Programme		
Robotics		
Degree	Type	Academic year
Msc	full-time	2020/2021

Purposes

The program is designed as a high-quality educational offer in the area of advanced and intelligent robotics. After graduation the students will have mastered the diverse areas of robotics (mathematical modeling, control engineering, computer engineering, mechanical design) to an extent to be able to deal with robotics systems as a whole rather than just to focus on one particular area. The future career prospects for graduates are very good as the proposed courses are relevant to today’s advanced technology society and because the current output of universities is insufficient to meet the demand of industry and research programmes. Students may take the master as a professional terminal degree, or join PhD programmes afterwards. The graduate of the Robotics studies will demonstrate both the knowledge and abilities necessary for creative work in design, construction, programming and analysis of automation and control systems, as well as industrial and service robot systems. He/she will be capable of solving complex, interdisciplinary problems dealing with control and robotics. The graduate will have general and engineering knowledge at the level enabling him/her to conduct research in RTD centres. The graduate can be employed as senior management in mechanical, electrotechnical, chemical and related industrial sectors. He/she will be capable of designing and analysing complex robotics systems with the use of modern advanced design and analytical tools. He/she will be provided with the theoretical background enabling the solution of research problems in the

Effects of education

Code of effect:	**AiR2_W01**
Description:	Has advanced and deep knowledge in some areas of mathematics covering mathematical methods necessary to model and analyse operations of advanced control elements and robotic systems
Area of study related learning outcomes	P7U_W, I.P7S_WG
Code of effect:	**AiR2_W02**
Description:	Has advanced and deep knowledge on engineering physics, such as on heat exchange processes and biophysics needed to understand the conditions of work of industrial and medical robots.
Area of study related learning outcomes	P7U_W, III.P7S_WG.o, I.P7S_WG
Code of effect:	**AiR2_W03**
Description:	Has advanced and theoretically founded knowledge in the area of description and analysis methods of complex control systems, including multilayered, cascade systems; has knowledge on fuzzy and robust control
Area of study related learning outcomes	I.P7S_WG, P7U_W, III.P7S_WG.o
Code of effect:	**AiR2_W04**
Description:	Has advanced and theoretically founded knowledge on methods of solving tasks of optimum control and linear-square problems
Area of study related learning outcomes	P7U_W, III.P7S_WG.o, I.P7S_WG
Code of effect:	**AiR2_W05**
Description:	Has advanced knowledge on design of digital automation systems
Area of study related learning outcomes	P7U_W, III.P7S_WG.o, I.P7S_WG
Code of effect:	**AiR2_W06**
Description:	Has advanced and structured knowledge on

Effects of education	
	methods of modelling and identification of automation and robotic systems; has structured knowledge on measuring dynamic quantities
Area of study related learning outcomes	III.P7S_WG.o, I.P7S_WG, P7U_W
Code of effect:	**AiR2_W07**
Description:	Has advanced and structured knowledge on theories and methods of local, global, discrete and mixed optimisation
Area of study related learning outcomes	P7U_W, I.P7S_WG
Code of effect:	**AiR2_W08**
Description:	Has advanced and structured knowledge on the rules of modelling, constructing and analysing, in particular strength and collision analyses of mechanical systems of robots, biorobots, manipulators and mobile robots
Area of study related learning outcomes	I.P7S_WG, P7U_W, III.P7S_WG.o
Code of effect:	**AiR2_W09**
Description:	Has structured knowledge on modelling the dynamics of mechatronic systems and their description in the language of analytical mechanics.
Area of study related learning outcomes	P7U_W, I.P7S_WG
Code of effect:	**AiR2_W10**
Description:	Has structured knowledge on advanced tools of computer mechanics and the possibility of their application in modelling and evaluation of characteristics of robotic and biorobotic systems
Area of study related learning outcomes	I.P7S_WG, P7U_W, III.P7S_WG.o
Code of effect:	**AiR2_W11**
Description:	Has knowledge on development trends and most important new achievements in automation and robotics
Area of study related learning outcomes	P7U_W, III.P7S_WK.o, I.P7S_WK
Code of effect:	**AiR2_W12**
Description:	Has structured knowledge on robot control and programming methods
Area of study related learning outcomes	I.P7S_WK, P7U_W, III.P7S_WG.o, I.P7S_WG, III.P7S_WG
Code of effect:	**AiR2_W13**
Description:	Has the knowledge necessary to understand the social, economic, legal and other non-technical determinants of engineering activity and taking them into account in engineering practice.
Area of study related learning outcomes	III.P7S_WK, I.P7S_WK, P7U_W
Code of effect:	**AiR2_U01**
Description:	Can gather information from literature, databases and other chosen sources; can integrate the information obtained, interpret it and evaluate critically, as well as draw conclusions, and formulate and justify opinions well
Area of study related learning outcomes	III.P7S_UW.o, I.P7S_UW.o, P7U_U
Code of effect:	**AiR2_U02**

Effects of education	
Description:	Can work individually and in a team; can evaluate the timeframe of a task; can lead a small team to guarantee completion of a task by a given deadline
Area of study related learning outcomes	I.P7S_UO
Code of effect:	**AiR2_U03**
Description:	Can prepare detailed documentation on the results of an experiment, project or research task; can prepare a presentation of the results
Area of study related learning outcomes	III.P7S_UW.1.o, I.P7S_UW
Code of effect:	**AiR2_U04**
Description:	Can prepare and give a presentation on completion of a project or research task and lead a discussion on the presentation
Area of study related learning outcomes	I.P7S_UK
Code of effect:	**AiR2_U05**
Description:	Uses English well enough to communicate, also on professional matters, read and understand professional literature, and also prepare and make a short presentation on completion of a project or a research task
Area of study related learning outcomes	I.P7S_UK
Code of effect:	**AiR2_U06**
Description:	Can use mathematical methods and models and modify them if needed, for analysis and design of automation and robotic elements and systems
Area of study related learning outcomes	I.P7S_UW, III.P7S_UW.4.o, III.P7S_UW.2.o
Code of effect:	**AiR2_U07**
Description:	Can build a model of a simple automation and robotic system and identify it
Area of study related learning outcomes	III.P7S_UW.2.o, I.P7S_UW
Code of effect:	**AiR2_U08**
Description:	Can plan a process of testing a simple automation and robotic system
Area of study related learning outcomes	III.P7S_UW.1.o, I.P7S_UW
Code of effect:	**AiR2_U09**
Description:	Can configure and programme simple automation and robotic devices, also digitally controlled ones
Area of study related learning outcomes	III.P7S_UW.4.o, I.P7S_UW
Code of effect:	**AiR2_U10**
Description:	Can conduct a process of optimisation of an automation and robotic system using his/her own or dedicated tools.
Area of study related learning outcomes	I.P7S_UW, III.P7S_UW.4.o, III.P7S_UW.3.o
Code of effect:	**AiR2_U11**
Description:	Can formulate and plan tasks of optimum control and conduct a stability analysis of control systems.
Area of study related learning outcomes	I.P7S_UW
Code of effect:	**AiR2_U12**
Description:	When formulating and solving tasks connected with design, modelling and control of automation and robotic systems and elements, can integrate

Effects of education	
	knowledge from various sources.
Area of study related learning outcomes	III.P7S_UW.2.o, I.P7S_UW, III.P7S_UW.4.o
Code of effect:	**AiR2_U13**
Description:	Can estimate the costs of the process of design and completion of an automation and robotic system.
Area of study related learning outcomes	III.P7S_UW.4.o, III.P7S_UW.2.o, I.P7S_UW
Code of effect:	**AiR2_U14**
Description:	Can design mechanical and robot control systems taking into consideration given application and economic criteria, when needed by adjusting existing design methods or CAD and engineering calculation tools or developing new ones.
Area of study related learning outcomes	III.P7S_UW.4.o, III.P7S_UW.2.o, I.P7S_UW
Code of effect:	**AiR2_U15**
Description:	Can design robot mechanical systems for various applications, including biorobotic applications
Area of study related learning outcomes	III.P7S_UW.4.o, I.P7S_UW
Code of effect:	**AiR2_U16**
Description:	Can evaluate the usefulness and possibility of using new achievements in the field of materials, components and design methods and control for synthesis of robotic systems that employ innovative solutions.
Area of study related learning outcomes	III.P7S_UW.3.o, III.P7S_UW.1.o, I.P7S_UW
Code of effect:	**AiR2_U17**
Description:	Basis on the project – verification of the ability of emplying the innovative solutions basis on idividual concept of bio-inspired robot
Area of study related learning outcomes	III.P7S_UW.3.o, I.P7S_UW
Code of effect:	**AiR2_U18**
Description:	Can formulate and test hypotheses connected with engineering problems and simple research problems
Area of study related learning outcomes	III.P7S_UW.3.o, III.P7S_UW.1.o, I.P7S_UW
Code of effect:	**AiR2_U19**
Description:	Is prepared to work in the industry and knows work-related safety standards
Area of study related learning outcomes	I.P7S_UO
Code of effect:	**AiR2_U20**
Description:	has language skills in the field of automation and robotics and related fields, in accordance with the requirements of the B2+ level.
Area of study related learning outcomes	P7U_U, I.P7S_UK
Code of effect:	**AiR2_U21**
Description:	Can define the directions of further learning and implement the process of self-education, as well as direct others in this area.
Area of study related learning outcomes	P7U_U, I.P7S_UU
Code of effect:	**AiR2_K01**
Description:	Can think and act in a creative and entrepreneurial way

Effects of education	
Area of study related learning outcomes	I.P7S_KO, I.P7S_KK
Code of effect:	**AiR2_K02**
Description:	Understands the need to formulate and deliver, especially via mass media, information and opinions on technical achievements in automation and robotics and other aspects of engineering activity in automation and robotics; strives to make the information and opinions widely understandable, presenting various points of view
Area of study related learning outcomes	I.P7S_KR, I.P7S_KO
Code of effect:	**AiR2_K03**
Description:	Understands the importance of knowledge in solving cognitive and practical problems and the need to consult experts in case of difficulties in solving the problem on their own.
Area of study related learning outcomes	I.P7S_KK, P7U_K

Courses by semester

Semester 1

Block	Group	Course	ECTS	Lect.	Exrc.	Lab.	Proj.	Comp. l
Robotics	Elective courses	Attitude and navigation systems	4	15	15	0	15	0
Robotics	Elective courses	Business Law	2	15	15	0	0	0
Robotics	Elective courses	Elective course(s)	4	15	15	15	15	0
Robotics	Elective courses	Future Power Technologies	2	30	0	0	0	0
Robotics	Obligatory courses	Computer vision	5	30	15	0	0	0
Robotics	Obligatory courses	Modeling and control of manipulators	6	30	30	0	0	0
Robotics	Obligatory courses	Neural networks	5	30	15	0	0	0
Robotics	Obligatory courses	Real-time systems	5	30	0	30	15	0
Robotics	Obligatory courses	Signal processing	5	30	15	0	0	0

Semester 2

Block	Group	Course	ECTS	Lect.	Exrc.	Lab.	Proj.	Comp. l
Robotics	Elective courses	Elective course(s)	5	15	15	15	15	0
Robotics	Elective courses	Group project	5	0	0	0	75	0
Robotics	Obligatory courses	Artificial intelligence	4	30	15	0	0	0
Robotics	Obligatory courses	Embedded systems	4	30	15	0	0	0
Robotics	Obligatory courses	Mechanical design in robotics	5	30	0	0	30	0
Robotics	Obligatory courses	Mobile robots	4	30	30	0	0	0
Robotics	Obligatory courses	Optimisation techniques	4	15	15	0	0	0
Robotics	Obligatory courses	Robot programming methods	4	30	30	0	0	0

Semester 3

Block	Group	Course	ECTS	Lect.	Exrc.	Lab.	Proj.	Comp. l
Robotics	Elective courses	Advanced Renewable Energy Sources	3	30	15	0	0	0
Robotics	Elective courses	Elective course(s)	4	15	15	15	15	0
Robotics	Elective courses	Sensors and Measurement Systems	3	15	0	15	0	0
Robotics	Obligatory courses	Advanced mechanical design	5	30	15	0	0	0
Robotics	Obligatory courses	Bio-robotics	5	30	0	0	15	0
Robotics	Obligatory courses	Biomechanics	5	30	15	0	0	0
Robotics	Obligatory courses	Dynamics of multi-body systems	5	30	15	0	0	0
Robotics	Obligatory courses	Research methodology	6	15	0	0	0	0

Semester 4

Block	Group	Course	ECTS	Lect.	Exrc.	Lab.	Proj.	Comp. l

Robotics	Obligatory courses	MSc thesis	30	0	0	0	150	0

Description of course

Code of course	ANS647	
Name of course	Attitude and navigation systems	
Version of course	2019	
A. Place of the course in system of studies		
Level of education	Second cycle studies	
Form and mode of studies	full-time	
Profile of studies	General academic profile	
Specialisation	-	
Place of teaching of course	Faculty of Power and Aeronautical Engineering	
Place of realization of course	Faculty of Power and Aeronautical Engineering.	
Coordinator of course	Prof Janusz Narkiewicz	
B. General characteristic of the course		
Block of courses	Robotics	
Group of courses	Elective courses	
Type of course	Compulsory	
Language of course	english	
Nominal semester	1 (a. y. 2020/2021)	
Time of completion in the academic year	summer semester	
Preliminary requirements	None, but it is recommended to have the base knowledge of flight mechanics, and aeronautical systems.	
Limit of students		
C. Effects of education and manner of teaching		
Purpose of course	To get acquainted navigation systems and methods for determination of position and attitude used in various fields of technology.	
Effects of education	See Table 1.	
Form of didactic studies and number of hours per semester	Lecture	15h
	Exercise type of course	15h
	Laboratory	0h
	Project type of course	15h
	Computer lessons	0h
Contents of education	Lecture: Overview of the methods for position and attitude determination. Architecture of the attitude systems. Sensors and their errors. Accelerometers. Gyroscpes: mechanical, vibrating, dynamically tunned, laser and FOG. Earth gravity and gravity sensors. Earth shape and coordinate systems. Non-othogonal sensors. Application of GNSS for attitude determination. Leveling and gyrocompassing. INS/GPS integration. Project. Design of navigation system composed of prescribed sensors. Design algorithm and program simulation the system. Tutorials: Examples for illustrating topic presented during lectures.	
Methods of evaluation	One test during semester. Report and presentation of the project.	
Methods of verification of learning outcomes	See Table 1.	
Exam	no	
Literature	Literature will be given for each lecture based on books available in university and faculty library.	

Description of course

	Specialised literature will be offered for projects.
Website of the course	

D. Student's activity

Number of ECTS credits	4
Number of hours of student's work to achieve learning outcomes	1) Number of hours that require the presence of a teacher - 50, including: a) attendance at the lectures - 15 hours; b) attendance at the exercises - 15 hours; c) attendance at the design exercises - 15 hours; d) consultancy meetings - 5 hours. 2) The number of hours of independent work of student - 50, including: • systematic preparation for classes - 10 hours; • reading recommended literature by the teacher - 10 hours; • work on the project - 20 hours; • preparing for test - 10 hours. Total - 100 hours.
Number of ECTS credits on the course with direct participation of academic teacher	2 ECTS credits - 50 hours, including: a) attendance at the lectures - 15 hours; b) attendance at the exercises - 15 hours; c) attendance at the design exercises - 15 hours; d) consultancy meetings - 5 hours.
Number of ECTS credits on practical activities on the course	2 ECTS credits - 55 hours, including: a) attendance at the design exercises - 15 hours; b) attendance at the exercises - 15 hours; c) consultancy meetings - 5 hours. d) work on the project - 20 hours.

E. Additional information

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Table 1. Learning outcomes

General academic profile - knowledge

Code of effect:	**ANS647_W01**
Description:	Students should know the principles of aircraft navigation systems.
Verification:	Test
Field of study related learning outcomes	AiR2_W01
Area of study related learning outcomes	I.P7S_WG, P7U_W
Code of effect:	**ANS647_W02**
Description:	Students should know how to measure position, attitude, and velocity of an object in space including aircrafts.
Verification:	Test
Field of study related learning outcomes	AiR2_W06
Area of study related learning outcomes	I.P7S_WG, III.P7S_WG.o, P7U_W

General academic profile - skils

Code of effect:	**ANS647_U01**
Description:	Students should be able to design a simple navigation system composed of provided sensors.
Verification:	Report and presentation of the project
Field of study related learning outcomes	AiR2_U06
Area of study related learning outcomes	I.P7S_UW, III.P7S_UW.2.o, III.P7S_UW.4.o

Table 1. Learning outcomes	
Code of effect:	**ANS647_U02**
Description:	Students should be able to present a project on navigation systems.
Verification:	Report and presentation of the project.
Field of study related learning outcomes	AiR2_U03, AiR2_U04
Area of study related learning outcomes	I.P7S_UW, III.P7S_UW.1.o, I.P7S_UK

Description of course

Code of course	ANK371	
Name of course	Business Law	
Version of course	2019	
A. Place of the course in system of studies		
Level of education	Second cycle studies	
Form and mode of studies	full-time	
Profile of studies	General academic profile	
Specialisation	-	
Place of teaching of course	Faculty of Power and Aeronautical Engineering	
Place of realization of course	Faculty of Administration and Social Sciences	
Coordinator of course	dr Dominik Sypniewski	
B. General characteristic of the course		
Block of courses	Robotics	
Group of courses	Elective courses	
Type of course	Compulsory	
Language of course	english	
Nominal semester	1 (a. y. 2020/2021)	
Time of completion in the academic year	summer semester	
Preliminary requirements	-	
Limit of students	150	
C. Effects of education and manner of teaching		
Purpose of course	The course aims at introducing students basic concepts of business law. Firstly students are familiarized with basic concepts of jurisprudence, introduction to constitutional law, sources of Polish and European business law. The course covers basic concepts of civil and commercial law, including property law, contracts, intellectual property law partnerships and companies. The last part of course concerns administrative aspects of conducting business activities including: registration in the National Court Register or in the Economic Activity Records; different forms of restrictions: concessions, regulated activities and permissions and finally basic concepts of labour law, competition law and tax law.	
Effects of education	See Table 2.	
Form of didactic studies and number of hours per semester	Lecture	15h
	Exercise type of course	15h
	Laboratory	0h
	Project type of course	0h
	Computer lessons	0h
Contents of education	1. Introduction to jurisprudence. Basic concepts. 2. Constitutional Law. 3. Sources of Polish and European business law. 4. Civil Law (1) – general provisions. 5. Civil Law (2) – property law. 6. Civil Law (3) – contracts. 7. Civil Law (4) – intellectual property law. 8. Partnerships. 9. Companies. 10. The National Court Register & the Economic Activity Records. 11. Concessions, Regulated Activities and Permissions. 12. Labour Law. 13.	

