outcome achievement
F1	PEU_W01	Final test
F2	PEU_U01	Evaluation of laboratory classes results
P(Lecture)=F1, P(Laboratory)=F2		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] Bartneck, C., Belpaeme, T., Eyssel, F., Kanda, T., Keijsers, M., & Šabanović, S. (2020). Human-Robot Interaction: An Introduction. Cambridge: Cambridge University Press. doi:10.1017/9781108676649

[2] Breazeal, C., Dautenhahn, K., Kanda, T. (2016). Social Robotics. In: Siciliano, B., Khatib, O. (eds) Springer Handbook of Robotics. Springer Handbooks. Springer, Cham. https://doi.org/10.1007

[3] Fong, T. , Nourbakhsh, I., Dautenhahn. K., A survey of socially interactive robots, Robotics and Autonomous Systems, Volume 42, Issues 3–4, 2003, Pages 143-166, ISSN 0921-8890, https://doi.org/10.1016/S0921-8890(02)00372-X

SECONDARY LITERATURE:

[1] Joscha Bach, Principles of Synthetic Intelligence PSI: An Architecture of Motivated Cognition, Oxford University Press, 2009 DOI:10.1093/acprof:oso/9780195370676.001.0001

[2] C. Breazeal, Designing Sociable Robots, MIT Press, Cambridge, MA, 2002

[3] Matarić, M.J., Scassellati, B. (2016). Socially Assistive Robotics. In: Siciliano, B., Khatib, O. (eds) Springer Handbook of Robotics. Springer Handbooks. Springer, Cham. https://doi.org/10.1007/978-3- 319-32552-1_73

[4] Nao, https://www.softbankrobotics.com/

[5] Joao Miguel de Sousa de Assis Dias, FearNot!: Creating Emotional Autonomous Synthetic Characters for Empathic Interactions, UNIVERSIDADE TÉCNICA DE LISBOA, doctoral dissertation

[6] Wickens, Gordon, and Liu, "Chapter 2: Research Methods", W: An Introduction to Human Factors Engineering, 1998.

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Faculty of Electronics, Fotonics and Microsystems (W12N) / Department of Cybernetics and Robotics (K29W12ND02)

SUBJECT CARD

Name of subject in Polish: **Teoria sterowania**

Name of subject in English: **Control Theory**

Main field of study (if applicable): **Control Engineering and Robotics (AiR)**

Profile: **academic**

Level and form of studies: **2nd level, full-time**

Kind of subject: **obligatory**

Subject code: **W12AIR-SM0007**

Group of courses: **No**

	Lecture	Exercise	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30	15	15		
Number of hours of total student workload (CNPS)	60	60	60		
Form of crediting	Examination	Crediting with grade	Crediting with grade		
For group of courses mark (X) the final course					
Number of ECTS points	2	2	2		
including number of ECTS points for practical (P) classes		2.0	2.0		
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	1.0	1.5	1.5		

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. none

SUBJECT OBJECTIVES

C1. Gaining knowledge and skills in a stability analysis of input/state/output representations for nonlinear control systems.

C2. Gaining knowledge and skills in in the scope of nonlinear system control such as feedback linearization, output tracking, sliding control, optimal control.

SUBJECT LEARNING OUTCOMES
Relating to knowledge: PEU_W01 - As a result of the course, the student is able to explain the structure, representation and essential properties of nonlinear feedback control systems and characterise the control tasks and associated model based control algorithms. Relating to skills: PEU_U01 - As a result of the classes, the student is able to analyse selected properties of nonlinear control systems and perform calculations necessary for the synthesis and analysis of control algorithms such systems, both theoretically and using the software environment for engineering and scientific calculations.

PROGRAM CONTENT		
Lecture		**Number of hours**
Lec1	Introduction to nonlinear control systems	2
Lec2	Stability, the I-st Lyapunov method	2
Lec3	II-nd Lyapunov method	2
Lec4	Input/Output stability, selected topics	2
Lec5	Basics of differential geometry	2
Lec6	Feedback linearization	4
Lec7	Output trajectory tracking	4
Lec8	Sliding control	2
Lec9	Introduction to optimal control, Pontryagin Maximum Principle	2
Lec10	Application of the Maximum Principle: minimum energy, time optimal control	2
Lec11	Singular optimal control	2
Lec12	Hamilton-Jacobi-Bellman equation, linear quadratic control	2
Lec13	Dynamical programming: discrete time case	2
	Total hours:	30

Exercise		**Number of hours**
Ex1	linear and nonlinear systems, simple models and selected properties	3
Ex2	stability	2
Ex3	selected topics on basics of differential geometry	2
Ex4	feedback linearization	2
Ex5	output trajectory tracking	2
Ex6	sliding control, optimal control	2
Ex7	final test	2
	Total hours:	15

Laboratory		**Number of hours**
Lab1	introduction to a software environment designed for numerical and symbolic computations	3

Lab2	modeling and numerical analysis of selected models of linear and nonlinear dynamical systems	2
Lab3	stability	2
Lab4	feedback linearization	2
Lab5	output trajectory tracking	2
Lab6	sliding control	2
Lab7	optimal control	2
	Total hours:	15

TEACHING TOOLS USED
N1. traditional and/or online lecture with use of real/virtual witeboard and multimedia tools
N2. calculus exercises in traditional form
N3. Computer exercises using software for numerical and symbolic calculations
N4. self-study
N5. office hours

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation: F — forming (during semester), C — concluding (at semester end)	Learning outcome code	Way of evaluating learning outcome achievement
F1	PEU_W01	written and/or oral final exam
F2	PEU_U01	final test
F3	PEU_U01	laboratory reports
P(Lect)=F1; P(Exerc)=F2; P(Lab)=F3		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] J-J. E. Slotine, Weiping Li, Applied Nonlinear Control, Prentice-Hall International, Inc. 1991

[2] Riccardo Marino, Patrizio Tomei, Nonlinear Control Design. Geometric, Adaptive and Robust, Prentice Hall, 1995

[3] Thomas L. Vincent, Walter J. Grantham, Nonlinear and Optimal Control Systems, John Wiley & Sons, Inc., 1997

SECONDARY LITERATURE:

[1] Harry G. Kwatny, Gilmer L. Blankenship, Nonlinear Control and Analytical Mechanics. A Computational Approach. Birkhauser, 2000

[2] K. Tchoń and R. Muszyński. Mathematical Methods of Automation and Robotics. Department of Cybernetics and Robotics, Wrocaw University of Science and Technology, 2018.

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SUBJECT CARD

Name of subject in Polish: **Teoria sterowania**

Name of subject in English: **Control Theory**

Main field of study (if applicable): **Control Engineering and Robotics (AiR)**

Profile: **academic**

Level and form of studies: **2nd level, full-time**

Kind of subject: **obligatory**

Subject code: **W12AIR-SM0723**

Group of courses: **No**

	Lecture	Exercise	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30	15	15		
Number of hours of total student workload (CNPS)	60	60	30		
Form of crediting	Examination	Crediting with grade	Crediting with grade		
For group of courses mark (X) the final course					
Number of ECTS points	2	2	1		
including number of ECTS points for practical (P) classes		2.0	1.0		
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	1.0	1.5	0.7		

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. none

SUBJECT OBJECTIVES

C1. Gaining knowledge and skills in a stability analysis of input/state/output representations for nonlinear control systems.

C2. Gaining knowledge and skills in in the scope of nonlinear system control such as feedback linearization, output tracking, sliding control, optimal control.

SUBJECT LEARNING OUTCOMES
Relating to knowledge: PEU_W01 - As a result of the course, the student is able to explain the structure, representation and essential properties of nonlinear feedback control systems and characterise the control tasks and associated model based control algorithms. Relating to skills: PEU_U01 - As a result of the classes, the student is able to analyse selected properties of nonlinear control systems and perform calculations necessary for the synthesis and analysis of control algorithms such systems, both theoretically and using the software environment for engineering and scientific calculations.

PROGRAM CONTENT		
Lecture		**Number of hours**
Lec1	Introduction to nonlinear control systems	2
Lec2	Stability, the I-st Lyapunov method	2
Lec3	II-nd Lyapunov method	2
Lec4	Input/Output stability, selected topics	2
Lec5	Basics of differential geometry	2
Lec6	Feedback linearization	4
Lec7	Output trajectory tracking	4
Lec8	Sliding control	2
Lec9	Introduction to optimal control, Pontryagin Maximum Principle	2
Lec10	Application of the Maximum Principle: minimum energy, time optimal control	2
Lec11	Singular optimal control	2
Lec12	Hamilton-Jacobi-Bellman equation, linear quadratic control	2
Lec13	Dynamic programming: discrete time case	2
	Total hours:	30

Exercise		**Number of hours**
Ex1	linear and nonlinear systems, simple models and selected properties	3
Ex2	stability	2
Ex3	selected topics on basics of differential geometry	2
Ex4	feedback linearization	2
Ex5	output trajectory tracking	2
Ex6	sliding control, optimal control	2
Ex7	final test	2
	Total hours:	15

Laboratory		**Number of hours**
Lab1	introduction to a software environment designed for numerical and symbolic computations	3

Lab2	modeling and numerical analysis of selected models of linear and nonlinear dynamical systems	2
Lab3	stability	2
Lab4	feedback linearization	2
Lab5	output trajectory tracking	2
Lab6	sliding control	2
Lab7	optimal control	2
	Total hours:	15

TEACHING TOOLS USED
N1. traditional and/or online lecture with use of real/virtual witeboard and multimedia tools
N2. calculus exercises in traditional form
N3. Computer exercises using software for numerical and symbolic calculations
N4. self-study
N5. office hours

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation: F — forming (during semester), C — concluding (at semester end)	Learning outcome code	Way of evaluating learning outcome achievement
F1	PEU_W01	written or oral final exam
F2	PEU_U01	final test
F3	PEU_U01	laboratory reports
P1(Lecture)=F1; P2(Exercises)=F2; P3(Laboratory)=F3		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] Jean-Jacques E. Slotine, Weiping Li, Applied Nonlinear Control, Prentice Hall International, Inc., 1991

[2] Riccardo Marino, Patrizio Tomei, Nonlinear Control Design. Geometric, Adaptive and Robust, Prentice Hall, 1995

[3] Thomas L. Vincent, Walter J. Grantham, Nonlinear and Optimal Control Systems, John Wiley & Sons, Inc., 1997

SECONDARY LITERATURE:

[1] Harry G. Kwatny, Gilmer L. Blankenship, Nonlinear Control and Analytical Mechanics. A Computational Approach. Birkhauser, 2000

[2] K. Tchoń and R. Muszyński. Mathematical Methods of Automation and Robotics. Department of Cybernetics and Robotics, Wrocaw University of Science and Technology, 2018.

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SUBJECT CARD

Name of subject in Polish: **Robotyka mobilna**
Name of subject in English: **Mobile robotics**
Main field of study (if applicable): **Control Engineering and Robotics (AiR)**
Specialization: **Embedded Robotics (AER)**
Profile: **academic**
Level and form of studies: **2nd level, full-time**
Kind of subject: **facultative**
Subject code: **W12AIR-SM0726**
Group of courses: **No**

	Lecture	Exercise	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15		30		
Number of hours of total student workload (CNPS)	30		90		
Form of crediting	Examination		Crediting with grade		
For group of courses mark (X) the final course					
Number of ECTS points	2		2		
including number of ECTS points for practical (P) classes			2.0		
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	1.2		2.0		

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. knowledge of elementary mathematics (probbility)
2. good programming skills required

SUBJECT OBJECTIVES

C1. Obtaining knowledge about the methods of robot localization
C2. Acquiring knowledge about the methods of mapping
C3. Development of the ability to implement algorithms for mobile robots

SUBJECT LEARNING OUTCOMES
Relating to knowledge: PEU_W01 - Students can name and explain typical problems of mobile robotics PEU_W02 - Students can characterize the methods of locating mobile robots PEU_W03 - Students can distinguish between the tasks of building maps and SLAM and characterize the basic algorithms Relating to skills: PEU_U01 - Students can solve the problem of self-localization of a mobile robot PEU_U02 - Students are able to develop and implement an algorithm for mapping by a mobile robot PEU_U03 - Students can use sensors and a map of the environment to navigate the robot PEU_U04 - Students are able to design and implement a system to navigate mobile robots in presence of obstacles

PROGRAM CONTENT		
Lecture		**Number of hours**
Lec1	Introduction. Applications and problems of mobile robots. Models of mobile robots.	1
Lec2	Review of mathematical tools used during the course	2
Lec3	Methods of filtration and fusion of data from sensors of mobile robots	2
Lec4	Robot localization: odometry, Markov models, EKF	2
Lec5	Mapping: metric, topological and hybrid maps	2
Lec6	Basics of SLAM: idea and methods	2
Lec7	The problem of exploration	2
Lec8	Current research trends in mobile robotics	2
	Total hours:	15

Laboratory		**Number of hours**
Lab1	Introduction and OHS in the laboratory. Communication in the ROS system with mobile robots	3
Lab2	Robot self-localization using incremental methods	3
Lab3	Marker based localization	3
Lab4	Data fusion in localization	6
Lab5	Mapping	6
Lab6	Robot motion planning	3
Lab7	Robot navigation using a constantly updated map	6
	Total hours:	30

TEACHING TOOLS USED
N1. Lecture N2. Laboratory classes N3. Consultation N4. Self education – self study and preparation for the final test

N5. Self education – preparation for laboratory classes

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation: F — forming (during semester), C — concluding (at semester end)	Learning outcome code	Way of evaluating learning outcome achievement
F1	PEU_U01 - PEU_U04	Oral answers, evaluation of the implementation of laboratory tasks, laboratory reports
F2	PEU_W01 - PEU_W03	Exam
P(lecture)=F2, P(laboratory)=F1		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] R.Siegwart, Introduction to Autonomous Mobile Robots, MIT Press, 2011.

[2] S.Thrun i in., Probabilistic robotics, MIT Press, 2006.

[3] A.Kelly, Mobile Robotics: Mathematics, Models, and Methods, Cambridge University Press, 2013.

SECONDARY LITERATURE:

[1] Handbook of robotics, Springer, 2008.

[2] M. Ben-Ari, F. Mondada, Elements of Robotics, Springer 2018.

[3] H.Choset et al, Principles of Robot Motion: Theory, Algorithms, and Implementations, A Bradford Book, 2005.

[4] The DARPA Urban Challenge, Springer, 2010.

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SUBJECT CARD

Name of subject in Polish: **Wybrane zagadnienia robotyki**
Name of subject in English: **Selected Topics in Robotics**
Main field of study (if applicable): **Control Engineering and Robotics (AiR)**
Specialization: **Electronic Control Systems (AEU)**
Profile: **academic**
Level and form of studies: **2nd level, full-time**
Kind of subject: **obligatory**
Subject code: **W12AIR-SM0208W**
Group of courses: **No**

	Lecture	Exercise	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	Crediting with grade				
For group of courses mark (X) the final course					
Number of ECTS points	2				
including number of ECTS points for practical (P) classes					
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	1.6				

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Knowledge in the field of robotics at the level of engineering studies in the field of Automation and Robotics

SUBJECT OBJECTIVES

C1. Acquisition of knowledge on modern methods of robotics in the field of modeling and control
C2. Understanding principles of operation of selected robotic devices
C3. Acquisition of knowledge on practical applications of robotic methods and devices

SUBJECT LEARNING OUTCOMES
Relating to knowledge: PEU_W01 - Has knowledge on selected topics of advanced robotic methods and devices

PROGRAM CONTENT		
Lecture		**Number of hours**
Lec1	Methodology of robotic systems design	5
Lec2	Methods of modelling a robot and its environoment	4
Lec3	Navigation and motiion planning of robots	6
Lec4	Robot control algorithms with applications	5
Lec5	Robot perception systems with applications	6
Lec6	Case study - from concept to implementation	2
Lec7	Final test	2
	Total hours:	30

TEACHING TOOLS USED
N1. Lecture with the use of blackboard and multimedia N2. Own work and consultations

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation: F — forming (during semester), C — concluding (at semester end)	Learning outcome code	Way of evaluating learning outcome achievement
F1	PEU_W01	test, assignment on selected topics, activity in the classroom
P(Lec) = F1		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] R. Siegwart, I.R. Nourbakhsh, D. Scaramuzza, Introduction to Autonomous Mobile Robots, The MIT Press, 2011

[2] S.M. LaValle, Planning algorithms, Cambridge Univ. Press, 2006

[3] C. Canudas de Wit, B. Siciliano, G. Bastin: Theory of Robot Control, Springer, Londyn, 1996.

[4] S. Miller, Theory of Machines and Mechanisms: Analysis of Kinematic Systems. Oficyna Wydawnicza Politechniki Wrocławskiej, 1996 (in Polish)

SECONDARY LITERATURE:

[1] B. Siciliano, O. Khatib, Handbook of robotics. Springer, 2008

[2] K. Tchoń et al., Manipulators and Mobile Robots: Modelling, Motion Planning, and Control, PLJ, Warszawa 2000 (in Polish)

[3] A. Gronowicz, Fundamentals of Kinematic Systems Analysis. Oficyna Wydawnicza Politechniki Wrocławskiej 2003 (in Polish)

SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)
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Faculty of Electronics, Fotonics and Microsystems (W12N) / Department of Field Theory, Electronic Circuits and Optoelectronics (K35W12ND02)

SUBJECT CARD

Name of subject in Polish: **Uczenie maszynowe**
Name of subject in English: **Machine learning**
Main field of study (if applicable): **Control Engineering and Robotics (AiR)**
Specialization: **Electronic Control Systems (AEU)**
Profile: **academic**
Level and form of studies: **2nd level, full-time**
Kind of subject: **obligatory**
Subject code: **W12AIR-SM0203**
Group of courses: **No**

	Lecture	Exercise	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15			30	
Number of hours of total student workload (CNPS)	60			60	
Form of crediting	Crediting with grade			Crediting with grade	
For group of courses mark (X) the final course					
Number of ECTS points	2			2	
including number of ECTS points for practical (P) classes				2.0	
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	1.0			1.5	

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

SUBJECT OBJECTIVES

C1. Be familiar with unsupervised learning methods
C2. Be familiar with supervised learning methods

SUBJECT LEARNING OUTCOMES
Relating to knowledge: PEU_W01 - lists and explains fundamental methods for dimensionality reduction and feature extraction PEU_W02 - lists and explains fundamental blind source separation methods for statistically independent signals PEU_W03 - lists and explains fundamental statistical classifiers PEU_W04 - lists and explains fundamental clustering methods Relating to skills: PEU_U01 - be able to reduce the dimensionality and extract features from analyzed data PEU_U02 - be able to select the right classifier to a given problem PEU_U03 - be able to find hidden structure in analyzed data PEU_U04 - be able to use selected blind source separation methods

PROGRAM CONTENT		
Lecture		**Number of hours**
LecW1	Dimensionality reduction methods: PCA	3
LecW2	Dimensionality reduction methods: NMF	3
LecW3	Multilinear dimensionality reduction methods	3
LecW4	Blind source separation methods for statistically independent signals	2
LecW5	Statistical classifiers and clustering methods	3
LecW6	Test	1
	Total hours:	15

Project		**Number of hours**
PrP1-P15	Projects covering various topics from the area of machine learning, including: multilinear feature extraction and dimensionality reduction methods, tensor networks, nonnegative matrix factorization, convolutional neural networks, radial neural networks, regression, statistical classifiers, clustering methods, blind source separation methods, etc.	30
	Total hours:	30

TEACHING TOOLS USED
N1. Lecture notes and slides N2. Project classes - implementation of machine learning algorithms in computational environment (Matlab, Python) N3. Example scripts of implemented algorithms N4. Consultation hours N5. Homework – preparation to project tasks N6. Homework – self-study of literature

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation: F — forming (during semester), C — concluding (at semester end)	Learning outcome code	Way of evaluating learning outcome achievement
F1	PEU_W01-04	Written exam
F2	PEU_U01-04	Project grade
P(Lect)=F1, P(Proj)=F2		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] Ch. M. Bishop, Pattern Recognition and Machine Learning, Springer, 2006

[2] J. Hopcroft, R. Kannan, Foundations of Data Science, E-book, 2014, http://www.ime.usp.br/ yoshi/TMP/Hopcroft-Kannan.pdf

[3] D. Barber, Bayesian Reasoning and Machine Learning, Cambridge University Press, 2012

[4] A. Cichocki, R. Zdunek, A. H. Phan, S.-I. Amari, Nonnegative Matrix and Tensor Factorization: Applications to Exploratory Multi-way Data Analysis and Blind Source Separation, Wiley and Sons, UK, 2009

[5] C. C. Aggarwal, Neural Networks and Deep Learning: A Textbook, Springer, 2018

SECONDARY LITERATURE:

[1] Latest papers from IEEE Xplore, Elsevier, Wiley, devoted to machine learning methods

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

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SUBJECT CARD

Name of subject in Polish: **Energoelektronika**
Name of subject in English: **Energy Electronics**
Main field of study (if applicable): **Control Engineering and Robotics (AiR)**
Specialization: **Electronic Control Systems (AEU)**
Profile: **academic**
Level and form of studies: **2nd level, full-time**
Kind of subject: **obligatory**
Subject code: **W12AIR-SM0210**
Group of courses: **No**

	Lecture	Exercise	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30		15		
Number of hours of total student workload (CNPS)	60		60		
Form of crediting	Crediting with grade		Crediting with grade		
For group of courses mark (X) the final course					
Number of ECTS points	2		2		
including number of ECTS points for practical (P) classes			2.0		
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	1.0		2.0		

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Basic knowledge of electronic circuits from a 1st-level study.

SUBJECT OBJECTIVES

C1. Gaining knowledge about electronic components and systems used in power electronics.

C2. Getting to know the principles of functioning of electric shock protection systems in low voltage installations.

C3. Getting to know the principles of testing low voltage electrical installations.

SUBJECT LEARNING OUTCOMES
Relating to knowledge: PEU_W01 - Defines, recognizes and describes the basic elements and systems of power electronics. PEU_W02 - Knows the effects of electric current on the human body, means of electric shock protection and its effectiveness criteria in low voltage installations. Relating to skills: PEU_U01 - Designs simple power electronics systems to control machines and devices. PEU_U02 - Be able to perform measurements on low voltage electrical installations, evaluate their results and prepare documentation. Relating to social competences: PEU_K01 - Works as part of a team to perform electrical system testing.

PROGRAM CONTENT		
Lecture		**Number of hours**
Lec1, 2	Basic elements of power electronics. Problems of heating and cooling high power electronic devices.	4
Lec3, 4	Measurement and control sensors of physical quantities.	4
Lec5, 6	Basics of designing drive systems	4
Lec7, 8	General characteristics of regulations and standards for the construction of electrical equipment, installations and networks.	4
Lec9,10,11	Protection against electric shock - technical means of protection. Protection against direct and indirect contact in network systems with voltage up to 1kV.	6
Lec12,13	Principles of operation and operating instructions for electrical power equipment, installations and networks.1kV	4
Lec14	Generation, transmission, distribution of electric energy. Electric power system and its parameters.	2
Lec15	Final test	2
	Total hours:	30

Laboratory		**Number of hours**
Lab1	Admission: - Familiarize students with the principles of safety in the laboratory; - Familiarize students with support equipment	1
Lab2,3,4	Fault loop impedance measurements. Measurement of protective conductor continuity. Insulation resistance wires. Measurements RCDs. Earth resistance measurements.	7
Lab5,6,7	Combining basic circuit low voltage electrical installations (way switches, circuit breakers cross, bistable switches, stair machines, dusk sensors, PIR motion detectors).	7
	Total hours:	15

TEACHING TOOLS USED
N1. Traditional and / or online lecture with the use of multimedia tools N2. Laboratory, performance and documentation of measurements N3. Own work - independent studies.

