



## Subject card

Subject name and code	Fundamentals of Control Engineering I, PG_00053200						
Field of study	Automation, Robotics and Control Systems						
Date of commencement of studies	October 2021	Academic year of realisation of subject			2022/2023		
Education level	first-cycle studies	Subject group			Obligatory subject group in the field of study Subject group related to scientific research in the field of study		
Mode of study	Full-time studies	Mode of delivery			at the university		
Year of study	2	Language of instruction			Polish		
Semester of study	3	ECTS credits			5.0		
Learning profile	general academic profile	Assessment form			exam		
Conducting unit	Katedra Inteligentnych Systemów Sterowania i Wspomagania Decyzji -> Faculty of Electrical and Control Engineering						
Name and surname of lecturer (lecturers)	Subject supervisor	dr inż. Rafał Łangowski					
	Teachers	dr inż. Rafał Łangowski dr hab. inż. Robert Piotrowski					
Lesson types and methods of instruction	Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
	Number of study hours	30.0	30.0	0.0	0.0	0.0	60
	E-learning hours included: 0.0						
Learning activity and number of study hours	Learning activity	Participation in didactic classes included in study plan	Participation in consultation hours		Self-study		SUM
	Number of study hours	60	5.0		60.0		125
Subject objectives	The main module objectives are:  a) to acquire knowledge needed for modelling and analysis of dynamic systems of low order,  b) to design of regulatory controllers for such systems.						

Learning outcomes	Course outcome	Subject outcome	Method of verification
	K6_U07	On successful completion of this course, the student will be able to: - Derive the first principle dynamic models of the low complexity systems such as R, L, C electrical circuits, DC electrical motors, heat transfer and fluid flow systems; - Analyse basic properties of single input - single output (SISO) linear time invariant dynamic systems based on zeros and poles nad to analytically calculate their responses to typical input signals; - Investigate stability of SISO systems based on the poles by applying the algebraic Routh-Hurwitz criterion - Investigate stability of feedback systems by applying the frequency domain based Nyquist stability criterion - Assess stability robustness of feedback systems based on the open loop system phase and gain margins.	[SU3] Assessment of ability to use knowledge gained from the subject
	K6_W07	On successful completion of this course, the student will be able to: - Explain structures and properties of P, PI and PID controllers and experimentally determine their parameters by applying Ziegler - Nichols methods to lower order processes; - Explain structures of state-feedback controllers, also in the case of unmeasured state variables to lower order processes; - Design by pole placement the basic controller systems meeting the performance specifications in time domain and state observers.	[SW1] Assessment of factual knowledge
Subject contents	<p><b>LECTURES:</b> Modelling the continuous time system dynamics for the SISO systems in time an frequency domain; linear differential equations, transfer function and frequency response function. Applications of the frequency response function to a low pass filter design. Calculating the linear system responses to the impulse, step and sinewave input signals. Calculating response of a linear system to an arbitrary input signal by applying convolution of the system impulse response and the input signal. Zeros and poles and their links with basic properties of a linear time invariant dynamic system. Algebraic Routh Hurwitz stability criterion. System structures: cascade and with feedback, Phase and gain margins. Performance measures in time domain of the control systems and their relationships with location of zeros and poles for the second order system dynamics. The P, PI and PID controllers: analysis and applicability conditions. Tuning the controller parameters by placement of poles and zeros and by Ziegler Nichols experimental rules. Structures of state-feedback controllers, also in the case of unmeasured state variables. Tuning the state observers gains by placement of poles. Illustration by applications to the R, L, C electrical circuits, simple mass-spring-damper mechanical systems, heat transfer and hydraulic systems.</p> <p><b>TUTORIALS:</b> Modelling of control system elements and an overall control system, block diagram models of systems and their equivalent transformations, linearity versus nonlinearity of system dynamics, linearization of nonlinear system dynamics model, Laplace transforms in control systems, transfer function and frequency response function, Bode plots, Routh, Hurwitz and Nyquist stability criteria and application to feedback control systems, steady state errors in tracking control systems; P, PI and PID controller: structures, performance, applicability limits and parameter tuning.</p>		
Prerequisites and co-requisites	Fundamentals of electrical circuits, DC motors and physics of simple mechanical, heat transfer and hydraulic systems. Linear time invariant and scalar differential equations, Laplace transforms, complex numbers. The Pre-Requisites: Mathematics terms 1,2; Physics term 1, Elektrotechnics term 1.		
Assessment methods and criteria	Subject passing criteria	Passing threshold	Percentage of the final grade
	Midterm colloquium	50.0%	20.0%
	Tests	50.0%	30.0%
	Exam	50.0%	50.0%

Recommended reading	Basic literature	1. Dorf C.D., Bishop R. H.: Modern control systems. Eleventh Edition. Pearson Prentice Hall, Upper Saddle River, NJ 07458, 2008.2. Kaczorek T. Teoria układów regulacji automatycznej, Wydawnictwa Naukowo-Techniczne, Warszawa, 1974.3. Kabziński J. Teoria sterowania Projektowanie układów regulacji, Wydawnictwo Naukowe PWN, Warszawa, 2021.4. Ogata K.: Modern Control Engineering. Fifth Edition, Pearson Prentice Hall, Upper Saddle River, NJ 07458, 2010.5. Nise N.S. Control System Engineering. 3th edition. John Wiley & Sons, 2000.6. Ljung L., Glad T.: Modelling of Dynamic Systems, Prentice Hall, 1994.
	Supplementary literature	1. Ogata K. Designing Linear Control Systems with MATLAB. Prentice Hall, 2002.2. Franklin G.E., Powell J.D., Emami-Naeini E. Feedback Control of Dynamic Systems. Addison Wesley Publishing Company, 1994.3. Dutton K., Thompson S., Barraclough B. The Art of Control Engineering. Pearson, Prentice Hall, 1997.
	eResources addresses	Adresy na platformie eNauczenie:
Example issues/ example questions/ tasks being completed	1) Linearity and nonlinearity;2) Hurwitz, Routh and Nyquist stability criteria;3) PID controller design;4) State-feedback gains design;5) State observer design;	
Work placement	Not applicable	