Mechanical Engineering

Master Degree Studies

Mechanical Engineering

Subject:	Basics of Mechatronics
Subject type:	
Subject code:	
Year:	II
Semester:	2
Form of studies:	Full-time course
Type of classes and hours per semester:	60
Lecture	30
Exercise	
Laboratory practice	30
Project	
ECTS points:	4
Form of credit:	Assessment
Lecture language:	

Subject objective	
C1	Presentation of the basic issues of mechatronics and typical applications of mechatronic systems
C2	Introduction to the structure, principle of operation and methods of control of actuators in mechatronic systems
C3	Introduction to the structure and methods of tuning of servo drives
C4	Introduction to the structures of robots, their area of applications and issues of design, implementation of industrial robots in different work environments
C5	Acquainting students with the techniques of programming of industrial robots, in particular programming the manipulators

Prerequisites in knowledge, skills and other competencies	
1	Student has the knowledge in the field of mathematics, including algebra, analysis and elements of analytic and spatial geometry, discrete and applied mathematics, including mathematical methods necessary to: the use of mathematical tools to describe the issues of mechanical, electrical, electronic and technological processes
2	Student has the basic knowledge of physics, including mechanics, thermodynamics, optics, electricity and magnetism, and of solid-state physics, including the knowledge necessary to understand the basic physical phenomena in nature and technology
3	Student has the basic knowledge of theory of control in one-dimensional linear systems.
4	Student is able to obtain information from literature, databases and other sources.

Educational effects	
	Knowledge:
EK 1	Student is familiar with the construction and operation of basic sensors and drives used in mechatronic systems
EK 2	Student knows the general structure of the servo drive, the basic control algorithms and methods of tuning
EK 3	Student can describe the typical structures of industrial robots, the types of drives and name their appliances
EK 4	Student knows the basics of programming sequential control systems in ladder diagram (LD)
	Skills:
EK 5	Student can design and program sequence control system
EK 6	Student is able to program the motion of a five-axis universal industrial robot
EK 7	Student can perform kinematics calculations and design drive system for simple manipulator
EK 8	Student is able to make tuning of the algorithm of servo drive controller due to given criteria
	Social competencies:
EK 9	Student is able to present in an interesting way the role of mechatronic systems in selected areas of life
Curriculum content of Subject	
Form of classes – Lecture	
	Curriculum content
W1	Origins of mechatronics. Interdisciplinarity of mechatronics. Overview of the basic concepts, application areas and examples of mechatronic systems.
W2	Typical measuring transducers in mechatronic systems: encoders of: position, speed, distance, force (pressure), color, presence of objects (proximity transducers).
W3	Electric drive components in mechatronic systems: induction, synchronous, stepper, brushless, linear motors; advantages and disadvantages; typical applications.
W4	Control of electric actuators: control of the PWM technique, stepper motor controller, brushless and synchronous motor controller, frequency converter (inverter).

W5	Pneumatic and hydraulic drives in mechatronic systems: actuators and motors, artificial muscles, proportional control elements. Advantages and disadvantages, typical applications.
W6	Typical drive transmission parts: synchronous belt transmissions, ball screws bearings, planetary gears, guide rails, linear bearings, magnetic levitation.
W7	Servo drives: block diagram, control algorithm, cascade control system, tuning of the controller, quality of control.
W8	Discrete control systems - implementation using relay technique.
W9	Programmable logic controller: structure, discrete inputs and outputs circuits, working cycle, basics of ladder diagram (LD).
W10	Programming sequential controller in LD.
W11	Basic concepts in the field of robotics, the development of the idea of robots and robotics, an overview of applications of robots, typical issues in the field of robotics.
W12	Industrial robots; structures: Unimate, Stanford Arm, PUMA, SCARA; typical applications: spot welding, constant welding, assembly, transportation, sorting, palletizing, painting, direct treatment of elements
W13	Kinematics of industrial robots: description of a point and a rigid body in space, robot posture, rotation matrix, translation vector, translation matrix, Euler angles, the Denavit-Hartenberg parameters, examples; workspace, the robot reach.
W14	Gripping devices, exoskeletons; grippers' requirements, examples of the structure; sensors used in grippers; slip detection; materials used for the grippers, electrically controlled artificial muscles; exoskeletons: presentation of selected structures
W15	Micro and nano-robots - some problems of nanotechnology, structural solutions, methods of manufacture and assembly at the micro scale, impacts, drives, sensors, control methods, applications.
Class form: laboratory practice	
	Curriculum content
L1	Hydraulic servo drive – construction of model of hydraulic servo drive, computer simulation, tuning of servo controller
L2	Kinematics of robots - determination of equations of manipulator kinematics based on the DH parameters, determining the position and orientation of the gripper
L3	Kinematics of robots – calculation of the manipulator kinematics, simple and inverse kinematics task
L4	Programming the electrical drive with frequency inverter. Part I. The basic configuration and starting-up the drive.
L5	Programming the electrical drive with frequency inverter. Part. II. Configuring, testing and tuning of the rotational speed control system.
L6	Programming of industrial manipulator, designing sequences of movements, test of resistance to interference.