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation: F — forming (during semester), C — concluding (at semester end)	Learning outcome code	Way of evaluating learning outcome achievement
F1	PEU_W01, PEU_W02	Fnal test
F2	PEU_U01, PEU_U02	Evaluation of reports and activity in laboratory classes
P(Lec) = F1 P(Lab) = F2		

PRIMARY AND SECONDARY LITERATURE
PRIMARY LITERATURE: [1] M.P. Kaźmierkowski, R. Krishnan, F. Blaabjerg, Control in Power Electronics Selected Problems, San Diego: Academic Press, Elsevier Science, 2002, [2] The Electrical Engineering Handbook, Wai-Kai Chen, 2005 Elsevier Inc.

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SUBJECT CARD

Name of subject in Polish: **Sieci przemysłowe**
Name of subject in English: **Industria networks**
Main field of study (if applicable): **Control Engineering and Robotics (AiR)**
Specialization: **Electronic Control Systems (AEU)**
Profile: **academic**
Level and form of studies: **2nd level, full-time**
Kind of subject: **obligatory**
Subject code: **W12AIR-SM0204**
Group of courses: **No**

	Lecture	Exercise	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15		30		
Number of hours of total student workload (CNPS)	60		60		
Form of crediting	Crediting with grade		Crediting with grade		
For group of courses mark (X) the final course					
Number of ECTS points	2		2		
including number of ECTS points for practical (P) classes			1.0		
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	2.0		1.0		

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Basics of C programming

SUBJECT OBJECTIVES

C1. Learning communication methods between electronic modules used in industrial networks

C2. Gain design skills in designing an electronic module and using various transmission protocols to exchange data in industrial networks.

SUBJECT LEARNING OUTCOMES
Relating to knowledge: PEU_W01 - As a result of the course the student should be able to define and characterize basic communication protocols used in industrial networks. Relating to skills: PEU_U01 - As a result of the course, the student should be able to select, operate and implement basic communication protocols used in industrial networks.

PROGRAM CONTENT		
Lecture		**Number of hours**
Lec1	Introduction, basic information about industrial networks.	2
Lec2	Fundamentals of RS 232, RS 485. Transmission protocols Profibus DP and Profinet-IO.	3
Lec3	Modbus/TCP, Modbus/RTU, and EtherNet/IP protocols.	3
Lec4	Wireless communication systems in industrial networks.	2
Lec5	Basic transmission protocols for IoT - I2C, SPI, USB	2
Lec6	Current loop 4...20mA, CAN	2
Lec7	Final test	1
	Total hours:	15

Laboratory		**Number of hours**
Lab1	Introductory activities	3
Lab2	System design and transmission via RS 232	3
Lab3	System design and transmission via RS 485	3
Lab4	System design and transmission via ModBus 485/RTU	3
Lab5	Projekt układu i transmisja poprzez ModBus 485/ASCI	3
Lab6	Projekt układu i transmisja poprzez ModBus/TCP	3
Lab7	Circuit design and transmission via I2C	3
Lab8	Profibus and Profinet transmission.	3
Lab9	Circuit design and transmission via SPI	3
Lab10	Additional Term	3
	Total hours:	30

TEACHING TOOLS USED
N1. FIXME: Translate N2. FIXME: Translate

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation: F — forming (during semester), C — concluding (at semester end)	Learning outcome code	Way of evaluating learning outcome achievement
F1	PEU_W01	final test

F2	PEU_U01	evaluation of the implementation of laboratory activities
P(W) = F1; P(L)=F2		

PRIMARY AND SECONDARY LITERATURE
PRIMARY LITERATURE:
[1] Papers and webpages recommended by the teacher

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SUBJECT CARD

Name of subject in Polish: **Praktyczne aspekty przetwarzania sygnałów**
Name of subject in English: **Practical aspect of signal processing**
Main field of study (if applicable): **Control Engineering and Robotics (AiR)**
Specialization: **Electronic Control Systems (AEU)**
Profile: **academic**
Level and form of studies: **2nd level, full-time**
Kind of subject: **obligatory**
Subject code: **W12AIR-SM0209**
Group of courses: **No**

	Lecture	Exercise	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15		30		
Number of hours of total student workload (CNPS)	60		30		
Form of crediting	Crediting with grade		Crediting with grade		
For group of courses mark (X) the final course					
Number of ECTS points	2		1		
including number of ECTS points for practical (P) classes			1.0		
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	1.5		1.0		

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Basics of digital signal processing
2. Basics of C language programming
3. Basics of microcontroller program development tools

SUBJECT OBJECTIVES

C1. Getting to know the architecture and operation of DSP processing structures, in particular multi-core processors supporting DSP processing

C2. Learn and become skilled in using code generation tools, running signal processors and their environment

C3. Ability to identify and evaluate processor chip architectures that support signal processing and hardware to facilitate multi-core processor designsre to facilitate multi-core processor designs

SUBJECT LEARNING OUTCOMES
Relating to knowledge: PEU_W01 - As a result of the course, the student should be familiar with the architectures and operations of DSP processing structures, particularly ARM microcontrollers. Relating to skills: PEU_U01 - As a result of the classes the student should be able to use development tools starting from the installation stage through configuration and preparation to running and debugging the program

PROGRAM CONTENT		
Lecture		**Number of hours**
Lec1	Requirements, introduction to signal processing, peripheral tasks, introduction to DSP technology	2
Lec2	Basic architecture of DSP and DSC on the example of STM32 family, basic mechanisms of efficient operation. From analog world to vector digital representation of analog signal. Data representation in DSP, limitations, implications	2
Lec3	Space of time and frequency - Discrete Fourier Transform a useful tool - a connector of these two spaces. Accelerate signal analysis with the Fast FFT transform.	2
Lec4	IIR and IIR digital filters. Digital signal generation (DDS). Multirate systems - with variable sampling rate, mechanisms of changing the frequency of signal representation - decimation and interpolation. Possibilities, limitations.	2
Lec5	Linux in DSP processing. Using the system shell and Phyton and C languages in accessing peripherals.	2
Lec6	Using the OpenCV library to process images in a recognized environment.	2
Lec7	Neural networks in DSP processing.	2
Lec8	Final exam	1
	Total hours:	15

Laboratory		**Number of hours**
Lab1	Introduction to STM32CubeIDE and class rules presentation. First code run.	3
Lab2	Using of ADC on STM32 series processors using various sample conditioning techniques.	3
Lab3	ADC support in STM32 series processors using different sample generation techniques. Digital signal generation methods and their effect on the real signal. DDS technique and its implementation.	3
Lab4	Basic signal processing path, from ADC to DAC. Signal filtering methods in DSP systems.	3
Lab5	Fast Fourier Transform.	3
Lab6	Introduction to digital signal processing in operating systems using the Python language.	3
Lab7	Vision systems using OpenCV libraries.	3
Lab8	Neural networks - perceptron	3

Lab9,10	Convolutional Neural Network - image classification	6
	Total hours:	30

TEACHING TOOLS USED
N1. A traditional and/or online lecture using multimedia tools
N2. Computer-based lab, materials on course website
N3. Consultation of problems by the lecturer
N4. Laboratory exercises ending with a report
N5. Own work - independent studies and preparation for a credit test
N6. Individual studies of technical documentation

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation: F — forming (during semester), C — concluding (at semester end)	Learning outcome code	Way of evaluating learning outcome achievement
F1	PEU_W01	colloquium
F2	PEU_U01	Reports and activity at laboratory exercises
P(Lect) = F1, P(Lab) = F2		

PRIMARY AND SECONDARY LITERATURE
PRIMARY LITERATURE:
[1] S. Furber: ARM System-on-chip architecture. 2 edition, Addison-Wesley Publishers, 2000, ISBN - 978-0201675191
[2] Understanding-digital-signal-processing. 3-th.Ed.- Richard-G. Lyons [Available Polish translation – „Wprowadzenie do cyfrowego przetwarzania sygnałów"; Richard G. Lyons; WKŁ 2010]
[3] The Scientist and Engineer's Guide to DSP- S.W.Smith [Available Polish translation – „Cyfrowe przetwarzania sygnałów. Praktyczny poradnik dla inżynierów i naukowców"; Steven W. Smith; BTC]

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Faculty of Electronics, Fotonics and Microsystems (W12N) / Department of Acoustics, Multimedia and Signal Processing (K76W12ND02)

SUBJECT CARD

Name of subject in Polish: **Badania operacyjne w automatyce**
Name of subject in English: **Operations research in control theory**
Main field of study (if applicable): **Control Engineering and Robotics (AiR)**
Specialization: **Electronic Control Systems (AEU)**
Profile: **academic**
Level and form of studies: **2nd level, full-time**
Kind of subject: **obligatory**
Subject code: **W12AIR-SM0206**
Group of courses: **No**

	Lecture	Exercise	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15		30		
Number of hours of total student workload (CNPS)	30		60		
Form of crediting	Crediting with grade		Crediting with grade		
For group of courses mark (X) the final course					
Number of ECTS points	1		2		
including number of ECTS points for practical (P) classes			2.0		
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	0.5		1.6		

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. knowledge of elementary mathematics (algebra, logics)
2. good programming skills required

SUBJECT OBJECTIVES

C01. Getting a knowledge about metaheuristics
C02. Getting skills how to solve complex optimization problems using new, efficient methods

SUBJECT LEARNING OUTCOMES
Relating to knowledge: PEU_W01 - knows methods of solving complex optimization problems Relating to skills: PEU_U01 - is able to built apps based on known metaheuristic algorithms

PROGRAM CONTENT		
Lecture		**Number of hours**
Lec1	Introduction, a brief reminder of basic knowledge in the field of optimization	1
Lec2	Optimization problems in control theory: continuous, discrete, continuous-discrete, examples, mathematical description	2
Lec3	Genetic algorithms and evolutionary strategies	2
Lec4	Swarms and colonies	2
Lec5	Hybrid algorithms	2
Lec6	Metahuristics in control theory and robotics	4
Lec7	Summary and written exam	2
	Total hours:	15

Laboratory		**Number of hours**
Lab1	Introduction, rules. Analysis of chosen basic combinatorial problem.	2
Lab2	Design and analysis of basic local search algorithms for chosen discrete and continuous problems.	4
Lab3	Design and analysis of basic genetic algorithms for chosen discrete and continuous problems.	4
Lab4	Design and analysis of basic swarm/colony algorithms for chosen discrete and continuous problems.	4
Lab5	Design and analysis of hybrid algorithms for chosen discrete and continuous problems.	6
Lab6	Design and implementation of chosen metaheuristic algorithm for given optimization problem.	10
	Total hours:	30

TEACHING TOOLS USED
N1. Traditional form of a lecture with multimedia presentations N2. Lab classes with computers, course materials available on a webpage N3. self work - literature study

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation: F — forming (during semester), C — concluding (at semester end)	Learning outcome code	Way of evaluating learning outcome achievement
F1	PEU_W01	Written examination at the last lecture

F2	PEU_U01	Evaluation of the performance of laboratory assignments.
P(Lec)=F1, P(Lab)=F2		

PRIMARY AND SECONDARY LITERATURE
PRIMARY LITERATURE:
[1] Operations Research: Applications and Algorithms, 4th Edition, Wayne Winston
[2] Operations Research: An Introduction, 9th Edition, Hamdy Taha
[3] Metaheuristic and Evolutionary Computation: Algorithms and Applications, Hasmat Malik, Atif Iqbal, Puneet Joshi, Sanjay Agrawal, Farhad Ilahi Bakhsh

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Faculty of Electronics, Fotonics and Microsystems (W12N) / Department of Field Theory, Electronic Circuits and Optoelectronics (K35W12ND02)

SUBJECT CARD

Name of subject in Polish: **Elektronika automatyki przemysłowej**
Name of subject in English: **Industrial Automation Electronics**
Main field of study (if applicable): **Control Engineering and Robotics (AiR)**
Specialization: **Electronic Control Systems (AEU)**
Profile: **academic**
Level and form of studies: **2nd level, full-time**
Kind of subject: **obligatory**
Subject code: **W12AIR-SM0205**
Group of courses: **No**

	Lecture	Exercise	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15		30	15	
Number of hours of total student workload (CNPS)	60		60	60	
Form of crediting	Examination		Crediting with grade	Crediting with grade	
For group of courses mark (X) the final course					
Number of ECTS points	2		2	2	
including number of ECTS points for practical (P) classes			2.0	2.0	
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	0.6		1.1	1.6	

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Basic knowledge of electronic circuits from a 1st-level study.

SUBJECT OBJECTIVES

C1. Gain knowledge of electronic components and circuits used in industrial automation.

C2. Gain knowledge of noise and interference sources in electronic circuits, how to reduce them, and their effect on signal integrity.

C3. Gain skills in analog circuit design and laboratory experiments using advanced measurement equipment.

SUBJECT LEARNING OUTCOMES
Relating to knowledge: PEU_W01 - As a result of the classes, the student should be able to define, recognize and describe essential components and electronic systems of industrial automation. In addition, the student will be able to define the sources of noise and interference in electronic circuits and explain ways to reduce them. Relating to skills: PEU_U01 - As a result of the classes, the student should be able to carry out laboratory experiments using advanced measuring equipment for complex electronic circuits. PEU_U02 - A student should be able to correctly design and select the configuration of analog circuits cooperating with a digital system, considering the problems of interference reduction and resistance to external interference.

PROGRAM CONTENT		
Lecture		**Number of hours**
Lec1	Introduction. Analog electronics and measurement systems such as sensors, analog signal conditioning, and ”front-end” systems are used in industrial automation.	6
Lec2	Analog-to-digital and digital-to-analog processing of measurement signals.	1
Lec3	Electrical automation execution systems; Power factor.	1
Lec4	Fundamental EMC issues; Legal regulations on electromagnetic interference emissions; Protection of the electromagnetic environment.	2
Lec5	Interference sources and paths of their penetration; Signal integrity in electronic circuits design aspects: balancing, filtering, grounding; RFI elements: shielding, connector protection; Interference in digital circuits - reduction of emission; Electrostatic and atmospheric discharge - protection.	4
Lec6	Summary.	1
	Total hours:	15

Laboratory		**Number of hours**
Lab1	Four laboratory exercises to choose from: Power factor measurement; Stepper motor controller; Phase synchronization circuit (PLL); MEMS pressure sensor with ADC; Operational amplifier - measurement amplifier; ”front-end” circuits - transconductance amplifier; ”front-end” circuits - measurement amplifier; Optoelectronics - light sources; Optoelectronics - photodetectors; Electromechanical and SSR relays; Permanent magnet DC motor; Biomedical sensors; Gas sensors; Basic communication interfaces (SPI, I2C, UART).	15
Lab2	Four lab exercises selected from: PCB design and signal integrity - path routing relative to the ground, radiation, crosstalk, signal path branching change in path impedance, ground routing, power routing to ICs; Resonant frequencies of different types of capacitors; Coaxial cables - shielding quality (transfer impedance); Resonant frequencies of different types of capacitors; Resonant frequencies of capacitors depending on mounting and value; Effectiveness of noise filters.	15
	Total hours:	30

Project		Number of hours
Pr1	Design of a "front-end" circuit of a selected type of sensor, taking into account the type of measurement interface and execution system (electromagnetic relay, electric stepper motor (BLCD, PM, and others). Prevention of EMI emissions and ways to increase the immunity of devices to interference.	15
	Total hours:	15

TEACHING TOOLS USED
N1. - Traditional and/or online lectures using multimedia tools.
N2. - Laboratory stations are equipped with, among others, a digital oscilloscope, DDS generator, power quality meter, stepper motor controller with microprocessor circuit, optical spectrum analyzer, spectrum analyzer up to 6GHz, specialized PCBs with measuring circuits, and laboratory materials (PCBs, electronic components, tools, etc.)
N3. - Students' work.
N4. - Consultations.

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation: F — forming (during semester), C — concluding (at semester end)	Learning outcome code	Way of evaluating learning outcome achievement
F1	PEU_W01	Exam
F2	PEU_U01	Reports of laboratories conducted.
F3	PEU_U02	Present a self-made electronic circuit design.
P(Lect)=F1; P(Lab)=F2; P(Proj)=F3		

PRIMARY AND SECONDARY LITERATURE
PRIMARY LITERATURE:
[1] H.W.Ott, Electromagnetic Compatibility, WILEY, 2009 U. Tietze, Ch. Schenk, Electronic circuits. Handbook for Design and Application, Springer, 2009. P. Horowitz, W. Hill, The Art. Of Electronics, Cambridge University Press 2015
SECONDARY LITERATURE:
[1] C. Kitchin, L. Counts, A Designer's Guide To Instrumentation Amplifiers, Analog Devices,3rd edition, 2006. A. Pressman , K. Billings, T. Morey, Switching Power Supply Design, McGraw-Hill T. Wiliams, EMC for Product Designers, 4th edition, ELSEVIER, 2009 M.I. Monterose, Printed Circuit Board Design Techniques for EMC Compliance, Wiley, 2012 References given during lectures

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Faculty of Electronics, Fotonics and Microsystems (W12N) / Department of Field Theory, Electronic Circuits and Optoelectronics (K35W12ND02)

SUBJECT CARD

Name of subject in Polish: **Sterowniki programowalne**
Name of subject in English: **Programmable Controllers**
Main field of study (if applicable): **Control Engineering and Robotics (AiR)**
Specialization: **Electronic Control Systems (AEU)**
Profile: **academic**
Level and form of studies: **2nd level, full-time**
Kind of subject: **obligatory**
Subject code: **W12AIR-SM0201**
Group of courses: **No**

	Lecture	Exercise	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30		30		
Number of hours of total student workload (CNPS)	90		60		
Form of crediting	Examination		Crediting with grade		
For group of courses mark (X) the final course					
Number of ECTS points	3		2		
including number of ECTS points for practical (P) classes			2.0		
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	2.0		1.0		

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Programming in C/C++
2. Basic digital electronics
3. Electronic circuits
4. Calculus I

SUBJECT OBJECTIVES

C1. Gaining skills for programming real-time systems
C2. Gaining understanding of basic issues related to practical implementation of real-time systems
C3. Understand the design and programming of programmable logic controllers (PLCs)

SUBJECT LEARNING OUTCOMES
Relating to knowledge: PEU_W01 - has knowledge about structure of modern embedded programming toolchains PEU_W02 - has knowledge about basic software architecture for real-time embedded systems PEU_W03 - Has knowledge of the design and programming of programmable logic controllers (PLCs) Relating to skills: PEU_U01 - can use integrated development environments to create practical embedded applications PEU_U02 - can efficiently use documentation for modern 32-bit microcontrollers PEU_U03 - can design architecture for a basic real-time program PEU_U04 - knows how to use programmable controllers

PROGRAM CONTENT		
Lecture		**Number of hours**
Lec1-2	Introductory Lecture. Overview of the program content. Instroduction to programmable controllers	4
Lec3-5	Construction of programmable controllers - microprocessors, microcontrollers, programmable systems FPGA and SoC, power supplies, sensors, signal conditioning circuits	6
Lec6-7	Overview and comparison of the main MCU cores of 8-, 16- and 32-bit microcontroller families. ARM cores. FPGA and SoC units.	4
Lec8	Mid-semester colloquium	2
Lec9-10	Advanced microcontroller peripherals. Communication peripherals. Timing peripherals. Analog peripheries. Security peripherals.	4
Lec11-12	Real-time system software architecture. Multitasking in microcontrollers. Implementation of cooperative multitasking and multitasking with preemption	4
Lec13-14	Programming languages of PLC programmable controllers	4
Lec15	Summary of lectures	2
	Total hours:	30

Laboratory		**Number of hours**
Lab1	Introduction, getting to know the tools	2
Lab2-3	Writing libraries for devices on the development kit	4
Lab4-5	Developing a solution for the first practical problem (basic control of the robot)	4
Lab6-10	Developing a solution for the second practical problem (regulation and sensors)	10
Lab11-15	Developing a solution for the third practical problem (data processing and decision making)	10
	Total hours:	30

TEACHING TOOLS USED
N1. Laboratory exercises on a development kit
N2. Laboratory, solving particular engineering issues on a development kit
N3. Own work, preparation fot the laboratory exercises
N4. Traditional lecture with multimedia presentations
N5. Self-work - independent study.

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation: F — forming (during semester), C — concluding (at semester end)	Learning outcome code	Way of evaluating learning outcome achievement
F1	PEU_W01 - PEU_W02 + PEU_W03	Exam
F2	PEU_U01 + PEU_U02 + PEU_U03 + PEU_U04	evaluation of the results of exercises in the form of programs
P(Lec) = F1, P(Lab) = F2		

PRIMARY AND SECONDARY LITERATURE
PRIMARY LITERATURE:
[1] The Art of Electronics / Sztuka Elektroniki (Paul Horowitz)
[2] Wstęp do Programowania Sterowników PLC (Sałat Robert , Korpysz Krzysztof , Obstawski Paweł) (in Polish)

SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)
Grzegorz Budzyń, grzegorz.budzyn@pwr.edu.pl;Jakub Mnich, jakub.mnich@pwr.edu.pl

Faculty of Electronics, Fotonics and Microsystems (W12N) / Department of Field Theory, Electronic Circuits and Optoelectronics (K35W12ND02)

SUBJECT CARD

Name of subject in Polish: **Elementy i systemy optyczne**
Name of subject in English: **Optical Components and Systems**
Main field of study (if applicable): **Control Engineering and Robotics (AiR)**
Specialization: **Electronic Control Systems (AEU)**
Profile: **academic**
Level and form of studies: **2nd level, full-time**
Kind of subject: **obligatory**
Subject code: **W12AIR-SM0202**
Group of courses: **No**

	Lecture	Exercise	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15		15		15
Number of hours of total student workload (CNPS)	60		30		30
Form of crediting	Crediting with grade		Crediting with grade		Crediting with grade
For group of courses mark (X) the final course					
Number of ECTS points	2		1		1
including number of ECTS points for practical (P) classes			1.0		1.0
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	1.5		1.0		1.0

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

SUBJECT OBJECTIVES

C1. Learning the basics of optics. Wave and geometrical optics.

C2. To learn about basic passive and active optical elements. Understand the phenomena occurring in them.

C3. To understand the issues related to light propagation in optical fiber. To learn about fiber optic technology, basic types of optical fibers and their parameters.

C4. Introduction to the basics of laser technology. Introduction to the most commonly used types of lasers and their parameters.

C5. Master the ability to acquire knowledge from scholarly materials published in English.

SUBJECT LEARNING OUTCOMES
Relating to knowledge: PEU_W01 - Has knowledge of the basics of optics. Knows passive and active optical components and their parameters. Knows the propagation principle of optical fibres and understands their phenomena. Knows the types of optical fibres and their applications. Can describe the principle of operation of a laser. Knows the basic types of lasers and their applications. Relating to skills: PEU_U01 - Can carry out a simple experiment in optics, laser, and fibre optics. Is able to analyze the results of the experiment and interpret them appropriately. PEU_U02 - Able to find the necessary information in the literature and prepare a presentation based on that information and present it.

