

FACULTY OF ELECTRICAL  
ENGINEERING**SUBJECT CARD**

Name in Polish: **Podstawy automatyki 2**  
 Name in English: **Fundamentals of control engineering 2**  
 Main field of study (if applicable): **Control Engineering and Robotics**  
 Specialization (if applicable):  
 Level and form of studies: **1st level, full-time**  
 Kind of subject: **obligatory**  
 Subject code: **ARR042102**  
 Group of courses: **NO**

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU):	30	15	30		
Number of hours of total student workload (CNPS):	90	30	60		
Form of crediting:	examination	crediting with grade	crediting with grade		
For group of courses mark (X) final course:					
Number of ECTS points:	3	1	2		
including number of ECTS points for practical (P) classes :		1	2		
including number of ECTS points for direct teacher-student contact (BK) classes:	2.10	0.70	1.40		

**PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

1. Student should have the basic knowledge on analysis of dynamic and steady state characteristics of linear continuous and discrete systems
2. Student should know how to apply basic tools for analysis linear continuous and discrete systems: Laplace transformation and Z transformation.
3. Student should know how to determine the stability of basic dynamic systems.
4. Student should have ability to think and act in a creative way. Student should have ability to work in a team.

**SUBJECT OBJECTIVES**

- C1. To provide knowledge for analysis of continuous and discrete systems including steady state error calculation.  
 C2. Learning how to determine the stability of nonlinear systems with using of the first and the second Liapunov's method, describing function and the phase trajectories.  
 C3. To provide knowledge of analysis dynamical and frequency characteristics of the systems.  
 C4. Familiarization with designing methods for automatic control systems and their practical verification.

**SUBJECT EDUCATIONAL EFFECTS***relating to knowledge:*

- PEK\_W01 Student gets the knowledge on description of continuous and discrete control systems; their analysis from the point of view of statics, dynamics and stability of continuous and discrete control systems.  
 PEK\_W02 Student gets the knowledge regarding correction of continuous linear and discrete control systems, state variables method and nonlinear control systems.

*relating to skills:*

- PEK\_U01 Student is able to solve the problems related to continuous and discrete control systems. He can apply mathematical methods for a system analysis in time and frequency domain.  
 PEK\_U02 Student is able to design, simulate and analyse simple control system for continuous, discrete and nonlinear domain. He can analyse test results and prepare adequate report.

*relating to social competences:*

- PEK\_K01 Student can act independently and cooperate within a group working on a complex engineering project.

## PROGRAMME CONTENT

Form of classes - lecture		Number of hours:
Lec 1	General introduction – aims of the course. Establishing conditions for passing and marking the course. Task of the course. Structure of the continuous linear control system.	2
Lec 2	Methods of control systems correction.	2
Lec 3	Methods of series correction of control systems.	2
Lec 4	Application of different correction principles: parallel correctors, correctors in feedback, additive and predictive correction.	2
Lec 5	PID regulators: structure and feature analysis.	2
Lec 6	PID regulators: methods of tuning.	2
Lec 7	Steady state characteristics of discrete systems, synthesis of discrete correctors.	2
Lec 8	Digital PID regulators.	2
Lec 9	Direct design of discrete correctors. Dead-beat correctors.	2
Lec 10	Nonlinear control systems. Basic features, equilibrium states, limit cycles. Stability according to Lyapunov.	2
Lec 11	Local stability. State variables description of nonlinear systems. Stability of the linearized system: first Lyapunov method.	2
Lec 12	Direct Lyapunov method. Global stability.	2
Lec 13	Harmonic linearization: describing function.	2
Lec 14	Analysis of the nonlinear systems based on describing function, application. Extended Nyquist method.	2
Lec 15	Analysis of the nonlinear systems with using of the phase trajectories concept. Relay control systems. Correction of nonlinear control systems.	2
Total hours:		<b>30</b>

Form of classes - class		Number of hours:
Cl 1	Calculation of steady state closed-loop systems. System type.	2
Cl 2	Determination of the series corrector parameters. Analysis of pre- and post- correction characteristics.	2
Cl 3	PID regulators: tuning and feature analysis.	2
Cl 4	Steady state errors of discrete systems.	2
Cl 5	Discrete PID regulators: difference equation. Direct determination of discrete correctors.	2
Cl 6	Determination of the nonlinear system stability according to the first Lyapunov method.	2
Cl 7	Determination of the nonlinear system stability according to the describing function method.	2
Cl 8	Qualified test	1
Total hours:		<b>15</b>