Description of course

	Competition Law. 14. Introduction to tax law.
Methods of evaluation	Multiple choice test.
Methods of verification of learning outcomes	See Table 2.
Exam	no
Literature	1. M. Możdzeń-Marcinkowski, Introduction to Polish Administrative Law, C.H. Beck, Warsaw 2009. 2. J. Jabłońska-Błońca, Introduction to Law, LexisNexis, Warsaw 2008. 3. R. Lewandowski, Polish Commercial Law: An Introduction, C.H. Beck 2007. 4. Documents and slideshows delivered by the lecturer.
Website of the course	-

D. Student’s activity

Number of ECTS credits	2
Number of hours of student’s work to achieve learning outcomes	1) Number of hours that require the presence of a teacher - 32, including: a) attendance at the lectures- 15 hours; b) attendance at the exercises – 15 hours; c) consultancy meetings – 2 hours. 2) The number of hours of independent work of student: • systematic preparation for classes - 15 hours; • preparing for final test - 6 hours; • homework – 5 hours. TOTAL: 53 hours.
Number of ECTS credits on the course with direct participation of academic teacher	1,3 ECTS credits – number of of hours that require the presence of a teacher - 32, including: a) attendance at the lectures- 15 hours; b) attendance at the exercises – 15 hours; c) consultancy meetings – 2 hours.
Number of ECTS credits on practical activities on the course	-

E. Additional information

Notes	-
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Table 2. Learning outcomes

General academic profile - social competences

Code of effect:	**ANK371_K1**
Description:	Is able to conduct administrative aspects of business.
Verification:	Final test
Field of study related learning outcomes	AiR2_K01
Area of study related learning outcomes	I.P7S_KK, I.P7S_KO

Description of course

Code of course	EM06	
Name of course	Elective course(s)	
Version of course	2019	
A. Place of the course in system of studies		
Level of education	Second cycle studies	
Form and mode of studies	full-time	
Profile of studies	General academic profile	
Specialisation	-	
Place of teaching of course	Faculty of Power and Aeronautical Engineering	
Place of realization of course	FPAE	
Coordinator of course	x	
B. General characteristic of the course		
Block of courses	Robotics	
Group of courses	Elective courses	
Type of course	Elective	
Language of course	english	
Nominal semester	1 (a. y. 2020/2021)	
Time of completion in the academic year	summer semester	
Preliminary requirements	xx	
Limit of students	100	
C. Effects of education and manner of teaching		
Purpose of course	x	
Effects of education	See Table 3.	
Form of didactic studies and number of hours per semester	Lecture	15h
	Exercise type of course	15h
	Laboratory	15h
	Project type of course	15h
	Computer lessons	0h
Contents of education	x	
Methods of evaluation	x	
Methods of verification of learning outcomes	See Table 3.	
Exam	no	
Literature	x	
Website of the course	xxx	
D. Student’s activity		
Number of ECTS credits	4	
Number of hours of student’s work to achieve learning outcomes	x	
Number of ECTS credits on the course with direct participation of academic teacher	x	
Number of ECTS credits on practical activities on the course	x	
E. Additional information		
Notes	x	
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Table 3. Learning outcomes

Description of course

Code of course	ANS535	
Name of course	Future Power Technologies	
Version of course	2019	
A. Place of the course in system of studies		
Level of education	Second cycle studies	
Form and mode of studies	full-time	
Profile of studies	General academic profile	
Specialisation	-	
Place of teaching of course	Faculty of Power and Aeronautical Engineering	
Place of realization of course	Faculty of Power and Aeronautical Engineering	
Coordinator of course	prof. dr hab. inż. Krzysztof Badyda	
B. General characteristic of the course		
Block of courses	Robotics	
Group of courses	Elective courses	
Type of course	Compulsory	
Language of course	english	
Nominal semester	1 (a. y. 2020/2021)	
Time of completion in the academic year	summer semester	
Preliminary requirements	-	
Limit of students		
C. Effects of education and manner of teaching		
Purpose of course	After completing the course the student has a basic knowledge of the possible directions of energy development, including the legal and economic conditions.	
Effects of education	See Table 4.	
Form of didactic studies and number of hours per semester	Lecture	30h
	Exercise type of course	0h
	Laboratory	0h
	Project type of course	0h
	Computer lessons	0h
Contents of education	Selected elements of the theory of energy conversion. Current trends in energy development. Technical and economic considerations. Overview of promising energy technologies (gas-steam systems, combustion techniques, gasification of fuels, fuel cells, nuclear reactors and fusion, etc..). Ecological determinants of energy.	
Methods of evaluation	The scoring system includes the work of students in the class and test results are final.	
Methods of verification of learning outcomes	See Table 4.	
Exam	no	
Literature		
Website of the course		
D. Student’s activity		
Number of ECTS credits	2	
Number of hours of student’s work to achieve learning outcomes	1) Number of hours that require the presence of a teacher - 35, including: a) attendance at the lectures- 30 hours; b) consultancy meetings - 5 hours. 2) The number of hours of independent work of student – 25, including: • systematic	

Description of course

	preparation for classes - 15 hours; • preparing for test -10 hours.
Number of ECTS credits on the course with direct participation of academic teacher	1,5 ECTS credits – number of hours that require the presence of a teacher - 35, including: a) attendance at the lectures - 30 hours; b) consultancy meetings - 5 hours.
Number of ECTS credits on practical activities on the course	

E. Additional information

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Table 4. Learning outcomes

General academic profile - knowledge

Code of effect:	**ANS535_W01**
Description:	Students should have basic knowledge on the advancements in energy industry.
Verification:	Final test
Field of study related learning outcomes	AiR2_W02
Area of study related learning outcomes	I.P7S_WG, III.P7S_WG.o, P7U_W

Description of course

Code of course	EM04	
Name of course	Computer vision	
Version of course	2019	
A. Place of the course in system of studies		
Level of education	Second cycle studies	
Form and mode of studies	full-time	
Profile of studies	General academic profile	
Specialisation	-	
Place of teaching of course	Faculty of Power and Aeronautical Engineering	
Place of realization of course	Institute of Control and Computation Engineering, The Faculty of Electronics and Information Technology	
Coordinator of course	Włodzimierz Kasprzak, Ph.D., D.Sc. Professor	
B. General characteristic of the course		
Block of courses	Robotics	
Group of courses	Obligatory courses	
Type of course	Compulsory	
Language of course	english	
Nominal semester	1 (a. y. 2020/2021)	
Time of completion in the academic year	summer semester	
Preliminary requirements	-	
Limit of students	100	
C. Effects of education and manner of teaching		
Purpose of course	The objective is to learn the methods of image processing and image analysis, especially dedicated to robot vision problems, like the 3-D object recognition, -reconstruction and -tracking. The goal is also practically to exercise the use of such methods.	
Effects of education	See Table 5.	
Form of didactic studies and number of hours per semester	Lecture	30h
	Exercise type of course	15h
	Laboratory	0h
	Project type of course	0h
	Computer lessons	0h
Contents of education	Contents: 1. Image formation and auto-calibration. 2. Two-view geometry - stereo-vision. 3. Low-level image processing: image normalization, colour spaces, image compression and image filtering. 4. Image segmentation: edge detection, chain and line segment detection, Hough transforms, homogeneous region-, shape- and texture description. 5. Processing of RGB-D images: point cloud processing, 3-D occupancy map creation, map approximation, 3-D point descriptors. 6. Image motion estimation: gradient- and block-based optical flow, discrete feature motion and active contour tracking. 7. Object recognition: dynamic programming search, hypothesis generation-and-test, model-to-image matching and graph search. 8. 3-D Object reconstruction: surface-from-shading, multi-view and motion-	

Description of course

	based object reconstruction. 9. Dynamic vision: object tracking – recursive state estimation, autonomous navigation, discrete self-localization. Practical Work: Computational and computer exercises on image processing and image analysis, illustrating the algorithms introduced at the lecture. Solving a homework – a design and implementation of an image processing and analysis algorithm, or an object recognition, -reconstruction or –tracking algorithm.
Methods of evaluation	70% continuous assessment, 30% from end-semester examination
Methods of verification of learning outcomes	See Table 5.
Exam	yes
Literature	Recommended texts: - W. Kasprzak, Computer Vision, lecture e-notes, WUT, 2008-2014. - Y. Ma, S. Soatto, J. Kosecka, S. Sastry, An Invitation to 3D Vision. From Images to Geometric Models, Springer-Verlag, New York 2004. on-line: vision.ucla.edu/MASKS/ - I. Pitas, Digital Image Processing Algorithms, Prentice Hall, New York, 1993. - O. Faugeras, Three-dimensional computer vision. A geometric viewpoint, The MIT Press. Cambridge, Mass. 1993, 2001 Further readings: • B. Siciliano, O. Khatib (eds.): Handbook of Robotics. Springer, Berlin Heidelberg, 2008 • OpenCV documentation: http://opencv.org/documentation.html • PCL (point clouds library) documentation: http://pointclouds.org/documentation/
Website of the course	http://studia.elka.pw.edu.pl/pub/14Z/ECOVI.A/

D. Student’s activity

Number of ECTS credits	5
Number of hours of student’s work to achieve learning outcomes	1) Number of hours that require the presence of a teacher – 50, including a) presence of the lectures - 30; b) presence in the exercises - 15 c) presence on consultation - 5 2) The number of hours of independent work of student - 85
Number of ECTS credits on the course with direct participation of academic teacher	2 ECTS credits – number of hours that require the presence of a teacher – 50, including a) presence of the lectures - 30; b) presence in the exercises - 15 c) presence on consultation - 5
Number of ECTS credits on practical activities on the course	3 ECTS credits – which are obtained during classes of a practical nature; number of hours during classes of a practical nature - 80, including b) presence in the exercises - 15 c) presence on consultation – 5 d) independent work of student on solving practical exercise tasks and a homework task – 60

E. Additional information

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Table 5. Learning outcomes	
General academic profile - knowledge	
Code of effect:	**EM04_W1**
Description:	Knowledge of different image processing methods
Verification:	Continuous assessment at tutorials regarding the acquired knowledge needed to solve computational and algorithmic exercise tasks, related to the content of this course. Written assessment of the course outcomes by a written mid-time test. Written assessment of the course outcomes by a final exam
Field of study related learning outcomes	AiR2_W01, AiR2_W04, AiR2_W11, AiR2_W12
Area of study related learning outcomes	I.P7S_WG, P7U_W, III.P7S_WG.o, I.P7S_WK, III.P7S_WK.o, III.P7S_WG
General academic profile - skils	
Code of effect:	**EM04_U1**
Description:	Ability to select proper image processing method for a specific pu
Verification:	Continuous assessment at tutorials regarding the acquired knowledge needed to solve computational and algorithmic exercise tasks, related to the content of this course.
Field of study related learning outcomes	AiR2_U16, AiR2_U01, AiR2_U06
Area of study related learning outcomes	III.P7S_UW.3.o, P7U_U, I.P7S_UW.o, III.P7S_UW.o, I.P7S_UW, III.P7S_UW.2.o, III.P7S_UW.4.o, III.P7S_UW.1.o
Code of effect:	**EM04_U2**
Description:	Able to process the images for the purpose of getting the required information
Verification:	Continuous assessment at tutorials regarding the acquired knowledge needed to solve computational and algorithmic exercise tasks, related to the content of this course.
Field of study related learning outcomes	AiR2_U06, AiR2_U12, AiR2_U16
Area of study related learning outcomes	I.P7S_UW, III.P7S_UW.2.o, III.P7S_UW.4.o, III.P7S_UW.1.o, III.P7S_UW.3.o
Code of effect:	**EM04_U3**
Description:	Able to use the vision for objects recognition and robot motion guidance
Verification:	Continuous assessment at tutorials regarding the acquired knowledge needed to solve computational and algorithmic exercise tasks, related to the content of this course.
Field of study related learning outcomes	AiR2_U14, AiR2_U17
Area of study related learning outcomes	I.P7S_UW, III.P7S_UW.2.o, III.P7S_UW.4.o, III.P7S_UW.3.o

Description of course

Code of course	EM01
Name of course	Modeling and control of manipulators
Version of course	2019

A. Place of the course in system of studies

Level of education	Second cycle studies
Form and mode of studies	full-time
Profile of studies	General academic profile
Specialisation	-
Place of teaching of course	Faculty of Power and Aeronautical Engineering
Place of realization of course	Institute of Control and Computation Engineering, The Faculty of Electronics and Information Technology
Coordinator of course	prof. C. Zielinski, prof. P. Tatjewski

B. General characteristic of the course

Block of courses	Robotics
Group of courses	Obligatory courses
Type of course	Compulsory
Language of course	english
Nominal semester	1 (a. y. 2020/2021)
Time of completion in the academic year	summer semester
Preliminary requirements	The student must have mastered mathematics encompassing the fundamentals of matrix algebra, differential and integral calculus as well as differential equations. Moreover, he/she should know the basics of physics, especially mechanics of rigid bodies.
Limit of students	100

C. Effects of education and manner of teaching

Purpose of course	This course presents the fundamentals of the modelling and control techniques of serial manipulators. Topics include robot architectures, geometric modelling, kinematic models, dynamic modelling and its applications, as well as the classical PID controller and computed torques controller.	
Effects of education	See Table 6.	
Form of didactic studies and number of hours per semester	Lecture	30h
	Exercise type of course	30h
	Laboratory	0h
	Project type of course	0h
	Computer lessons	0h
Contents of education	The following subjects will be treated: Robot architectures, joint space, operational space, Homogenous transformation matrices, Description of manipulator kinematics using modified Denavit and Hartenberg notations, Direct geometric model, Inverse geometric models using Paul’s method, Piper’s method and general methods, Calculation of kinematic Jacobian matrix, Inverse kinematics for regular and redundant robots, Dynamic modelling using the Lagrange formalism, Dynamic modelling using recursive Newton-Euler	

Description of course

	method, Trajectory generation between two points in the joint space and in the operational space, Classical PID control Computed torque Control.
Methods of evaluation	20% continuous assessment, 80% from end of semester examination.
Methods of verification of learning outcomes	See Table 6.
Exam	yes
Literature	Recommended texts: - W. Khalil, and E. Dombre, Modelling, identification and control of robots, Hermes Penton, London, 2002. Further readings: - C.Canudas, B. Siciliano, G.Bastin (editors), Theory of Robot Control, Springer-Verlag, 1996 - J. Angeles, Fundamentals of Robotic Mechanical Systems, Springer-Verlag, New York, 2002.
Website of the course	https://studia.elka.pw.edu.pl/priv/14Z/EMOMA.A/

D. Student's activity

Number of ECTS credits	6
Number of hours of student's work to achieve learning outcomes	1) Number of hours that require the presence of a teacher - 65, including a) participation in the the lectures- 30; b) participation in the exercises - 30 c) participation in the consultations - 5 2) The number of hours of independent work of a student 85 hrs: literature studies – 20 hrs, homework 1 – 40 hrs, homework 2 – 25 hrs
Number of ECTS credits on the course with direct participation of academic teacher	3 ECTS credits - number of hours that require the presence of a teacher - 65, including a) participation in the the lectures- 30; b) participation in the exercises - 30 c) participation in the consultations - 5
Number of ECTS credits on practical activities on the course	4 ECTS credits, including a) participation in the exercises – 30; b) solution of homework problems and self study - 85

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Table 6. Learning outcomes

General academic profile - knowledge

Code of effect:	**EM01_W1**
Description:	Understands fundamentals of mathematical models of serial robot manipulators and their applications in robots design, control and simulation.
Verification:	Exam
Field of study related learning outcomes	AiR2_W01, AiR2_W06, AiR2_W09, AiR2_W12
Area of study related learning outcomes	I.P7S_WG, P7U_W, III.P7S_WG.o, I.P7S_WK, III.P7S_WG
Code of effect:	**EM01_W2**
Description:	Understands the influence of the kinematic parameters on the manipulator characteristics.
Verification:	Exam