PROGRAM CONTENT		
Lecture		**Number of hours**
Lec1	Introduction to the optics. Light propagation. Wave and ray optics.	3
Lec2	Basic passive optical components. Their parameters and applications.	1
Lec3	Active optical components. Photodetectors, light sources, modulators.	3
Lec4	Introduction to optical communications. Optical fibers basics.	2
Lec5	Basics of laser technology. main laser types.	2
Lec6	Lasers applications. Metrology, laser machining, medicine.	2
Lec7	Non-telecom optical fibers applications. Fiber sensors. High power fibers.	2
	Total hours:	15

Laboratory		**Number of hours**
Lab1	Organizational activities. Safety of working with lasers and fiber optics.	1
Lab2	Semiconductor laser. Parameters, characteristics. Direct modulation of the laser.	2
Lab3	He-Ne lasers. Modes of laser radiation, diffraction, and propagation of laser beams.	2
Lab4	Pulsed fiber laser. Characteristics and parameters.	2
Lab5	Interferometry. Michelson interferometer.	2
Lab6	Plotter micromachining system.	2
Lab7	Galvo-scan micromachining system.	2
Lab8	Compensatory term.	2
	Total hours:	15

Seminar		Number of hours
Sem0	Organizational meeting. Discussion of the topics. Assignment of topics to be presented.	2
Sem1	The first round of presentations. Basic topics: optical components, lenses, prisms, mirrors, detectors, and light sources. Parameters and applications.	6
Sem2	The second round of presentations. Advanced topics: advanced optical and optoelectronic systems. Lasers, fibers, and their applications.	7
	Total hours:	15

TEACHING TOOLS USED
N1. Lecture delivered using multimedia presentation.
N2. Laboratory stations equipped with the necessary equipment.
N3. Laboratory classes - making measurements, independent interpretation of results.
N4. Student's own work, independent literature studies.
N5. Student's own work, preparation of a seminar presentation.

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation: F — forming (during semester), C — concluding (at semester end)	Learning outcome code	Way of evaluating learning outcome achievement
F1	PEU_W01	Lecture credit test.
F2	PEU_U01	Average of partial grades for lab exercise reports.
F3	PEU_U02	Evaluation for the technical and substantive side of the seminar presentation. Aesthetics of the presentation, efficiency of the presentation.
P(Lec) = F1, P(Lab)=F2, P(Sem)=F3		

PRIMARY AND SECONDARY LITERATURE
PRIMARY LITERATURE:
[1] B. Ziętek, Optoelektronika, Wydaw. Uniwersytetu Mikołaja Kopernika, Toruń, 2011
[2] J. E. Midwinter, Y. L. Guo, Optoelektronika i technika światłowodowa, WKiŁ, Warszawa 1995
[3] J. Siuzdak Systemy i sieci fotoniczne WKiŁ,2009
[4] Z. Kaczmarek Światłowodowe czujniki i przetworniki pomiarowe Wydawnictwo PAK, 2008
SECONDARY LITERATURE:
[1] A. Rogalski, Z. Bielecki, Detekcja sygnałów optycznych, Wydawnictwo Naukowe PWN, 2020
[2] F. Träger, Handbook of Lasers and Optics, Springer, 2007

SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)
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Faculty of Electronics, Fotonics and Microsystems (W12N) / Department of Cybernetics and Robotics (K29W12ND02)

SUBJECT CARD

Name of subject in Polish: **Sterowanie zdarzeniowe**
Name of subject in English: **Event-based Control**
Main field of study (if applicable): **Control Engineering and Robotics (AiR)**
Specialization: **Embedded Robotics (AER)**
Profile: **academic**
Level and form of studies: **2nd level, full-time**
Kind of subject: **facultative**
Subject code: **W12AIR-SM0725**
Group of courses: **No**

	Lecture	Exercise	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15			15	
Number of hours of total student workload (CNPS)	60			30	
Form of crediting	Crediting with grade			Crediting with grade	
For group of courses mark (X) the final course					
Number of ECTS points	2			1	
including number of ECTS points for practical (P) classes				1.0	
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	1.2			0.7	

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. No requirements concerning the second level.

SUBJECT OBJECTIVES

C1. Acquirement of the basic knowledge of the Discrete Event System (DES) theory and its applications, including the concepts of formal languages, finite state automata, and Petri nets.

C2. Acquirement of the ability to apply the theory of DES in the modeling of robotics and automation systems as well as the design and development of the supervisory control.

SUBJECT LEARNING OUTCOMES
Relating to knowledge: PEU_W01 - Knows the basic formalisms for modeling discrete event systems (DES), including Petri nets and finite state automata. PEU_W02 - Understands the supervisory control synthesis based on DES models and its application in selected automation and robotics systems. Relating to skills: PEU_U01 - Can create DES models of complex systems and develop supervisory control for them.

PROGRAM CONTENT		
Lecture		**Number of hours**
Lec1	Introduction to Discrete Event Systems (DES). Event-based control: a new modeling and control paradigm.	2
Lec2	Network DES models: Petri nets of the place / transition type. Graphical and algebraic representation.	2
Lec3	High level Petri nets: predicate and colored nets.	2
Lec4	Automation of DES model synthesis. RAS systems (Resource Allocation Systems). Problems of ensuring the correctness and effectiveness of control.	2
Lec5	Supervisory control systems for material concurrent processes in FMS (Flexible Manufacturing System). Algorithms for ensuring system liveness.	2
Lec6	Formally correct overriding control in MMRS (Multiple Mobile Robot System). Centralized and distributed systems.	4
Lec7	Summary (colloquium).	1
	Total hours:	15

Project		**Number of hours**
Pr1	Presentation of the content and organization of the project: team work, model construction and computer implementation of supervisory control for the selected system of complex processes in automation. Division into project groups and presentation of the required structure of the initial project description (problem, approach, task list, schedule, responsible persons).	2
Pr2	Development of the object model, control algorithms and object simulator. Documentation in the form of a partial report.	4
Pr3	Computer implementation of the control system and object simulator. Documentation in the form of a partial report.	6
Pr4	Demonstration of project results and final report.	3
	Total hours:	15

TEACHING TOOLS USED
N1. Traditional and/or online lecture with use of multimedia tools N2. Project classes N3. Office hours N4. Own work - self study and preparation for the final exam N5. Own work - developing the project

N6. WUST e-learning platform (http://eportal.pwr.edu.pl)

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation: F — forming (during semester), C — concluding (at semester end)	Learning outcome code	Way of evaluating learning outcome achievement
F1	PEU_W01 ÷ PEU_W02	the final test
F2	PEU_U01	Evaluation of the project proposal (initial description of the project), of the project development process, and of the project result
P(lecture)=F1; P(project)=F2		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] C.G. Cassandras, S. Lafortune, Introduction to Discrete Event Systems, Kluwer Academic Publishers, 1999. Rozdziały 1 - 5.

[2] R. David, H. Alla, Petri Nets and Grafcet: tools for modeling discrete event systems, Prentice Hall, 1992, selected chapters.

SECONDARY LITERATURE:

[1] W. Reisig, Sieci Petriego, WNT, 1988.

[2] M. Szpyrka, Sieci Petriego w modelowaniu i analizie systemów współbieżnych, WNT, 2008.

[3] S.A. Reveliotis, Real - Time Management of Resource Allocation Systems: A Discrete - Event Systems Approach , Springer, NY, 2005.

[4] W.M. Wonham, Supervisory Control of Discrete Event Systems, http://www.control.utoronto.ca/cgi-bin/dldes.cgi.

[5] M.C. Zhou, M.P. Fanti (editors), Deadlock Resolution in Computer - Integrated Systems, Marcel Dekker, 2005.

[6] IEEE Transactions on Automatic Control

[7] IEEE Transactions on Automation Science and Engineering

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

Katarzyna Zadarnowska, katarzyna.zadarnowska@pwr.edu.pl

Faculty of Electronics, Fotonics and Microsystems (W12N) / Department of Electronic and Photonic Metrology (K31W12ND02)

SUBJECT CARD

Name of subject in Polish: **Inteligentna wirtualizacja systemów i automatyzacja procesów**
Name of subject in English: **Intelligent virtualization of systems and process automation**
Main field of study (if applicable): **Control Engineering and Robotics (AiR)**
Profile: **academic**
Level and form of studies: **2nd level, full-time**
Kind of subject: **obligatory**
Subject code: **W12AIR-SM0722**
Group of courses: **No**

	Lecture	Exercise	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15			30	
Number of hours of total student workload (CNPS)	60			60	
Form of crediting	Examination			Crediting with grade	
For group of courses mark (X) the final course					
Number of ECTS points	2			2	
including number of ECTS points for practical (P) classes				2.0	
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	1.2			1.6	

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. System-oriented knowledge, knowledge and skills in calculus, mathematical statistics and programming (e.g. Matlab, Python, C++)

SUBJECT OBJECTIVES

C1. Obtaining a fundamental knowledge on virtualization and automation of technical systems, optimization methods, fundamentals on artificial intelligence (AI) methods, criteria for selection of an optimal AI algorithm for a given technical task, typical applications of artificial intelligence methods.

C2. Earning the skills in the selection and application of artificial intelligence methods to a selected technical task related to intelligent virtualization of the system and/or process automation

SUBJECT LEARNING OUTCOMES
Relating to knowledge: PEU_W01 - As a result of the course, the student should be able to describe a practical problem requiring the use of intelligent methods for system virtualization and/or process automation and is able to describe methods for selecting appropriate algorithms to solve it. Relating to skills: PEU_U01 - As a result of the course, the student should be able to formulate a practical problem requiring the use of intelligent methods for system virtualization and/or process automation, outline a plan for its solution, apply the selected method for intelligent modeling of data and systems, and interpret the obtained results.

PROGRAM CONTENT		
Lecture		**Number of hours**
Lec1	Introduction to the lecture contents, requirements and form of evaluation.	1
Lec2	State-of-the-art on system virtualization and process automation. The role of artificial intelligence methods in systems virtualization and process automation.	2
Lec3	Optimization in solving system virtualization and process automation tasks. Extracting knowledge from data.	2
Lec4	Programming tools and libraries dedicated to designing and implementation of the artificial intelligence methods - the perspective of system virtualization and process automation. Application maintenance.	2
Lec5	Artificial neural networks for system virtualization and process automation.	2
Lec6	Fuzzy logic and genetic algorithms in system virtualization and process automation.	2
Lec7	Boosting and bagging, decision trees in system virtualization and process automation tasks. Decision support systems.	2
Lec8	Lecture summary	2
	Total hours:	15

Project		**Number of hours**
Pr1	Introduction to project meetings, the outline on project topics, requirements and form of obtaining a credit, OHS regulations.	2
Pr2	Project topic selection.	2
Pr3	Literature study on a selected topic of the project. Proposal of a conception for project realization.	4
Pr4	Selection of a software tools for project realization.	2
Pr5	Software deveopment implementing the defined project topic.	10
Pr6	Validation of the software that implements the project objective.	2
Pr7	Analysis of the results obtained for the project scope.	2
Pr8	Written report on realized project tasks and obtained results.	4
Pr9	Summary on realizaed projects, projects evaluation.	2
	Total hours:	30

TEACHING TOOLS USED
N1. Traditional and/or online lecture supported with multimedia tools
N2. Project - discussion of a selected technical problem, progress of work and results obtained
N3. Self-studies - preparation for project sessions.
N4. Verification of the acquired knowledge and skills in written or oral form.

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation: F — forming (during semester), C — concluding (at semester end)	Learning outcome code	Way of evaluating learning outcome achievement
F1	PEU_W01	A final test in a written form
F2	PEU_U01	Oral answers, discussions of solved problems, written report on the implementation and obtained results of project tasks
P(Lecture) = F1 ; P(Project) = F2		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] Oguchi N., Katagiri, T., Kazuki M., Wang X., Sekiya M.: Virtualization and softwarization technologies for end-to-end networking. Fujitsu Sci. Technol. J., Vol. 53, No. 5, pp. 78-87, 2017.

[2] Salahuddin M., Al-Fuqaha A., Guizani M., Shuaib K.: Softwarization of Internet of Things infrastructure for secure and smart healthcare, Computer, Vol. 50, No. 7, pp. 74-79, 2017.

[3] Blenk A., Basta A., Reisslein M., Kellerer W.: A survey on network virtualization hypervisors for software defined networking, IEEE Commun. Surveys Tuts., Vol. 18, No. 1, pp. 655-685, 2016

[4] Lake D., Wang N., Tafazolli R., Samuel L.: Softwarization of 5G networks - implications to open platforms and standardization, IEEE Access, Vol.9, 88902-88930, 2021.

[5] Bonaccorso G.:Mastering machine learning algorithms, Packt Publishing, Birmingham-Mumbai, 2020.

SECONDARY LITERATURE:

[1] Flasiński M.: Wstęp do sztucznej inteligencji, PWN, Warszawa 2011.

[2] Goldberg D.: Algorytmy genetyczne i ich zastosowania, WNT, Warszawa 2003

[3] Osowski S.: Sieci neuronowe do przetwarzania informacji, Oficyna Wydawnicza Politechniki Warszawskiej, Warszawa 2006

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Ireneusz Jabłoński, ireneusz.jablonski@pwr.edu.pl

Faculty of Electronics, Fotonics and Microsystems (W12N) / K71W12ND02 (K71W12ND02)

SUBJECT CARD

Name of subject in Polish: **Sensory**
Name of subject in English: **Sensors**
Main field of study (if applicable): **Control Engineering and Robotics (AiR)**
Specialization: **Electronic Control Systems (AEU)**
Profile: **academic**
Level and form of studies: **2nd level, full-time**
Kind of subject: **obligatory**
Subject code: **W12AIR-SM0200**
Group of courses: **No**

	Lecture	Exercise	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15		15		
Number of hours of total student workload (CNPS)	30		30		
Form of crediting	Crediting with grade		Crediting with grade		
For group of courses mark (X) the final course					
Number of ECTS points	1		1		
including number of ECTS points for practical (P) classes			1.0		
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	0.6		1.0		

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Basic knowledge of physics

SUBJECT OBJECTIVES

C1. Acquiring knowledge on the principles of operation, structures and technologies of manufacturing sensors of physical quantities

C2. Acquiring the ability to analyze the structure and characteristics of sensors

C3. Participation in the research on the parameters of sensor structures developed at the Faculty

SUBJECT LEARNING OUTCOMES
Relating to knowledge: PEU_W01 - Student knows the principle of operation, construction and the basics of technology used to produce sensors of physical quantities PEU_W02 - Student knows the classification, principle of operation and basic parameters of temperature, flow, pressure and acceleration sensors Relating to skills: PEU_U01 - Student can analyze the processing characteristics and define the basic parameters of sensors of the indicated physical quantities Relating to social competences: PEU_K01 - Student understands the need to use sensors to improve safety, automate processes in various fields of technology, as well as increase the comfort of human activity.

PROGRAM CONTENT		
Lecture		**Number of hours**
Lec1	Introduction. Resistive temperature sensors	2
Lec2	Thermoelectric temperature sensors	2
Lec3	Sensors for measuring infrared radiation	2
Lec4	Flow sensors	2
Lec5	Stress and strain sensors	2
Lec6	Pressure sensors	2
Lec7	Acceleration sensors	2
Lec8	Final test	1
	Total hours:	15

Laboratory		**Number of hours**
Lab1	Temperature sensors	3
Lab2	Flow sensors	3
Lab3	Acceleration sensors	3
Lab4	Stress and pressure sensors	3
Lab5	Term for carrying out an overdue exercise	3
	Total hours:	15

TEACHING TOOLS USED
N1. Traditional lecture with the use of multimedia presentations
N2. Independent work - self study and preparation for the final test
N3. Laboratory stands with setups for the characterization of sensors
N4. Independent work - theoretical preparation for laboratory classes

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation: F — forming (during semester), C — concluding (at semester end)	Learning outcome code	Way of evaluating learning outcome achievement
F1	PEU_W01, PEU_K01	Final test
F2	PEU_U01	Grade on report on completed tasks on laboratories
F3	PEU_W02	Grade on theoretical preparation for the laboratory
P(Lec) = F1 P(Lab)= 0.5*F2 + 0.5*F3 (in order to pass the laboratory, both F2 and F3 must be positive)		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] Jörg Scholz (Volume Editor), Teresio Ricolfi (Volume Editor), Wolfgang Göpel (Editor), Joachim Hesse (Editor), J. N. Zemel (Editor), Sensors, A Comprehensive Survey, Volume 4, Thermal Sensors, ISBN: 978-3-527-62046-3 July 2008

[2] H. Bau (Volume Editor), N. F. DeRooij (Volume Editor), B. Kloeck (Volume Editor), Wolfgang Göpel (Editor), Joachim Hesse (Editor), J. N. Zemel (Editor), Sensors, A Comprehensive Survey, Volume 7, Mechanical Sensors, ISBN: 978-3-527-62020-3 March 2008

[3] Wacław Gawędzki, Electrical measurements of non-electrical quantities (in Polish), Wydawnictwa AGH, Kraków 2010

SECONDARY LITERATURE:

[1] Articles in scientific journals, eg. Sensors, Sensors and Actuators A: Physical

[2] Materials from international conference Eurosensors

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

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Faculty of Electronics, Fotonics and Microsystems (W12N) / Department of Electronic and Photonic Metrology (K31W12ND02)

SUBJECT CARD

Name of subject in Polish: **Inteligentna wirtualizacja systemów i automatyzacja procesów**
Name of subject in English: **Intelligent virtualization of systems and process automation**
Main field of study (if applicable): **Control Engineering and Robotics (AiR)**
Profile: **academic**
Level and form of studies: **2nd level, full-time**
Kind of subject: **obligatory**
Subject code: **W12AIR-SM0006**
Group of courses: **No**

	Lecture	Exercise	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15			30	
Number of hours of total student workload (CNPS)	60			60	
Form of crediting	Examination			Crediting with grade	
For group of courses mark (X) the final course					
Number of ECTS points	2			2	
including number of ECTS points for practical (P) classes				2.0	
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	1.2			1.6	

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. System-oriented knowledge, knowledge and skills in calculus, mathematical statistics and programming (e.g. Matlab, Python, C++)

SUBJECT OBJECTIVES

C1. Obtaining a fundamental knowledge on virtualization and automation of technical systems, optimization methods, fundamentals on artificial intelligence (AI) methods, criteria for selection of an optimal AI algorithm for a given technical task, typical applications of artificial intelligence methods.

C2. Earning the skills in the selection and application of artificial intelligence methods to a selected technical task related to intelligent virtualization of the system and/or process automation

SUBJECT LEARNING OUTCOMES
Relating to knowledge: PEU_W01 - As a result of the course, the student should be able to describe a practical problem requiring the use of intelligent methods for system virtualization and/or process automation and is able to describe methods for selecting appropriate algorithms to solve it. Relating to skills: PEU_U01 - As a result of the course, the student should be able to formulate a practical problem requiring the use of intelligent methods for system virtualization and/or process automation, outline a plan for its solution, apply the selected method for intelligent modeling of data and systems, and interpret the obtained results.

PROGRAM CONTENT		
Lecture		**Number of hours**
Lec1	Introduction to the lecture contents, requirements and form of evaluation.	1
Lec2	State-of-the-art on system virtualization and process automation. The role of artificial intelligence methods in systems virtualization and process automation.	2
Lec3	Optimization in solving system virtualization and process automation tasks. Extracting knowledge from data.	2
Lec4	Programming tools and libraries dedicated to designing and implementation of the artificial intelligence methods - the perspective of system virtualization and process automation. Application maintenance.	2
Lec5	Artificial neural networks for system virtualization and process automation.	2
Lec6	Fuzzy logic and genetic algorithms in system virtualization and process automation.	2
Lec7	Boosting and bagging, decision trees in system virtualization and process automation tasks. Decision support systems.	2
Lec8	Lecture summary	2
	Total hours:	15

Project		**Number of hours**
Pr1	Introduction to project meetings, the outline on project topics, requirements and form of obtaining a credit, OHS regulations.	2
Pr2	Project topic selection.	2
Pr3	Literature study on a selected topic of the project. Proposal of a conception for project realization.	4
Pr4	Selection of a software tools for project realization.	2
Pr5	Software deveopment implementing the defined project topic.	10
Pr6	Validation of the software that implements the project objective.	2
Pr7	Analysis of the results obtained for the project scope.	2
Pr8	Written report on realized project tasks and obtained results.	4
Pr9	Summary on realizaed projects, projects evaluation.	2
	Total hours:	30

TEACHING TOOLS USED
N1. Traditional and/or online lecture supported with multimedia tools
N2. Project - discussion of a selected technical problem, progress of work and results obtained
N3. Self-studies - preparation for project sessions.
N4. Verification of the acquired knowledge and skills in written or oral form.

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation: F — forming (during semester), C — concluding (at semester end)	Learning outcome code	Way of evaluating learning outcome achievement
F1	PEU_W01	A final test in a written form
F2	PEU_U01	Oral answers, discussions of solved problems, written report on the implementation and obtained results of project tasks
P(Lecture) = F1 ; P(Project) = F2		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] Oguchi N., Katagiri, T., Kazuki M., Wang X., Sekiya M.: Virtualization and softwarization technologies for end-to-end networking. Fujitsu Sci. Technol. J., Vol. 53, No. 5, pp. 78-87, 2017.

[2] Salahuddin M., Al-Fuqaha A., Guizani M., Shuaib K.: Softwarization of Internet of Things infrastructure for secure and smart healthcare, Computer, Vol. 50, No. 7, pp. 74-79, 2017.

[3] Blenk A., Basta A., Reisslein M., Kellerer W.: A survey on network virtualization hypervisors for software defined networking, IEEE Commun. Surveys Tuts., Vol. 18, No. 1, pp. 655-685, 2016

[4] Lake D., Wang N., Tafazolli R., Samuel L.: Softwarization of 5G networks - implications to open platforms and standardization, IEEE Access, Vol.9, 88902-88930, 2021.

[5] Bonaccorso G.:Mastering machine learning algorithms, Packt Publishing, Birmingham-Mumbai, 2020.

SECONDARY LITERATURE:

[1] Flasiński M.: Wstęp do sztucznej inteligencji, PWN, Warszawa 2011.

[2] Goldberg D.: Algorytmy genetyczne i ich zastosowania, WNT, Warszawa 2003

[3] Osowski S.: Sieci neuronowe do przetwarzania informacji, Oficyna Wydawnicza Politechniki Warszawskiej, Warszawa 2006

SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)
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Faculty of Electronics, Fotonics and Microsystems (W12N) / Department of Cybernetics and Robotics (K29W12ND02)

SUBJECT CARD

Name of subject in Polish: **Zaawansowane układy robotyczne**
Name of subject in English: **Advanced robotic systems**
Main field of study (if applicable): **Control Engineering and Robotics (AiR)**
Specialization: **Robotics (ARR)**
Profile: **academic**
Level and form of studies: **2nd level, full-time**
Kind of subject: **facultative**
Subject code: **W12AIR-SM0113**
Group of courses: **No**

	Lecture	Exercise	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15			15	
Number of hours of total student workload (CNPS)	30			30	
Form of crediting	Crediting with grade			Crediting with grade	
For group of courses mark (X) the final course					
Number of ECTS points	1			1	
including number of ECTS points for practical (P) classes				1.0	
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	0.6			0.8	

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. none

SUBJECT OBJECTIVES

C1. Gaining knowledge about advanced robotic systems.

C2. Gaining skills in the field of design, analysis and implementation in a simulation environment of robotic systems.