L7	Programming the five-axis manipulator, determination of trajectory of motion, the accuracy of positioning, design of assembly sequence
L8	Programming the electrical servo drive, determination of the dynamic characteristics and positioning error.
L9	Discrete control systems. Part. I. Programming the simple switching circuits in LD language
L10	Discrete control systems. Part. II. Programming of simple sequential circuits in LD language.
L11	Discrete control systems. Part. III. Synthesis of sequential pneumatic manipulator control
L12	Design of pneumatic or hydraulic drive for an industrial manipulator, the selection of the basic elements, computer simulation of the drive.
L13	Determination of the mechanical characteristics of the stepper motor
L14	Properties examination of pneumatic servo drive (linear positioner)

Teaching methodology	
1	Lecture with multimedia presentation
2	Laboratory exercises, solving tasks

Student workload	
Form of activity	Average hours to complete activity
Teacher contact hours, including:	*63*
Attendance at lectures	*30*
Attendance at laboratory practice	*30*
Consultation	3
Total student work time, including:	37
Preparation for laboratory practice	30
Preparation for assessment	7
Total student work time	100
Total ECTS for the subject:	4
Total of ECTS for practical classes (exercise, laboratory practice, projects)	2

Basic reference literature	
1	B. Heimann, W. Gerth, K. Popp: Mechatronika : komponenty, metody, przykłady PWN, Warszawa,2013
2	Szkodny T.: Podstawy robotyki. Wyd. Pol. Śląskiej. 2011
Complementary reference literature	
1	Domachowski Z.: Automatyka i robotyka – podstawy, Wyd. PG, Gdańsk, 2003
2	Frączek J., Wojtyra M., Kinematyka układów wieloczłonowych. Metody obliczeniowe, WNT 2008
3	Jezierski E.: Dynamika robotów, WNT, Warszawa, 2006
4	Kozłowski K., Dutkiewicz P., Wróblewski W.: Modelowanie i sterowanie robotów.

	PWN, Warszawa, 2003

Educational effect matrix					
Educational effect	Specific educational effect reference to curriculum-wide effects (PEK)	Subject objective	Curriculum content	Teaching methodology	Evaluation methods
EK 1	MBM2A_W07+	*C2*	*W2-W5 L1, L4, L5, L8, L13, L14*	*1, 2*	*O1, O2*
EK 2	*MBM2A_W01+ MBM2A_W03+*	*C2, C3*	*W6, W7 L1, L2, L8*	*1, 2*	*O1, O2*
EK 3	*MBM2A_W10+ MBM2A_W11++*	*C4, C5*	*W11-W14 L2, L3, L7*	*1, 2*	*O1, O2*
EK 4	*MBM2A_W06+*	*C5*	*W8-W10 L9-L11*	*1, 2*	**O1, O2**
EK 5	*MBM2A_U13++*	*C2, C5*	*W8-W10 L9-L11*	*1, 2*	*O1, O2*
EK 6	*MBM2A_U13++*	*C5*	*W13 L6, L7*	*1, 2*	*O1, O2*
EK 7	*MBM2A_U13+++ MBM2A_U12+*	*C2, C4*	*W3, W7, W13 L2, L3*	*1, 2*	*O1, O2*
EK 8	*MBM2A_U11++ MBM2A_U13+*	*C3*	*W7 L5, L8*	*1, 2*	*O1, O2*
EK 9	*MBM2A_K06+*	*C1*	*W1*	*1*	*O1*

			W15		

Evaluation methods and criteria		
Evaluation method symbol	Evaluation method description	Pass threshold
O1	Evaluation of control tests conducted during laboratory classes	*70%*
O2	Evaluation of the assessment	*100%*

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