Table 6. Learning outcomes	
Field of study related learning outcomes	AiR2_W06, AiR2_W09
Area of study related learning outcomes	I.P7S_WG, III.P7S_WG.o, P7U_W
Code of effect:	**EM01_W3**
Description:	Understands practical applications of mathematical modelling of manipulators
Verification:	Exam
Field of study related learning outcomes	AiR2_W09
Area of study related learning outcomes	I.P7S_WG, P7U_W
General academic profile - skils	
Code of effect:	**EM01_U1**
Description:	Can apply the most appropriate computational method to generate a manipulator model.
Verification:	Practical activities
Field of study related learning outcomes	AiR2_U06, AiR2_U07
Area of study related learning outcomes	III.P7S_UW.4.o, I.P7S_UW, III.P7S_UW.2.o
Code of effect:	**EM01_U2**
Description:	Can use of symbolic and numerical software packages (Matlab, Simulink, Maple, Mathematica, ...),
Verification:	Practical activities
Field of study related learning outcomes	AiR2_U01, AiR2_U06, AiR2_U14, AiR2_U16
Area of study related learning outcomes	P7U_U, I.P7S_UW.o, III.P7S_UW.o, I.P7S_UW, III.P7S_UW.2.o, III.P7S_UW.4.o, III.P7S_UW.1.o, III.P7S_UW.3.o

Description of course

Code of course	EM05	
Name of course	Neural networks	
Version of course	2019	
A. Place of the course in system of studies		
Level of education	Second cycle studies	
Form and mode of studies	full-time	
Profile of studies	General academic profile	
Specialisation	-	
Place of teaching of course	Faculty of Power and Aeronautical Engineering	
Place of realization of course	FPAE	
Coordinator of course	dr inż. Andrzej Kordecki	
B. General characteristic of the course		
Block of courses	Robotics	
Group of courses	Obligatory courses	
Type of course	Compulsory	
Language of course	english	
Nominal semester	1 (a. y. 2020/2021)	
Time of completion in the academic year	summer semester	
Preliminary requirements	Fundamentals of mathematics and control systems.	
Limit of students	100	
C. Effects of education and manner of teaching		
Purpose of course	The goal of the class is to present neural networks as tools for pattern classification, function approximation, and system modelling and prediction. Neural methodology will be thus treated as a step in development of dynamic systems. Neural networks are presented as static or dynamic systems whose main distinctive properties are modularity and adaptability. They are presented in the context of classification, function approximation, dynamical system modelling, and other applications.	
Effects of education	See Table 7.	
Form of didactic studies and number of hours per semester	Lecture	30h
	Exercise type of course	15h
	Laboratory	0h
	Project type of course	0h
	Computer lessons	0h
Contents of education	Contents: Classification abilities are discussed for contemporary versions of Rosenblatt’s perceptron, support vector machines, and multi-layer perceptrons. They are complemented with elements of learning theory and probably approximately correct estimators. Approximation properties of neural networks are outlined for multilayer perceptrons and for radial basis function networks, and connected to linear regression models. In particular, approximation quality and generalization problems are discussed. Back-propagation is derived as an effective way to calculate gradients in large	

Description of course

	systems. Theoretical abilities of function approximation properties of multi-layer perceptrons and radial basis function networks are also analyzed. Dynamic neural networks are outlined in the context of dynamical system modelling, contents-addressable memories, and combinatorial system optimization. Neural ARMA models will be derived as a generalization of ARMA models, and their properties will be analyzed. Stability of dynamic networks is discussed in the context of system optimization and contents-addressable memories. Practical Work: Exercises on the application of the neural networks
Methods of evaluation	30% continuous assessment, 70% from end of semester examination.
Methods of verification of learning outcomes	See Table 7.
Exam	yes
Literature	Recommended texts: G.C.Bekey, K.Y.Goldberg, Neural Networks in Robotics, Kluwer 1993 R. Callan, The Essence of Neural Networks, Pearson Education (Academic), 1998 Further readings: will be provided by lecturer
Website of the course	xxx

D. Student’s activity

Number of ECTS credits	5
Number of hours of student’s work to achieve learning outcomes	1) Number of hours that require the presence of a teacher - 50, including a) presence of the lectures- 30, b) presence in the exercises -15, c) presence on consultation -5. 2) The number of hours of independent work of student - 50hrs 20hrs – solving the examples, 30hrs – self study
Number of ECTS credits on the course with direct participation of academic teacher	3 ECTS credits - number of hours that require the presence of a teacher - 50, including a) presence of the lectures- 30, b) presence in the exercises -15, c) presence on consultation -5.
Number of ECTS credits on practical activities on the course	1 ECTS a) tutorials – 15hrs b) solving the examples within self study – 20hrs Practical Work: Exercises on the application of the neural networks.

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Table 7. Learning outcomes

General academic profile - knowledge

Code of effect:	**EM05_W1**
Description:	Understand the commonly used neural network architectures and learning algorithms.
Verification:	exam
Field of study related learning outcomes	AiR2_W01, AiR2_W03
Area of study related learning outcomes	I.P7S_WG, P7U_W, III.P7S_WG.o

Table 7. Learning outcomes	
Code of effect:	**EM05_W2**
Description:	Distinguish classes of problems to which neural networks offer solutions superior to other methods.
Verification:	exam
Field of study related learning outcomes	AiR2_W06, AiR2_W07
Area of study related learning outcomes	I.P7S_WG, III.P7S_WG.o, P7U_W
General academic profile - skils	
Code of effect:	**EM05_U1**
Description:	Design a neural network to solve a practical problem.
Verification:	Practical activities
Field of study related learning outcomes	AiR2_U06, AiR2_U07
Area of study related learning outcomes	I.P7S_UW, III.P7S_UW.2.o, III.P7S_UW.4.o
Code of effect:	**EM05_U2**
Description:	Gain a practical experience on how to apply neural network methods to classification problems.
Verification:	Practical activities
Field of study related learning outcomes	AiR2_U06, AiR2_U08
Area of study related learning outcomes	I.P7S_UW, III.P7S_UW.2.o, III.P7S_UW.4.o, III.P7S_UW.1.o
Code of effect:	**EM05_U3**
Description:	Approximate diverse functions by neural networks.
Verification:	Exam
Field of study related learning outcomes	AiR2_U06
Area of study related learning outcomes	III.P7S_UW.2.o, III.P7S_UW.4.o, I.P7S_UW
Code of effect:	**EM05_U4**
Description:	Set-up a dynamical neural model
Verification:	practical activities
Field of study related learning outcomes	AiR2_U06, AiR2_U07, AiR2_U08
Area of study related learning outcomes	I.P7S_UW, III.P7S_UW.2.o, III.P7S_UW.4.o, III.P7S_UW.1.o

Description of course

Code of course	EM02	
Name of course	Real-time systems	
Version of course	2019	
A. Place of the course in system of studies		
Level of education	Second cycle studies	
Form and mode of studies	full-time	
Profile of studies	General academic profile	
Specialisation	-	
Place of teaching of course	Faculty of Power and Aeronautical Engineering	
Place of realization of course	Institute of Control and Computation Engineering, The Faculty of Electronics and Information Technology	
Coordinator of course	dr inż. T. Kruk	
B. General characteristic of the course		
Block of courses	Robotics	
Group of courses	Obligatory courses	
Type of course	Compulsory	
Language of course	english	
Nominal semester	1 (a. y. 2020/2021)	
Time of completion in the academic year	summer semester	
Preliminary requirements	It is recommended to know basics of programming .	
Limit of students	100	
C. Effects of education and manner of teaching		
Purpose of course	To learn about designing real-time systems, specific features of such systems and about real-time operating systems	
Effects of education	See Table 8.	
Form of didactic studies and number of hours per semester	Lecture	30h
	Exercise type of course	0h
	Laboratory	30h
	Project type of course	15h
	Computer lessons	0h
Contents of education	Contents: The program of the lecture: 1.Real-time systems, its features, hard and soft variant of a real-time system. 2.Production process of a real-time system. 3.Real-time operating systems, examples of such systems: VX Works, VERTEX, QNX Neutrino, etc. 4.Real-time variants of Linux. 5.Specific features of QNX Neutrino [or alternatively of RT Linux, depending on the platform that will be used on project classes] – about four or five lectures. 6.Basics of real-time programming languages, programming in ADA. 7.Task scheduling in real-time systems. 8.Examples of real-time systems.	
Methods of evaluation	50% continuous assessment basis on laboratory work, 50% exam. Practical Work: laboratory classes and/or project, where students will design and implement a simple real-time system, e.g., a control program for a simple robot.	
Methods of verification of learning outcomes	See Table 8.	

Description of course

Exam	yes
Literature	Recommended texts: 1) Jane W.S. Liu, Real-Time Systems, Prentice Hall, 2000. 2) Giorgio C. Buttazo, Hard Real-time Computing Systems, Kluwer Academic publishers, 1997. 3) Documentation on http://www.qnx.com . Further readings: - W.A.Halang, K.M.Sacha: Real-time Systems. World Scientific 1992 - will be provided by lecturer
Website of the course	-

D. Student's activity

Number of ECTS credits	5
Number of hours of student's work to achieve learning outcomes	1) Number of hours that require the presence of a teacher - 90, including a) presence of the lectures – 30; b) presence in the labs – 30, c) presence in the design exercises - 15 d) presence on consultation - 30 2) The number of hours of independent work of student 70 h
Number of ECTS credits on the course with direct participation of academic teacher	4 ECTS credits – number of hours that require the presence of a teacher - 105, including a) uczestniczenie w wykładzie/ presence of the lectures - 30; b) uczestniczenie w laboratoriach/ presence in the labs – 30, c) uczestniczenie w ćwiczeniach projektowych/ presence in the design exercises - 15 d) uczestniczenie w konsultacjach/ presence on consultation: 30
Number of ECTS credits on practical activities on the course	3

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Table 8. Learning outcomes

General academic profile - knowledge

Code of effect:	**EM02_W1**
Description:	Students should have knowledge on design principles of real-time operating systems and specific features of such systems.
Verification:	exam
Field of study related learning outcomes	AiR2_W05, AiR2_W12
Area of study related learning outcomes	I.P7S_WG, III.P7S_WG.o, P7U_W, I.P7S_WK, III.P7S_WG

General academic profile - skils

Code of effect:	**EM02_U1**
Description:	Students should be able to specify and implement a simple real-time based system , with: tasks scheduling, process specification implementation using one of the explained systems.
Verification:	exam, practical activities
Field of study related learning outcomes	AiR2_U02, AiR2_U03, AiR2_U09, AiR2_U12
Area of study related learning outcomes	I.P7S_UO, I.P7S_UW, III.P7S_UW.1.o,

Table 8. Learning outcomes	
	III.P7S_UW.4.o, III.P7S_UW.2.o
General academic profile - social competences	
Code of effect:	**EM02_K1**
Description:	Students should creatively think and collectively operate in a project of designing simple real-time operating system.
Verification:	Project and lab classes.
Field of study related learning outcomes	AiR2_K01
Area of study related learning outcomes	I.P7S_KK, I.P7S_KO

Description of course

Code of course	EM03	
Name of course	Signal processing	
Version of course	2019	
A. Place of the course in system of studies		
Level of education	Second cycle studies	
Form and mode of studies	full-time	
Profile of studies	General academic profile	
Specialisation	-	
Place of teaching of course	Faculty of Power and Aeronautical Engineering	
Place of realization of course	Institute of Control and Computation Engineering, The Faculty of Electronics and Information Technology	
Coordinator of course	Włodzimierz Kasprzak, Ph.D., D.Sc. Professor.	
B. General characteristic of the course		
Block of courses	Robotics	
Group of courses	Obligatory courses	
Type of course	Compulsory	
Language of course	english	
Nominal semester	1 (a. y. 2020/2021)	
Time of completion in the academic year	summer semester	
Preliminary requirements	None	
Limit of students	30	
C. Effects of education and manner of teaching		
Purpose of course	The main goal is to present the methods of deterministic signal description (both in the time-domain and frequency domain), their transformation (by means of the Fourier, Laplace and z-transform) and their processing by applying linear time-invariant systems (filters), for both continuous and discrete time signals. The goal is also to present basic knowledge about random signals representation. Also, there will be presented basic filter types and their design issues. Abilities. After completing this course, the students will be able to: • Represent continuous signals by their discrete equivalents, • Analyze random signals, • Understand linear time-invariant systems, • Decompose complex signals and systems, • Analyze the signals in Fourier domain, • Design and apply basic filters for signal processing, • Understand the Laplace and z-transform, • Design speech signal processing algorithms.	
Effects of education	See Table 9.	
Form of didactic studies and number of hours per semester	Lecture	30h
	Exercise type of course	15h
	Laboratory	0h
	Project type of course	0h
	Computer lessons	0h
Contents of education	Part I. Signals and systems 1. Signals (statistics, probability and noise, analog and digital signals, ADC and DAC). 2. Systems (linear systems,	

Description of course

	common signal decompositions). 3. Convolution (principle, properties, common impulse responses, correlation). Part II. Fourier transform 4. Discrete Fourier Transform. Real DFT. 5. Fourier transform properties. 6. Complex Fourier Transform. FFT. Part III. Digital filters 7. FIR filters. 8. Custom filters. 9. Recursive filters - IIR. Part IV. Transforms 10. The Laplace transform. 11. The z-transform. 12. Speech analysis
Methods of evaluation	40% continuous assessment, 60% from end of semester examination Assessment will be marked out of a hundred points, where 40% is continuous assessment, and 60% comes from end-semester examination. In particular, points can be earned from: • tutorial, including a homework project, 0-40 pts.; • final exam, 0-60 pts. The attendance requirements: an obligatory attendance of tutorial and an optional attendance of lecture.
Methods of verification of learning outcomes	See Table 9.
Exam	yes
Literature	Recommended texts: [1] Steven W. Smith, The Scientist and Engineer's Guide to Digital Signal Processing. Second Edition, California Technical Publishing, San Diego, CA, 1999, on-line: www.dspguide.com. [2] A.V. Oppenheim, R.W. Schafer, J.R. Buc, Discrete-Time Signal Processing. Second Edition. Prentice-Hall 1999. Further readings: will be provided by lecturer.
Website of the course	http://studia.elka.pw.edu.pl/pub/14Z/ESPRO.A/

D. Student’s activity

Number of ECTS credits	5
Number of hours of student’s work to achieve learning outcomes	1) Number of hours that require the presence of a teacher – 50, including a) presence of the lectures - 30; b) presence in the exercises - 15 c) presence on consultation - 5 2) The number of hours of independent work of student - 85
Number of ECTS credits on the course with direct participation of academic teacher	2 ECTS credits – number of hours that require the presence of a teacher - 50, including a) presence of the lectures - 30; b) presence in the exercises - 15 c) presence on consultation – 5
Number of ECTS credits on practical activities on the course	3 ECTS credits – which are obtained during classes of a practical nature; number of hours during classes of a practical nature - 80, including b) presence in the exercises - 15 c) presence on consultation – 5 d) independent work of student on solving practical exercise tasks and a homework task – 60

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Table 9. Learning outcomes

General academic profile - knowledge	
Code of effect:	**EM03_W1**
Description:	Students should be acquainted with basic mathematical representations of different signals
Verification:	exam
Field of study related learning outcomes	AiR2_W01, AiR2_W05
Area of study related learning outcomes	I.P7S_WG, P7U_W, III.P7S_WG.o
Code of effect:	**EM03_W2**
Description:	Students should know major mathematical tools of signal analysis.
Verification:	exam
Field of study related learning outcomes	AiR2_W01, AiR2_W05, AiR2_W06
Area of study related learning outcomes	I.P7S_WG, P7U_W, III.P7S_WG.o
Code of effect:	**EM03_W3**
Description:	Students should be familiar with mathematical techniques applicable to random signals
Verification:	exam
Field of study related learning outcomes	AiR2_W05, AiR2_W06, AiR2_W01
Area of study related learning outcomes	P7U_W, I.P7S_WG, III.P7S_WG.o
General academic profile - skils	
Code of effect:	**EM03_U1**
Description:	Students should be able to represent continuous signals by their discrete equivalents
Verification:	exam, practical avtivities
Field of study related learning outcomes	AiR2_U06, AiR2_U11
Area of study related learning outcomes	I.P7S_UW, III.P7S_UW.2.o, III.P7S_UW.4.o
Code of effect:	**EM03_U2**
Description:	Students should be able to decompose complex signals.
Verification:	exam, practical avtivities
Field of study related learning outcomes	AiR2_U06, AiR2_U11
Area of study related learning outcomes	I.P7S_UW, III.P7S_UW.2.o, III.P7S_UW.4.o
Code of effect:	**EM03_U3**
Description:	Students should be able to analyze signals in Fourier domain
Verification:	exam, practical activities
Field of study related learning outcomes	AiR2_U06, AiR2_U11
Area of study related learning outcomes	I.P7S_UW, III.P7S_UW.2.o, III.P7S_UW.4.o
Code of effect:	**EM03_U4**
Description:	Students should be able to apply filter to process the signal.
Verification:	practical activities
Field of study related learning outcomes	AiR2_U06, AiR2_U11, AiR2_U16
Area of study related learning outcomes	I.P7S_UW, III.P7S_UW.2.o, III.P7S_UW.4.o, III.P7S_UW.1.o, III.P7S_UW.3.o
Code of effect:	**EM03_U5**
Description:	Students should be capable to design basic filters for signals processing.
Verification:	exam, practical activities
Field of study related learning outcomes	AiR2_U06, AiR2_U16, AiR2_U17
Area of study related learning outcomes	I.P7S_UW, III.P7S_UW.2.o, III.P7S_UW.4.o, III.P7S_UW.1.o, III.P7S_UW.3.o
Code of effect:	**EM03_U6**
Description:	Students should be able to analyze random signals.