Form of classes - laboratory		Number of hours:
Lab 1	Presentation of health and safety rules, and general regulations of the laboratory. Establishing conditions for passing and marking the project course. The lab presentation.	2
Lab 2	Analysis methods for linear continuous control systems.	2
Lab 3	Analogue correction of linear continuous control systems.	2
Lab 4	Analogue correction of linear continuous control systems.	2
Lab 5	Analysis of PID regulators (tuning, characteristics).	2
Lab 6	Synthesis and analysis of combinatorial logic circuits.	2
Lab 7	Analysis of linear discrete control systems.	2
Lab 8	Digital PID regulators: tuning and sampling time determination.	2
Lab 9	Direct computer control.	2
Lab 10	PLC controllers application to direct control system correction.	2
Lab 11	Dahlin and Vogel-Edgar method for direct correction of discrete control system.	2
Lab 12	Analysis of nonlinear continuous control system.	2
Lab 13	Correction of nonlinear continuous control system.	2
Lab 14	Microprocessor sequential controllers.	2
Lab 15	Additional term.	2
Total hours:		<b>30</b>

### TEACHING TOOLS USED

- N1. Informative lecture.  
N2. Calculation exercises.  
N3. Lab with reports.

### EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT

Evaluation <i>F - forming (during semester) P - concluding (at semester end)</i>	Educational effect number	Way of evaluating educational effect achievement
F1(w)	PEK_W01 PEK_W02	Attendance on lectures.
F2(w)	PEK_W01 PEK_W02	Exam
P(w)	$P = 0,1F1 + 0,9F2$	
F1(c)	PEK_U01	Activity in the class
F2(c)	PEK_U01	Preparation of the report
P(c)	$P = 0,3F1 + 0,7F2$	
F1(L)	PEK_U02 PEK_K01	Activity in the lab
F2(L)	PEK_U02 PEK_K01	Preparation of the report
P(L)	$P = 0,3F1 + 0,7F2$	

### PRIMARY AND SECONDARY LITERATURE

#### PRIMARY LITERATURE:

- [1] <http://www.rose.pwr.wroc.pl/> - course materials.
  - [2] KACZOREK T., Teoria sterowania i systemów, PWN, Warszawa 1999.
  - [3] RUMATOWSKI K., Podstawy regulacji automatycznej. Wydawnictwo Politechniki Poznańskiej, Poznań 2008.
  - [4] GREBLICKI W., Podstawy automatyki. Oficyna Wydawnicza Politechniki Wrocławskiej, Wrocław 2006.
  - [5] MAZUREK J., VOGT H., ŻYDANOWICZ W., Podstawy automatyki. Oficyna Wydawnicza Politechniki Warszawskiej, Warszawa 2006.
  - [6] KOWAL J., Podstawy automatyki, t. 1 i 2, AGH, Kraków, 2004.
  - [7] WISZNIEWSKI A. (red.), Podstawy automatyki. Ćwiczenia laboratoryjne, skrypt Politechniki Wrocławskiej, Wrocław 2000.
  - [8] Staszewski J., Skrypt zadań z Podstaw Automatyki \*
- \*position [8] available at the teacher.

#### SECONDARY LITERATURE:

- [1] <http://bcs.wiley.com/he-bcs/Books?action=index&itemId=0471134767&itemTypeld=BKS&bcsId=2357> - strona do kursu: Automatic Control Systems, Benjamin C. Kuo and Farid Golnaraghi.
- [2] OGATA K., Modern Control Engineering. Prentice-Hall, Inc., Upper Saddle River, New Jersey, 2002.
- [3] Larminant P., Thomas Y., Automatyka - układy liniowe, WNT, Warszawa 1983.
- [4] Kaczorek T., Dzieliński A., Dąbrowski W., Łopatka R.: Podstawy teorii sterowania, WNT, Warszawa 2005.

### SUBJECT SUPERVISOR

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MATRIX OF CORRELATION BETWEEN EDUCATIONAL EFFECTS FOR SUBJECT  
**ARR042102 - Fundamentals of control engineering 2**  
AND EDUCATIONAL EFFECTS FOR MAIN FIELD OF STUDY **Control Engineering and Robotics**

Subject educational effect	Correlation between subject educational effect and educational effects defined for main field of study and specialization (if applicable)	Subject objectives	Programme content	Teaching tool number
PEK_W01	K1AiR_W23	C.1 C.2	Lec1 Lec2 Lec3 Lec4 Lec5	N.1
PEK_W02	K1AiR_W23	C.3 C.4	Lec6 Lec7 Lec8 Lec9 Lec10 Lec11 Lec12 Lec13 Lec14 Lec15	N.1
PEK_U01	K1AiR_U21	C.1 C.2	CI1 CI2 CI3 CI4 CI5 CI6 CI7 CI8	N.2
PEK_U02	K1AiR_U21	C.3 C.4	Lab1 Lab2 Lab3 Lab4 Lab5 Lab6 Lab7 Lab8 Lab9 Lab10 Lab11 Lab12 Lab13 Lab14 Lab15	N.2 N.3
PEK_K01	K1AiR_K05	C.1 C.2 C.3 C.4	CI1 CI2 CI3 CI4 CI5 CI6 CI7 CI8 Lab1 Lab2 Lab3 Lab4 Lab5 Lab6 Lab7 Lab8 Lab9 Lab10 Lab11 Lab12 Lab13 Lab14 Lab15	N.1 N.2 N.3