SUBJECT LEARNING OUTCOMES
Relating to knowledge: PEU_W01 - Knows the methodology in the field of modeling and analysis of advanced robotic systems Relating to skills: PEU_U01 - Can use the programming environment in order to carry out a numerical experiment verifying the properties of advanced robotic systems

PROGRAM CONTENT		
Lecture		**Number of hours**
Lec1	Introduction: course program, rules, literature.	1
Lec2	Holonomic and nonholonomic constraints (1st and 2nd order).	2
Lec3-4	Open and closed kinematic chain manipulators. Passive joint manipulators. Mobile manipulators.	4
Lec5-6	Mobile robots, including flying and floating robots.	4
Lec7	Normal forms of affine control systems.	2
Lec8	Summary of the course, the final test.	2
	Total hours:	15

Project		**Number of hours**
Pr1	Project related to the issues discussed during the lecture.	15
	Total hours:	15

TEACHING TOOLS USED
N1. Traditional and/or online lecture using a multimedia tools
N2. Project classes
N3. Office hours
N4. Independent work - developing the project

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation: F — forming (during semester), C — concluding (at semester end)	Learning outcome code	Way of evaluating learning outcome achievement
F1	PEU_W01	Short tests, the final test
F2	PEU_U01	Evaluation of the project assignments
P(lecture)=F1; P(project)=F2		

PRIMARY AND SECONDARY LITERATURE
PRIMARY LITERATURE:
[1] Bruno Siciliano, Oussama Khatib. Springer Handbook of Robotics. Springer-Verlag, Berlin, Heidelberg. 2007.
[2] Isabelle Fantoni, Rogelio Lozano. Non-linear Control for Underactuated Mechanical Systems. Springer London. 2002.
[3] Lecture notes
SECONDARY LITERATURE:
[1] Internet resources

SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)
Joanna Ratajczak, joanna.ratajczak@pwr.edu.pl

Faculty of Electronics, Fotonics and Microsystems (W12N) / Department of Electronic and Photonic Metrology (K31W12ND02)

SUBJECT CARD

Name of subject in Polish: **Sztuczne sieci neuronowe**

Name of subject in English: **Artificial Neural Networks**

Main field of study (if applicable): **Control Engineering and Robotics (AiR)**

Profile: **academic**

Level and form of studies: **2nd level, full-time**

Kind of subject: **obligatory**

Subject code: **W12AIR-SM0721**

Group of courses: **No**

	Lecture	Exercise	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15			15	
Number of hours of total student workload (CNPS)	60			30	
Form of crediting	Crediting with grade			Crediting with grade	
For group of courses mark (X) the final course					
Number of ECTS points	2			1	
including number of ECTS points for practical (P) classes				1.0	
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	1.5			0.8	

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Knowledge and skills in calculus, mathematical statistics and programming (e.g. Matlab, Python, C++)

SUBJECT OBJECTIVES

C1. Obtaining knowledge on the artificial intelligence methods, especially on the artificial neural networks, including: the skills in parametrization of artificial neural networks, their optimization, training strategies and knowledge of their applications.

C2. Obtaining the skills in selection of data processing methods, artificial neural network parametrization and its optimization for practical application.

SUBJECT LEARNING OUTCOMES
Relating to knowledge: PEU_W01 - is able to describe the basic role and selected practical applications of the artificial neural networks as a artificial intelligence methods and to describe the basis of neuron scheme, an artificial neuron model, basic architectures of artificial neural networks, training strategies, optimization methods and quality assessment of selected models. Relating to skills: PEU_U01 - At the output of the course, the student is able to formulate a practical problem proper for artificial neural networks (ANN) application, outline a plan for its solution, apply the selected ANN architecture and learning method, and interpret the obtained results.

PROGRAM CONTENT		
Lecture		**Number of hours**
Lec1	Introduction. The role of artificial neural networks in process automation and controls.	1
Lec2	Fundamentals of artificial neural networks: biological neuron and artificial neuron model	2
Lec3	Architectures of artificial neural networks. Perceptron, multilayer feedforward neural networks, recurrent networks.	2
Lec4	Training neural networks. Supervised and unsupervised learning. Learning algorithms.	2
Lec5	Types of applications of artificial neural networks: classification, regression, prediction.	2
Lec6	Optimization and evaluation of artificial neural network models. Neural network generalization.	2
Lec7	Applications of artificial neural networks.	2
Lec8	Application of deep learning. Summary.	2
	Total hours:	15

Project		**Number of hours**
Pr1	Introduction to project content. Prereqisition of project realization.	1
Pr2	Definition of the project scope and title. Review on tools and libraries dedicated for designing, training and optimization of artificial neural networks.	2
Pr3	A literature review on the selected project topic.	2
Pr4	Selection of a software tools valid for solution of the defined problem. Data inspection and preprocessing.	2
Pr5	Selection of artificial neural network architecture, its parametrization and training scheme.	2
Pr6	Artificial neural network implementation, training and its parameters optimization.	2
Pr7	Preparation of summarized results and its interpretations.	2
Pr8	Project presentation and evaluation. Summary.	2
	Total hours:	15

TEACHING TOOLS USED
N1. Traditional and/or online lecture using multimedia tools
N2. Project - discussion on a selected technical problem, work progress and results.
N3. Consultations.
N4. Self-work - independent study and preparation for project realization.
N5. Verification of acquired knowledge and skills in written or oral form

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation: F — forming (during semester), C — concluding (at semester end)	Learning outcome code	Way of evaluating learning outcome achievement
F1	PEU_U01	Consultations during project classes, oral answers, observation of the project work, evaluation of the project presentation of the obtained results
F2	PEU_W01	Evaluation of the knowledge in written form
P(lecture)=F2; P(project)=F1		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] Lu, H., Li, Y. (Eds.). (2017). Artificial intelligence and computer vision. Springer International Publishing.

[2] Patterson, J., Gibson, A. (2017). Deep learning: A practitioner's approach. O'Reilly Media, Inc.

[3] Haykin, S. S. (2009). Neural networks and learning machines.

SECONDARY LITERATURE:

[1] Aldrich, C., Auret, L. (2013). Unsupervised process monitoring and fault diagnosis with machine learning methods (Vol. 16, No. 3, pp. 593-606). London: Springer.

[2] Bartecki K., (2010). Sztuczne sieci neuronowe w zastosowaniach : zbiór ćwiczeń laboratoryjnych z wykorzystaniem przybornika Neural Network programu Matlab. Oficyna Wydawnicza Politechniki Opolskiej

[3] Koshkouei, A. J., Haas, O. C. L. Theory and practice of artificial intelligence for control.

[4] Mello, F., (2018). Machine Learning. Springer International Publishing

[5] Dokumentacja program MATLAB firmy Mathworks: [www.mathworks.com/help/matlab/]

SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)
Monika Prucnal, monika.a.prucnal@pwr.edu.pl

Faculty of Electronics, Fotonics and Microsystems (W12N) / Department of Cybernetics and Robotics (K29W12ND02)

SUBJECT CARD

Name of subject in Polish: **Systemy zdarzeniowe**
Name of subject in English: **Discrete Event Systems**
Main field of study (if applicable): **Control Engineering and Robotics (AiR)**
Specialization: **Robotics (ARR)**
Profile: **academic**
Level and form of studies: **2nd level, full-time**
Kind of subject: **facultative**
Subject code: **W12AIR-SM0114**
Group of courses: **No**

	Lecture	Exercise	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15			15	
Number of hours of total student workload (CNPS)	60			30	
Form of crediting	Crediting with grade			Crediting with grade	
For group of courses mark (X) the final course					
Number of ECTS points	2			1	
including number of ECTS points for practical (P) classes				1.0	
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	1.2			0.7	

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Competence in the basics of: automation and robotics, control theory, operating systems and programming

SUBJECT OBJECTIVES

C1. Acquirement of the basic knowledge of the Discrete Event System (DES) theory and its applications, including the concepts of formal languages, finite state automata, and Petri nets.

C2. Acquirement of the ability to apply the theory of DES in the modeling of robotics and automation systems as well as the design and development of the supervisory control.

SUBJECT LEARNING OUTCOMES
Relating to knowledge: PEU_W01 - Knows the basic formalisms for modeling discrete event systems (DES), including Petri nets and finite state automata. PEU_W02 - Understands the supervisory control synthesis based on DES models and its application in selected automation and robotics systems. Relating to skills: PEU_U01 - Can abstract the operation of systems using the DES formalism. Can solve the problems of controlling such systems in an algorithmic method and create programs that implement the designated control logic.

PROGRAM CONTENT		
Lecture		**Number of hours**
Lec1	Introduction to Discrete Event Systems (DES). Event-based control: a new modeling and control paradigm.	2
Lec2	Formal models of DES behavior: languages and finite state automata. Examples of application in automation.	2
Lec3	Network DES models: Petri nets of the place / transition type. Graphical and algebraic representation.	2
Lec4	High level Petri nets: predicate and colored nets.	2
Lec5	Automation of DES model synthesis. RAS systems (Resource Allocation Systems). Problems of ensuring the correctness and effectiveness of control.	2
Lec6	Supervisory control systems for material concurrent processes in FMS (Flexible Manufacturing System). Algorithms for ensuring system liveness.	2
Lec7	Formally correct overriding control in MMRS (Multiple Mobile Robot System). Centralized and distributed systems.	2
Lec8	Summary (colloquium).	1
	Total hours:	15

Project		**Number of hours**
Pr1	Presentation of the content and organization of the project: team work, model construction and computer implementation of supervisory control for the selected system of complex processes in automation. Division into project groups and presentation of the required structure of the initial project description (problem, approach, task list, schedule, responsible persons).	2
Pr2	Development of the object model, control algorithms and object simulator. Documentation in the form of a partial report.	4
Pr3	Computer implementation of the control system and object simulator. Documentation in the form of a partial report.	6
Pr4	Demonstration of project results and final report.	3
	Total hours:	15

TEACHING TOOLS USED
N1. Traditional and/or online lecture with use of multimedia tools
N2. Project classes
N3. Office hours
N4. Own work - self study and preparation for the final exam
N5. Own work - developing the project
N6. WUST e-learning platform (http://eportal.pwr.edu.pl)

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation: F — forming (during semester), C — concluding (at semester end)	Learning outcome code	Way of evaluating learning outcome achievement
F1	PEU_W01 ÷ PEU_W02	the final test
F2	PEU_U01	Evaluation of the project proposal (initial description of the project), of the project development process, and of the project result
P(lecture)=F1; P(project)=F2		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] C.G. Cassandras, S. Lafortune, Introduction to Discrete Event Systems, Kluwer Academic Publishers, 1999. Rozdziały 1 - 5.

[2] R. David, H. Alla, Petri Nets and Grafcet: tools for modeling discrete event systems, Prentice Hall, 1992, selected chapters.

SECONDARY LITERATURE:

[1] W. Reisig, Sieci Petriego, WNT, 1988.

[2] M. Szpyrka, Sieci Petriego w modelowaniu i analizie systemów współbieżnych, WNT, 2008.

[3] S.A. Reveliotis, Real - Time Management of Resource Allocation Systems: A Discrete - Event Systems Approach , Springer, NY, 2005.

[4] W.M. Wonham, Supervisory Control of Discrete Event Systems, http://www.control.utoronto.ca/cgi-bin/dldes.cgi.

[5] M.C. Zhou, M.P. Fanti (editors), Deadlock Resolution in Computer - Integrated Systems, Marcel Dekker, 2005.

[6] IEEE Transactions on Automatic Control

[7] IEEE Transactions on Automation Science and Engineering

SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)
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Faculty of Electronics, Fotonics and Microsystems (W12N) / Department of Electronic and Photonic Metrology (K31W12ND02)

SUBJECT CARD

Name of subject in Polish: **Sztuczne sieci neuronowe**

Name of subject in English: **Artificial Neural Networks**

Main field of study (if applicable): **Control Engineering and Robotics (AiR)**

Profile: **academic**

Level and form of studies: **2nd level, full-time**

Kind of subject: **obligatory**

Subject code: **W12AIR-SM0005**

Group of courses: **No**

	Lecture	Exercise	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15			15	
Number of hours of total student workload (CNPS)	60			30	
Form of crediting	Crediting with grade			Crediting with grade	
For group of courses mark (X) the final course					
Number of ECTS points	2			1	
including number of ECTS points for practical (P) classes				1.0	
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	1.5			0.8	

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Knowledge and skills in calculus, mathematical statistics and programming (e.g. Matlab, Python, C++)

SUBJECT OBJECTIVES

C1. Obtaining knowledge on the artificial intelligence methods, especially on the artificial neural networks, including: the skills in parametrization of artificial neural networks, their optimization, training strategies and knowledge of their applications.

C2. Obtaining the skills in selection of data processing methods, artificial neural network parametrization and its optimization for practical application.

SUBJECT LEARNING OUTCOMES
Relating to knowledge: PEU_W01 - is able to describe the basic role and selected practical applications of the artificial neural networks as a artificial intelligence methods and to describe the basis of neuron scheme, an artificial neuron model, basic architectures of artificial neural networks, training strategies, optimization methods and quality assessment of selected models. Relating to skills: PEU_U01 - At the output of the course, the student is able to formulate a practical problem proper for artificial neural networks (ANN) application, outline a plan for its solution, apply the selected ANN architecture and learning method, and interpret the obtained results.

PROGRAM CONTENT		
Lecture		**Number of hours**
Lec1	Introduction. The role of artificial neural networks in process automation and controls.	1
Lec2	Fundamentals of artificial neural networks: biological neuron and artificial neuron model	2
Lec3	Architectures of artificial neural networks. Perceptron, multilayer feedforward neural networks, recurrent networks.	2
Lec4	Training neural networks. Supervised and unsupervised learning. Learning algorithms.	2
Lec5	Types of applications of artificial neural networks: classification, regression, prediction.	2
Lec6	Optimization and evaluation of artificial neural network models. Neural network generalization.	2
Lec7	Applications of artificial neural networks.	2
Lec8	Application of deep learning. Summary.	2
	Total hours:	15

Project		**Number of hours**
Pr1	Introduction to project content. Prereqisition of project realization.	1
Pr2	Definition of the project scope and title. Review on tools and libraries dedicated for designing, training and optimization of artificial neural networks.	2
Pr3	A literature review on the selected project topic.	2
Pr4	Selection of a software tools valid for solution of the defined problem. Data inspection and preprocessing.	2
Pr5	Selection of artificial neural network architecture, its parametrization and training scheme.	2
Pr6	Artificial neural network implementation, training and its parameters optimization.	2
Pr7	Preparation of summarized results and its interpretations.	2
Pr8	Project presentation and evaluation. Summary.	2
	Total hours:	15

TEACHING TOOLS USED
N1. Traditional and/or online lecture using multimedia tools
N2. Project - discussion on a selected technical problem, work progress and results.
N3. Consultations.
N4. Self-work - independent study and preparation for project realization.
N5. Verification of acquired knowledge and skills in written or oral form

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation: F — forming (during semester), C — concluding (at semester end)	Learning outcome code	Way of evaluating learning outcome achievement
F1	PEU_U01	Consultations during project classes, oral answers, observation of the project work, evaluation of the project presentation of the obtained results
F2	PEU_W01	Evaluation of the knowledge in written form
P(lecture)=F2; P(project)=F1		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] Lu, H., Li, Y. (Eds.). (2017). Artificial intelligence and computer vision. Springer International Publishing.

[2] Patterson, J., Gibson, A. (2017). Deep learning: A practitioner's approach. O'Reilly Media, Inc.

[3] Haykin, S. S. (2009). Neural networks and learning machines.

SECONDARY LITERATURE:

[1] Aldrich, C., Auret, L. (2013). Unsupervised process monitoring and fault diagnosis with machine learning methods (Vol. 16, No. 3, pp. 593-606). London: Springer.

[2] Bartecki K., (2010). Sztuczne sieci neuronowe w zastosowaniach : zbiór ćwiczeń laboratoryjnych z wykorzystaniem przybornika Neural Network programu Matlab. Oficyna Wydawnicza Politechniki Opolskiej

[3] Koshkouei, A. J., Haas, O. C. L. Theory and practice of artificial intelligence for control.

[4] Mello, F., (2018). Machine Learning. Springer Int. Publishing

[5] Dokumentacja program MATLAB firmy Mathworks: [www.mathworks.com/help/matlab/]

SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)
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Faculty of Electronics, Fotonics and Microsystems (W12N) / Department of Cybernetics and Robotics (K29W12ND02)

SUBJECT CARD

Name of subject in Polish: **Projekt specjalnościowy**
Name of subject in English: **Specialization project**
Main field of study (if applicable): **Control Engineering and Robotics (AiR)**
Specialization: **Robotics (ARR)**
Profile: **academic**
Level and form of studies: **2nd level, full-time**
Kind of subject: **facultative**
Subject code: **W12AIR-SM0102P**
Group of courses: **No**

	Lecture	Exercise	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				Crediting with grade	
For group of courses mark (X) the final course					
Number of ECTS points				2	
including number of ECTS points for practical (P) classes				2.0	
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)				1.6	

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Knowledge, skills and competences appropriate for the completion of the first-cycle studies in the field of Computer engineering and Robotics

SUBJECT OBJECTIVES

C1. Acquisition of skills in designing sensory systems and robot control systems and robotic systems, as well as using the achievements of robotics development, from industrial to social robotics

SUBJECT LEARNING OUTCOMES
Relating to knowledge: PEU_W01 - Analyzes, interprets, evaluates and uses the achievements and trends in the development of robotics, from industrial to social robotics. Relating to skills: PEU_U01 - Is able to use at an advanced level the modern literature on the methods of designing robots, algorithms for planning their movement and processing sensory data Relating to social competences: PEU_K01 - Understands the need to provide technical information in an understandable way.

PROGRAM CONTENT

Project		Number of hours
Pr1	Organizational matters, division into project groups, determination of the topics.	2
Pr2	Development of project assumptions including: scope of the project, schedule for implementation and presentation of results.	2
Pr3	Searching for and agreeing on a solution: problem analysis, implementation of the solution, discussion in groups and with the teacher. Preparation of reports and presentations.	26
	Total hours:	30

TEACHING TOOLS USED
N1. Discussion on the concept of the project
N2. Work on the project, periodic presentation of the obtained results
N3. Consultation
N4. Project implementation, presentation preparation, report preparation

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation: F — forming (during semester), C — concluding (at semester end)	Learning outcome code	Way of evaluating learning outcome achievement
F1	PEU_W01, PEU_U01, PEU_K01	Presentation of the project progress
P = F1		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] K. Tchoń et al., Manipulatory i roboty mobilne, Akademicka Oficyna Wydawnicza, Warszawa, 2000.

[2] J. J. Craig, Wprowadzenie do robotyki, WNT, Warszawa, 1983.

[3] J. C. Latombe, Robot Motion Planning, Kluwer, Boston, 1993.

[4] S. M. LaValle, Planning Algorithms, Cambridge University Press, 2006.

[5] A. Morecki, J. Knopczyk, Podstawy robotyki, WNT, Warszawa, 1994.

SECONDARY LITERATURE:

[1] K. Kozłowski et al., Modelowanie i sterowanie robotów, PWN, Warszawa, 2003.

[2] De Luca C., Electromyography. Encyclopedia of Medical Devices and Instrumentation, (John G. Webster, Ed.) John Wiley Publisher, 98 - 109, 2006.

[3] H. R. Everett, Sensors for mobile robot, AK Peters, Ltd., Wellesley 1995.

[4] A. Wołczowski, M. Kurzyński, Human – machine interface in bioprosthesis control using EMG signal classification, Expert Systems 27, 53 - 70, 2010.

[5] W. Jacak, Roboty Inteligentne - metody planowania działań i ruchu, PWr, Wroclaw 1991.

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Wojciech Domski, wojciech.domski@pwr.edu.pl

Faculty of Electronics, Fotonics and Microsystems (W12N) / Department of Cybernetics and Robotics (K29W12ND02)

SUBJECT CARD

Name of subject in Polish: **Algorytmy robotyki mobilnej**
Name of subject in English: **Algorithms for mobile robotics**
Main field of study (if applicable): **Control Engineering and Robotics (AiR)**
Specialization: **Robotics (ARR)**
Profile: **academic**
Level and form of studies: **2nd level, full-time**
Kind of subject: **facultative**
Subject code: **W12AIR-SM0104**
Group of courses: **No**

	Lecture	Exercise	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15		15		15
Number of hours of total student workload (CNPS)	30		60		30
Form of crediting	Crediting with grade		Crediting with grade		Crediting with grade
For group of courses mark (X) the final course					
Number of ECTS points	1		2		1
including number of ECTS points for practical (P) classes			2.0		1.0
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	0.6		2.0		1.0

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. knowledge of elementary mathematics (probabilistics)
2. good programming skills required

SUBJECT OBJECTIVES

C1. Obtaining knowledge about the methods of robot localization
C2. Acquiring knowledge about the methods of mapping
C3. Development of the ability to implement algorithms for mobile robots
C4. Development of the ability to analyze the current directions of development of mobile robotics

SUBJECT LEARNING OUTCOMES
Relating to knowledge: PEU_W01 - Students can name and explain typical problems of mobile robotics PEU_W02 - Students can characterize the methods of locating mobile robots PEU_W03 - Students can distinguish between the tasks of building maps and SLAM and characterize the basic algorithms Relating to skills: PEU_U01 - Studetns can solve the problem of self-localization of a mobile robot PEU_U02 - Students are able to develop and implement an algorithm for mapping by a mobile robot PEU_U03 - Students can use sensors and a map of the environment to navigate the robot PEU_U04 - Students are able to analyze and present mobile robotics algorithms published in the current specialist literature

PROGRAM CONTENT		
Lecture		**Number of hours**
Lec1	Introduction. Applications and problems of mobile robots. Models of mobile robots.	1
Lec2	Review of mathematical tools used during the course	2
Lec3	Methods of filtration and fusion of data from sensors of mobile robots	2
Lec4	Robot localization: odometry, Markov models, EKF	2
Lec5	Mapping: metric, topological and hybrid maps	2
Lec6	Basics of SLAM: idea and methods	2
Lec7	The problem of exploration	2
Lec8	Current research trends in mobile robotics	2
	Total hours:	15

Laboratory		**Number of hours**
Lab1	Introduction and OHS in the laboratory. Communication in the ROS system with mobile robots	3
Lab2	Robot self-localization using incremental methods	3
Lab3	Sensory data fusion for robot localization	3
Lab4	Mapping	3
Lab5	Robot navigation using a constantly updated map	3
	Total hours:	15

Seminar		**Number of hours**
Sem1	Introduction. Presentation of the topics. Selection of topics to be presented.	1
Sem2	Presentation of the theoretical foundations of selected modern mobile robotics algorithms	6
Sem3	Presentation of the results of the operation of selected algorithms in a simulation or real environment	6

Sem4	Summary and discussion of the results	2
	Total hours:	15

TEACHING TOOLS USED
N1. Lecture
N2. Laboratory classes
N3. Consultation
N4. Self education – self study and preparation to the final exam
N5. Self education – preparation for laboratory classes
N6. Multimedia presentation – preparation and delivering

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation: F — forming (during semester), C — concluding (at semester end)	Learning outcome code	Way of evaluating learning outcome achievement
F1	PEU_U01 - PEU_U03	Oral answers, evaluation of the implementation of laboratory tasks, laboratory reports
F2	PEU_U04	Assessment of the preparation and presentation of selected topics
F3	PEU_W01 - PEU_W03	Written test
P(lecture)=F3, P(laboratory)=F1, P(seminar)=F2		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] R.Siegwart, Introduction to Autonomous Mobile Robots, MIT Press, 2011.

[2] S.Thrun i in., Probabilistic robotics, MIT Press, 2006.

[3] A.Kelly, Mobile Robotics: Mathematics, Models, and Methods, Cambridge University Press, 2013.

SECONDARY LITERATURE:

[1] Handbook of robotics, Springer, 2008.

[2] M. Ben-Ari, F. Mondada, Elements of Robotics, Springer 2018.

[3] H.Choset et al, Principles of Robot Motion: Theory, Algorithms, and Implementations, A Bradford Book, 2005.

[4] The DARPA Urban Challenge, Springer, 2010.

SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)
Janusz Jakubiak, janusz.jakubiak@pwr.edu.pl

Faculty of Electronics, Fotonics and Microsystems (W12N) / Department of Cybernetics and Robotics (K29W12ND02)

SUBJECT CARD

Name of subject in Polish: **Rozproszone systemy sterowania**
Name of subject in English: **Distributed Control Systems**
Main field of study (if applicable): **Control Engineering and Robotics (AiR)**
Specialization: **Robotics (ARR)**
Profile: **academic**
Level and form of studies: **2nd level, full-time**
Kind of subject: **facultative**
Subject code: **W12AIR-SM0103**
Group of courses: **No**

	Lecture	Exercise	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15		30		
Number of hours of total student workload (CNPS)	60		60		
Form of crediting	Crediting with grade		Crediting with grade		
For group of courses mark (X) the final course					
Number of ECTS points	2		2		
including number of ECTS points for practical (P) classes			2.0		
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	1.6		1.6		

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Knowledge about writing computer programs in C/C++ language
2. Knowledge of the basics of control and robotics

SUBJECT OBJECTIVES

C1. Gaining knowledge of the component-based software development
C2. Gaining knowledge about distributed control systems
C3. Gaining knowledge about communication protocols
C4. Learn about selected robotic environments and programming libraries

SUBJECT LEARNING OUTCOMES
Relating to knowledge: PEU_W01 - knows the basics of the component-based software development PEU_W02 - knows the basics of designing distributed control systems PEU_W03 - knows the basic communication protocols used in distributed systems PEU_W04 - knows selected robotic environments and programming libraries Relating to skills: PEU_U01 - is able to design and implement distributed heterogeneous control systems PEU_U02 - can decompose complex systems, define components and interfaces PEU_U03 - is able to use available programming environments and tools in order to implement complex distributed control systems Relating to social competences: PEU_K01 - understands the need for self-education and developing the ability to independently apply the knowledge and skills

PROGRAM CONTENT		
Lecture		**Number of hours**
Lec1	Distributed control systems - introduction	1
Lec2	A component-oriented approach in the design of distributed control systems	3
Lec3	Communication protocols	3
Lec4	OROCOS framework	3
Lec5	ROS framework	3
Lec6	Development tools and libraries	2
	Total hours:	15

Laboratory		**Number of hours**
Lab1	Introduction, OHS training, preparation of the work environment	2
Lab2	Modeling of systems	2
Lab3	Communication in distributed systems	2
Lab4	Introduction to OROCOS	2
Lab5	Designing a component in OROCOS	2
Lab6	Implementation of a distributed system in OROCOS	4
Lab7	Introduction to ROS	2
Lab8	Component design in ROS	2
Lab9	Implementation of a distributed system in ROS	4
Lab10	Integration of ROS and OROCOS	4
Lab11	Programming libraries	4
	Total hours:	30

TEACHING TOOLS USED
N1. Traditional lecture
N2. Laboratory classes
N3. Consultation
N4. Self education – preparation for laboratory classes
N5. Self education – self literature study

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation: F — forming (during semester), C — concluding (at semester end)	Learning outcome code	Way of evaluating learning outcome achievement
F1	PEU_W01 - PEU_W04	The final written test
F2	PEU_U01 - PEU_U03, PEU_K01	Performing laboratory exercises
P(W)=F1, P(L)=F2		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] R. Simmons, D. Kortencamp, D. Brugali: Robotics Systems Achitectures and Programming, Handbook of Robotics Hed.

[2] R. Bischoff, T. Guhl, E. Prassler, W. Nowak, G. Kraetzschmar, H. Bruyninckx, P. Soetens, M. Haegele, A. Pott, P. Breedveld, J. Broenink, D. Brugali and N. Tomatis: BRICS – Best practice in robotics. In Proc. Of the IFR International Symposium on Robotics (ISR 2010), June 2010, Munich, Germany

[3] R. Patrick Goebel: ROS By Example HYDRO – Volume 1, 2014

SECONDARY LITERATURE:

[1] B. Houska, H.J. Ferreau, M. Diehl: ACADO Toolkit: An Open – Source Framework for Automatic Control and Dynamic Optimization, Optimal Control Methods and Application 32, 298 - 312 (2011)

[2] D. Brugali and P. Scandurra: Component – based Robotic Engineering. Part II: Models and systems, In IEEE Robotics and Automation Magazine, March 2010

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Faculty of Electronics, Fotonics and Microsystems (W12N) / Department of Cybernetics and Robotics (K29W12ND02)

SUBJECT CARD

Name of subject in Polish: **Sztuczna inteligencja i uczenie maszynowe**
Name of subject in English: **Artificial Intelligence and Machine Learning**
Main field of study (if applicable): **Control Engineering and Robotics (AiR)**
Specialization: **Embedded Robotics (AER)**
Profile: **academic**
Level and form of studies: **2nd level, full-time**
Kind of subject: **facultative**
Subject code: **W12AIR-SM0702**
Group of courses: **No**

	Lecture	Exercise	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30			30	
Number of hours of total student workload (CNPS)	60			90	
Form of crediting	Crediting with grade			Crediting with grade	
For group of courses mark (X) the final course					
Number of ECTS points	2			3	
including number of ECTS points for practical (P) classes				3.0	
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	2.0			2.0	

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. knowledge of elementary mathematics (algebra, logics)
2. good programming skills required

SUBJECT OBJECTIVES
C1. General understanding of the knowledge representation, reasoning, and machine learning issues
C2. Learn about using heuristics and their use in problem solving.
C3. Learn about using logic and theorem proving in reasoning.
C4. Learn about using probability, the Bayes rule, utilities, and Markov processes algorithms for single and sequential decision making.
C5. Learn about the induction and reinforcement learning methods.
C6. Gain a practical ability to use one of the existing formal paradigms to build abstract representation of practical problems, and solve them.

SUBJECT LEARNING OUTCOMES
Relating to knowledge:
PEU_W01 - understands the concept of artificial intelligence, knowledge representation, and reasoning
PEU_W02 - knows the search methods for different classes of problems, and the use of heuristics in problem solving
PEU_W03 - understands the application of mathematical logic to problem representation, and the importance of uncertainty
PEU_W04 - understands the application of probability to problem description, the bayesian networks, the Markov decision processes, and the basic algorithms for solving them
PEU_W05 - knows the basic induction and reinforcement machine learning methods
Relating to skills:
PEU_U01 - can create abstract descriptions of hard practical problems and implement algorithms to solve them

PROGRAM CONTENT		
Lecture		**Number of hours**
Lec1	Introduction: program, requirements, literature. Basic concepts and issues. Definition of artificial intelligence. The Turing test. Strong and weak artificial intelligence. Knowledge representation. Machine learning. History of AI.	2
Lec2	State space representation. Searching. Hill-climbing strategies. Utilizing heuristic information. Graph searching. The A* algorithm. Properties. Constructing heuristics.	2
Lec3	Constraint satisfaction problems. Arc consistency. Basic algorithms. Searching for games. The Minimax algorithm. Alpha-beta cuts. Generalizations of the minimax.	2
Lec4	Representation in first order logic. Theorem proving. Refutation reasoning.	2
Lec5	Logic programming in Prolog. Utilizing incomplete and uncertain information. Nonmonotonic logic.	2
Lec6	Probabilistic representation. Conditional probability. Bayes' rule. Probabilistic belief networks.	2
Lec7	Simple decision making. Utility functions. Influence diagrams. Value of information.	2
Lec8	Sequential decision problems. Markov decision processes. Dynamic programming. Value and policy iteration.	2

Lec9	Reinforcement learning. Basic algorithms. Exploration. Function approximation.	2
Lec10	Introduction to induction machine learning. Decision tree learning. Entropy and information gain. Stopping condition and pruning. Binary decision trees.	2
Lec11	Efficiency of induction machine learning. Testing and error measures. Cross validation. Detecting overfitting and underfitting.	2
Lec12	The Na\"ive Bayes classification method. Na\"ive Bayes for continuous inputs. The logistic regression. Regularization.	2
Lec13	The Nearest Neighbors method. Key issues in classification machine learning: feature engineering, the curse of dimensionality, ensemble learning.	2
Lec14	Artificial neural networks. Multilayer perceptron. Backpropagation. Deep learning models. Convolution networks.	2
Lec15	Unsupervised learning: the k-means algorithm, the expectation maximization algorithm, hierarchical clustering. Dimension reduction: the PCA algorithm.	2
	Total hours:	30

Project		**Number of hours**
Pr1÷6	A series of six individual projects concerning the topics covered in lectures: heuristic searching, programming in logic, probabilistic knowledge representation and decision making, induction and reinforcement machine learning.	30
	Total hours:	30

TEACHING TOOLS USED
N1. traditional lecture using video projector
N2. on-line demonstrations during lecture
N3. project classes
N4. office hours
N5. independent work - self study and preparation for the final exam
N6. independent work - developing the project
N7. distant education portal of the WrUST http://eportal.pwr.edu.pl/

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation: F — forming (during semester), C — concluding (at semester end)	Learning outcome code	Way of evaluating learning outcome achievement
F1	PEU_W01 ÷ PEU_W05	short tests conducted during all lectures, final written test
F2	PEU_U01	evaluation of the project assignments
P(lecture)=F1; P(project)=F2		

PRIMARY AND SECONDARY LITERATURE
PRIMARY LITERATURE:
[1] S.J.Russell, P.Norvig, Artificial Intelligence A Modern Approach (4th Ed.), Prentice-Hall, 2021
[2] T.Mitchell, Machine Learning, McGraw Hill, 1997
SECONDARY LITERATURE:
[1] Lecture notes
[2] Internet resources

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Faculty of Electronics, Fotonics and Microsystems (W12N) / Department of Cybernetics and Robotics (K29W12ND02)

SUBJECT CARD

Name of subject in Polish: **Logika stosowana**

Name of subject in English: **Applied logic**

Main field of study (if applicable): **Control Engineering and Robotics (AiR)**

Profile: **academic**

Level and form of studies: **2nd level, full-time**

Kind of subject: **obligatory**

Subject code: **W12AIR-SM0720**

Group of courses: **No**

	Lecture	Exercise	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30	15			
Number of hours of total student workload (CNPS)	60	60			
Form of crediting	Crediting with grade	Crediting with grade			
For group of courses mark (X) the final course					
Number of ECTS points	2	2			
including number of ECTS points for practical (P) classes		2.0			
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	1.6	2.0			

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Basics of Propositional Calculus and Finite Automatons

SUBJECT OBJECTIVES

C1. Presenting the basics of modal logic, especially Linear Temporal Logic. Defining Büchi automata and showing their relationship with automatic verification.

C2. Getting practical skills connected to basic methods of modal logic, LTL and Büchi automata.

C3. Promela and Spin.

SUBJECT LEARNING OUTCOMES
Relating to knowledge: PEU_W01 - know the resolution method in propositional calculus PEU_W02 - know basic notion and properties of LTL logic PEU_W03 - know the notion of Büchi automaton and its connection with LTL formulas PEU_W04 - can model properties of discrete systems in formal languages Relating to skills: PEU_U01 - can prove basic tautologies of modal logic and LTL PEU_U02 - can transform LTL-sentence into Büchi automaton PEU_U03 - can model basic properties of protocols in LTL PEU_U04 - can model simple protocols in Spin

PROGRAM CONTENT		
Lecture		**Number of hours**
Lec1	Valuations, tautologies, consistency.	2
Lec2	Deductive systems. Completeness of resolution.	2
Lec3	Normal form of formulas and the P=NP problem.	2
Lec4	Modal logics and Kripke models.	4
Lec5	Linear Temporal Logic	3
Lec6	Description of system behavior using LTL logic sentences	1
Lec7	Finite automatons and regular languages.	2
Lec8	Büchi automatons.	2
Lec9	Another ω-automata	2
Lec10	ω-regular languages.	2
Lec11	Modeling LTL formulas via Büchi automatons.	2
Lec12	Discrete systems	2
Lec13	Automatic verification.	2
Lec14	Promela language and SPIN.	2
	Total hours:	30

Exercise		**Number of hours**
Ex1	Propositional Calculus. Resolution.	2
Ex2	Modal logics and Kripke models.	2
Ex3	Linear Temporal Logic.	2
Ex4	Büchi automatons.	2
Ex5	ω-regular languages.	2
Ex6	Modeling LTL formulas via Büchi automatons.	2
Ex7	Promela and Spin.	3
	Total hours:	15

TEACHING TOOLS USED
N1. traditional lecture using video projector
N2. independent work - self study and preparation for the final exam
N3. students self-work with dedicated software
N4. classes, solving problems

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation: F — forming (during semester), C — concluding (at semester end)	Learning outcome code	Way of evaluating learning outcome achievement
F1	PEU_W01 ÷ PEU_W04	Final written exam
F2	PEU_U01 ÷ PEU_U04	Evaluation of small tasks during the semester
P(lecture) = F1; P(exercise) = F2		

PRIMARY AND SECONDARY LITERATURE
PRIMARY LITERATURE:
[1] W. Rautenberg, A Concise Introduction to Mathematical Logic, Springer, 2009
[2] M. Ben-Ari, Principles of the Spin Model Checker, Springer, 2008
SECONDARY LITERATURE:
[1] http://spinroot.com/
[2] G. J. Holzmann, The SPIN Model Checker: Primer and Reference Manual

SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)
Szymon Żeberski, szymon.zeberski@pwr.edu.pl

Faculty of Electronics, Fotonics and Microsystems (W12N) / Department of Cybernetics and Robotics (K29W12ND02)

SUBJECT CARD

Name of subject in Polish: **Teoria sterowania dla systemów wbudowanych**
Name of subject in English: **Control Theory for Embedded Systems**
Main field of study (if applicable): **Control Engineering and Robotics (AiR)**
Specialization: **Embedded Robotics (AER)**
Profile: **academic**
Level and form of studies: **2nd level, full-time**
Kind of subject: **facultative**
Subject code: **W12AIR-SM0709**
Group of courses: **No**

	Lecture	Exercise	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15		15		
Number of hours of total student workload (CNPS)	30		60		
Form of crediting	Crediting with grade		Crediting with grade		
For group of courses mark (X) the final course					
Number of ECTS points	1		2		
including number of ECTS points for practical (P) classes			2.0		
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	0.5		1.5		

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Control Theory

SUBJECT OBJECTIVES

C1. Gaining knowledge on classical methods for control systems design.

C2. Gaining knowledge on design and analysis of adaptive control systems.

C3. Gaining knowledge on computer techniques for analysis, synthesis and deploying to embedded controllers of robust and adaptive control systems.

SUBJECT LEARNING OUTCOMES

Relating to knowledge:

PEU_W01 - He/She knows the fundamentals of the feedback theory: basic feedback configurations and properties, stability, stability robustness, loop shaping; the classical control objectives and performance criteria, classical compensator design methods: lead and lag compensation, root-locus, Guillemin-Truxal design procedure;

PEU_W02 - He/She knows a general structure of adaptive control systems and the mathematical apparatus used for analysis of adaptive systems; design and properties of a simple adaptive law (a gradient estimation algorithm with dead zone), a robust adaptive Luenberger observer, a robust adaptive pole placement controller.

PEU_W03 - He/She knows implications induced by real software on deployment of mathematical control laws on a physical hardware, basic stages of deployment of a mathematical control law (according to the V-model) that are supported by the Matlab/Simulink software, in particular: Simulation, Rapid Prototyping, On-Target Rapid Prototyping, Software-in-the-Loop, Processor-in-the-Loop, Hardware-in-the- Loop, is familiar with the following toolboxes of a numerical computing system MATLAB/Simulink: Control System, Robust Control, System Identification, Real-Time Windows Target, Simulink Coder, Embedded Coder, SimMechanics, SimMechanicsLink.

Relating to skills:

PEU_U01 - He/She is able to loop shaping, determine amplitude and phase margins and use the Doyle s stability robustness criterion, use the Nyquist criterion and a polynomial criterion to investigate stability, design a compensator using classical methods: lead and lag compensation, root-locus, Guillemin-Truxal design procedure (calculations using paper with support dedicated software systems as Matlab).

PEU_U02 - He/She is able to design adaptive control algorithm based on the certainty equivalence principle, knows how to use selected technical lemmas when analyzing stability of adaptive control systems, apply a robust adaptive law (e.g. recursiveestimation algorithm with dead zone or adapt one of available recursive identification algorithms available i Matlab / System Identification Toolbox) when designing adaptive feedback control system, design a robust adaptive pole placement controller for a SISO plant and carry out simulation analysis of such a control system in Matlab/Simulink.

PEU_U03 - He/She knows how to use rapid control prototyping technology when designing a control algorithm, how to employ Matlab/Real-Time Windows Target Toolbox integrated with a data acquisition card to control a physical plant from a Simulink level, and for collecting data to carry out identification using Matlab/System Identification Toolbox, automatically generate C code for a specific microcontroller using Simulink / Embedded Coder Toolbox from a block diagram in Simulink that represents a control algorithm, transform 3D CAD model into a Simulink diagram that consists of blocks from SimMechanics Toolbox and employ such a Simulink model for designing and analysis of a control algorithm.

PROGRAM CONTENT

Lecture		**Number of hours**
Lec1	General Structure of Control Systems	2
Lec2,3	Classical Control System Design	3
Lec4	Deploying Designs to Embedded Controllers Through Automatic Code Generation in Matlab/Simulink	2
Lec5	General Structure of Adaptive Control Systems, Stability	2
Lec6	Robust Adaptive Laws	2
Lec7	Robust Adaptive Observer	2
Lec8	Robust Adaptive Pole Assignment	2

	Total hours:	15

Laboratory		Number of hours
Lab1	Introduction to Laboratory Classes	1
Lab2	Modelling and identification of a pendulum on a cart	2
Lab3	DC motor: modelling and identification	2
Lab4	DC motor: control	2
Lab5	Pendulum on cart: control	2
Lab6	2R Manipulator: control	2
Lab7	2R Manipulator: controller deployment	2
Lab8	Term for Carrying Out an Overdue Exercise	2
	Total hours:	15

TEACHING TOOLS USED
N1. traditional and/or online lecture with the use of real/virtual whiteboard and multimedia tools
N2. office hours
N3. laboratory classes
N4. self-study
N5. individual work solving selected problems using a software environment for numerical computation, as Matlab/Simulink or Octave
N6. ePortal - a WUST e-learning platform (http://eportal.pwr.edu.pl/)

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation: F — forming (during semester), C — concluding (at semester end)	Learning outcome code	Way of evaluating learning outcome achievement
F1	PEU_W01 ÷ PEU_W03	final test
F2	PEU_U01 ÷ PEU_U03	reports on the completed tasks
P(Lecture)=F1; P(Laboratory)=F2		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] B. N. Datta, Numerical Methods for Linear Control Systems - Design and Analysis, Elsevier 2004, http://www.knovel.com/web/portal/browse/display?_EXT_KNOVEL_DISPLAY_bookid=1920

[2] T. Wescott, Applied Control Theory for Embedded Systems, Elsevier, 2006, http://www.knovel.com/web/portal/basic_search/display?_EXT_KNOVEL_DISPLAY_bookid=1927

[3] P. A. Ioannou, J. Sun, Robust Adaptive Control, Prentice-Hall, 1996 http://www-rcf.usc.edu/ioannou/RobustAdaptiveBook95.pdf

[4] K. Zhou, J. C. Doyle, K. Glover, Robust and Optimal Control, Prentice Hall, 1996

SECONDARY LITERATURE:

[1] R. A. Freeman, P. A. Kokotović, Robust Nonlinear Control Design, State-Space and Lyapunov Techniques, Birkhäuser, 1996
[2] I. D. Landau, R. Lozano, M. M'Saad, Adaptive Control, Springer-Verlag London
[3] G. Tao, Adaptive Control Design and Analysis, John Willey \& Sons, 2003
[4] Thomas Bräunl, Embedded Robotics. Mobile Robot Design and Application with Embedded Systems, Springer, 2008.
[5] B. Shahian, M. Hassul, Control System Design Using Matlab, Englewood Cliffs, 1993
[6] The Mathworks. Matlab/Simulink software documentation, `http://www.mathworks.com`
[7] Okko H. Bosgra, Huibert Kwakernaak, Gjerrit Meinsma, Design Methods for Control Systems, Notes for a course of the Dutch Institute of Systems and Control Winter term 2007–2008, http://docplayer.net/3174971-Design-methods-for-control-systems.html

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Faculty of Electronics, Fotonics and Microsystems (W12N) / Department of Cybernetics and Robotics (K29W12ND02)

SUBJECT CARD

Name of subject in Polish: **Seminarium dyplomowe**
Name of subject in English: **Diploma Seminar**
Main field of study (if applicable): **Control Engineering and Robotics (AiR)**
Specialization: **Embedded Robotics (AER)**
Profile: **academic**
Level and form of studies: **2nd level, full-time**
Kind of subject: **facultative**
Subject code: **W12AIR-SM0718S**
Group of courses: **No**

	Lecture	Exercise	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)					30
Number of hours of total student workload (CNPS)					90
Form of crediting					Crediting with grade
For group of courses mark (X) the final course					
Number of ECTS points					3
including number of ECTS points for practical (P) classes					3.0
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)					1.5

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. none

SUBJECT OBJECTIVES

C1. learn to acquire multi-source knowledge useful and appropriate to propose original contributions

C2. learn to prepare a presentation in a clear manner presenting own ideas, concepts and solutions

C3. acquire knowledge how to discuss and argue for and against, using substantial arguments

C4. gain ability to present own achievements in a written form.

SUBJECT LEARNING OUTCOMES
Relating to skills: PEU_U01 - Students are able to prepare a multi-media presentation illustrating their achievements. PEU_U02 - Students are able to argument own ideas. PEU_U03 - Students are able to prepare a multi-media presentation illustrating their achievements.