Table 9. Learning outcomes	
Verification:	practical activities
Field of study related learning outcomes	AiR2_U06, AiR2_U17
Area of study related learning outcomes	I.P7S_UW, III.P7S_UW.2.o, III.P7S_UW.4.o, III.P7S_UW.3.o

Description of course

Code of course	EM14	
Name of course	Elective course(s)	
Version of course	2019	
A. Place of the course in system of studies		
Level of education	Second cycle studies	
Form and mode of studies	full-time	
Profile of studies	General academic profile	
Specialisation	-	
Place of teaching of course	Faculty of Power and Aeronautical Engineering	
Place of realization of course	WMEiL	
Coordinator of course	x	
B. General characteristic of the course		
Block of courses	Robotics	
Group of courses	Elective courses	
Type of course	Elective	
Language of course	english	
Nominal semester	2 (a. y. 2020/2021)	
Time of completion in the academic year	summer semester	
Preliminary requirements	xx	
Limit of students	100	
C. Effects of education and manner of teaching		
Purpose of course	x	
Effects of education	See Table 10.	
Form of didactic studies and number of hours per semester	Lecture	15h
	Exercise type of course	15h
	Laboratory	15h
	Project type of course	15h
	Computer lessons	0h
Contents of education	x	
Methods of evaluation	x	
Methods of verification of learning outcomes	See Table 10.	
Exam	no	
Literature	x	
Website of the course	xxx	
D. Student’s activity		
Number of ECTS credits	5	
Number of hours of student’s work to achieve learning outcomes	x	
Number of ECTS credits on the course with direct participation of academic teacher	x	
Number of ECTS credits on practical activities on the course	x	
E. Additional information		
Notes	x	
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Table 10. Learning outcomes

Description of course

Code of course	EM07	
Name of course	Group project	
Version of course	2019	
A. Place of the course in system of studies		
Level of education	Second cycle studies	
Form and mode of studies	full-time	
Profile of studies	General academic profile	
Specialisation	-	
Place of teaching of course	Faculty of Power and Aeronautical Engineering	
Place of realization of course	WMEiL	
Coordinator of course	Lecturers	
B. General characteristic of the course		
Block of courses	Robotics	
Group of courses	Elective courses	
Type of course	Elective	
Language of course	english	
Nominal semester	2 (a. y. 2020/2021)	
Time of completion in the academic year	winter semester	
Preliminary requirements	All compulsory modules from first semester.	
Limit of students	100	
C. Effects of education and manner of teaching		
Purpose of course	The aim of this module is to provide students with the opportunity to apply their specialized knowledge to the solution of a real problem, and gain practical experience of the processes involved in the team-based design and testing of a robotic system.	
Effects of education	See Table 11.	
Form of didactic studies and number of hours per semester	Lecture	0h
	Exercise type of course	0h
	Laboratory	0h
	Project type of course	75h
	Computer lessons	0h
Contents of education	1. Lectures about project management: This lecture is based on the corpus of knowledge PMBoK (Project Management Book ok Knowledge) and will comprise some practical works on a project management: - Introduction to project management (organization, process, ...) - Initiating, Planning, Executing, Controlling and closing a project, - Risks evaluation and management: Human and organisational risks, Risks management. - Professional Responsibility 2. Solution of robotic problem with innovative function or structure. The problem solution should be defined by the group and must make use of advanced sensors and control algorithms.	
Methods of evaluation	100% Group project work, based on the documentation produced at each stage of the process, a presentation and demonstration of the final product, the effectiveness of the team's management of the project, and the	

Description of course

	understanding and contribution of each individual.
Methods of verification of learning outcomes	See Table 11.
Exam	no
Literature	Will be given by the lecturers.
Website of the course	-

D. Student's activity

Number of ECTS credits	5
Number of hours of student's work to achieve learning outcomes	1) Number of hours that require the presence of a teacher - 20 including a) presence of the lectures- 15; b) presence on consultation - 5 2) The number of hours of independent work of student 110hrs: defining the problem solution, work plan and workload distrubution, preparing the solution proposal, solving the problem, implementing in the robotics system, testing, writting the report.
Number of ECTS credits on the course with direct participation of academic teacher	1.3 ECTS credit – number of hours that require the presence of a teacher - 20, including a) presence of the lectures - 15; b) presence on consultation - 5.
Number of ECTS credits on practical activities on the course	3.7 ECTS credits 110hrs: defining the problem solution, work plan and workload distrubution, preparing the solution proposal, solving the problem, implementing in the robotics system, testing, writting the report.

E. Additional information

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Table 11. Learning outcomes

General academic profile - skils

Code of effect:	**EM07_U1**
Description:	Students should be able to gather information from literature, databases and other selected sources; they should integrate, interpret, and critically review the facts with a purpose to draw conclusions to support opinions.
Verification:	Based on the quality of project realization and distribution of the workload.
Field of study related learning outcomes	AiR2_U01, AiR2_U05
Area of study related learning outcomes	P7U_U, I.P7S_UW.o, III.P7S_UW.o, I.P7S_UK
Code of effect:	**EM07_U2**
Description:	Students should be able to work individually and in a team; can evaluate the timeframe of a task; can lead a small team to guarantee completion of a task by a given deadline.
Verification:	Based on the quality of project realization and distribution of the workload.
Field of study related learning outcomes	AiR2_U02, AiR2_U05
Area of study related learning outcomes	I.P7S_UO, I.P7S_UK
Code of effect:	**EM07_U3**
Description:	Students should be able to prepare detailed documentation of the experimental results,

Table 11. Learning outcomes	
	project or research done and should be able to present the outcome.
Verification:	Based on the report quality.
Field of study related learning outcomes	AiR2_U03, AiR2_U05
Area of study related learning outcomes	I.P7S_UW, III.P7S_UW.1.o, I.P7S_UK
General academic profile - social competences	
Code of effect:	**EM07_K1**
Description:	Students should be able to think and act in a creative and entrepreneurial way.
Verification:	Based on the project quality in the context of applied knowledge, project planning, and management.
Field of study related learning outcomes	AiR2_K01
Area of study related learning outcomes	I.P7S_KK, I.P7S_KO

Description of course

Code of course	EM11	
Name of course	Artificial intelligence	
Version of course	2019	
A. Place of the course in system of studies		
Level of education	Second cycle studies	
Form and mode of studies	full-time	
Profile of studies	General academic profile	
Specialisation	-	
Place of teaching of course	Faculty of Power and Aeronautical Engineering	
Place of realization of course	Institute of Control and Computation Engineering, The Faculty of Electronics and Information Technology	
Coordinator of course	Włodzimierz Kasprzak, Ph.D., D.Sc. Professor	
B. General characteristic of the course		
Block of courses	Robotics	
Group of courses	Obligatory courses	
Type of course	Compulsory	
Language of course	english	
Nominal semester	2 (a. y. 2020/2021)	
Time of completion in the academic year	winter semester	
Preliminary requirements	x	
Limit of students	100	
C. Effects of education and manner of teaching		
Purpose of course	The objective is to learn about advanced techniques of artificial intelligence from the perspective of robotics (i.e. as control elements of an autonomous agent). The focus is on designing utility-based agents that are searching and planning their actions, and have the ability to represent, to inference from uncertain knowledge, to make decisions and to learn. Particular topics include: knowledge representation and inference in logic, search and planning algorithms, fuzzy inference, Bayesian networks, dynamic Bayesian networks, Markov Decision Processes and reinforcement learning, inductive and stochastic learning.	
Effects of education	See Table 12.	
Form of didactic studies and number of hours per semester	Lecture	30h
	Exercise type of course	15h
	Laboratory	0h
	Project type of course	0h
	Computer lessons	0h
Contents of education	The first part covers logical inference systems based on perfect knowledge representation and inference - the predicate logic and its extensions like non-monotonic and descriptive logic. The second parts deals with general-purpose algorithms for problem solving, including state space search, constraint satisfaction search and agent action planning algorithms. The third part discusses imperfect knowledge representation	

Description of course

	and inference techniques, especially the fuzzy inference and probabilistic inference in Bayesian networks. This also includes an introduction to stochastic Markov Processes and dynamic Bayesian networks. The final part consists of machine learning techniques - learning from observations, reinforcement learning and statistical learning.
Methods of evaluation	Assessment will be marked out of a hundred points, where 60% is continuous assessment, and 40% comes from end-semester examination. In particular, points can be earned from: • tutorial, 0-20 pts.; • a midterm test, 0-40 pts.; • final exam, 0-40 pts. The attendance requirements: an obligatory attendance of tutorial and an optional attendance of lecture.
Methods of verification of learning outcomes	See Table 12.
Exam	yes
Literature	Recommended reading: 1. S. Russel, P. Norvig: Artificial Intelligence. A Modern Approach. Prentice Hall, Second Edition, 2002, Third Edition, 2010 2. W. Kasprzak: Artificial Intelligence Methods. Lecture e-notes, Warsaw University of Technology, 2010-2014. Further reading: 1. N.J. Nilsson N.J.: Artificial Intelligence. Morgan Kaufmann Publ., 1998. 2. D.L.Poole, A.K. Mackworth: Artificial Intelligence - foundations of computational agents. Cambridge University Press, 2009.
Website of the course	http://studia.elka.pw.edu.pl/pub/14L/EAI.A/

D. Student’s activity

Number of ECTS credits	4
Number of hours of student’s work to achieve learning outcomes	1) Number of hours that require the presence of a teacher - 50, including a) presence of the lectures-30; b) presence in the exercises -15 c) presence on consultation - 5 2) The number of hours of independent work of student: 40
Number of ECTS credits on the course with direct participation of academic teacher	2 ECTS credits – number of hours that require the presence of a teacher - 50, w including a) presence of the lectures - 30, b) presence in the exercises - 15, c) presence on consultation - 5.
Number of ECTS credits on practical activities on the course	2 ECTS credits – which are obtained during classes of a practical nature; number of hours during classes of a practical nature - 50, including b) presence in the exercises - 15 c) presence on consultation – 5 d) independent work of student on solving practical exercise tasks – 30

E. Additional information

Notes	-
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Table 12. Learning outcomes

General academic profile - knowledge

Table 12. Learning outcomes	
Code of effect:	**EM11_W1**
Description:	Students should be familiar with logical inference systems designed for perfect and imperfect knowledge representations.
Verification:	Continuous assessment at tutorials regarding the acquired knowledge needed to solve computational and algorithmic exercise tasks, related to the content of this course. Written assessment of the course outcomes by a written mid-time test. Written assessment of the course outcomes by a final exam.
Field of study related learning outcomes	AiR2_W04, AiR2_W07
Area of study related learning outcomes	I.P7S_WG, III.P7S_WG.o, P7U_W
Code of effect:	**EM11_W2**
Description:	Students should know state space search and agent action planning algorithms used in artificial intelligence.
Verification:	Continuous assessment at tutorials regarding the acquired knowledge needed to solve computational and algorithmic exercise tasks, related to the content of this course. Written assessment of the course outcomes by a written mid-time test. Written assessment of the course outcomes by a final exam.
Field of study related learning outcomes	AiR2_W04, AiR2_W07
Area of study related learning outcomes	I.P7S_WG, III.P7S_WG.o, P7U_W
Code of effect:	**EM11_W3**
Description:	Students should be familiar with knowledge representation systems and reasoning techniques.
Verification:	Continuous assessment at tutorials regarding the acquired knowledge needed to solve computational and algorithmic exercise tasks, related to the content of this course. Written assessment of the course outcomes by a written mid-time test. Written assessment of the course outcomes by a final exam.
Field of study related learning outcomes	AiR2_W04, AiR2_W07
Area of study related learning outcomes	I.P7S_WG, III.P7S_WG.o, P7U_W
Code of effect:	**EM11_W4**
Description:	Students should know machine learning techniques.
Verification:	Continuous assessment at tutorials regarding the acquired knowledge needed to solve computational and algorithmic exercise tasks, related to the content of this course. Written assessment of the course outcomes by a written mid-time test. Written assessment of the course outcomes by a final exam.
Field of study related learning outcomes	AiR2_W04, AiR2_W07
Area of study related learning outcomes	I.P7S_WG, III.P7S_WG.o, P7U_W
General academic profile - skils	
Code of effect:	**EM11_U1**
Description:	Student should be able to design elements of

Table 12. Learning outcomes	
	autonomous agents.
Verification:	Continuous assessment at tutorials regarding the acquired knowledge needed to solve computational and algorithmic exercise tasks, related to the content of this course. Written assessment of the course outcomes by a written mid-time test. Written assessment of the course outcomes by a final exam.
Field of study related learning outcomes	AiR2_U01, AiR2_U06, AiR2_U16
Area of study related learning outcomes	I.P7S_UW.o, III.P7S_UW.o, I.P7S_UW, III.P7S_UW.2.o, III.P7S_UW.4.o, III.P7S_UW.1.o, III.P7S_UW.3.o, P7U_U
Code of effect:	**EM11_U2**
Description:	Student should be able to design knowledge-based systems, especially when implementing logical inference systems.
Verification:	Continuous assessment at tutorials regarding the acquired knowledge needed to solve computational and algorithmic exercise tasks, related to the content of this course. Written assessment of the course outcomes by a written mid-time test. Written assessment of the course outcomes by a final exam.
Field of study related learning outcomes	AiR2_U01, AiR2_U06
Area of study related learning outcomes	P7U_U, I.P7S_UW.o, III.P7S_UW.o, I.P7S_UW, III.P7S_UW.2.o, III.P7S_UW.4.o
Code of effect:	**EM11_U3**
Description:	Student should be able to deal with imperfect information, especially by designing fuzzy reasoning and probabilistic reasoning systems.
Verification:	Continuous assessment at tutorials regarding the acquired knowledge needed to solve computational and algorithmic exercise tasks, related to the content of this course. Written assessment of the course outcomes by a written mid-time test. Written assessment of the course outcomes by a final exam.
Field of study related learning outcomes	AiR2_U01, AiR2_U06
Area of study related learning outcomes	P7U_U, I.P7S_UW.o, III.P7S_UW.o, I.P7S_UW, III.P7S_UW.2.o, III.P7S_UW.4.o
Code of effect:	**EM11_U4**
Description:	Student should be able to solve agent’s activity control problems by advanced search and action planning algorithms.
Verification:	Continuous assessment at tutorials regarding the acquired knowledge needed to solve computational and algorithmic exercise tasks, related to the content of this course. Written assessment of the course outcomes by a written mid-time test. Written assessment of the course outcomes by a final exam.
Field of study related learning outcomes	AiR2_U16, AiR2_U17, AiR2_U01, AiR2_U06
Area of study related learning outcomes	III.P7S_UW.3.o, I.P7S_UW, P7U_U, I.P7S_UW.o, III.P7S_UW.o, III.P7S_UW.2.o, III.P7S_UW.4.o,

Table 12. Learning outcomes	
	III.P7S_UW.1.o
Code of effect:	**EM11_U5**
Description:	Student should be able to design machine learning algorithms (knowledge acquisition) by using: active observation, reinforcement learning and statistical learning.
Verification:	Continuous assessment at tutorials regarding the acquired knowledge needed to solve computational and algorithmic exercise tasks, related to the content of this course. Written assessment of the course outcomes by a written mid-time test. Written assessment of the course outcomes by a final exam.
Field of study related learning outcomes	AiR2_U01, AiR2_U06, AiR2_U16, AiR2_U17
Area of study related learning outcomes	P7U_U, I.P7S_UW.o, III.P7S_UW.o, I.P7S_UW, III.P7S_UW.2.o, III.P7S_UW.4.o, III.P7S_UW.1.o, III.P7S_UW.3.o

Description of course

Code of course	EM13	
Name of course	Embedded systems	
Version of course	2019	

A. Place of the course in system of studies

Level of education	Second cycle studies	
Form and mode of studies	full-time	
Profile of studies	General academic profile	
Specialisation	-	
Place of teaching of course	Faculty of Power and Aeronautical Engineering	
Place of realization of course	WMEiL	
Coordinator of course	Visiting Professor	

B. General characteristic of the course

Block of courses	Robotics	
Group of courses	Obligatory courses	
Type of course	Compulsory	
Language of course	english	
Nominal semester	2 (a. y. 2020/2021)	
Time of completion in the academic year	winter semester	
Preliminary requirements	-	
Limit of students	100	

C. Effects of education and manner of teaching

Purpose of course	This course presents the fundamentals of embedded systems from both the architectural point of view and the basics of programming, with particular attention to sensing and actuating devices.	
Effects of education	See Table 13.	
Form of didactic studies and number of hours per semester	Lecture	30h
	Exercise type of course	15h
	Laboratory	0h
	Project type of course	0h
	Computer lessons	0h
Contents of education	The following topics are treated: • General overview of existing families of micro-controllers, DSPs, FPGAs, ASICs. • Basics of developing for embedded systems: coding, compiling, linking, downloading, executing. • Different kinds of memory devices and memory organization. • On-chip and off-chip peripherals units and basic I/O operations: ADC, DAC, PWM, Parallel port, Counters, Timers. • Buses and communication channels. • Interrupt-driven programming. • Fundamentals of real-time programming for embedded systems. Practical Work: Exercises will be set, which will involve design and implementation and testing of real-time code for micro-controllers.	
Methods of evaluation	30% class work, 70% end-semester exam	
Methods of verification of learning outcomes	See Table 13.	
Exam	yes	
Literature	- Q. Li, C. Yao, Real-Time Concepts for Embedded Systems, CMP Books, 2003. (ISBN:1578201241).	

