COURSE DESCRIPTION CARD

BIALYSTOK UNIVERSITY OF TECHNOLOGY		**Faculty of Electrical Engineering**	
Field of study	Electrical and Electronics Engineering	**Level and form of study**	bachelor's degree, full time programme
A group of modules /specialty	-	**Education profile**	-
Course name	Fundamentals of Control Engineering	**Course code**	IS-FEE-10072W
		Course type	*elective*

Course form(s) and number of hours	**L**	**C**	**LC**	**P**	**SW**	**FW**	**S**	**Semester**	**winter**
	30		30		30			**ECTS credits**	**8**

The programme is valid from	2024/2025
Introductory courses	-
Course objectives	Introducing students to the structures, tasks and methods of analysis and synthesis of simple control systems. Analyzing dynamical system properties in time and frequency domain. Applying various methods of controller design for controlling simple processes.
Framework programme content	**Lecture:** Mathematical modelling of dynamical systems. Laplace transform method. Transient response analysis of first and second-order systems. Stability of linear time-invariant systems, including Hurwitz, Routh and Nyquist asymptotic stability criteria. Performance indexes of control process based on time and frequency domains. Automatic control systems and the tuning of PID controllers (analytical and experimental methods). Discrete-time and digital control systems. Analytical techniques required for discrete-time system analysis. Stability analysis and the influence of discretization on stability property. Design methods for discrete-time controllers. Nonlinear systems - practical aspects including relay-controlled systems (PD and PID compensation). **Specialisation workshop:** Analytical and numerical analysis of dynamical systems' mathematical models. Transient and frequency response analysis. Stability analysis using various criteria: poles placement, Hurwitz and Routh criteria, stability margins, Nyquist theorem, etc. Analytical methods for PID controller tuning. Analysis of discretisation methods and their influence on the dynamical properties of the discrete-time systems. **Laboratory classes:** Step responses measurements of a various types of control plants. Fundamental methods of identification. Computer-aided control systems design. Industry PID controller configuration and tuning methods. Experiments with various types of control systems (water level control, water flow control, pressure control, temperature relay control.
Other information about the course	-
	the course develops practical skills

Calculation:

Student workload related to:	**Total number of hours**	**including contact**	**including practical**
participation in lectures	30	30	
participation in other forms of activities	60	60	60
participation in an examination	0	0	
participation in consultations	5	5	3
completion of professional training	0	0	0
preparation for passing a lecture/an examination	15		
preparation for practical classes	30		30
preparation of laboratory clasess reports	30		30
preparation of specialization workshop reports	30		30
Total number of hours:	**200**	**95**	**153**
Total number of ECTS credits:	**8**	**3,8**	**6,1**

Expected discipline learning outcomes	Knowledge	Skills	Social competence

Objectives and framework content prepared by	PhD. Eng. Krzysztof Rogowski	Date:	
Implementation in the academic year	**2024/2025**		

Programme content

	Lecture
1	Introduction, presentation of the course and rules
2	Fundamental notions used in control theory
3	Time domain characteristics of dynamic systems
4	Frequency domain characteristics
5	Asymtotic stability for continuous-time linear systems
6	Conditions and criteria for asymptotic stability
7	PID controllers, structure, characteristics, and parameters
8	Experimental and analytical methods for PID controllers tuning
9	Quality of control: time, frequency and itegral indicators of quality
10	Mathematical modeling of dynamical systems
11	Fundamentals of discrete-time systems
12	Property of discrete-time dynamical systems
13	Discrete-time PID control systems
14	Nonlinear elements in control systems, relay control systems
15	Final evaluation of lecture
	Specialist workshop
1	Introduction, presentation of the rules and software used in the workshop
2	Mathematical models: dynamic equation, transfer function, state-space equation (part I)
3	Mathematical models: dynamic equation, transfer function, state-space equation (part II)
4	Transient responses of dynamic systems - analytical and numerical analysis (part I)
5	Transient responses of dynamic systems - analytical and numerical analysis (part II)
6	Frequency domain characteristics - analytical and numerical analysis (part I)
7	Frequency domain characteristics - analytical and numerical analysis (part II)