PROGRAM CONTENT

Seminar		Number of hours
Sem1	Principles of preparing and writing diploma work	2
Sem2	Presentation of contemporary robotic literature related to diploma work pointing out original contributions.	8
Sem3	Discussions on a literature specific to subject of diploma work scope. Assumptions taken and solutions proposed.	6
Sem4	Presentations of diploma work pointing out original contributions. Discussions on the diploma achievements.	14
	Total hours:	30

TEACHING TOOLS USED
N1. multimedia presentation N2. discussions N3. individual study

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation: F — forming (during semester), C — concluding (at semester end)	Learning outcome code	Way of evaluating learning outcome achievement
F1	PEU_U01	Presentation
F2	PEU_U02, PEU_U03	discussion
C = 0,5*F1 + 0,5*F2 (in order to pass the course, both F1 and F2 must be positive)		

PRIMARY AND SECONDARY LITERATURE
PRIMARY LITERATURE: [1] Springer Handbook of Robotics, Springer, wyd. I 2008, wyd. II 2016 [2] Literature specific to diploma work

SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)
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Faculty of Electronics, Fotonics and Microsystems (W12N) / Department of Cybernetics and Robotics (K29W12ND02)

SUBJECT CARD

Name of subject in Polish: **Systemy wbudowane**
Name of subject in English: **Embedded Systems**
Main field of study (if applicable): **Control Engineering and Robotics (AiR)**
Specialization: **Embedded Robotics (AER)**
Profile: **academic**
Level and form of studies: **2nd level, full-time**
Kind of subject: **facultative**
Subject code: **W12AIR-SM0703**
Group of courses: **No**

	Lecture	Exercise	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30		30		
Number of hours of total student workload (CNPS)	90		60		
Form of crediting	Crediting with grade		Crediting with grade		
For group of courses mark (X) the final course					
Number of ECTS points	3		2		
including number of ECTS points for practical (P) classes			2.0		
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	1.8		1.6		

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. none

SUBJECT OBJECTIVES

C1. Gaining knowledge about functional blocks in microcontrollers
C2. Gaining knowledge about the methods of software design embedded systems
C3. Acquiring knowledge on the principles of functioning and structure of embedded systems
C4. Acquiring skills in using programming tools for embedded systems

SUBJECT LEARNING OUTCOMES
Relating to knowledge: PEU_W01 - ability to describe microcontroller modules used in embedded controllers PEU_W02 - ability to summarize the methods of programming and debugging embedded systems PEU_W03 - ability to explain the principles of operation and structure of embedded controllers Relating to skills: PEU_U01 - Ability to use programming tools for microcontrollers

PROGRAM CONTENT		
Lecture		**Number of hours**
Lec1-2	Introduction to microprocessors, microcontrollers and embedded systems	4
Lec3	Debugging embedded systems. Tools, techniques.	2
Lec4-5	Digital Signal Processing - application areas, algorithms, equipment	4
Lec6-7	Interfaces in embedded systems	4
Lec8	Midsemester test	2
Lec9-10	Internet of things - idea, protocols, tools	4
Lec11	Industrial protocols: EtherCAT, PowerLink, Profinet, Sercos, CANopen	2
Lec12-13	RTOS in embedded systems: FreeRTOS, Linux	4
Lec14-15	FPGA - introduction	4
	Total hours:	30

Laboratory		**Number of hours**
Lab1	Introduction	2
Lab2,3	Tools for embedded systems	4
Lab4,5,6	Basic technics of programming embedded systems	6
Lab7,8	Processing digital signals	4
Lab9,10	Implementation of the Ethernet stack	4
Lab11,12	Examples of RTOS implementation	4
Lab13,14	Examples of FPGA programming	4
Lab15	Final exam	2
	Total hours:	30

TEACHING TOOLS USED
N1. traditional lecture using video projector N2. office hours N3. independent work - self study and preparation for the final exam

N4. independent work - preparation for the laboratory classes

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation: F — forming (during semester), C — concluding (at semester end)	Learning outcome code	Way of evaluating learning outcome achievement
F1	PEU_W01 ÷ PEU_W03	The final written exam
F2	PEU_U01	evaluation of the project assignments
P(lec) = F1; P(lab) = F2		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] Furber S., „ARM System On-Chip Architecture," Pearsons Educated Limited, 2000
[2] Franklin M., „Network Processor Design: Issues and Practices," Elsevier, 2003
[3] Yui J., „The Definitive Guide to the ARM Cortex-M3," Newnes, 2007
[4] Thomas Braunl, Embedded Robotics, Springer 2003, 2006
[5] Kirk Zurell, C Programming for Embedded Systems, Taylor \& Francis 2000

SECONDARY LITERATURE:

[1] Architecture and Programming of PSoC Microcontrollers," http://www.easypsoc.com/book/
[2] Lane J., „DSP Filter Cookbook," Prompt, 2008
[3] Webpages: www.atmel.com, www.ti.com, www.arm.com, www.analog.com

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

Name of subject in Polish: **Robotyczne środowiska programistyczne**
Name of subject in English: **Robotic Programming Environments**
Main field of study (if applicable): **Control Engineering and Robotics (AiR)**
Specialization: **Embedded Robotics (AER)**
Profile: **academic**
Level and form of studies: **2nd level, full-time**
Kind of subject: **facultative**
Subject code: **W12AIR-SM0724**
Group of courses: **No**

	Lecture	Exercise	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15		30		
Number of hours of total student workload (CNPS)	60		60		
Form of crediting	Examination		Crediting with grade		
For group of courses mark (X) the final course					
Number of ECTS points	2		2		
including number of ECTS points for practical (P) classes			2.0		
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	2.0		2.0		

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Is able to develop software in C/C ++ languages, knows programming tools
2. Knows the basics of automation, robotics and control

SUBJECT OBJECTIVES

C1. General understanding of the component oriented programing.
C2. General understanding of the distributed control systems.
C3. General understanding of the communication protocols.
C4. Learn about robotic middleware frameworks.
C5. Learn about robotic simulation frameworks.
C6. Learn about programing libraries and tools supporting implementation of the control system.

SUBJECT LEARNING OUTCOMES
Relating to knowledge: PEU_W01 - knows the basic of component oriented programming PEU_W02 - knows the basic of distributed control system development PEU_W03 - knows the basic of communication protocols for distributed systems PEU_W04 - knows the robotic programing frameworks \\knows the robotic simulation frameworks \\knows the programing libraries and tools supporting control system development Relating to skills: PEU_U01 - can design and implement distributed control system PEU_U02 - can decompose complex system into set of generic components with well defined interfaces and functionalities. PEU_U03 - can develop distributed, portable application that operates on more then one physical platform PEU_U04 - can use well known robotic programming framework to implements complex distributed control system for autonomous robot PEU_U05 - can use well known robotic simulation framework to model robot and its environment PEU_U06 - can use well known programing libraries to solve ordinary differential equation, nonlinear optimization problems, nonlinear model predictive control problems and motion planning problems. Relating to social competences: PEU_K01 - understands the need for self-study and knowledge sharing

PROGRAM CONTENT		
Lecture		**Number of hours**
Lec1	Introduction to robotic programming environments	1
Lec2	Component/agent based approach for distributed control system	1
Lec3	Communication protocols	1
Lec4	OROCOS framework	3
Lec5	ROS framework	4
Lec6	Simulation environments	2
Lec7	Mathematical libraries (algebra, ODE)	1
Lec8	Optimization and model predictive control libraries	1
Lec9	Motion planning libraries	1
	Total hours:	15

Laboratory		**Number of hours**
Lab1	Introduction to laboratory classes, setup programming environment	2
Lab2	Component/agent based modeling	2
Lab3	Distributed communication	2
Lab4	Introduction to OROCOS framework	2
Lab5	OROCOS component design	2
Lab6	Developing distributed system with OROCOS	2
Lab7	Introduction to ROS framework	2

Lab8	ROS node design	2
Lab9	Developing distributed system with ROS	2
Lab10	Integration ROS with OROCOS	2
Lab11	Introduction to simulation environment	2
Lab12	Integration simulation environment with ROS/OROCOS	2
Lab13	Solving system of linear, nonlinear and ordinary differential equation using mathematical libraries	2
Lab14	Introduction to optimization and model predictive control frameworks	2
Lab15	Introduction to ROS navigation stack	2
	Total hours:	30

TEACHING TOOLS USED
N1. traditional lecture using a video projector
N2. laboratory classes
N3. office hours
N4. independent work - preparation for the laboratory classes
N5. independent work - self study and preparation for the final exam
N6. independent work - literature study

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation: F — forming (during semester), C — concluding (at semester end)	Learning outcome code	Way of evaluating learning outcome achievement
F1	PEU_W01 ÷ PEU_W04, PEU_K01	The final written test
F2	PEU_U01 ÷ PEU_U06	evaluation of the project assignments
P(Lecture)=F1, P(Lab)=F2		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] R. Simmons, D. Kortencamp, D. Brugali. Robotics Systems Architectures and Programming, Handbook of Robotics IIed. , Springer 2013

[2] R. Bischoff, T. Guhl, E. Prassler, W. Nowak, G. Kraetzschmar, H. Bruyninckx, P. Soetens, M. Haegele, A. Pott, P. Breedveld, J. Broenink, D. Brugali and N. Tomatis. BRICS Best practice in robotics. In Proc. of the IFR International Symposium on Robotics (ISR 2010), June 2010, Munich, Germany.

[3] R. Patrick Goebel, „ROS By Example FUERTE - Volume 1", 2012

[4] R. Patrick Goebel, „ROS By Example GROOVY - Volume 1", 2013

SECONDARY LITERATURE:

[1] Houska, B., Ferreau, H. J., Diehl, M.: ACADO Toolkit - An Open-Source Framework for Automatic Control and Dynamic Optimization. Optimal Control Methods and Application 32, 298–312 (2011)

[2] D. Brugali and P. Scandurra. Component-based Robotic Engineering. Part I: Reusable building blocks. In IEEE Robotics and Automation Magazine, December 2009.

[3] D. Brugali and A. Shakhimardanov. Component-based Robotic Engineering. Part II: Models and systems. In IEEE Robotics and Automation Magazine, March 2010.

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SUBJECT CARD

Name of subject in Polish: **Sensory i siłowniki**
Name of subject in English: **Sensors and Actuators**
Main field of study (if applicable): **Control Engineering and Robotics (AiR)**
Specialization: **Embedded Robotics (AER)**
Profile: **academic**
Level and form of studies: **2nd level, full-time**
Kind of subject: **facultative**
Subject code: **W12AIR-SM0707**
Group of courses: **No**

	Lecture	Exercise	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15		15		
Number of hours of total student workload (CNPS)	30		60		
Form of crediting	Crediting with grade		Crediting with grade		
For group of courses mark (X) the final course					
Number of ECTS points	1		2		
including number of ECTS points for practical (P) classes			2.0		
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	1.0		2.0		

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. No requirements concerning the second level.

SUBJECT OBJECTIVES

C1. Understanding of physical principles of basic sensors used in robots
C2. Gain a knowledge of construction of basic sensors used in robots.
C3. Learn about a construction of basic circuits used in measurements systems.
C4. Learn about data processing obtained from specific sensors.
C5. Learn about basic actuators used in robots
C6. Gain a knowledge of limitation of sesors application.

SUBJECT LEARNING OUTCOMES
Relating to knowledge: PEU_W01 - knows purposes of usage of sensors in specific applications PEU_W02 - knows physical principles of basic sensors used in robots PEU_W03 - understands a construction of basic sensors used in robots PEU_W04 - understands basic circuits used in measurements systems Relating to skills: PEU_U01 - a student can interpret data obtained from basic sensors used in robots

PROGRAM CONTENT		
Lecture		**Number of hours**
Lec1	Introduction: program, requirements, literature. Basic concepts and issues	1
Lec2	Force and torque sensors	2
Lec3	Optical distance sensors	2
Lec4	Rangefinders and 3D systems using ultrasonic signals	2
Lec5	Capacitive and inductive sensors. Temperature sensors	2
Lec6	Inertial sensors and magnetometers	2
Lec7	Actuators	2
Lec8	Summary of the lectures; Final test	2
	Total hours:	15

Laboratory		**Number of hours**
Lab1	Introduction: program, requirements, literature	1
Lab2	Linear variable differential transformer	2
Lab3	Strain gauge	2
Lab4	Temperature transducers	2
Lab5	Water level measurements, capacitive sensor	2
Lab6	Resistive force sensors	2
Lab7	Ultrasonic range rinders	2
Lab8	Optical distance sensors	2
	Total hours:	15

TEACHING TOOLS USED
N1. Traditional lecture with the use of a video projector N2. Laboratory classes N3. Consultations N4. Independent work - self study and preparation for the final exam

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation: F — forming (during semester), C — concluding (at semester end)	Learning outcome code	Way of evaluating learning outcome achievement
F1	PEU_W01 ÷ PEU_W04	The final written test
F2	PEU_U01	Activity in the classroom laboratory, evaluation reports of laboratory tasks
P(Lecture) = F1, P(Laboratory) = F2		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] J. Fraden, Handbook of Modern Sensors – Physics, Design, and Applications, Springer-Verlag, 2016

[2] B. Siciliano, et. al., Robotics – Modelling, Planning and Control, Springer-Verlag London Limited, 2009

SECONDARY LITERATURE:

[1] P. Janert, Gnuplot in Action, Manning Publications, 2016

[2] E. Gaura, R. Newman, Smart MEMS and Sensor Systems, Imperial College Press, 2006

[3] Lecture notes

[4] Internet resources

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Faculty of Electronics, Fotonics and Microsystems (W12N) / Department of Cybernetics and Robotics (K29W12ND02)

SUBJECT CARD

Name of subject in Polish: **Roboty społeczne**
Name of subject in English: **Social Robots**
Main field of study (if applicable): **Control Engineering and Robotics (AiR)**
Specialization: **Embedded Robotics (AER)**
Profile: **academic**
Level and form of studies: **2nd level, full-time**
Kind of subject: **facultative**
Subject code: **W12AIR-SM0715**
Group of courses: **No**

	Lecture	Exercise	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15		15		
Number of hours of total student workload (CNPS)	30		30		
Form of crediting	Crediting with grade		Crediting with grade		
For group of courses mark (X) the final course					
Number of ECTS points	1		1		
including number of ECTS points for practical (P) classes			1.0		
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	0.5		0.7		

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. None

SUBJECT OBJECTIVES

C1. Gaining ability to create a common social space of robots and humans
C2. Gaining basic knowledge on technology of social robots

SUBJECT LEARNING OUTCOMES

Relating to knowledge:

PEU_W01 - Knowledge of the fundamental features of a social robot, in particular on a socially intelligent agent and an ebodiment, and on Human-Robot Interactions

Relating to skills:

PEU_U01 - The ability of programming of a humanoid robot NAO, designing and programming of socially interactive behaviours for NAO as well as implementation of short-term scenarios of multimodal human-robot interactions involving NAO

PROGRAM CONTENT		
Lecture		**Number of hours**
Lec1	Introduction to Social Robots	2
Lec2	Computational Models of Emotion, Personality	2
Lec3	User Models, Intentionality	2
Lec4	Embodiment	2
Lec5	Human - Robot Communication	3
Lec6	Human - Robot Interactions	2
Lec7	Selected topics in social robotics and Human-Robot Interactions	2
	Total hours:	15

Laboratory		**Number of hours**
Lab1	Introduction to Laboratory Classes	1
Lab2	Basics of Graphical Programming of Nao in Choreographe	2
Lab3	Perception of Human and Environment by Nao	2
Lab4	Motion, Action, Expressive Behavior	2
Lab5	Voice Communication Between Human and Robot, Dialog System in Nao	2
Lab6	Programming of Interactive Behaviour of Nao with use of Python	2
Lab7	Human – Robot Interactions, Animation of Social Behaviours of a Robot	2
Lab8	Socially Intelligent Agent	2
	Total hours:	15

TEACHING TOOLS USED
N1. traditional lecture using video projector
N2. laboratory classes
N3. office hours
N4. self-study

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation: F — forming (during semester), C — concluding (at semester end)	Learning outcome code	Way of evaluating learning outcome achievement
F1	PEU_W01	Final test
F2	PEU_U01	Evaluation of laboratory classes results
P(Lecture)=F1, P(Laboratory)=F2		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] Terrence Fong, Illah Nourbakhsh, Kerstin Dautenhahn, A survey of socially interactive robots , Robotics and Autonomous Systems, Volume 42, Issues 3-4, pp.143-166

[2] C. Breazeal, A. Takanishi, T. Kobayashi, Social Robots that Interact with People, chapter in: Springer Handbook of Robotics, pp. 1349-1369, Springer Berlin Heidelberg, 2008

[3] Joscha Bach, Dietrich Dörner, Ronnie Vuine, Psi and MicroPsi A Novel Approach to Modeling Emotion and Cognition in a Cognitive Architecture, The 7th International Conference on Cognitive Modeling

[4] Cynthia Breazeal, Emotion and sociable humanoid robots, International Journal of Human-Computer Studies, vol. 59, Issues 1-2, July 2003, pp.119-155

[5] Scassellati, B. Theory of Mind for a Humanoid Robot. Autonomous Robots 12, 13–24 (2002). https://doi.org/10.1023/A:1013298507114

[6] C. Breazeal, Designing Sociable Robots, MIT Press, Cambridge, MA, 2002

[7] Breazeal, C., Dautenhahn, K., Kanda, T. (2016). Social Robotics. In: Siciliano, B., Khatib, O. (eds) Springer Handbook of Robotics. Springer Handbooks. Springer, Cham. https://doi.org/10.1007

SECONDARY LITERATURE:

[1] Joao Miguel de Sousa de Assis Dias, FearNot!: Creating Emotional Autonomous Synthetic Characters for Empathic Interactions, UNIVERSIDADE TÉCNICA DE LISBOA, doctoral dissertation

[2] Bartneck, C., Belpaeme, T., Eyssel, F., Kanda, T., Keijsers, M., & Šabanović, S. (2020). Human-Robot Interaction: An Introduction. Cambridge: Cambridge University Press. doi:10.1017/9781108676649

[3] Wickens, Gordon, and Liu, "Chapter 2: Research Methods", W: An Introduction to Human Factors Engineering, 1998.

[4] Nao, https://www.softbankrobotics.com/

[5] Joscha Bach, Principles of Synthetic Intelligence PSI: An Architecture of Motivated Cognition, Oxford University Press, 2009 DOI:10.1093/acprof:oso/9780195370676.001.0001

[6] Mutlu, B., Roy, N., Šabanović, S. (2016). Cognitive Human–Robot Interaction. In: Siciliano, B., Khatib, O. (eds) Springer Handbook of Robotics. Springer Handbooks. Springer, Cham. https://doi.org/10.1007/978-3-319-32552-1_71 Scassellati, B. Theory of Mind for a Humanoid Robot. Autonomous Robots 12, 13–24 (2002). https://doi.org/10.1023/A:1013298507114

[7] Scassellati, B., Admoni, H., Matarić, M. Robots for use in autism research, Annu Rev Biomed Eng. 2012;14:275-94. doi: 10.1146/annurev-bioeng-071811-150036.

[8] K. Dautenhahn, Methodology \& themes of human-robot interaction: A growing research field. International Journal of Advanced Robotic Systems, 2007, vol.4 (1), s. 103–108.

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

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Faculty of Electronics, Fotonics and Microsystems (W12N) / Department of Cybernetics and Robotics (K29W12ND02)

SUBJECT CARD

Name of subject in Polish: **Seminarium specjalnościowe**
Name of subject in English: **Specialization seminar**
Main field of study (if applicable): **Control Engineering and Robotics (AiR)**
Specialization: **Embedded Robotics (AER)**
Profile: **practical**
Level and form of studies: **2nd level, full-time**
Kind of subject: **facultative**
Subject code: **W12AIR-SM0706S**
Group of courses: **No**

	Lecture	Exercise	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					Crediting with grade
For group of courses mark (X) the final course					
Number of ECTS points					2
including number of ECTS points for practical (P) classes					2.0
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)					1.0

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. None

SUBJECT OBJECTIVES

C1. Acquirement of knowledge on recent developments in the specific area of Embedded Robotics as well as in the broader area of Control Engineering and Robotics

C2. Acquirement of the skills to study technical literature, make a synthesis of collected information, and prepare and deliver a comprehensible seminar in the field

C3. Acquirement of the skills to prepare and present seminar.

C4. Acquirement of the skills to participate constructively in a scientific/technical discussion

SUBJECT LEARNING OUTCOMES

Relating to skills:

PEU_U01 - is able to prepare and present a scientific/technical seminar using traditional and electronic resources.

PEU_U02 - is able to lead and participate in a scientific/technical discussion.

PROGRAM CONTENT

Seminar		Number of hours
Sem1	Presentation of the thematic scope of the seminar, main sources of the material, and principles of preparing and delivering the seminar	2
Sem2	Discussion on the propositions of individual students, acceptance of the seminar topics, and setting the schedule.	2
Sem3 ÷ 15	Individual presentations and class discussions on the delivered material	26
	Total hours:	30

TEACHING TOOLS USED

N1. multimedia presentation

N2. class discussion

N3. independent work

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

Evaluation: F — forming (during semester), C — concluding (at semester end)	Learning outcome code	Way of evaluating learning outcome achievement
F1	PEU_U01	Presentation
F2	PEU_U02	discussion
C = 0,7*F1 + 0,3*F2 (in order to pass the course, both F1 and F2 must be positive)		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] IEEE Robotics \&Automation Magazine

[2] IEEE Transactions on Robotics

[3] IEEE Transactions on Robotics

SECONDARY LITERATURE:

[1] Thomas Braunl, Embedded Robotics, Springer-Verlag, Berlin Heidelberg, 2008

[2] e-books and e-journals in the field accessible through CWiINT at P.Wr.

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Elżbieta Roszkowska, elzbieta.roszkowska@pwr.edu.pl

Faculty of Electronics, Fotonics and Microsystems (W12N) / Department of Cybernetics and Robotics (K29W12ND02)

SUBJECT CARD

Name of subject in Polish: **Planowanie zadań i ruchu**
Name of subject in English: **Task and Motion Planning**
Main field of study (if applicable): **Control Engineering and Robotics (AiR)**
Specialization: **Embedded Robotics (AER)**
Profile: **academic**
Level and form of studies: **2nd level, full-time**
Kind of subject: **facultative**
Subject code: **W12AIR-SM0714**
Group of courses: **No**

	Lecture	Exercise	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30				15
Number of hours of total student workload (CNPS)	60				30
Form of crediting	Crediting with grade				Crediting with grade
For group of courses mark (X) the final course					
Number of ECTS points	2				1
including number of ECTS points for practical (P) classes					1.0
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	1.5				0.7

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Control theory and Optimization
2. mathematical analysis
3. basics of robotics

SUBJECT OBJECTIVES

C1. to acquire knowledge on factors influencing formulation and solution of motion planning tasks
C2. to learn how to select properly a method to a given task
C3. to acquire knowledge on selected methods of motion planning for varied environments and types of models
C4. to gain advanced knowledge, from a technical literature, on applications of action and motion planning methods

SUBJECT LEARNING OUTCOMES
Relating to knowledge: PEU_W01 - Students acquire a knowledge of terminology and mathematical backgrounds of motion planning PEU_W02 - Students are familiar with methods and algorithms of motion planning for various types of robots working in different environments Relating to skills: PEU_U01 - Students are able to locate motion planning among tasks of robotics. PEU_U02 - Students can propose a motion planning method to a given task exploiting some knowledge of its model and desired properties. Relating to social competences: PEU_K01 - Students are aware of necessity to search and collect information permanently and to analyze it critically.

PROGRAM CONTENT		
Lecture		**Number of hours**
Lec1	Terminology and classification of action and motion planning tasks.	2
Lec2	Representations of a state, a space and obstacles. Distance measures between objects.	2
Lec3	Interpolation and approximation methods	2
Lec4	Path planning based on the Newton algorithm.	2
Lec5,6	Motion planning for robots with specific structures or in specific environments	4
Lec7	Sampling-based methods.	2
Lec8	Combinatorial motion planning	2
Lec9,10	Selected analytical methods of motion planning under differential constraints.	4
Lec11,12	Action planning while playing either with a nature or an opponent.	4
Lec13	Biologically inspired motion planning methods.	2
Lec14	Motion planning for multi-agent systems.	2
Lec15	Summary of lectures. Credit Colloquium.	2
	Total hours:	30

Seminar		**Number of hours**
Sem1	Presentation of possible subjects of seminars. Students select one among presented subjects or propose their own subject concerning planning issues.	2
Sem2-7	Seminar presentations on motion planning methods and algorithms or related topics.	12
Sem8	Evaluation of seminar presentations. Seminar summary.	1
	Total hours:	15

TEACHING TOOLS USED
N1. traditional lecture using video projector or remote lecture N2. office hours N3. independent work - self study and preparation for the seminar N4. Seminar discussions.