Description of course

	Further readings: • D. E. Simon, An Embedded Software Primer, Addison-Wesley Professional, 1999. (ISBN: 020161569X) • S. Berger, Embedded Systems Design: An Introduction to Processes, Tools and Techniques, CMP Books, 2001. (ISBN: 1578200733).
Website of the course	-

D. Student's activity

Number of ECTS credits	4
Number of hours of student's work to achieve learning outcomes	1) Number of hours that require the presence of a teacher – 50, including a) presence of the lectures - 30; b) presence in the exercises - 15 c) presence on consultation - 5 2) The number of hours of independent work of student 68h – 28 self study, 40 - impelentation of individual embedded system (problem solution, programing, testing)
Number of ECTS credits on the course with direct participation of academic teacher	3 ECTS credits – number of hours that require the presence of a teacher - 50, including a) presence of the lectures- 30; b) presence in the exercises - 15; c) presence on consultation - 5.
Number of ECTS credits on practical activities on the course	2 ECTS credits in that: a) tutorial – 15 b) individual project - 40

E. Additional information

Notes	-
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Table 13. Learning outcomes

General academic profile - knowledge

Code of effect:	**EM13_W1**
Description:	Students should have knowledge on embedded systems both from architectural and practical point of view.
Verification:	Final exam
Field of study related learning outcomes	AiR2_W05
Area of study related learning outcomes	I.P7S_WG, III.P7S_WG.o, P7U_W
Code of effect:	**EM13_W2**
Description:	Students should be familiar with fundamental programming techniques used in embedded systems with particular attention to sensing and actuating devices.
Verification:	Final exam
Field of study related learning outcomes	AiR2_W05
Area of study related learning outcomes	I.P7S_WG, III.P7S_WG.o, P7U_W

General academic profile - skils

Code of effect:	**EM13_U1**
Description:	Students should be able to design, implement, and deploy real-time code for micro-controllers.
Verification:	By the project: impelentation of individual embedded system (problem solution, programing, testing). Obtaining properly working system.
Field of study related learning outcomes	AiR2_U08, AiR2_U09, AiR2_U19

Table 13. Learning outcomes	
Area of study related learning outcomes	I.P7S_UW, III.P7S_UW.1.o, III.P7S_UW.4.o, I.P7S_UO

Description of course

Code of course	EM08	
Name of course	Mechanical design in robotics	
Version of course	2019	
A. Place of the course in system of studies		
Level of education	Second cycle studies	
Form and mode of studies	full-time	
Profile of studies	General academic profile	
Specialisation	-	
Place of teaching of course	Faculty of Power and Aeronautical Engineering	
Place of realization of course	FPAE	
Coordinator of course	Dr. Krzysztof Mianowski	
B. General characteristic of the course		
Block of courses	Robotics	
Group of courses	Obligatory courses	
Type of course	Compulsory	
Language of course	english	
Nominal semester	2 (a. y. 2020/2021)	
Time of completion in the academic year	winter semester	
Preliminary requirements	Modeling and control of robots	
Limit of students	100	
C. Effects of education and manner of teaching		
Purpose of course	This course presents the overview of the design process – specification, conceptual design, product design. The students will learn basic principles of industrial robot design.	
Effects of education	See Table 14.	
Form of didactic studies and number of hours per semester	Lecture	30h
	Exercise type of course	0h
	Laboratory	0h
	Project type of course	30h
	Computer lessons	0h
Contents of education	The following subjects will be discussed: - Conceptual design: concept generation, concept evaluation. - Product design: documentation, product generation, evaluation for function and performance, evaluation for cost, ease of assembly and other measures. - Computer aids for mechanical design. CAD/CAE/CAM systems. - The design of robotic production cell. - Fundamentals of integrated design of control and drive systems taking into account measurement, gearing and transmission systems. - Design of a serial robot manipulator (using CAD).	
Methods of evaluation	30% continuous assessment (houseworks and colloquium, and project), 70% from end of semester examination	
Methods of verification of learning outcomes	See Table 14.	
Exam	yes	
Literature	K.C.Gupta, Mechanics and Control of Robots, Springer 1997 J.E.Shigley, J.J.Uicker, Theory of Machines and Mechanisms, McGraw Hill 1995. Further readings: CAD software documentation	

Description of course

Website of the course	http://ztmir.meil.pw.edu.pl/index.php?/pol/Dydaktyka/Prowadzone-przedmioty/Mechanical-Design_Methods_in_Robotics

D. Student's activity

Number of ECTS credits	5
Number of hours of student's work to achieve learning outcomes	1) Number of hours that require the presence of a teacher - 70, including a) presence of the lectures- 30, b) presence in the exercises - 30, c) w konsultacjach/ presence on consultation - 10. 2) The number of hours of independent work of student – 85 (exercises concerned with robot-manipulator design: documentation, product generation, evaluation for function and performance, evaluation for cost, ease of assembly and other measures).
Number of ECTS credits on the course with direct participation of academic teacher	3 ECTS credits – number of hours that require the presence of a teacher - 70, including a) presence of the lectures- 30hrs, 2 ECTS, b) presence in the exercises – 30hrs, 1 ECTS, c) presence on consultation - 10hrs.
Number of ECTS credits on practical activities on the course	3 ECTS credits - presence in the exercises – 30hrs, 1 ECTS - housework - project– 85hrs, 2 ECTS

E. Additional information

Notes	x
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Table 14. Learning outcomes

General academic profile - knowledge

Code of effect:	**EM08_W1**
Description:	Has knowledge on basic kinematic structures of robotic mechanical systems as well as design methods for shaping mechanical links, driving, transmission systems and grippers.
Verification:	Colloqium 1
Field of study related learning outcomes	AiR2_W01, AiR2_W06, AiR2_W08, AiR2_W10
Area of study related learning outcomes	I.P7S_WG, P7U_W, III.P7S_WG.o
Code of effect:	**EM08_W2**
Description:	Is familiar with typical design solutions for serial-structure manipulators and methods of choosing measuring and sensor systems.
Verification:	Colloqium 2
Field of study related learning outcomes	AiR2_W08, AiR2_W11
Area of study related learning outcomes	I.P7S_WG, III.P7S_WG.o, P7U_W, I.P7S_WK, III.P7S_WK.o

General academic profile - skils

Code of effect:	**EM08_U1**
Description:	Can formulate appropriate design requirements for a given task and can analyze and synthetize a robotic mechanical system.
Verification:	Colloqium 1
Field of study related learning outcomes	AiR2_U03, AiR2_U14, AiR2_U15, AiR2_U17, AiR2_U18, AiR2_U01, AiR2_U02

Table 14. Learning outcomes	
Area of study related learning outcomes	I.P7S_UW, III.P7S_UW.1.o, III.P7S_UW.2.o, III.P7S_UW.4.o, III.P7S_UW.3.o, P7U_U, I.P7S_UW.o, III.P7S_UW.o, I.P7S_UO
Code of effect:	**EM08_U2**
Description:	Can formulate design requirements for a robot-manipulator associated with basic functional and technical properties in the framework of technical project by taking into account mechanical parts, driving systems, transmission systems and control system issues.
Verification:	Colloqium 2, class project
Field of study related learning outcomes	AiR2_U15, AiR2_U16, AiR2_U02, AiR2_U03, AiR2_U04, AiR2_U06, AiR2_U12, AiR2_U13, AiR2_U14
Area of study related learning outcomes	I.P7S_UW, III.P7S_UW.4.o, III.P7S_UW.1.o, III.P7S_UW.3.o, I.P7S_UO, I.P7S_UK, III.P7S_UW.2.o
General academic profile - social competences	
Code of effect:	**EM08_K1**
Description:	Can be an active member of a research/design team that works in a technical/technological project.
Verification:	Class project
Field of study related learning outcomes	AiR2_K01, AiR2_K02
Area of study related learning outcomes	I.P7S_KK, I.P7S_KO, I.P7S_KR

Description of course

Code of course	EM10	
Name of course	Mobile robots	
Version of course	2019	
A. Place of the course in system of studies		
Level of education	Second cycle studies	
Form and mode of studies	full-time	
Profile of studies	General academic profile	
Specialisation	-	
Place of teaching of course	Faculty of Power and Aeronautical Engineering	
Place of realization of course	Institute of Control and Computation Engineering, The Faculty of Electronics and Information Technology	
Coordinator of course	dr. hab. Wojciech Szynkiewicz	
B. General characteristic of the course		
Block of courses	Robotics	
Group of courses	Obligatory courses	
Type of course	Compulsory	
Language of course	english	
Nominal semester	2 (a. y. 2020/2021)	
Time of completion in the academic year	winter semester	
Preliminary requirements	-	
Limit of students	100	
C. Effects of education and manner of teaching		
Purpose of course	This course provides an introduction to autonomous mobile robots. Topics include the mobile robot locomotion; classification of wheeled robot structures; kinematic models of mobile robots, motion control; sensors for mobile robots; simultaneous localization and mapping; motion planning and obstacle avoidance. The course consists of lectures and lab-style activities.	
Effects of education	See Table 15.	
Form of didactic studies and number of hours per semester	Lecture	30h
	Exercise type of course	30h
	Laboratory	0h
	Project type of course	0h
	Computer lessons	0h
Contents of education	The following subjects will be addressed: - Locomotion concepts in mobile robotics. - Wheeled mobile robots, types of wheels and mobile bases. - Non-holonomic constraint equations. - Classification of wheeled robots, using the degrees of mobility and steerability. - Posture and configuration kinematic models of wheeled mobile robots. - Motion control of wheeled mobile robots. - Perception - sensors for mobile robots. - Mobile robot localization. - Simultaneous localization and mapping (SLAM) problem. - Robot motion planning and obstacle avoidance. Practical Work: The students will program mobile robots to implement simple control algorithms to follow some prescribed	

Description of course

	paths.
Methods of evaluation	30% continuous assessment from hands-on exercises, 15% from in class oral presentation, and 55% from end of semester examination.
Methods of verification of learning outcomes	See Table 15.
Exam	yes
Literature	x
Website of the course	xxx

D. Student’s activity

Number of ECTS credits	4
Number of hours of student’s work to achieve learning outcomes	1) Number of hours that require the presence of a teacher – 65, including a) presence of the lectures - 30; b) presence in the exercises - 30; c) presence on consultation – 5 2) The number of hours of independent work of student 38 hrs: literature study – 5hrs, preparing to hands-on exercises – 10hrs, prepering a presenation – 10hrs, preparing to the final examination – 13hrs
Number of ECTS credits on the course with direct participation of academic teacher	3 ECTS credits - number of hours that require the presence of a teacher – 65hrs, including a) presence of the lectures - 30hrs; b) presence in the exercises - 30hrs; c) presence on consultation – 5hrs
Number of ECTS credits on practical activities on the course	3 ECTS credits, including presence in the exercises – 30hrs;

E. Additional information

Notes	• C.Canudas, B. Siciliano, G.Bastin (editors), Theory of Robot Control, Springer-Verlag, 1996. (chapters 7,8, and 9) • Springer Handbook of Robotics. Eds. B. Siciliano, O. Khatib. Springer. 2008. • R. Siegwart, I. Nourbakhsh: Introduction to Autonomous Mobile Robots. The MIT Press, 2ed. 2011.
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Table 15. Learning outcomes

General academic profile - knowledge

Code of effect:	**EM10_W1**
Description:	Students should understand foundational knowledge in mobile robotics.
Verification:	Final examination, results of hands-on exercises.
Field of study related learning outcomes	AiR2_W06, AiR2_W08, AiR2_W11, AiR2_W12
Area of study related learning outcomes	I.P7S_WG, III.P7S_WG.o, P7U_W, I.P7S_WK, III.P7S_WK.o, III.P7S_WG
Code of effect:	**EM10_W2**
Description:	Students should know basic locomotion mechanisms and wheeled mobile platforms.
Verification:	Final examination, results of hands-on exercises.
Field of study related learning outcomes	AiR2_W11, AiR2_W12, AiR2_W05, AiR2_W06
Area of study related learning outcomes	III.P7S_WK.o, P7U_W, I.P7S_WG, III.P7S_WG.o, I.P7S_WK, III.P7S_WG

General academic profile - skils

Table 15. Learning outcomes	
Code of effect:	**EM10_U1**
Description:	Students should be able to formulate basic kinematic models for wheeled mobile robots.
Verification:	Final examination. In-class presentation delivered by the student.
Field of study related learning outcomes	AiR2_U01, AiR2_U09, AiR2_U14, AiR2_U15
Area of study related learning outcomes	P7U_U, I.P7S_UW.o, III.P7S_UW.o, I.P7S_UW, III.P7S_UW.4.o, III.P7S_UW.2.o
Code of effect:	**EM10_U2**
Description:	Students should be able to develop a simple motion control algorithm and implement the scheme in the framework of mobile robot control system.
Verification:	Final examination. In-class presentation delivered by a student.
Field of study related learning outcomes	AiR2_U16, AiR2_U17, AiR2_U08, AiR2_U09, AiR2_U11, AiR2_U12, AiR2_U14
Area of study related learning outcomes	I.P7S_UW, III.P7S_UW.1.o, III.P7S_UW.3.o, III.P7S_UW.4.o, III.P7S_UW.2.o

Description of course

Code of course	EM12	
Name of course	Optimisation techniques	
Version of course	2019	
A. Place of the course in system of studies		
Level of education	Second cycle studies	
Form and mode of studies	full-time	
Profile of studies	General academic profile	
Specialisation	-	
Place of teaching of course	Faculty of Power and Aeronautical Engineering	
Place of realization of course	Institute of Control and Computation Engineering, The Faculty of Electronics and Information Technology	
Coordinator of course	Prof. Włodzimierz Ogryczak	
B. General characteristic of the course		
Block of courses	Robotics	
Group of courses	Obligatory courses	
Type of course	Compulsory	
Language of course	english	
Nominal semester	2 (a. y. 2020/2021)	
Time of completion in the academic year	winter semester	
Preliminary requirements	-	
Limit of students	100	
C. Effects of education and manner of teaching		
Purpose of course	The lecture presents different theoretical and computational aspects of a wide range of optimization methods for solving a variety of problems in engineering and robotics. It enables students to understand different theoretical and computational aspects of a wide range of optimization methods, realize the possibilities offered by the different optimization methods, use of optimization toolbox.	
Effects of education	See Table 16.	
Form of didactic studies and number of hours per semester	Lecture	15h
	Exercise type of course	15h
	Laboratory	0h
	Project type of course	0h
	Computer lessons	0h
Contents of education	Contents: Basic concepts of optimization, Linear and Mixed Integer Programming, Nonlinear Programming, Gradient based methods, Evolutionary algorithms, Multi objective optimization methods, Robust optimization methods, Multidisciplinary optimization problems, Programming aspects. Practical Work: individual edition and analysis of examples of mathematical models with the use of either MATLAB or algebraic modeling languages such as GAMS, AMPL. After model edition, the assignement assumes the selection and use of optimization algorithms from a library in order to perform given type of model analysis, or the development of some dedicated	

Description of course

	optimization procedures Student is able: - to build optimization models in modeling language (AMPL) or MATLAB package, - verify necessary and sufficient optimaty conditions, - understsnd basic methods of local and global optimization, discrete and mixed.
Methods of evaluation	30% design tutorials evaluation, 70% from end of semester examination.
Methods of verification of learning outcomes	See Table 16.
Exam	yes
Literature	R. Fletcher, Practical Methods of Optimization, John Wiley & Sons, 2000. Further readings will be given by lecturer
Website of the course	xxx

D. Student's activity

Number of ECTS credits	4
Number of hours of student's work to achieve learning outcomes	1) Number of hours that require the presence of a teacher - 35, including a) presence of the lectures - 15; b) presence in the design exercises – 15; c) presence on consultation – 5; 2) The number of hours of independent work of student 68 h
Number of ECTS credits on the course with direct participation of academic teacher	2 ECTS credits – Number of hours that require the presence of a teacher - 35, including a) presence of the lectures - 15; b) presence in the design exercises – 15; c) presence on consultation – 5
Number of ECTS credits on practical activities on the course	2.5 ECTS credits, including a) presence in the design exercises – 15; b) preparation of the project and report – self study - 68

E. Additional information

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Table 16. Learning outcomes

General academic profile - knowledge

Code of effect:	**EM12_W1**
Description:	Students should understand foundations of local and global optimization methods.
Verification:	Through individual project and final exam.
Field of study related learning outcomes	AiR2_W07
Area of study related learning outcomes	I.P7S_WG, P7U_W
Code of effect:	**EM12_W2**
Description:	Students should know how to select an appropriate optimization method to a given technical problem.
Verification:	Through individual project and final exam.
Field of study related learning outcomes	AiR2_W07
Area of study related learning outcomes	I.P7S_WG, P7U_W

General academic profile - skils

Code of effect:	**EM12_U1**
Description:	Students should be able to build optimization models in AMPL language or Matlab software.
Verification:	Through individual project.