	8	Stability - notion, Hurwitz, Routh and Nyquist criteria (part I)
	9	Stability - notion, Hurwitz, Routh and Nyquist criteria (part II)
	10	Analytical methods of PID tuning (part I)
	11	Analytical methods of PID tuning (part II)
	12	Discrete-time systems - discretization methods.
	13	Discrete-time control systems (part I)
	14	Discrete-time control systems (part II)
	15	Final evaluation of reports, discussion
		Laboratory classes
	1	Introduction to laboratory of control engineering (3 hours unit)
	2	Data registration and measurement processing (3 hours unit)
	3	Testing of fundamental dynamical blocks (3 hours unit)
	4	Testing of a simple closed-loop system with software PID controller (3 hours unit)
	5	Industrial PID controller (3 hours unit)
	6	Ziegler-Nichols method for PID controller tuning (3 hours unit)
	7	Water level control system (3 hours unit)
	8	DC motor control system (3 hours unit)
	9	Water flow control system (3 hours unit)
	10	Final evaluation of reports, discussion (3 hours unit)
Teaching methods (on-site classes)	L	lecture with examples of real control problems, discussion
	SW	Numerical simulations, analytical computations, discussion
	LC	laboratory experiments, discussion
	-	
Teaching methods (online classes)	L	lecture with examples of real control problems, discussion
	-	
	-	
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Forms of crediting	L	written final exam
	SW	evaluation of reports
	LC	evaluation of reports
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Conditions of crediting	L	The teacher will assess the answers given by the student.
	SW	The reports will be asessed by the teacher.
	LC	The reports will be asessed by the teacher.
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Outcome symbols	**Expected learning outcomes**	**Expected learning outcomes defined for the field of study**		
		Knowlegde	Skills	Social competence
	Knowledge: the student knows and understands			
E1	the methods of analysis and synthesis of a simple automatic control system			
E2	the methods of quality evaluation of a control system and the method to improve the quality of control process			
E3	the PID controller tuning methods			
	Skills: the student can			
E4	utilize numerical software for the analysis of mathematical models describing dynamical systems			
E5	design a simple control system for various processes			
E6	build a simple control system and configure the industrial controller			
E7	evaluate the quality of the control system using various quality indicatiors			
	Social competence: the student is ready to			
E8	*work with other students to solve the problem*			

Outcome symbols	**Methods of verification of learning outcomes**	**Course form subject to verification**
E1	*final exam*	L
E2	*final exam*	L
E3	*final exam, evaluation of reports*	SW, LC
E4	*evaluation of reports*	SW
E5	*evaluation of reports*	SW, LC
E6	*evaluation of reports*	LC
E7	*evaluation of reports*	SW, LC
E8	*evaluation of reports, observation of work in calsses*	SW, LC

Basic references	1	*Niese N.S., Control systems engineering, Eight ed., Hoboken: Wiley, 2019.*
	2	*Levine W.S., Control system fundamentals, CRC Press Taylor & Francis, Boca Raton, 2011.*
	3	Ellis G., Control system design guide: a practical guide, Elsevier Academic, 2004.
	4	*Veloni A., Miridakis N.I., Digital control systems: theoretical problems and simulation tools, CRC Press, 2021.*
	5	*Wang L.: PID Control System Design and Automatic Tuning using MATLAB/Simulink, Wiley, Newark, 2020.*
Supplementary references	1	*Astrom K.J., Murray R.M., Feedback systems: An introduction for scientists and engineers, Princeton University Press, New Jersey, 2010.*
	2	*Dorf C.D., Bishop R.H., Modern control systems, 13th ed., Harlow: Pearson Education, 2017.*
	3	*Patrick D.R., Fardo S.W., Industrial Process Control Systems, Second ed., Lilburn: Routledge, 2009.*
	4	*Palani S., Automatic control systems: with MATLAB, Second ed., Cham: Springer International Publ., 2022.*
	5	*Levine W.S., Control system advanced methods, CRC PressL Taylor & Francis, Boca Raton, 2011.*

Course coordinator	*PhD. Eng. Krzysztof Rogowski*	**Date:**	*26.02.2024*