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation: F — forming (during semester), C — concluding (at semester end)	Learning outcome code	Way of evaluating learning outcome achievement
F1	PEU_W01 ÷ PEU_W02 PEU_U01 ÷ PEU_U02 PEU_K01	Activity at lectures and semiars
F2	PEU_W01 ÷ PEU_W02 PEU_U01 ÷ PEU_U02 PEU_K01	The final written exam
F3	PEU_W01 ÷ PEU_W02 PEU_U01 ÷ PEU_U02 PEU_K01	seminar preparation and presentation, seminar discussion
P(Lect)=0.2*F1 +0.8*F2, P(Sem)=0.2*F1 + 0.8*F3		

PRIMARY AND SECONDARY LITERATURE
PRIMARY LITERATURE: [1] S. LaValle, Planning Algorithms, Cambridge Univ. Press., 2006. [2] J.C. Latombe “Robot motion planning” Kluwer, Boston, 1993 **SECONDARY LITERATURE:** [1] conference and journal papers on motion and action planning [2] Internet resources

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Faculty of Electronics, Fotonics and Microsystems (W12N) / Department of Cybernetics and Robotics (K29W12ND02)

SUBJECT CARD

Name of subject in Polish: **Modelowanie i identyfikacja**
Name of subject in English: **Modeling and identification**
Main field of study (if applicable): **Control Engineering and Robotics (AiR)**
Profile: **academic**
Level and form of studies: **2nd level, full-time**
Kind of subject: **obligatory**
Subject code: **W12AIR-SM0711**
Group of courses: **No**

	Lecture	Exercise	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30		30		
Number of hours of total student workload (CNPS)	90		60		
Form of crediting	Crediting with grade		Crediting with grade		
For group of courses mark (X) the final course					
Number of ECTS points	3		2		
including number of ECTS points for practical (P) classes			2.0		
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	2.0		1.6		

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. None

SUBJECT OBJECTIVES
C1. Gaining the knowledge about generation of pseudo-random numbers
C2. Gaining the knowledge about foundations of estimation theory and assessment of estimation quality
C3. Learning parametric and nonparametric methods of estimation of the probability density function and the regression function
C4. Learning identification methods of linear dynamic systems excited and disturbed by random signals
C5. Learning the least squares method, its properties, scope of applicability and numerical procedures
C6. Learning the instrumental variables method, and procedures of generation of instruments
C7. Learning selected method of identification of block-oriented (Hammerstein and Wiener) systems
C8. Introduction to 'System Identification Toolbox' of Matlab

SUBJECT LEARNING OUTCOMES
Relating to knowledge:
PEU_W01 - knows the methods of computer modeling of random environment
PEU_W02 - knows parametric and nonparametric algorithms of synthesis of linear and nonlinear systems on the basis of uncertain data
PEU_W03 - knows computer realizations of typical methods of system identification
PEU_W04 - knows the methods of generation of random numbers
PEU_W05 - knows selected methods of identification of block-oriented (Hammerstein and Wiener) systems
Relating to skills:
PEU_U01 - can use measurement data for building and testing models of linearand nonlinear plants under various prior knowledge
PEU_U02 - can forecast time series on the basis of collected data
PEU_U03 - can select suitable model for data
PEU_U04 - can conduct experimental analyses using dedicated software
Relating to social competences:
PEU_K01 - is aware of the importance of the ability of data searching and analysis
PEU_K02 - understand the necessity of further self-education and broadening knowledge and skills

PROGRAM CONTENT		
Lecture		**Number of hours**
Lec1	Random number generation by the inversion method	2
Lec2	Random number generation by the rejection method	2
Lec3	Estimation theory, quality of the estimate, limit theorems, types of probabilistic convergence. Parametric and nonparametric approach	2
Lec4	Nonparametric estimation of the distribution function	2
Lec5	Nonparametric estimation of the probability density function	2
Lec6	Regression function estimation – kernel method	2
Lec7	Regression function estimation – orthogonal expansion method	2
Lec8	Identification of linear dynamic systems. Least squares method - synthesis.	2

Lec9	Least squares method – properties	2
Lec10	Least squares method – recursive version	2
Lec11	Linear system excited by random signal. Cross-correlation analysis. Inverse filtering. Gauss-Markov estimate.	2
Lec12	Instrumental variables method	2
Lec13	Computational algorithms of the least square s method (spectral analysis, LU and SVD decomposition)	2
Lec14	Hammerstein and Wiener systems	2
Lec15	Summary	2
	Total hours:	30

Laboratory		**Number of hours**
Lab1	Generation of random numbers – inverse method	2
Lab2	Generation of random numbers – rejection method	2
Lab3	Estimation, limit theorems, mean and sample median and their properties	2
Lab4	Nonparametric identification of distribution function	2
Lab5	Nonparametric identification of probability density function	2
Lab6	Regression function estimation. Kernel method	2
Lab7	Regression function estimation. Orthogonal expanssion method	2
Lab8	Identification of linear systems by the least squares method	2
Lab9	Recursive least squares method	2
Lab10	Cross-correlation analysis, inverse filtering. Gauss-Markov estimate	2
Lab11	Instrumental variables method	2
Lab12	Computational algorithms of the least squares method (spectral analysis, LU and SVD decomposition)	2
Lab13	Hammerstein system	2
Lab14	Wiener system	2
Lab15	Summary	2
	Total hours:	30

TEACHING TOOLS USED
N1. traditional lecture using video projector
N2. laboratory classes
N3. Consultations
N4. independent work - self study and preparation for the final exam
N5. independent work - preparation for the laboratory classes

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation: F — forming (during semester), C — concluding (at semester end)	Learning outcome code	Way of evaluating learning outcome achievement
F1	PEU_W01 ÷ PEU_W05	final written exam

F2	PEU_U01 ÷ PEU_U04 PEU_K01 ÷ PEU_K02	Written tests, Observation on the laboratory, Written reports
P(Lecture) = F1, P(Laboratory)= F2		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] Greblicki, Pawlak – „Nonlinear system identification", Cambridge 2008.
[2] Kincaid, Cheney — "Analiza numeryczna", WNT Warszawa, 2006.
[3] Ljung "System Identification - Theory For the User"
[4] Söderström, Stoica — "Identyfikacja systemów", WNT, Warszawa 1997. wersja angielska: "System identification", Prentice Hall, 1989.
[5] http://diuna.ict.pwr.wroc.pl
[6] L. Ljung, System identification: Theory for the user, Peorson Education (US), 2008
[7] R. Pintelon and J. Schoukens. System Identification: A Frequency Domain Approach. Wiley-IEEE Press, 2004.
[8] J. Schoukens, Mastering System Identification in 100 Exercises , Wiley, 2012.

SECONDARY LITERATURE:

[1] Chow, Teicher — "Probability theory"
[2] Strang — "Introduction to linear algebra"
[3] Hannan, Deistler — "The statistical theory of linear systems"

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

Grzegorz Mzyk, grzegorz.mzyk@pwr.edu.pl

Faculty of Electronics, Fotonics and Microsystems (W12N) / Department of Cybernetics and Robotics (K29W12ND02)

SUBJECT CARD

Name of subject in Polish: **Modelowanie i identyfikacja**
Name of subject in English: **Modeling and identification**
Main field of study (if applicable): **Control Engineering and Robotics (AiR)**
Profile: **academic**
Level and form of studies: **2nd level, full-time**
Kind of subject: **obligatory**
Subject code: **W12AIR-SM0001**
Group of courses: **No**

	Lecture	Exercise	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30		30		
Number of hours of total student workload (CNPS)	90		60		
Form of crediting	Crediting with grade		Crediting with grade		
For group of courses mark (X) the final course					
Number of ECTS points	3		2		
including number of ECTS points for practical (P) classes			2.0		
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	2.0		1.6		

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. None

SUBJECT OBJECTIVES
C1. Gaining the knowledge about generation of pseudo-random numbers
C2. Gaining the knowledge about foundations of estimation theory and assessment of estimation quality
C3. Learning parametric and nonparametric methods of estimation of the probability density function and the regression function
C4. Learning identification methods of linear dynamic systems excited and disturbed by random signals
C5. Learning the least squares method, its properties, scope of applicability and numerical procedures
C6. Learning the instrumental variables method, and procedures of generation of instruments
C7. Learning selected method of identification of block-oriented (Hammerstein and Wiener) systems
C8. Introduction to selected programming tools used in system identification problems

SUBJECT LEARNING OUTCOMES
Relating to knowledge:
PEU_W01 - Knows the methods of computer modeling of random environment
PEU_W02 - knows parametric and nonparametric algorithms of synthesis of linear and nonlinear systems on the basis of uncertain data
PEU_W03 - Knows computer realizations of typical methods of system identification
PEU_W04 - Knows the methods of generation of random numbers
PEU_W05 - Knows selected methods of identification of block-oriented (Hammerstein and Wiener) systems
Relating to skills:
PEU_U01 - can use measurement data for building and testing models of linearand nonlinear plants under various prior knowledge
PEU_U02 - can design a simple model of a given phenomenon based on collected measurements
PEU_U03 - can select suitable model for data
PEU_U04 - can conduct experimental analyses using dedicated software
Relating to social competences:
PEU_K01 - is aware of the importance of the ability of data searching and analysis
PEU_K02 - understand the necessity of further self-education and broadening knowledge and skills

PROGRAM CONTENT		
Lecture		**Number of hours**
Lec1	Random number generation by the inversion method	2
Lec2	Random number generation by the rejection method	2
Lec3	Estimation theory, quality of the estimate, limit theorems, types of probabilistic convergence. Parametric and nonparametric approach	2
Lec4	Nonparametric estimation of the distribution function	2
Lec5	Nonparametric estimation of the probability density function	2
Lec6	Regression function estimation – kernel method	2
Lec7	Regression function estimation – orthogonal expansion method	2
Lec8	Identification of linear dynamic systems. Least squares method - synthesis.	2

Lec9	Least squares method – properties	2
Lec10	Least squares method – recursive version	2
Lec11	Linear system excited by random signal. Cross-correlation analysis. Gauss-Markov estimate.	2
Lec12	Instrumental variables method	2
Lec13	Computational algorithms of the least square s method (spectral analysis, LU and SVD decomposition)	2
Lec14	Hammerstein and Wiener systems	2
Lec15	Summary	2
	Total hours:	30

Laboratory		**Number of hours**
Lab1	Generation of random numbers – inverse method	2
Lab2	Generation of random numbers – rejection method	2
Lab3	Estimation, limit theorems, mean and sample median and their properties	2
Lab4	Nonparametric identification of distribution function	2
Lab5	Nonparametric identification of probability density function	2
Lab6	Regression function estimation. Kernel method	2
Lab7	Regression function estimation. Orthogonal expanssion method	2
Lab8	Identification of linear systems by the least squares method	2
Lab9	Recursive least squares method	2
Lab10	Cross-correlation analysis, inverse filtering. Gauss-Markov estimate	2
Lab11	Instrumental variables method	2
Lab12	Computational algorithms of the least squares method (spectral analysis, LU and SVD decomposition)	2
Lab13	Hammerstein system	2
Lab14	Wiener system	2
Lab15	Summary	2
	Total hours:	30

TEACHING TOOLS USED
N1. traditional lecture using video projector
N2. laboratory classes
N3. Consultations
N4. independent work - self study and preparation for the final exam
N5. independent work - preparation for the laboratory classes

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation: F — forming (during semester), C — concluding (at semester end)	Learning outcome code	Way of evaluating learning outcome achievement
F1	PEU_W01 ÷ PEU_W05	final written/oral exam

F2	PEU_U01 ÷ PEU_U04 PEU_K01 ÷ PEU_K02	Written reports
P(Lect)= F1, P(lab) =F2		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] Gajek, Kałuszka — "Wnioskowanie statystyczne dla studentów"
[2] Greblicki, Pawlak – „Nonlinear system identification", Cambridge 2008.
[3] Kiełbasiński, Schwetlick — "Numeryczna algebra liniowa — wprowadzenie do obliczeń zautomatyzowanych"
[4] Kincaid, Cheney — "Analiza numeryczna", WNT Warszawa, 2006.
[5] Ljung "System Identification - Theory For the User"
[6] Nahorski, Mańczak — "Komputerowa identyfikacja obiektów dynamicznych"
[7] Söderström, Stoica — "Identyfikacja systemów"
[8] Niederlinski — "Systemy komputerowe automatyki przemysłowej"
[9] http://diuna.ict.pwr.wroc.pl

SECONDARY LITERATURE:

[1] Magiera — "Modele i metody statystyki matematycznej", wyd. GiS, Wrocław, 2002.
[2] Stanisz — "Przystępny kurs statystyki w oparciu o pakiet STATISTICA"
[3] Klonecki — "Statystyka matematyczna dla inżynierów"
[4] Krysicki, Włodarski — "Statystyka matematyczna"
[5] Jakubowski, Stencel — "Wstęp do teorii prawdopodobieństwa", wyd. Script,Warszawa, 2004.
[6] Trybuła — "Statystyka matematyczna z elementami teorii decyzji", Ofic. Wyd. PWr., 2002.
[7] Fisz — "Rachunek prawdopodobieństwa i statystyka matematyczna"
[8] Feller — "Wstęp do rachunku prawdopodobieństwa"
[9] Chow, Teicher — "Probability theory"
[10] Strang — "Introduction to linear algebra"
[11] Hannan, Deistler — "The statistical theory of linear systems"
[12] Greblicki — "Podstawy automatyki"
[13] Łysakowska, Mzyk — "Komputerowa symulacja układów automatycznej regulacji w środowisku Matlab/Simulink"

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

Paweł Wachel, pawel.wachel@pwr.edu.pl

Faculty of Electronics, Fotonics and Microsystems (W12N) / Department of Cybernetics and Robotics (K29W12ND02)

SUBJECT CARD

Name of subject in Polish: **Teoria i metody optymalizacji**

Name of subject in English: **Theory and Methods of Optimization**

Main field of study (if applicable): **Control Engineering and Robotics (AiR)**

Profile: **academic**

Level and form of studies: **2nd level, full-time**

Kind of subject: **obligatory**

Subject code: **W12AIR-SM0003**

Group of courses: **No**

	Lecture	Exercise	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30	15			
Number of hours of total student workload (CNPS)	90	60			
Form of crediting	Crediting with grade	Crediting with grade			
For group of courses mark (X) the final course					
Number of ECTS points	3	2			
including number of ECTS points for practical (P) classes		2.0			
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	2.0	1.6			

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. The student has basic knowledge of calculus and algebra.

SUBJECT OBJECTIVES

C1. Learning of the basics of optimization theory

C2. Getting the knowledge of analytic methods of optimization and conditions of optimality

C3. Getting the knowledge of methods of linear and nonlinear optimization with and without constraints. Approximate methods

C4. Getting the skills of using accurate and approximate algorithms for the static optimization problems with and without constraints for continuous and discrete decision variables.

C5. Getting the skills of using standard procedures to solve practical optimization problems

SUBJECT LEARNING OUTCOMES
Relating to knowledge: PEU_W01 - the student has the knowledge about analytic methods of multi-variable and knows the conditions of optimality PEU_W02 - the student knows numerical procedures of local optimization dedicated for specific static optimization problems with and without constraints PEU_W03 - the student has the knowledge of heuristic algorithms, dedicated for specific problems of static optimization Relating to skills: PEU_U01 - the student is able to apply accurate and approximate algorithms to solve the tasks of static opimization with or without constraints PEU_U02 - the student is able to apply accurate and approximate algorithms to solve continuous and discrete optimization problems PEU_U03 - the student can use standard procedures and select suitable parameters for the selected methods PEU_U04 - the student can interpret the meaning of the obtained solution for the specific problems of control theory and robotics

PROGRAM CONTENT		
Lecture		**Number of hours**
Lec1	Optimization – mathematical models, classification of problems. Examples of optimization problems is control theory and robotics.	2
Lec2, 3, 4	Linear programming. Geometric interpretation. Two-phase simplex algorithm. Duality theory for linear programming problem.	6
Lec5	Integer programming. Branch and bound method. Mixed optimization problems.	2
Lec6, 7	Network optimization models. Maximum flow problem. Shortest path problem. Transportation problem.	4
Lec8, 9	Approximate methods of local optimization with and without constraints. Gradient methods.	4
Lec10	Quadratic programming.	2
Lec11, 12	Approximate methods of local optimization without constraints. Sequential quadratic programming. Frank-Wolfe metod. Gradient projection method. Barrier method.	4
Lec13, 14	Heuristic and evolutionary algorithms for selected optimization problems.	4
Lec15	Test.	2
	Total hours:	30

Exercise		**Number of hours**
Ex1	Formulating practical problems from control theory and robotics as optimization problems. Basic optimality conditions.	2
Ex2	Linear programming. Simplex method. Practical applications of linear programming.	4
Ex3	Integer optimization. Practical applications.	2
Ex4	Network optimization.	3

Ex5	Approximate optimization methods. Selection of method parameters.	2
Ex6	Selection of an appropriate optimization method for a given practical problem.	2
	Total hours:	15

TEACHING TOOLS USED
N1. traditional lecture using video projector
N2. Exercises
N3. office hours
N4. independent work - self study and preparation for the final exam
N5. independent work - homework

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation: F — forming (during semester), C — concluding (at semester end)	Learning outcome code	Way of evaluating learning outcome achievement
F1	PEU_W01 ÷ PEU_W03	final written test
F2	PEU_U01 ÷ PEU_U04	activity on classes, grades for homeworks.
P(Lecture) = F1; P(Exercise) = F2		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] S.P. Bradley, A.C. Hax, T.L. Magnanti, Applied Mathematical Programming, Addison-Wesley Publishing Company, 1977

[2] M. Minoux, Mathematical programming - Theory and algorithms, J. Wiley & Sons, 2008.

[3] F.S. Hillier and G.J. Lieberman, Introduction to Operations Research, McGraw-Hill, New York, 1995.

[4] H.P. Williams, Model Building in Mathematical Programming, J. Wiley & Sons, Chichester, UK, 1990.

[5] R. Fletcher, Practical methods of optimization, J. Wiley & Sons, 2000.

[6] G.L. Nemhauser and L.A. Wolsey, Integer and Combinatorial Optimization, J. Wiley & Sons, New York, 1988.

SECONDARY LITERATURE:

[1] A. Ruszczyński, Nonlinear optimization, Princeton University Press, Princeton, NJ, 2006.

[2] S. Boyd, L. Vanderberghe, Convex Optimization, Cambridge University Press, 2004.

[3] D.P. Bertsekas, Nonlinear Programming, Athena Scientific, Belmont, MA, 1999.

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

Piotr Więcek, piotr.wiecek@pwr.edu.pl

Faculty of Electronics, Fotonics and Microsystems (W12N) / Department of Cybernetics and Robotics (K29W12ND02)

SUBJECT CARD

Name of subject in Polish: **Teoria i metody optymalizacji**

Name of subject in English: **Theory and Methods of Optimization**

Main field of study (if applicable): **Control Engineering and Robotics (AiR)**

Profile: **academic**

Level and form of studies: **2nd level, full-time**

Kind of subject: **obligatory**

Subject code: **W12AIR-SM0708**

Group of courses: **No**

	Lecture	Exercise	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15	15			
Number of hours of total student workload (CNPS)	60	30			
Form of crediting	Crediting with grade	Crediting with grade			
For group of courses mark (X) the final course					
Number of ECTS points	2	1			
including number of ECTS points for practical (P) classes		1.0			
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	1.4	0.8			

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. The student has basic knowledge of calculus and algebra.

SUBJECT OBJECTIVES

C1. Learning of the basics of optimization theory

C2. Getting the knowledge of analytic methods of optimization and conditions of optimality

C3. Getting the knowledge of methods of linear and nonlinear optimization with and without constraints. Approximate methods

C4. Getting the skills of using accurate and approximate algorithms for the static optimization problems with and without constraints for continuous and discrete decision variables.

C5. Getting the skills of using standard procedures to solve practical optimization problems

SUBJECT LEARNING OUTCOMES
Relating to knowledge: PEU_W01 - the student has the knowledge about analytic methods of multi-variable and knows the conditions of optimality PEU_W02 - the student knows numerical procedures of local optimization dedicated for specific static optimization problems with and without constraints PEU_W03 - the student has the knowledge of heuristic algorithms, dedicated for specific problems of static optimization Relating to skills: PEU_U01 - the student is able to apply accurate and approximate algorithms to solve the tasks of static opimization with or without constraints PEU_U02 - the student is able to apply accurate and approximate algorithms to solve continuous and discrete optimization problems PEU_U03 - the student can use standard procedures and select suitable parameters for the selected methods PEU_U04 - the student can interpret the meaning of the obtained solution for the specific problems of control theory and robotics

PROGRAM CONTENT		
Lecture		**Number of hours**
Lec1	Optimization – mathematical models, classification of problems. Examples of optimization problems is control theory and robotics.	1
Lec2	Linear programming. Geometric interpretation. Two-phase simplex algorithm. Duality theory for linear programming problem.	4
Lec3	Integer programming. Branch and bound method. Mixed optimization problems.	2
Lec4	Network optimization models. Maximum flow problem. Shortest path problem.	2
Lec5	Approximate methods of local optimization with and without constraints. Gradient methods. Gradient projection method	2
Lec6	Heuristic and evolutionary algorithms for selected optimization problems.	2
Lec7	Test.	2
	Total hours:	15

Exercise		**Number of hours**
Ex1	Formulating practical problems from control theory and robotics as optimization problems. Basic optimality conditions.	2
Ex2	Linear programming. Simplex method. Practical applications of linear programming.	4
Ex3	Integer optimization. Practical applications.	2
Ex4	Network optimization.	3
Ex5	Approximate optimization methods. Selection of method parameters.	2
Ex6	Selection of an appropriate optimization method for a given practical problem.	2
	Total hours:	15

TEACHING TOOLS USED
N1. traditional lecture using video projector
N2. Exercises
N3. office hours
N4. independent work - self study and preparation for the final exam
N5. independent work - homework

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation: F — forming (during semester), C — concluding (at semester end)	Learning outcome code	Way of evaluating learning outcome achievement
F1	PEU_W01 ÷ PEU_W03	final written test
F2	PEU_U01 ÷ PEU_U04	activity on classes, grades for homeworks.
p(Lecture) = F1; P(Exercise) = F2		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] S.P. Bradley, A.C. Hax, T.L. Magnanti, Applied Mathematical Programming, Addison-Wesley Publishing Company, 1977

[2] M. Minoux, Mathematical programming - Theory and algorithms, J. Wiley & Sons, 2008.

[3] F.S. Hillier and G.J. Lieberman, Introduction to Operations Research, McGraw-Hill, New York, 1995.

[4] H.P. Williams, Model Building in Mathematical Programming, J. Wiley & Sons, Chichester, UK, 1990.

[5] R. Fletcher, Practical methods of optimization, J. Wiley & Sons, 2000.

[6] G.L. Nemhauser and L.A. Wolsey, Integer and Combinatorial Optimization, J. Wiley & Sons, New York, 1988.

SECONDARY LITERATURE:

[1] A. Ruszczyński, Nonlinear optimization, Princeton University Press, Princeton, NJ, 2006.

[2] S. Boyd, L. Vanderberghe, Convex Optimization, Cambridge University Press, 2004.

[3] D.P. Bertsekas, Nonlinear Programming, Athena Scientific, Belmont, MA, 1999.

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

Piotr Więcek, piotr.wiecek@pwr.edu.pl

Faculty of Electronics, Fotonics and Microsystems (W12N) / Department of Cybernetics and Robotics (K29W12ND02)

SUBJECT CARD

Name of subject in Polish: **Metody reprezentacji sceny**
Name of subject in English: **Methods of scene representation**
Main field of study (if applicable): **Control Engineering and Robotics (AiR)**
Specialization: **Robotics (ARR)**
Profile: **academic**
Level and form of studies: **2nd level, full-time**
Kind of subject: **obligatory**
Subject code: **W12AIR-SM0108W**
Group of courses: **No**

	Lecture	Exercise	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15				
Number of hours of total student workload (CNPS)	60				
Form of crediting	Crediting with grade				
For group of courses mark (X) the final course					
Number of ECTS points	2				
including number of ECTS points for practical (P) classes					
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	2.0				

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

SUBJECT OBJECTIVES

C1. Student knows fundamental mathematical methods used in pattern recognition theory.
C2. Student designs and builds basic functional blocks of automatic pattern recognition system.
C3. Student knows structure of automatic pattern recognition system.