Table 16. Learning outcomes	
Field of study related learning outcomes	AiR2_U10, AiR2_U11
Area of study related learning outcomes	I.P7S_UW, III.P7S_UW.3.o, III.P7S_UW.4.o

Description of course

Code of course	EM09	
Name of course	Robot programming methods	
Version of course	2019	

A. Place of the course in system of studies

Level of education	Second cycle studies	
Form and mode of studies	full-time	
Profile of studies	General academic profile	
Specialisation	-	
Place of teaching of course	Faculty of Power and Aeronautical Engineering	
Place of realization of course	Institute of Control and Computation Engineering The Faculty of Electronics and Information Technology	
Coordinator of course	Cezary Zieliński, Ph.D., D.Sc. Professor.	

B. General characteristic of the course

Block of courses	Robotics	
Group of courses	Obligatory courses	
Type of course	Compulsory	
Language of course	english	
Nominal semester	2 (a. y. 2020/2021)	
Time of completion in the academic year	winter semester	
Preliminary requirements	Modeling and control of manipulators	
Limit of students	30	

C. Effects of education and manner of teaching

Purpose of course	To learn the robot programming methods. To learn how to design robot control system structures, based on the tasks that the robot has to execute and its hardware composition (i.e. types of effectors and receptors).	
Effects of education	See Table 17.	
Form of didactic studies and number of hours per semester	Lecture	30h
	Exercise type of course	30h
	Laboratory	0h
	Project type of course	0h
	Computer lessons	0h
Contents of education	A broad view of robot programming will be assumed. Both the expression of tasks that the robot has to execute and software controlling robots will be discussed. In the introduction the concepts of: receptors, effectors, virtual sensors, robot ontologies, agents, multi-agent systems will be explained. Several historic and currently used specialised robot programming languages will be presented. Then focus will shift to robot programming frameworks, i.e.: libraries of modules, a pattern according to which they have to be assembled and tools for producing new modules. Robot will be treated as an embodied agent and its operation will be described formally in terms of transition functions. Both sequential and concurrent decompositions of those functions will be considered. Competitive and cooperative composition of results and the definition of	

Description of course

	complex behaviours will be the subject of presentation. The transition from synchronous to event driven systems will be shown. Deliberative vs. behavioural, fuzzy vs. crisp, deterministic vs. indeterministic systems will be described from the point of view of the definition of the transition functions governing their behaviour. Cooperation and coordination in multi-robot systems will be described. The course will also cover implementation issues, especially programming paradigms (procedural, object-oriented, component based). Error handling and debugging issues will also be explained. Cooperative box pushing and visual servoing will serve as examples of robotic system design.
Methods of evaluation	50% continuous assessment, 50% from end of semester examination; Marking: 51-60% - 3, 61-70%-3.5, 71-80% - 4, 81-90-4.5, 91-100% - 5 EMARO: 60-64% - 3, 65-69%-3.5, 70-79%-4, 80-89% - 4.5, 90-100% -5
Methods of verification of learning outcomes	See Table 17.
Exam	yes
Literature	Zieliński C.: Robot Programming Methods. Warsaw University of Technology Publishing House, 1995. Zieliński C.: Transition-Function Based Approach to Structuring Robot Control Software. In: Robot Motion and Control: Recent Developments. Ed. K. Kozłowski, Lecture Notes in Control and Information Sciences, Vol.335, Springer Verlag. 2006. pp 265–286. Further readings: will be provided by lecturer
Website of the course	https://studia.elka.pw.edu.pl/priv/14L/EPRM.A/

D. Student’s activity

Number of ECTS credits	4
Number of hours of student’s work to achieve learning outcomes	1) Number of hours that require the presence of a teacher - 65, including a) participation in the the lectures- 30; b) participation in the exercises - 30 c) participation in the consultations - 5 2) The number of hours of independent work of a student 50 hrs: literature studies – 10 hrs, homework – 40 hrs
Number of ECTS credits on the course with direct participation of academic teacher	3 ECTS credits – number of hours that require the presence of a teacher - 65, including a) participation in the lectures- 30; b) participation in the design exercises – 30; c) participation in the consultations 5
Number of ECTS credits on practical activities on the course	3 ECTS credits, /including a) participation in the exercises – 30; b) solution of homework problems and self study - 40

E. Additional information

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Table 17. Learning outcomes	
General academic profile - knowledge	
Code of effect:	**EM09_W1**
Description:	Has knowledge on robot programming methods.
Verification:	Verification through individual homework and final exam.
Field of study related learning outcomes	AiR2_W12
Area of study related learning outcomes	I.P7S_WG, III.P7S_WG.o, P7U_W, I.P7S_WK, III.P7S_WG
General academic profile - skils	
Code of effect:	**EM09_U1**
Description:	Is able to design robot control system architecture and select an appropriate hardware configuration based on the requirements that a robotic system is supposed to meet.
Verification:	Verification through individual homework and final exam.
Field of study related learning outcomes	AiR2_U01, AiR2_U03, AiR2_U06, AiR2_U09, AiR2_U12
Area of study related learning outcomes	P7U_U, I.P7S_UW.o, III.P7S_UW.o, I.P7S_UW, III.P7S_UW.1.o, III.P7S_UW.2.o, III.P7S_UW.4.o

Description of course

Code of course	ANS534	
Name of course	Advanced Renewable Energy Sources	
Version of course	2019	
A. Place of the course in system of studies		
Level of education	Second cycle studies	
Form and mode of studies	full-time	
Profile of studies	General academic profile	
Specialisation	-	
Place of teaching of course	Faculty of Power and Aeronautical Engineering	
Place of realization of course	Faculty of Power and Aeronautical Engineering	
Coordinator of course	prof. dr hab. inż. Roman Domański	
B. General characteristic of the course		
Block of courses	Robotics	
Group of courses	Elective courses	
Type of course	Elective	
Language of course	english	
Nominal semester	3 (a. y. 2020/2021)	
Time of completion in the academic year	summer semester	
Preliminary requirements	Knowledge of different energy sources and conversion methods. Knowledge of basic thermodynamics (Thermodynamics I or equivalent). Understanding of operating principles of essential types of energy conversion equipment: boilers, turbines, nuclear reactors, wind turbines, water turbines, photovoltaic cells.	
Limit of students	100	
C. Effects of education and manner of teaching		
Purpose of course	Upon completion of the course students will have: • understanding of capabilities and limitations of individual renewable energy types and renewable energy sector as a whole, • ability to evaluate potential of renewable energy sources at a specific region, • ability to identify challenges related to integration of renewable energy sources in a larger energy system and propose potential solutions to these challenges, • basic understanding of direct and indirect costs related to renewable energy utilisation.	
Effects of education	See Table 18.	
Form of didactic studies and number of hours per semester	Lecture	30h
	Exercise type of course	15h
	Laboratory	0h
	Project type of course	0h
	Computer lessons	0h
Contents of education	Lecture: • Basic terminology related to energy conversion processes. World’s energy resources (fossil fuel and nuclear)versus renewable energy sources. • The basic parameters for energy storage. • Energy conversionefficiency for selected processes and devices. Possibility of energy storage. • Renewable sources; sun as an energy source, conversion of solar radiation	

Description of course

	energy (collectors and photovoltaic systems). • Solarsystems for heating and hot water production. Biomass and biofuels – in energy and transportationsector. Solar power plants. Solar energy for heating and hot water generation. • Wind energy and windpower generation. • Energy of waters and oceans (tidal and wave energy conversion), OTEC. • Geothermy –geothermal systems, prospective hot dry rock technologies. Heat pump. Geothermy in Poland. • Hydrogen as an energy carrier, hydrogen production by renewables. • Examples of renewable energy conversionsystems for heat and power generation. Place for renewable in world energy scenario. • Prospectivepower generation technologies using the renewables. Typical solutions of waste utilisation used inpower engineering. • Rationalization of energy consumption, increase of energy conversion efficiencies. • Environmental footprint of renewable technologies. • Integration of renewable power generation systems with the grid. Exercises: • Calculations of actual cost of renewable electricity generation. • Calculations of required system reserves for compensating imbalance caused by renewable systems. • Comparisons of capacity factors for different technologies and different areas of the world. • Calculations of maximum share of renewables for different conditions.
Methods of evaluation	The final mark will be given as a weighted average of two components: • 60% of a multiple-choice final test, • 40% of a homework project. The project will be made in teams of several students with individually assigned subjects.
Methods of verification of learning outcomes	See Table 18.
Exam	yes
Literature	1. IEA World Energy Outlook (currentedition). 2. Duffie J.A., Beckman W.A.: Solar Engineering of ThermalProcesses, John Willey&Sons, 2006. 3. Klimstra J., Power SupplyChallenges, Vaasa 2014.
Website of the course	

D. Student’s activity

Number of ECTS credits	3
Number of hours of student’s work to achieve learning outcomes	1) Number of hours thatrequire the presence of a teacher - 47, including: a) attendanceat the lectures - 30hours; b) attendanceat the exercises- 15hours; c) consultancymeetings – 2 hours. 2) The number of hours of independent work of student: 10 hours for completion of homeworkproject.
Number of ECTS credits on the course with direct participation of academic teacher	2 ECTS credits– number of hours that require the presence of a teacher – 47, including: a) attendanceat the lectures - 30hours; b)

Description of course

	attendanceat the exercises – 15 hours; e) consultancymeetings – 2 hours.
Number of ECTS credits on practical activities on the course	

E. Additional information

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Table 18. Learning outcomes

General academic profile - knowledge

Code of effect:	**ANS534_W1**
Description:	Students should understand advantages and disadvantages of various renewable energy systems and should be familiar with the trends observable in renewable energy sector.
Verification:	Final test.
Field of study related learning outcomes	AiR2_W02
Area of study related learning outcomes	I.P7S_WG, III.P7S_WG.o, P7U_W
Code of effect:	**ANS534_W2**
Description:	Students should be aware of direct and indirect costs associated with renewable energy intake.
Verification:	Final test.
Field of study related learning outcomes	AiR2_W02
Area of study related learning outcomes	I.P7S_WG, III.P7S_WG.o, P7U_W

General academic profile - skils

Code of effect:	**ANS534_U1**
Description:	Students should be able to analyze a potential to apply a renewable energy system in a specific region.
Verification:	Final test and homework project.
Field of study related learning outcomes	AiR2_U01, AiR2_U18, AiR2_U19
Area of study related learning outcomes	P7U_U, I.P7S_UW.o, III.P7S_UW.o, I.P7S_UW, III.P7S_UW.1.o, III.P7S_UW.3.o, I.P7S_UO
Code of effect:	**ANS534_U2**
Description:	Students should be able to identify challenges associated with integration of renewable energy sources in the framework of a larger energy system and should be able to solve the emergent technical problems.
Verification:	Final test and homework project
Field of study related learning outcomes	AiR2_U01, AiR2_U18, AiR2_U19
Area of study related learning outcomes	P7U_U, I.P7S_UW.o, III.P7S_UW.o, I.P7S_UW, III.P7S_UW.1.o, III.P7S_UW.3.o, I.P7S_UO

Description of course

Code of course	EM20	
Name of course	Elective course(s)	
Version of course	2019	
A. Place of the course in system of studies		
Level of education	Second cycle studies	
Form and mode of studies	full-time	
Profile of studies	General academic profile	
Specialisation	-	
Place of teaching of course	Faculty of Power and Aeronautical Engineering	
Place of realization of course	WMEiL	
Coordinator of course	x	
B. General characteristic of the course		
Block of courses	Robotics	
Group of courses	Elective courses	
Type of course	Elective	
Language of course	english	
Nominal semester	3 (a. y. 2020/2021)	
Time of completion in the academic year	summer semester	
Preliminary requirements	xx	
Limit of students	100	
C. Effects of education and manner of teaching		
Purpose of course	x	
Effects of education	See Table 19.	
Form of didactic studies and number of hours per semester	Lecture	15h
	Exercise type of course	15h
	Laboratory	15h
	Project type of course	15h
	Computer lessons	0h
Contents of education	x	
Methods of evaluation	x	
Methods of verification of learning outcomes	See Table 19.	
Exam	no	
Literature	x	
Website of the course	xxx	
D. Student’s activity		
Number of ECTS credits	4	
Number of hours of student’s work to achieve learning outcomes	x	
Number of ECTS credits on the course with direct participation of academic teacher	x	
Number of ECTS credits on practical activities on the course	x	
E. Additional information		
Notes	x	
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Table 19. Learning outcomes

Description of course

Code of course	ANS511	
Name of course	Sensors and Measurement Systems	
Version of course	2019	
A. Place of the course in system of studies		
Level of education	Second cycle studies	
Form and mode of studies	full-time	
Profile of studies	General academic profile	
Specialisation	-	
Place of teaching of course	Faculty of Power and Aeronautical Engineering	
Place of realization of course	Faculty of Power and Aeronautical Engineering.	
Coordinator of course	dr inż. Przemysław Bibik	
B. General characteristic of the course		
Block of courses	Robotics	
Group of courses	Elective courses	
Type of course	Elective	
Language of course	english	
Nominal semester	3 (a. y. 2020/2021)	
Time of completion in the academic year	summer semester	
Preliminary requirements	Recommended Aeronautical Systems I and II.	
Limit of students	12 students in one group.	
C. Effects of education and manner of teaching		
Purpose of course	The course aims to familiarize students with the design of measurement systems, methods of measurement of physical quantities and methods of results analysis.	
Effects of education	See Table 20.	
Form of didactic studies and number of hours per semester	Lecture	15h
	Exercise type of course	0h
	Laboratory	15h
	Project type of course	0h
	Computer lessons	0h
Contents of education	The lecture covers the basic issues related to the design and operation of measurement systems and analysis of measurement results. It covers the design, operation and characteristics of typical sensors, the structure of the measuring systems, sensors, calibration methods, and methods of measurement systems protection against interference. Presented are the interfaces and buses used in common measuring systems, D/A and A/D converters and the principles of sampling and quantization of signals. It also covers the basic methods of statistical analysis of measurement results like the determination of mean, median, standard deviation and quantiles, histograms and box plots. In the laboratory, students are acquainted with the principle of operation, characteristics and errors of sensors and measuring systems of fundamental physical quantities.	
Methods of evaluation	Passing the course requires the completion of the lecture and laboratory. Completion of the lecture	

Description of course

	is based on the evaluation of two tests, the laboratory part completion is based on the average of the reports marks. Final mark is the average of the test and laboratory.
Methods of verification of learning outcomes	See Table 20.
Exam	no
Literature	1. Nawrocki, W.: „ Measurement Systems and Sensors”, 2005 ARTECH HOUSE, INC., e-book ebrary. 2. Fraden, J.: „ Handbook of Modern Sensors - Physics, Designs and Applications (3rd Edition)”, e-book Knovel . 3. Osiander, R.: „MEMS and microstructures in aerospace applications ”, 2006. 4. Pallet E.H.J.: „Aircraft Instrument Systems”, IAP, 1993. 5. Titterton, D.: „Strapdown Inertial Navigation Technology”, 1997. Additional: 1. Materials provided by the course leader.
Website of the course	-

D. Student’s activity

Number of ECTS credits	3
Number of hours of student’s work to achieve learning outcomes	1) Number of hours that require the presence of a teacher - 32, including: a) attendance at the labs - 15 hours; b) attendance at the lectures - 15 hours; c) consultancy meetings - 2 hours. 2) The number of hours of independent work of student - 45, including: • preparation for tests - 10 hours; • preparation for laboratories and making of reports – 25 hours; • reading recommended literature by the teacher - 10 hours. TOTAL: 77 hours.
Number of ECTS credits on the course with direct participation of academic teacher	1.3 ECTS credits - 32 hours, including: a) attendance at the labs - 15 hours; b) attendance at the lectures - 15 hours; c) consultancy meetings - 2 hours.
Number of ECTS credits on practical activities on the course	2 ECTS credits - 42 hours, including: a) attendance at the labs - 15 hours; b) consultancy meetings - 2 hours. c) preparation for laboratories and making of reports – 25 hours.

E. Additional information

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Table 20. Learning outcomes

General academic profile - knowledge

Code of effect:	**ANS511_W1**
Description:	Students should aqcuire both foundational knowledge on design, functioning, and characteristics of typical sensors as well as robust measurement methods that protect against interference.
Verification:	Final test
Field of study related learning outcomes	AiR2_W06
Area of study related learning outcomes	I.P7S_WG, III.P7S_WG.o, P7U_W
Code of effect:	**ANS511_W2**

Table 20. Learning outcomes	
Description:	Students should know the interfaces and buses used in common measuring systems, D/A and A/D converters and the principles of sampling and quantization of signals.
Verification:	Final test
Field of study related learning outcomes	AiR2_W06
Area of study related learning outcomes	I.P7S_WG, III.P7S_WG.o, P7U_W
Code of effect:	**ANS511_W3**
Description:	Students should understand statistical measurement data analysis methods and tools.
Verification:	Final test
Field of study related learning outcomes	AiR2_W06
Area of study related learning outcomes	I.P7S_WG, III.P7S_WG.o, P7U_W
General academic profile - skils	
Code of effect:	**ANS511_U1**
Description:	Students should be acquainted with the sensors' characteristics and the tools for analyzing measurement errors that appear in systems measuring various physical quantitites.
Verification:	Laboratory report marks
Field of study related learning outcomes	AiR2_U06, AiR2_U14
Area of study related learning outcomes	I.P7S_UW, III.P7S_UW.2.o, III.P7S_UW.4.o

Description of course

Code of course	EM19	
Name of course	Advanced mechanical design	
Version of course	2019	
A. Place of the course in system of studies		
Level of education	Second cycle studies	
Form and mode of studies	full-time	
Profile of studies	General academic profile	
Specialisation	-	
Place of teaching of course	Faculty of Power and Aeronautical Engineering	
Place of realization of course	The Institute of Aeronautics and Applied Mechanics, The Faculty of Power and Aeronautical Engineering	
Coordinator of course	Dr. Krzysztof Mianowski	
B. General characteristic of the course		
Block of courses	Robotics	
Group of courses	Obligatory courses	
Type of course	Compulsory	
Language of course	english	
Nominal semester	3 (a. y. 2020/2021)	
Time of completion in the academic year	summer semester	
Preliminary requirements	Modelling and control of manipulators	
Limit of students	100	
C. Effects of education and manner of teaching		
Purpose of course	This course presents the design methods for complete complex, precise mechanical structures. The students will learn how to design the mechanical structure together with mounting of actuators, driving systems, localisation of supply cables, controllers etc.	
Effects of education	See Table 21.	
Form of didactic studies and number of hours per semester	Lecture	30h
	Exercise type of course	15h
	Laboratory	0h
	Project type of course	0h
	Computer lessons	0h
Contents of education	The following subjects will be treated: - serial and parallel manipulators – difference in the requirements stated in the design, introduction to material science, - driving elements: their types and performances, - analysis of mechanical efficiency in mechanical systems considering mechanical resistance (i.e. friction) and limited efficiency of driving system and actuators, - actuating systems, specification of required motor power considering the designed robotics system, its mechanical efficiency and working conditions, - design procedure using material science (material choice with material strength analysis) and including driving system, actuators, power supply, etc. - examples considering robots for cardio-surgery, walking machines, mobile robots.	
Methods of evaluation	30% class work, 70% end-semester exam.	

Description of course

Methods of verification of learning outcomes	See Table 21.
Exam	yes
Literature	- A. Morecki, K. Knapczyk (ed.) , Basics of Robotics, Springer Verlag 1999, CISM Courses and Lecture Notes no.402, 1st edition - T. Zielinska, C. Zielinski (eds.), Robot Design, Dynamics and Control, RoManSy 16, CISM - Int. Center for Mechanical Sciences, Courses and Lectures no.487, Springer Wien New York 2006, ISBN-3-211-36064-6
Website of the course	-

D. Student's activity

Number of ECTS credits	5
Number of hours of student's work to achieve learning outcomes	1) Number of hours that require the presence of a teacher – 50, including a) presence of the lectures- 30; 2 ECTS b) presence in the exercises – 15; 1 ECTS c) presence on consultation – 5 2) Praca własna studenta/ The number of hours of independent work of student - project– 85 ; 2ECTS 85hrs - elaboration of basic foundations for robot-manipulator, working out of mechanical simulations for the project, working out the design of the typical link of robot-manipulator using CAD system.
Number of ECTS credits on the course with direct participation of academic teacher	3 ECTS credits number of hours that require the presence of a teacher – 50, including a) presence of the lectures- 30; 2 ECTS b) presence in the exercises – 15; 1 ECTS c) presence on consultation – 5
Number of ECTS credits on practical activities on the course	3.5 ECTS credits: elaboration of basic foundations for robot-manipulator, working out of mechanical simulations for the project, working out the design of the typical link of robot-manipulator using CAD system.

E. Additional information

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Table 21. Learning outcomes

General academic profile - knowledge

Code of effect:	**EM19_W1**
Description:	Students know how to formulate design requirements for a given task of a manipulator.
Verification:	Colloqium 1
Field of study related learning outcomes	AiR2_W01, AiR2_W02, AiR2_W06, AiR2_W10, AiR2_W11, AiR2_W12
Area of study related learning outcomes	I.P7S_WG, P7U_W, III.P7S_WG.o, I.P7S_WK, III.P7S_WK.o, III.P7S_WG
Code of effect:	**EM19_W2**
Description:	Students know how to conduct a systematic design of a typical manipulator using CAD system.

Table 21. Learning outcomes	
Verification:	Colloqium 2, Class project
Field of study related learning outcomes	AiR2_W02, AiR2_W08, AiR2_W10, AiR2_W11, AiR2_W12, AiR2_W01
Area of study related learning outcomes	I.P7S_WG, III.P7S_WG.o, P7U_W, I.P7S_WK, III.P7S_WK.o, III.P7S_WG
General academic profile - skils	
Code of effect:	**EM19_U1**
Description:	Students should implement design requirements for a typical manipulator in simulation-based scenario.
Verification:	Colloqiuom 1
Field of study related learning outcomes	AiR2_U14, AiR2_U15, AiR2_U16, AiR2_U01, AiR2_U02, AiR2_U03, AiR2_U04, AiR2_U13
Area of study related learning outcomes	III.P7S_UW.2.o, III.P7S_UW.4.o, I.P7S_UW, III.P7S_UW.1.o, III.P7S_UW.3.o, P7U_U, I.P7S_UW.o, III.P7S_UW.o, I.P7S_UO, I.P7S_UK
Code of effect:	**EM19_U2**
Description:	Students should perform kinematic and dynamic simulations for the purpose of design of a typical multi-link manipulator using CAD system.
Verification:	Colloqiuom 2, Class project
Field of study related learning outcomes	AiR2_U01, AiR2_U02, AiR2_U03, AiR2_U04, AiR2_U15, AiR2_U16, AiR2_U17, AiR2_U18, AiR2_U19
Area of study related learning outcomes	P7U_U, I.P7S_UW.o, III.P7S_UW.o, I.P7S_UO, I.P7S_UW, III.P7S_UW.1.o, I.P7S_UK, III.P7S_UW.4.o, III.P7S_UW.3.o
General academic profile - social competences	
Code of effect:	**EM19_K1**
Description:	Students should successfully cooperate in a research/design team working on a robotic project in the technical or technological matters.
Verification:	Class project
Field of study related learning outcomes	AiR2_K02, AiR2_K01
Area of study related learning outcomes	I.P7S_KR, I.P7S_KK, I.P7S_KO

Description of course

Code of course	EM17	
Name of course	Bio-robotics	
Version of course	2019	
A. Place of the course in system of studies		
Level of education	Second cycle studies	
Form and mode of studies	full-time	
Profile of studies	General academic profile	
Specialisation	-	
Place of teaching of course	Faculty of Power and Aeronautical Engineering	
Place of realization of course	WMEiL	
Coordinator of course	prof. Teresa Zielińska	
B. General characteristic of the course		
Block of courses	Robotics	
Group of courses	Obligatory courses	
Type of course	Compulsory	
Language of course	english	
Nominal semester	3 (a. y. 2020/2021)	
Time of completion in the academic year	summer semester	
Preliminary requirements	Modeling and control of manipulators, Mechanical design methods in robotics	
Limit of students	100	
C. Effects of education and manner of teaching		
Purpose of course	This course presents the fundamentals of bio-inspired robotics. The topics include the biological motion properties, motion planning and biological sensors. It will be presented how the knowledge of biological motion properties is transformed into robotics.	
Effects of education	See Table 22.	
Form of didactic studies and number of hours per semester	Lecture	30h
	Exercise type of course	0h
	Laboratory	0h
	Project type of course	15h
	Computer lessons	0h
Contents of education	Contents: • historical background, • motion properties of simple animals and their body build, • motion properties of complex animals and their body build, • summary of biological motion principles • robotics motion rules using biological inspirations, • design solutions inspired by biology, • discussion of the autonomy and adaptability observed in living world and autonomy obtained in robotics, • guided project on biologically inspired motion synthesis of mobile robots. or on the novel kinematic structures of autonomous moving robots. Practical Work: includes project elaboration using real mobile robots or professional design software.	
Methods of evaluation	30% class work, 70% end-semester exam.	
Methods of verification of learning outcomes	See Table 22.	
Exam	yes	
Literature	- T.Zielinska, Biological Aspects of Locomotion, (In	

Description of course

	F.Pfeiffer, T.Zielinska eds. Walking: Biological and Technological Aspects), Springer 2004, ISBN 3-211-22134-4; -T.Zielinska, Motion Synthesis (In: F.Pfeiffer, T.Zielinska eds. Walking: Biological and Technological Aspects), Springer 2004, ISBN 3-211-22134-4.
Website of the course	-

D. Student's activity

Number of ECTS credits	5
Number of hours of student's work to achieve learning outcomes	1) Number of hours that require the presence of a teacher - 50., including a) presence in the lectures - 30, b) presence in the design exercises - 15, c) presence on consultation - 5. 2) The number of hours of independent work of student 85hr: literature study – 15hrs, preparing of bio-inspired robot concept: specification, design concept, motion principles - 20hrs design works – 20hrs, writting the report and preparing presentations – 10hrs, studying the source materials, preparing to the exam –20hrs
Number of ECTS credits on the course with direct participation of academic teacher	3 ECTS credits – number of hours that require the presence of a teacher - 50, including a) presence of the lectures - 30; b) presence in the design exercises – 15; c) presence on consultation - 5.
Number of ECTS credits on practical activities on the course	3 ECTS credits, including a) presence in the design exercises – 15hrs; b) preparation of the project and presentations – self study - 85hrs.

E. Additional information

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Table 22. Learning outcomes

General academic profile - knowledge

Code of effect:	**EM17_W1**
Description:	Student is able to understand the aim of the use of biological patterns in robotics.
Verification:	Verification through individual project and final exam
Field of study related learning outcomes	AiR2_W10, AiR2_W11
Area of study related learning outcomes	I.P7S_WG, III.P7S_WG.o, P7U_W, I.P7S_WK, III.P7S_WK.o
Code of effect:	**EM17_W2**
Description:	Student is able to understand the fundamentals of biologically inspired motion synthesis.
Verification:	Verification through individual project and final exam
Field of study related learning outcomes	AiR2_W10, AiR2_W11
Area of study related learning outcomes	I.P7S_WG, III.P7S_WG.o, P7U_W, I.P7S_WK, III.P7S_WK.o

General academic profile - skils

Code of effect:	**EM17_U1**
Description:	Student is able to introduce novel kinematic

Table 22. Learning outcomes	
	structures using biological inspirations.
Verification:	Verification through individual project
Field of study related learning outcomes	AiR2_U17, AiR2_U03, AiR2_U04, AiR2_U15, AiR2_U16
Area of study related learning outcomes	III.P7S_UW.3.o, I.P7S_UW, III.P7S_UW.1.o, I.P7S_UK, III.P7S_UW.4.o
Code of effect:	**EM17_U2**
Description:	Student can synthetise the movements behaviours based on the biological reactions/reflexes and implement the schemes in a simple biologically inspired robot.
Verification:	Verification through individual project
Field of study related learning outcomes	AiR2_U03, AiR2_U04, AiR2_U15, AiR2_U16, AiR2_U17
Area of study related learning outcomes	I.P7S_UW, III.P7S_UW.1.o, I.P7S_UK, III.P7S_UW.4.o, III.P7S_UW.3.o

Description of course

Code of course	EM16	
Name of course	Biomechanics	
Version of course	2019	
A. Place of the course in system of studies		
Level of education	Second cycle studies	
Form and mode of studies	full-time	
Profile of studies	General academic profile	
Specialisation	-	
Place of teaching of course	Faculty of Power and Aeronautical Engineering	
Place of realization of course	WMEiL	
Coordinator of course	dr hab. inż. Cezary Rzymkowski	
B. General characteristic of the course		
Block of courses	Robotics	
Group of courses	Obligatory courses	
Type of course	Compulsory	
Language of course	english	
Nominal semester	3 (a. y. 2020/2021)	
Time of completion in the academic year	summer semester	
Preliminary requirements	None. However, basic knowledge of classical mechanics will be helpful.	
Limit of students	100	
C. Effects of education and manner of teaching		
Purpose of course	The aim of the course is to provide knowledge on conducting analyses of complex biological systems and processes applying theoretical and experimental methods used in machine theory and system dynamics. Objectives: This course presents the fundamental knowledge on the mechanics of the human body considering the skeleton and muscular system. The students will learn how to analyse static and dynamic forces and torques acting on the body parts during the motion and in working conditions. Abilities: After completing this course, the students will be able to: evaluate the load effort to the human body parts and relate them to the requirements meet during the design of exoskeletons or humanoid robots, evaluate the key biomechanical parameters of human motion and to propose the method of its measurement, elaborate the preferred human postures when manipulating loads using the strength analysis, etc.	
Effects of education	See Table 23.	
Form of didactic studies and number of hours per semester	Lecture	30h
	Exercise type of course	15h
	Laboratory	0h
	Project type of course	0h
	Computer lessons	0h
Contents of education	LECTURES: 1. Outline of the history of biomechanics. 2. Elements of human anatomy and anthropometry. 3. Biomechanical analysis of the human motion system – kinematics and kinetics	

Description of course

	(system approach). 4. Structure, operation, energy sources, work, power and efficiency of skeletal muscles. 5. Skeletal muscle control. 6. Biomechanics of bone tissue, functional adaptation of bone. 7. Electromyography (EMG). 8. Muscle cooperation. 9. Modeling and computer simulation of the human movement system for the needs of ergonomics, medicine and sport. 10. Fundamentals of occupational biomechanics – ergonomics, assessment and design of workplace, biomechanics of impact/injury, assessment and simulation of consequences of road accidents. 11. Application of the principles of mathematical modeling, optimization and control theory for the study of complex biological systems, technology inspired by nature. TUTORIALS/LABORTORY WORK: Measurement of biomechanical parameters of human motion (EMG signals, displacements, velocities, forces, moments, ...) – tools, methods, specialized equipment. Fundamentals of methods for planning and conducting experimental research as well as processing and analysis of results.
Methods of evaluation	Class work, student presentations and reports – 30%, end-semester exam/final test – 70%
Methods of verification of learning outcomes	See Table 23.
Exam	yes
Literature	1) K. Kędzior: Occupational Biomechanics. In: Karwowski W. (ed.), International Encyclopedia of Ergonomics and Human Factors, Vol. III, Taylor and Francis, London – New York 2001, 1545-1558. 2) Nigg B.M., Herzog W.: Biomechanics of the Musculo–skeletal System, John Wiley and Sons Ltd, 2007 (third edition). 3) Nordin M.,Frankel V.H. (eds): Basic Biomechanicsof the Musculoskeletal System, Lippincott Williams and Wilkins 2001 (third edition). 4) Panjabi M.M. and White A.A.: Biomechanics of the Musculoskeletal System, Churchill Livingstone, New York, Edinburg, London, Philadelphia, 2001. 5) Stewart G.J.: The Skeletal and Muscular Systems, Infobase Publishing, New York, 2009. 6) Schmitt, K.-U., Niederer, P.F., Cronin, D.S., Muser, M.H., Walz, F.: Trauma Biomechanics -- An Introduction to Injury Biomechanics, Springer, 2014. 7) Winter D.A.: Biomechanics and motor control of human movement, 4th ed., John Wiley & Sons, Inc., 2009. FURTHER READINGS: will be provided by lecturers.
Website of the course	xxx

D. Student's activity

Number of ECTS credits	5
Number of hours of student's work to achieve learning outcomes	1. Number of hours that require the presence of a teacher – 45 h, including: a) lectures – 30 h., b)

Description of course

	tutorials/laboratory – 15 h. 2. Private study/self-studying hours: 85, including: a) preparation for tutorials/laboratory exercises, literature studies – 50 h, b) preparation for the final test – 35 h. Total: 130 h, 5 ECTS.
Number of ECTS credits on the course with direct participation of academic teacher	2 ECTS (45 h), including a) lectures – 30 h., b) laboratory – 15 h.
Number of ECTS credits on practical activities on the course	0,6 ECTS, tutorials/laboratory exercises (15 h)

E. Additional information

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Table 23. Learning outcomes

General academic profile - knowledge

Code of effect:	**EM16_W1**
Description:	The student has a well-established knowledge on the measurement of selected dynamic quantities in biomechanical systems.
Verification:	Final test
Field of study related learning outcomes	AiR2_W06
Area of study related learning outcomes	I.P7S_WG, III.P7S_WG.o, P7U_W
Code of effect:	**EM16_W2**
Description:	The student knows the basics of kinematics and dynamics of mechanical and biomechanical systems.
Verification:	Final test
Field of study related learning outcomes	AiR2_W08
Area of study related learning outcomes	I.P7S_WG, III.P7S_WG.o, P7U_W
Code of effect:	**EM16_W3**
Description:	The student has a well-established knowledge on application of advanced computer methods in modelling and analysis of biomechanical and biorobotic systems.
Verification:	Final test
Field of study related learning outcomes	AiR2_W10
Area of study related learning outcomes	I.P7S_WG, III.P7S_WG.o, P7U_W

General academic profile - skils

Code of effect:	**EM16_U1**
Description:	The student is able to collect and integrate information from literature and other sources as well as to make a critical selection for the purpose of solving a specific problem in the field of biomechanics.
Verification:	Final test, classroom presentation
Field of study related learning outcomes	AiR2_U01, AiR2_U12
Area of study related learning outcomes	P7U_U, I.P7S_UW.o, III.P7S_UW.o, I.P7S_UW, III.P7S_UW.2.o, III.P7S_UW.4.o
Code of effect:	**EM16_U2**
Description:	The student is able to prepare a presentation and a concise report regarding selected biomechanical problems.