SUBJECT LEARNING OUTCOMES
Relating to knowledge: PEU_W01 - knows mathematical methods and tools which are necessary to create idea of automatic pattern recognition system PEU_W02 - knows basic functional blocks of automatic pattern recognition system PEU_W03 - posses knowledge necessary to create automatic pattern recognition system

PROGRAM CONTENT		
Lecture		**Number of hours**
Lec1	Introduction, requirements, bibliography. Decision functions.	1
Lec2	Pattern classification by distance functions. Cluster-seeking algorithms.	2
Lec3	Pattern classification as a statistical decision problem. Bayes classifiers.	2
Lec4	Bayesian discriminant functions: how to obtain probability density function. Density approximation. Principle of maximal entropy.	2
Lec5	Adaptive deterministic algorithms of classification. Perceptron.	2
Lec6	Support Vector Machine (SVM method) – optimal discriminant function.	2
Lec7	Adaptive statistical algorithms of classification. Algorithm of Robbins-Munro.	2
Lec8	Writing test.	2
	Total hours:	15

TEACHING TOOLS USED
N1. traditional lecture
N2. individual consulting
N3. independent study - preparation for the final exam

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation: F — forming (during semester), C — concluding (at semester end)	Learning outcome code	Way of evaluating learning outcome achievement
F1	PEU_W01, PEU_W02, PEU_W03	The final written test
P(Lect) = F1		

PRIMARY AND SECONDARY LITERATURE
PRIMARY LITERATURE:
[1] J. Tou, R. Gonzalez: Pattern recognition principles, Addison-Wesley, New York 1974.
[2] R. Tadeusiewicz, M. Flasiński: Rozpoznawanie obrazów. PWN, Warszawa 1991.
SECONDARY LITERATURE:
[1] V. Vapnik: The nature of statistical learning theory. Springer, New York 2000.
[2] M. Crichton: Park jurajski.

SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)
Alicja Mazur, alicja.mazur@pwr.edu.pl

Faculty of Electronics, Fotonics and Microsystems (W12N) / Department of Cybernetics and Robotics (K29W12ND02)

SUBJECT CARD

Name of subject in Polish: **Systemy sterowania robotów**
Name of subject in English: **Systems of robot control**
Main field of study (if applicable): **Control Engineering and Robotics (AiR)**
Specialization: **Robotics (ARR)**
Profile: **academic**
Level and form of studies: **2nd level, full-time**
Kind of subject: **facultative**
Subject code: **W12AIR-SM0105**
Group of courses: **No**

	Lecture	Exercise	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30			15	
Number of hours of total student workload (CNPS)	60			60	
Form of crediting	Crediting with grade			Crediting with grade	
For group of courses mark (X) the final course					
Number of ECTS points	2			2	
including number of ECTS points for practical (P) classes				2.0	
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	1.2			1.6	

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

SUBJECT OBJECTIVES

C1. Student knows main control algorithms for manipulators and mobile robots.

C2. Student can select appropriate control algorithm to design control system for robotic object depending of knowledge of robot's dynamics.

C3. Student can design control system for specific manipulator.

SUBJECT LEARNING OUTCOMES
Relating to knowledge: PEU_W01 - knows appropriate algorithms in case of full knowledge of robot's dynamics or for parametric/structural uncertainty in dynamics PEU_W02 - understands difference between linear approximation and linearization of nonlinear object PEU_W03 - can classify constraints appearing in motion of mobile robot and knows description of classes of conventional mobile robots PEU_W04 - can linearize nonholonomic system in static or dynamic way PEU_W05 - student can design control system for manipulator with elastic joints PEU_W06 - student can control cascade system

PROGRAM CONTENT		
Lecture		**Number of hours**
Lec1	Introduction to the lectures, requirements, bibliography.	2
Lec2	Nonadaptive computed torque control.	2
Lec3	Nonadaptive passivity-based control.	2
Lec4	Adaptive computed torque control.	2
Lec5	Adaptive passivity-based control. Proofs of convergence.	2
Lec6	Robust control. Sliding mode control.	2
Lec7	Input-output decoupling control for rigid manipulator.	2
Lec8	Algorithms for lack of knowledge about robot's dynamics – PD regulation, λ-tracking control.	2
Lec9	Static linearization for manipulator with elastic joints.	2
Lec10	Backstepping control for manipulator with elastic joints.	2
Lec11	Kinematics and dynamics of wheeled mobile robots with nonholonomic constraints.	2
Lec12	Steering using sinusoids for nonholonomic chained systems.	2
Lec13	Static linearization for nonholonomic wheeled mobile robots	2
Lec14	Dynamic linearization for nonholonomic wheeled mobile robots.	2
Lec15	Repetition.	2
	Total hours:	30

Project		**Number of hours**
Pr1	Transformation of robot dynamics into a form obligatory to implement in Matlab/Simulink.	2
Pr2	Checking of selected properties of robot dynamic model.	2
Pr3	Checking of faultless simulation of model – Qu and Dorsey algorithm.	2
Pr4	Admissible trajectory generator – simulation in Matlab/Simulink.	2
Pr5	Designing of appropriate control algorithm for selected manipulator and task.	2
Pr6	Simulation of closed-loop system (object with appropriate control algorithm).	2
Pr7	Simulation of block with parameter adaptation law – checking of correctness.	2
Pr8	Presentation of final report, discussion of results.	2
	Total hours:	16

TEACHING TOOLS USED
N1. traditional lecture N2. independent study - preparation for classes N3. independent study - final report and/or test

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation: F — forming (during semester), C — concluding (at semester end)	Learning outcome code	Way of evaluating learning outcome achievement
F1	PEU_U01, PEU_U02	Partial report, final report
F2	PEU_W01, PEU_W02, PEU_W03, PEU_W04, PEU_W05, PEU_W06	The final written test
P(project) = F1; P(lecture) = F2		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] Tchoń K., Mazur A., Dulęba I., Hossa R., Muszyński R.: Manipulatory i roboty mobilne: modele, planowanie ruchu, sterowanie, Akademicka Oficyna Wydawnicza PLJ, Warszawa 2000.

[2] Canudas de Wit C., Siciliano B., Bastin G.: Theory of Robot Control, Springer, Nowy Jork 1996.

SECONDARY LITERATURE:

[1] Jacak W., Tchoń K.: Podstawy robotyki, skrypt Politechniki Wrocławskiej, Wrocław 1992.

[2] Mazur A.: Sterowanie oparte na modelu dla nieholonomicznych manipulatorów mobilnych, Oficyna Wydawnicza Politechniki Wrocławskiej, Wrocław 2009.

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SUBJECT CARD

Name of subject in Polish: **Seminarium specjalnościowe**
Name of subject in English: **Specialization seminar**
Main field of study (if applicable): **Control Engineering and Robotics (AiR)**
Specialization: **Robotics (ARR)**
Profile: **academic**
Level and form of studies: **2nd level, full-time**
Kind of subject: **facultative**
Subject code: **W12AIR-SM0107S**
Group of courses: **No**

	Lecture	Exercise	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					Crediting with grade
For group of courses mark (X) the final course					
Number of ECTS points					2
including number of ECTS points for practical (P) classes					1.0
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)					1.6

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Can search for information related to the progress of robotics

SUBJECT OBJECTIVES

C1. Gaining knowledge on presentation preparation in order to present own ideas, concepts and solutions in accessible form

SUBJECT LEARNING OUTCOMES

Relating to knowledge:

PEU_W01 - Gains knowledge in a selected area of robotics in the field of robot modeling, robot movement planning, mapping and location algorithms, sensory data analysis

Relating to skills:

PEU_U01 - Is able to critically evaluate the scientific and technical solutions of other people

Relating to social competences:
PEU_K01 - Can substantively justify his original ideas and solutions in a discussion

PROGRAM CONTENT

Seminar		Number of hours
Sem1	Discussion of the thematic scope of the seminar and the rules of preparation presentation. Setting topics for individual students.	2
Sem2	Individual presentations	14
Sem3	Discussion in the seminar group on the topic presented in the presentation, with return attention to the state of literature knowledge and the author's own contribution to the concept of solving the problems discussed in the presentation.	14
	Total hours:	30

TEACHING TOOLS USED

N1. multimedia presentation
N2. discussion
N3. individual work

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

Evaluation: F — forming (during semester), C — concluding (at semester end)	Learning outcome code	Way of evaluating learning outcome achievement
F1	PEU_U01, PEU_W01	presentation
F2	PEU_K01, PEU_W01	discussion
P = 0.5*F1 + 0.5*F2 (in order to pass the course, both F1 and F2 must be positive)		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] K. Tchoń et al.: "Manipulatory i roboty mobilne", Akademicka Oficyna Wydawnicza, Warszawa, 2000.

[2] J. J. Craig: "Wprowadzenie do robotyki", WNT, W - wa, 1983.

[3] J. C. Latombe: "Robot Motion Planning", Kluwer, Boston, 1993.

[4] S. M. LaValle: "Planning Algorithms", Cambridge University Press, 2006.

[5] A. Morecki, J. Knopczyk: "Podstawy robotyki", WNT, W - wa, 1994.

SECONDARY LITERATURE:

[1] K. Kozłowski et al.: "Modelowanie i sterowanie robotów", PWN, Warszawa, 2003.

[2] De Luca C., "Electromyography. Encyclopedia of Medical Devices and Instrumentation", (John G. Webster, Ed.) John Wiley Publisher, 98 - 109, 2006.

[3] H. R. Everett, "Sensors for mobile robot", AK Peters, Ltd., Wellesley 1995.

[4] W. Jacak, "Roboty Inteligentne - metody planowania działań i ruchu", PWr, Wrocław, 1991.

[5] A. Wołczowski, M. Kurzyński, "Human – machine interface in bioprosthesis control using EMG signal classification", Expert Systems 27, 53 - 70, 2010.

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SUBJECT CARD

Name of subject in Polish: **Seminarium dyplomowe**
Name of subject in English: **Diploma Seminar**
Main field of study (if applicable): **Control Engineering and Robotics (AiR)**
Specialization: **Robotics (ARR)**
Profile: **academic**
Level and form of studies: **2nd level, full-time**
Kind of subject: **facultative**
Subject code: **W12AIR-SM0112S**
Group of courses: **No**

	Lecture	Exercise	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)					30
Number of hours of total student workload (CNPS)					90
Form of crediting					Crediting with grade
For group of courses mark (X) the final course					
Number of ECTS points					3
including number of ECTS points for practical (P) classes					3.0
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)					2.4

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. none

SUBJECT OBJECTIVES

C1. Acquire the ability to seek the selective knowledge necessary to create their own original solutions.

C2. Gain the ability to prepare a presentation to communicate own original ideas, concepts and solutions to an audience in a communicative manner.

C3. Acquire creative discussion skills in which one can justify and defend one's position in a factual and substantive manner.

C4. Acquire the ability to write a work that presents one's own achievements, including presenting one's own achievements against the background of the subject literature.

SUBJECT LEARNING OUTCOMES

Relating to skills:

PEU_U01 - is able to prepare a presentation containing the results of solutions to the problem posed

PEU_U02 - can substantiate his/her original ideas and solutions in a discussion

PEU_U03 - can critically evaluate scientific and technical solutions of others

PROGRAM CONTENT

Seminar		Number of hours
Sem1	Discussing the principles of preparing and writing the diploma work, in particular presenting the editorial principles	2
Sem2	Individual presentations concerning the discussion of the current state of knowledge related to the problems of the realized thesis and relating the anticipated, original own contribution to the achievements of the literature	8
Sem3	Discussion in a seminar group on the state of the literature knowledge and the assumed concept of solving problems constituting the thesis	6
Sem4	Individual presentations of the completed thesis with emphasis on the author's own original work, together with a seminar group discussion	14
Sem5	As time permits, discuss questions from the graduation exam	0
	Total hours:	30

TEACHING TOOLS USED

N1. multimedia presentation

N2. problem-based discussion

N3. personal work

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

Evaluation: F — forming (during semester), C — concluding (at semester end)	Learning outcome code	Way of evaluating learning outcome achievement
F1	PEU_U01	presentation
F2	PEU_U02, PEU_U03	seminar discussion
P = 0.5*F1 + 0.5*F2 (in order to pass the course, both F1 and F2 must be positive)		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

SECONDARY LITERATURE:

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SUBJECT CARD

Name of subject in Polish: **Planowanie ruchu robotów**
Name of subject in English: **Robot motion planning**
Main field of study (if applicable): **Control Engineering and Robotics (AiR)**
Specialization: **Robotics (ARR)**
Profile: **academic**
Level and form of studies: **2nd level, full-time**
Kind of subject: **facultative**
Subject code: **W12AIR-SM0111**
Group of courses: **No**

	Lecture	Exercise	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30				15
Number of hours of total student workload (CNPS)	60				30
Form of crediting	Crediting with grade				Crediting with grade
For group of courses mark (X) the final course					
Number of ECTS points	2				1
including number of ECTS points for practical (P) classes					1.0
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	1.5				0.7

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. control theory and optimization
2. basics of robotics

SUBJECT OBJECTIVES
C1. acquiring knowledge about methods and algorithms of motion planning of holonomic and non-holonomic systems
C2. acquiring knowledge about methods and algorithms of motion planning in special environments and robots (groups of robots) with a special structure
C3. gaining the ability to use contemporary English-language literature on robot motion planning methods
C4. acquiring the ability to analyze motion planning algorithms and their practical evaluation (complexity, class of solved tasks, range of applicability)

SUBJECT LEARNING OUTCOMES
Relating to knowledge:
PEU_W01 - has the mathematical knowledge necessary to formulate motion planning tasks
PEU_W02 - knows methods and algorithms of motion planning for various types of robots working in different environments
Relating to skills:
PEU_U01 - can place planning tasks among the tasks of robotics and is able to present the components of motion planning methods for robotic systems with different structures or operating in specific environments
PEU_U02 - can select a method for a given planning problem and to set properly its parameters
Relating to social competences:
PEU_K01 - can evaluate arguments, rationally explain and justify his/her own point of view using subject knowledge

PROGRAM CONTENT		
Lecture		**Number of hours**
Lec1	Terminology and classification of robot motion planning tasks.	2
Lec2,3	Interpolation and approximation methods for manipulator path planning.	4
Lec4	Planning in the neighborhood of singular configurations, modifications of Newton's classical algorithm for holonomic robots. Reducing the computational complexity of planning algorithms.	2
Lec5	Biologically inspired motion planning methods.	2
Lec6	The elastic band method in motion planning.	2
Lec7	Newton's method for nonholonomic driftless systems.	2
Lec8,9	Motion planning in specific environments (mazes).	4
Lec10,11	Lie algebraic method for motion planning of driftless systems.	4
Lec12,13	Motion planning of nonholonomic systems with a special structure.	4
Lec14	Motion planning of multi-robot systems.	2
Lec15	Lecture Summary. Pass mark colloquium.	2
	Total hours:	30

Seminar		Number of hours
Sem1	Presentation of proposed seminar topics. Selection of issues by students.	2
Sem2-7	Presentations of prepared issues on broad planning tasks.	12
Sem8	Summary and final evaluation of the presentation.	1
	Total hours:	15

TEACHING TOOLS USED
N1. Traditional lecture with the use of a video-projector or remote lecture
N2. Consultations
N3. Own work - individual literature studies and preparation for the seminar
N4. Seminar discourse
N5. Own work - preparation for the test

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation: F — forming (during semester), C — concluding (at semester end)	Learning outcome code	Way of evaluating learning outcome achievement
F1	PEU_W01-01, PEU_U01-02, PEU_K01	Activity at lectures and seminars
F2	PEU_W01-02, PEU_U01-02, PEU_K01	seminar preparation, seminar discussions
F3	PEU_W01, PEU_U01-02, PEU_K01	seminar preparation, seminar discussions
P(Lect)=0.2*F1 + 0.8*F2, P(Sem)=0.2*F1 + 0.8*F3		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] K. Tchoń i inni: Manipulatory i roboty mobilne: modele, planowanie ruchu, sterowanie, Akad. Oficyna Wyd PLJ., W - wa, 2000

[2] I. Dulęba: Metody i algorytmy planowania ruchu robotów mobilnych i manipulacyjnych, Akad. Oficyna Wyd. EXIT, W - wa, 2001

[3] J.C. Latombe: Robot motion planning Kluwer, Boston, 1993

SECONDARY LITERATURE:

[1] materiały Krajowych Konferencji Robotyki, czasopisma branżowe PAR, PAK

[2] M. Spong, M. Vidyasagar: Dynamika i sterowanie robotów, WNT, 1997

[3] J.J. Craig: Wprowadzenie do robotyki: mechanika i sterowanie, WNT, 1995

[4] S. LaValle: Planning Algorithms, Cambridge Univ. Press., 2006

[5] materiały międzynarodowych konferencji poświęconych robotyce (MMAR, ICRA, IROS)

[6] artykuły z czasopism: Int. Journ. of Rob. Research, Trans. on Robotics, Robotica, i inne

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SUBJECT CARD

Name of subject in Polish: **Uczenie maszynowe**
Name of subject in English: **Machine Learning**
Main field of study (if applicable): **Control Engineering and Robotics (AiR)**
Specialization: **Robotics (ARR)**
Profile: **academic**
Level and form of studies: **2nd level, full-time**
Kind of subject: **facultative**
Subject code: **W12AIR-SM0110**
Group of courses: **No**

	Lecture	Exercise	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15		15		
Number of hours of total student workload (CNPS)	30		30		
Form of crediting	Crediting with grade		Crediting with grade		
For group of courses mark (X) the final course					
Number of ECTS points	1		1		
including number of ECTS points for practical (P) classes			1.0		
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	1.0		0.8		

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Good programming skills in a C/C++/Java/Python type language

SUBJECT OBJECTIVES

C1. Gain elementary knowledge of machine learning methods: classification, and clustering.
C2. Acquire practical ability of building programs for data mining and machine learning.

SUBJECT LEARNING OUTCOMES

Relating to knowledge:
PEU_W01 - knows the basic supervised and unsupervised machine learning methods

Relating to skills:

PEU_U01 - can implement algorithms for automated data classification and clustering

PROGRAM CONTENT		
Lecture		**Number of hours**
Lec1	Introduction to machine learning. Types of ML algorithms: regression, classification, and clustering. Issues in machine learning: generalization, over- and underfitting, generative and discriminative models, parametric and nonparametric models.	1
Lec2	Decision tree learning. Information gain and entropy. Errors in data. Stopping condition and pruning. Problems with numerical parameters. Binary decision trees.	2
Lec3	Effectiveness of induction machine learning - accuracy and error. Training, validation, and testing sets. Cross validation. Detecting over- and underfitting. The Naïve Bayes classification method. Naïve Bayes for continuous inputs. Logistic regression.	2
Lec4	Error measures in machine learning. The Nearest Neighbors method. Issues in classification machine learning: curse of dimensionality, feature engineering, ensemble learning.	2
Lec5	Neural networks for machine learning. The multilayer perceptron. Network architectures. The backpropagation method.	2
Lec6	Neural networks for machine learning (continued). Tuning the hyper-parameters. Deep learning models. Convolution networks. Transfer learning.	2
Lec7	Unsupervised learning. The k-means algorithm. The Expectation Maximization algorithm. Hierarchical clustering. Dimension reduction - the PCA algorithm.	2
Lec8	The computational theory of learning. The general model. The PAC model. The conditions for PAC-learnability and the required length of the training series. The Vapnik-Chervonenkis dimension.	2
	Total hours:	15

Laboratory		**Number of hours**
Lab1-3	A series of three programming exercises related to the topics covered in the lecture: supervised, unsupervised, and reinforcement machine learning algorithms, feature engineering, evaluating errors, and detecting over- and underfitting.	15
	Total hours:	15

TEACHING TOOLS USED
N1. traditional lecture using a video projector
N2. on-line demonstrations during lectures
N3. laboratory classes
N4. individual consulting
N5. independent study - preparation for laboratory classes
N6. independent study - preparation for the final exam
N7. distant education portal of the WrUST http://eportal.pwr.edu.pl/

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation: F — forming (during semester), C — concluding (at semester end)	Learning outcome code	Way of evaluating learning outcome achievement
F1	PEU_W01	Tests conducted during all lectures, plus the final written test
F2	PEU_U01	Evaluation of the laboratory assignments (reports and programming packages)
P(Lecture) = F1; P(Laboratory) = F2		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] lecture notes

SECONDARY LITERATURE:

[1] S.J.Russell, P.Norvig, Artificial Intelligence A Modern Approach (4th Ed.), Prentice-Hall, 2021
[2] I.H.Witten, E.Frank, M.A.Hall: Data Mining Practical Machine Learning Tools and Techniques (3rd Ed.), Morgan Kaufman, 2011
[3] Kevin P. Murphy: Machine Learning A Probabilistic Perspective, MIT Press, 2012
[4] T.Mitchell, Machine Learning, McGraw Hill, 1997
[5] additional internet resources

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SUBJECT CARD

Name of subject in Polish: **Zaawansowane sterowanie robotami**
Name of subject in English: **Advanced Robot Control**
Main field of study (if applicable): **Control Engineering and Robotics (AiR)**
Specialization: **Embedded Robotics (AER)**
Profile: **academic**
Level and form of studies: **2nd level, full-time**
Kind of subject: **facultative**
Subject code: **W12AIR-SM0717**
Group of courses: **No**

	Lecture	Exercise	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15		15		
Number of hours of total student workload (CNPS)	30		30		
Form of crediting	Crediting with grade		Crediting with grade		
For group of courses mark (X) the final course					
Number of ECTS points	1		1		
including number of ECTS points for practical (P) classes			1.0		
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	0.5		1.0		

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Knowledge about writing computer programs in C/C++ language
2. Knowledge about writing MATLAB scripts
3. Knowledge about Python programming
4. Knowledge about Control Theory and algebra

SUBJECT OBJECTIVES

C1. Gaining knowledge about control algorithms for mobile platforms and manipulators

SUBJECT LEARNING OUTCOMES
Relating to knowledge: PEU_W01 - Knows control algorithms for mobile platforms and manipulators Relating to skills: PEU_U01 - Can implement control algorithms

PROGRAM CONTENT		
Lecture		**Number of hours**
Lec1	Introduction to advanced robot control	1
Lec2	Input-output decoupling method for rigid manipulator	2
Lec3	Static linearisation for (2, 0) mobile platform	2
Lec4	Model predictive control	2
Lec5	Microcontrollers in robotic applications	2
Lec6	RTOS operation based on FreeRTOS	2
Lec7	Embedded system decomposition	2
Lec8	Implementation of robotic driver for a microcontroller	2
	Total hours:	15

Laboratory		**Number of hours**
Lab1	Introduction to laboratories and programming environment	1
Lab2	Simulation of input-output decoupling for a rigid manipulator	2
Lab3	Static linearisation for a wheeled mobile robot	2
Lab4	Trajectory planning task based on Ackerman model with constraints	2
Lab5	Task synchronization for RTOS	2
Lab6	Events in RTOS	2
Lab7	PID controller – implementation and tuning	2
Lab8	Individual task	2
	Total hours:	15

TEACHING TOOLS USED
N1. Traditional lecture with multimedia aid N2. Online presentation N3. Laboratory classes N4. Self education – preparation for laboratory classes N5. Self education – self study and preparation to the final exam

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation: F — forming (during semester), C — concluding (at semester end)	Learning outcome code	Way of evaluating learning outcome achievement
F1	PEU_W01	colloquium

F2	PEU_U01	Laboratory exercise grades
P(lec) = F1; P(lab)=F2		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] Siciliano, B. and Khatib, O., Handbook of Robotics, 2007, Springer
[2] Ben-Ari, M. and Mondada, F., Elements of Robotics, 2018, Springer

SECONDARY LITERATURE:

[1] Astrom, K. J. and Hagglund, T., PID Controllers: Theory, Design, and Tuning, 1995, Instrument Society of America
[2] Real Time Engineers ltd., The FreeRTOS TM Reference Manual, 2016

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