Table 23. Learning outcomes	
Verification:	Classroom presentation, report assessment
Field of study related learning outcomes	AiR2_U04
Area of study related learning outcomes	I.P7S_UK
Code of effect:	**EM16_U3**
Description:	The student is able to use the known mathematical and modeling methods to conduct various analyses of biomechanical and biorobotic systems.
Verification:	Final test
Field of study related learning outcomes	AiR2_U06
Area of study related learning outcomes	I.P7S_UW, III.P7S_UW.2.o, III.P7S_UW.4.o
Code of effect:	**EM16_U4**
Description:	The student is able to use knowledge from research/observation of biological systems as the basis for proposing new solutions in the field of biorobotics.
Verification:	Final test
Field of study related learning outcomes	AiR2_U17
Area of study related learning outcomes	I.P7S_UW, III.P7S_UW.3.o

Description of course

Code of course	EM18	
Name of course	Dynamics of multi-body systems	
Version of course	2019	
A. Place of the course in system of studies		
Level of education	Second cycle studies	
Form and mode of studies	full-time	
Profile of studies	General academic profile	
Specialisation	-	
Place of teaching of course	Faculty of Power and Aeronautical Engineering	
Place of realization of course	WMEiL	
Coordinator of course	prof. dr hab. inż. Janusz Frączek, dr hab. inż. Marek Wojtyra, prof. PW	
B. General characteristic of the course		
Block of courses	Robotics	
Group of courses	Obligatory courses	
Type of course	Compulsory	
Language of course	english	
Nominal semester	3 (a. y. 2020/2021)	
Time of completion in the academic year	winter semester	
Preliminary requirements	Basic knowledge of classical mechanics, matrix algebra and calculus is welcome.	
Limit of students	24	
C. Effects of education and manner of teaching		
Purpose of course	Aims: — To prepare for understanding, formulating and solving problems in the field multibody kinematics and dynamics. — To gain basic skills in using professional multibody software	
Effects of education	See Table 24.	
Form of didactic studies and number of hours per semester	Lecture	30h
	Exercise type of course	15h
	Laboratory	0h
	Project type of course	0h
	Computer lessons	0h
Contents of education	LECTURES: 1. Position, velocity and acceleration. Mathematical model of a multibody system in various types of coordinates.. 2. Kinematic pairs and constraint equations. Driving constraints. Jacobian matrix. 4. Kinematics – task formulation and methods of solution. 5. Algorithm and program for automated kinematic analysis. . 6. Rigid body equations of motion. Constraint reactions. 7. Direct and inverse dynamics. Algorithm of automated simulation of dynamics TUTORIALS: 1. MSC.ADAMS characteristics 2. Building a simple model of a robotic gripper. 3. Forces, measures and sensors. Simulation and post-processing 4. Parametrization and optimization 5. Contact forces and run-time functions 6. Cam-follower mechanism. Parameter sensitivity 7. Mechanisms with redundant constraints	

Description of course

Methods of evaluation	20% – continuous assessment (tutorials) 50% – homework assignment 30% – final exam (oral)
Methods of verification of learning outcomes	See Table 24.
Exam	no
Literature	1. Nikravesh P.E.: Planar Multibody Dynamics. Formulation, Programming with MATLAB®, and Applications, 2nd Ed., Taylor & Francis, Boca Raton, 2018. 2. Haug E.J.: Computer-Aided Kinematics and Dynamics of Mechanical Systems. Volume I: Basic Methods, Allyn and Bacon, 1989. 3. Garcia de Jalon J., Bayo E.: Kinematic and Dynamic Simulation of Multibody Systems. Springer-Verlag, 1994.
Website of the course	—

D. Student's activity

Number of ECTS credits	5
Number of hours of student's work to achieve learning outcomes	1. Number of hours that require the presence of a teacher – 50, including: a) lectures – 30 h., b) tutorials – 15 h., c) consultations – 5 h. 2. Self-studying hours: 35: homework assignment consisting in conducting kinematic analysis with the use of self-created program (in MATLAB environment) and with the use of a professional multibody package (MSC.ADAMS) Total: 85 h – 5 ECTS.
Number of ECTS credits on the course with direct participation of academic teacher	3 ECTS – 50 contact hours,including: a) lectures – 30 h., b) tutorials – 15 h., c) consultations – 5 h.
Number of ECTS credits on practical activities on the course	3.5 ECTS – 65 hours, including: a) lectures – 30 h., b) tutorials – 15 h., c) consultations – 5 h. d) homework assignment consisting in conducting kinematic analysis with the use of self-created program (in MATLAB environment) and with the use of a professional multibody package (MSC.ADAMS) – 35 h.

E. Additional information

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Table 24. Learning outcomes

General academic profile - knowledge

Code of effect:	**EM18_W1**
Description:	The student knows the basics of kinematic analysis of mechanisms and multibody systems.
Verification:	Homework assignment, final exam
Field of study related learning outcomes	AiR2_W08
Area of study related learning outcomes	I.P7S_WG, III.P7S_WG.o, P7U_W
Code of effect:	**EM18_W2**
Description:	The student has knowledge regarding equations of motion of mechanisms and multibody systems
Verification:	Final exam
Field of study related learning outcomes	AiR2_W09
Area of study related learning outcomes	I.P7S_WG, P7U_W

Table 24. Learning outcomes	
Code of effect:	**EM18_W3**
Description:	The student has basic knowledge about the methods of integrating the equations of motion of multibody systems
Verification:	Homework assignment, final exam
Field of study related learning outcomes	AiR2_W01, AiR2_W10
Area of study related learning outcomes	I.P7S_WG, P7U_W, III.P7S_WG.o
General academic profile - skils	
Code of effect:	**EM18_U1**
Description:	The student can write the equations of kinematics for a mechanism or a complex multibody system
Verification:	Homework assignment, final exam
Field of study related learning outcomes	AiR2_U07
Area of study related learning outcomes	I.P7S_UW, III.P7S_UW.2.o
Code of effect:	**EM18_U2**
Description:	The student can numerically solve equations of kinematics.
Verification:	Homweork assignment, final exam
Field of study related learning outcomes	AiR2_U06, AiR2_U14
Area of study related learning outcomes	I.P7S_UW, III.P7S_UW.2.o, III.P7S_UW.4.o
Code of effect:	**EM18_U3**
Description:	The student can formulate equations of motion of complex mechanisms
Verification:	Homework assignment, final exam
Field of study related learning outcomes	AiR2_U06
Area of study related learning outcomes	I.P7S_UW, III.P7S_UW.2.o, III.P7S_UW.4.o
Code of effect:	**EM18_U4**
Description:	The student can conduct dynamic analysis of simple mechanisms using modern design and analysis tools
Verification:	Homework assignment
Field of study related learning outcomes	AiR2_U07, AiR2_U14
Area of study related learning outcomes	I.P7S_UW, III.P7S_UW.2.o, III.P7S_UW.4.o
Code of effect:	**EM18_U5**
Description:	The student can solve an engineering problem in the field of multibody systems modelling
Verification:	Homework assignment, final exam
Field of study related learning outcomes	AiR2_U03, AiR2_U14, AiR2_U18
Area of study related learning outcomes	I.P7S_UW, III.P7S_UW.1.o, III.P7S_UW.2.o, III.P7S_UW.4.o, III.P7S_UW.3.o

Description of course

Code of course	EM15	
Name of course	Research methodology	
Version of course	2019	
A. Place of the course in system of studies		
Level of education	Second cycle studies	
Form and mode of studies	full-time	
Profile of studies	General academic profile	
Specialisation	-	
Place of teaching of course	Faculty of Power and Aeronautical Engineering	
Place of realization of course	FPAE	
Coordinator of course	prof. Teresa Zielińska	
B. General characteristic of the course		
Block of courses	Robotics	
Group of courses	Obligatory courses	
Type of course	Compulsory	
Language of course	english	
Nominal semester	3 (a. y. 2020/2021)	
Time of completion in the academic year	summer semester	
Preliminary requirements	All obligatory courses from 1st and 2nd semester	
Limit of students	100	
C. Effects of education and manner of teaching		
Purpose of course	This module is intended to provide the student with the necessary skills and tools to carry out and present a research topic. This module includes also the background study and collect information part for the master thesis topic, which will be completed during the fourth semester.	
Effects of education	See Table 25.	
Form of didactic studies and number of hours per semester	Lecture	15h
	Exercise type of course	0h
	Laboratory	0h
	Project type of course	0h
	Computer lessons	0h
Contents of education	Research methodology. Written communication: reports, theses, journal & conference papers. Oral communication: research presentations (e.g. attending conference & presenting a paper). Setting goals and defining objectives of the thesis.	
Methods of evaluation	Written report about related work of the thesis research topic of the student (70%), oral presentation (30%).	
Methods of verification of learning outcomes	See Table 25.	
Exam	no	
Literature	• J. Collis, R. Hussey, Business Research A Practical Guide for Undergraduate and Postgraduate Students, 2nd Edition, Basingstoke: Palgrave, 2003. • M. Polonsky, D. Waller, Designing and Managing a Research Project, Sage, 2005.	
Website of the course	-	
D. Student's activity		
Number of ECTS credits	6	

Description of course

Number of hours of student’s work to achieve learning outcomes	1) Number of hours that require the presence of a teacher - 50, including a) presence of the lectures - 10; b) presence on consultation - 40 2) The number of hours of independent work of student - 140
Number of ECTS credits on the course with direct participation of academic teacher	2 ECTS credits number of hours that require the presence of a teacher - 50, including a) presence of the lectures- 10; b) presence on consultation 40
Number of ECTS credits on practical activities on the course	x

E. Additional information

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Table 25. Learning outcomes

General academic profile - knowledge

Code of effect:	**EM15_W1**
Description:	Students should know how to conduct research, set the thesis objectives, and write a technical report.
Verification:	Quality of submitted diploma thesis
Field of study related learning outcomes	AiR2_W11
Area of study related learning outcomes	I.P7S_WK, III.P7S_WK.o, P7U_W
Code of effect:	**EM15_W2**
Description:	Has the knowledge necessary to understand the social, economic, legal and other non-technical determinants of engineering activity and taking them into account in engineering practice
Verification:	Verification through individual meetings with a supervisor and group seminars.
Field of study related learning outcomes	AiR2_W13
Area of study related learning outcomes	P7U_W, I.P7S_WK, III.P7S_WK

General academic profile - skils

Code of effect:	**EM15_U1**
Description:	Uses English well enough to communicate, also on professional matters, read and understand professional literature, and also prepare and make a short presentation on completion of a project or a research task.
Verification:	Quality of submitted diploma thesis
Field of study related learning outcomes	AiR2_U05
Area of study related learning outcomes	I.P7S_UK
Code of effect:	**EM15_U2**
Description:	Can gather information from literature, databases and other chosen sources; can integrate the information obtained, interpret it and evaluate critically, as well as draw conclusions, and formulate and justify opinions well.
Verification:	Review of the state of the art section in the thesis and the soundness of conclusions.
Field of study related learning outcomes	AiR2_U01

Table 25. Learning outcomes	
Area of study related learning outcomes	P7U_U, I.P7S_UW.o, III.P7S_UW.o
Code of effect:	**EM15_U3**
Description:	Can prepare detailed documentation on the results of an experiment, project or research task; can prepare a presentation of the results
Verification:	Quality of submitted diploma thesis
Field of study related learning outcomes	AiR2_U03
Area of study related learning outcomes	I.P7S_UW, III.P7S_UW.1.o
Code of effect:	**EM15_U4**
Description:	Can prepare and give a presentation on completion of a project or research task and lead a discussion on the presentation
Verification:	Oral presentation quality.
Field of study related learning outcomes	AiR2_U04
Area of study related learning outcomes	I.P7S_UK
Code of effect:	**EM15_U5**
Description:	Can define the directions of further learning and implement the process of self-education, as well as direct others in this area.
Verification:	Verification through individual meetings with a supervisor and group seminars.
Field of study related learning outcomes	AiR2_U21
Area of study related learning outcomes	P7U_U, I.P7S_UU
General academic profile - social competences	
Code of effect:	**EM15_K1**
Description:	Understands the need to formulate and deliver information and opinions on technical achievements in automation and robotics and other aspects of engineering activity in automation and robotics; strives to make the information and opinions widely understandable, presenting various points of view.
Verification:	Verification through individual meetings with a supervisor and group seminars.
Field of study related learning outcomes	AiR2_K02
Area of study related learning outcomes	I.P7S_KO, I.P7S_KR
Code of effect:	**EM15_K2**
Description:	Understands the importance of knowledge in solving cognitive and practical problems and the need to consult experts in case of difficulties in solving the problem on their own.
Verification:	Verification through individual meetings with a supervisor and group seminars.
Field of study related learning outcomes	AiR2_K03
Area of study related learning outcomes	P7U_K, I.P7S_KK

Description of course

Code of course	ANW137	
Name of course	MSc thesis	
Version of course	2019	
A. Place of the course in system of studies		
Level of education	Second cycle studies	
Form and mode of studies	full-time	
Profile of studies	General academic profile	
Specialisation	-	
Place of teaching of course	Faculty of Power and Aeronautical Engineering	
Place of realization of course	FPAE	
Coordinator of course	All staff	
B. General characteristic of the course		
Block of courses	Robotics	
Group of courses	Obligatory courses	
Type of course	Compulsory	
Language of course	english	
Nominal semester	4 (a. y. 2020/2021)	
Time of completion in the academic year	summer semester	
Preliminary requirements	x	
Limit of students	1 student – 1 supervisor	
C. Effects of education and manner of teaching		
Purpose of course	After completing this module, the students will be able to: - research the background and literature relating to a practical problem, - write a dissertation about the work, - write a scientific paper for a conference or scientific journal, - give an oral presentation and answer questions about the project.	
Effects of education	See Table 26.	
Form of didactic studies and number of hours per semester	Lecture	0h
	Exercise type of course	0h
	Laboratory	0h
	Project type of course	150h
	Computer lessons	0h
Contents of education	The thesis is carried out under the indidual supervision. It leads to a substantial dissertation summarizing significant original research in robotics. During this semester the student will apply the principles and techniques learned during the different courses to solve a practical problem. The dissertation will be defended in front of a jury composed according to university rule. Two of which are not the supervisors.	
Methods of evaluation	Following University rules.	
Methods of verification of learning outcomes	See Table 26.	
Exam	yes	
Literature	Will be provided by the supervisors.	
Website of the course	xxx	
D. Student's activity		
Number of ECTS credits	30	
Number of hours of student's work to achieve learning outcomes	The number of hours of independent work of student – work over the whole semester –	

Description of course

	nominally 510hrs
Number of ECTS credits on the course with direct participation of academic teacher	1 ECTS credit Consultancy – 15hrs
Number of ECTS credits on practical activities on the course	29 ECTS credits – 525hrs – (5daysx7hrsx15weeks) Literature studies – 20hrs, state of the art – 5hrs, problem statement, solution plan - 5hrs, solving the problem (laboratory work) - 360 hrs, writting the report - 60 hrs, preparing to diploma exam– 60hrs, preparing presentation – 5hrs

E. Additional information

Notes	x
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Table 26. Learning outcomes

General academic profile - skils

Code of effect:	**ANW137_U1**
Description:	Student is able to investigate the matter of a given subject with respect to practical issues.
Verification:	Based on the state of the art in the diploma thesis.
Field of study related learning outcomes	AiR2_U01
Area of study related learning outcomes	P7U_U, I.P7S_UW.o, III.P7S_UW.o
Code of effect:	**ANW137_U2**
Description:	Student is able to write a dissertation that summarizes the conducted research.
Verification:	Quality of submitted diploma thesis.
Field of study related learning outcomes	AiR2_U03
Area of study related learning outcomes	I.P7S_UW, III.P7S_UW.1.o
Code of effect:	**ANW137_U3**
Description:	Student is able to write a scientific paper for a conference or scientific journal.
Verification:	Quality of submitted diploma thesis
Field of study related learning outcomes	AiR2_U03
Area of study related learning outcomes	I.P7S_UW, III.P7S_UW.1.o
Code of effect:	**ANW137_U4**
Description:	Student is able to give an oral presentation and answer questions about the project.
Verification:	Oral presentation quality
Field of study related learning outcomes	AiR2_U04
Area of study related learning outcomes	I.P7S_UK

General academic profile - social competences

Code of effect:	**ANW137_K1**
Description:	Understands the need to formulate and deliver, especially via mass media, information and opinions on technical achievements in automation and robotics and other aspects of engineering activity in automation and robotics; strives to make the information and opinions widely understandable, presenting various points of view.
Verification:	Verification through discussions with the members of the committee.

Table 26. Learning outcomes	
Field of study related learning outcomes	AiR2_K02
Area of study related learning outcomes	I.P7S_KO, I.P7S_KR