GDAŃSK UNIVERSITY OF TECHNOLOGY

Subject card

<table>
<tr><td>Subject name and code</td><td colspan="3">Control of Continuous Processes, PG_00038108</td></tr>
<tr><td>Field of study</td><td colspan="3">Automation, Robotics and Control Systems</td></tr>
<tr><td>Date of commencement of studies</td><td>October 2022</td><td>Academic year of realisation of subject</td><td>2024/2025</td></tr>
<tr><td>Education level</td><td>first-cycle studies</td><td>Subject group</td><td>Obligatory subject group in the field of study
Subject group related to scientific research in the field of study</td></tr>
<tr><td>Mode of study</td><td>Full-time studies</td><td>Mode of delivery</td><td>at the university</td></tr>
<tr><td>Year of study</td><td>3</td><td>Language of instruction</td><td>Polish</td></tr>
<tr><td>Semester of study</td><td>5</td><td>ECTS credits</td><td>4.0</td></tr>
<tr><td>Learning profile</td><td>general academic profile</td><td>Assessment form</td><td>assessment</td></tr>
<tr><td>Conducting unit</td><td colspan="3">Department of Control Systems Engineering -> Faculty of Electrical and Control Engineering</td></tr>
<tr><td rowspan="2">Name and surname of lecturer (lecturers)</td><td>Subject supervisor</td><td colspan="2">dr inż. Rafał Łangowski</td></tr>
<tr><td>Teachers</td><td colspan="2"></td></tr>
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<tr><td rowspan="3">Lesson types and methods of instruction</td><td>Lesson type</td><td>Lecture</td><td>Tutorial</td><td>Laboratory</td><td>Project</td><td>Seminar</td><td>SUM</td></tr>
<tr><td>Number of study hours</td><td>30.0</td><td>15.0</td><td>15.0</td><td>0.0</td><td>0.0</td><td>60</td></tr>
<tr><td colspan="7">E-learning hours included: 0.0</td></tr>
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<tr><td rowspan="2">Learning activity and number of study hours</td><td>Learning activity</td><td>Participation in didactic classes included in study plan</td><td>Participation in consultation hours</td><td>Self-study</td><td>SUM</td></tr>
<tr><td>Number of study hours</td><td>60</td><td>4.0</td><td>36.0</td><td>100</td></tr>
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<tr><td>Subject objectives</td><td colspan="3">To teach: how to run and maintain a control system in industrial environment under normal and disturbed conditions; how to act as a member of interdisciplinary project team set up to design a control system of desired performance for industrial and military applications. To gain fundamental knowledge required for graduate course in control engineering.</td></tr>
<tr><td rowspan="3">Learning outcomes</td><td>Course outcome</td><td>Subject outcome</td><td>Method of verification</td></tr>
<tr><td>[K6_W10] has basic knowledge related to mechatronics and robotics systems</td><td></td><td></td></tr>
<tr><td>[K6_U07] can build and analyze models of systems and systems in the field related to control systems and automation</td><td></td><td></td></tr>
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Subject contents	LECTURES State - space modelling the system dynamics. Controllability, observability, transition matrix and stability of linear time invariant and continuous – time dynamic systems. Control design for linear time invariant SISO deterministic dynamic systems: advanced tuning the parameters of P, PI, PID controllers, anti-windup mechanisms, implementation of D term, state – feedback, state – feedback dominating pole approach to design controller, state observers, separation principle and the state feedback – observer controllers. Control design under uncertainty: state-feedback integral controllers, measurement noise filters in the feedback loops, feedforward disturbance compensation with the disturbance input observer. Integral control of MIMO systems under slowly varying disturbance inputs. Robust state feedback gains. Cascade and feedback structures of sampled data systems. Modelling in the time domain and frequency domain, dynamics of computer system with zero order hold interpolator (ZOH) for control of continuous - time process by exact ZOH discretisation. Methods for discretising continuous – time controllers. Introduction to nonlinear system dynamics. Fuzzy Takagi – Sugeno systems. Utilising of linear regional controllers to synthesis of global nonlinear control systems. TUTORIALS State space modelling the SISO R, L, C electrical circuits: deriving the equations and analysis of system dynamics properties. A heat exchanger state space modelling as the MIMO system with two control inputs and two control outputs: deriving nonlinear model equations, model linearization, deriving transfer matrix of the linearised dynamics and analysis of the cross term gains, deriving the transition matrix and analysis of the cross term gains in time domain based on the impulse responses, simplification of the MIMO dynamics to two independent SISO systems. Stabilising control of inverted pendulum at an upper equilibrium point: linearising the model dynamics, synthesising the state feedback control law by pole placement and implementing in Simulink environment, links between the derived controller and the P, PI, PID controllers. Stabilising control of inverted pendulum at an upper equilibrium point under limited access to the state variables: synthesis of the pendulum speed observer and design of the state feedback – observer stabilising controller by pole placement. Application of the dominant poles approach to design of the state feedback controller stabilising with the low quality speed sensor having not negligible dynamics the inverted pendulum at an upper equilibrium point. Design of integral state feedback controllers for academic example systems. Design of digital control system with D.C. motor actuator for tracking manouverouning objects. Design of digital P, PI, PID controllers for control of lower order example dynamic systems. LABORATORY EXERCISES Controlling DC motor speed in NI – Elvis 2 environment by digital PI controller under the active actuator constraints and speed sensor measurement noise: integrated tuning of parameters of the anti-windup filter, noise filter, PI controller and of sampling rate for selected speed reference trajectories. Position control of DC motor in NI – Elvis 2 environment by digital PID controller under stiction torque and disturbance load: determining the dominant reference dynamics of second order, which meets the control performance specifications in time domain and tuning the PID parameters by zero and pole placement. Control of product outflow and its component concentrations in the continuous stirred tank chemical reactor under the inflow and its composition disturbance inputs: derivation of the reactor nonlinear dynamics model and implementation in Simulink environment, linearization of the model equations, design of MIMO integral controller by pole placement and LQ controller in Matlab environment, implementation of the controllers in Simulink and experimentally determining their applicability limits in relation to the disturbance magnitudes. Considered is a heat system coupled to Mitsubishi PLC, which performs on-line the measurement data acquisition, visualization, monitoring and the system temperature control activities by digital PID controller: designing the Kalman filter in order to optimally reduce the temperature measurement noise and implementing in the PLC, implementing in PLC the digital PID controller algorithm coupled with the Kalman filter, experimentally tuning the Kalman filter gains and PID controller parameters in order to effectively compensate unmeasurable disturbance inputs. Stabilising control of inverted pendulum in NI – Elvis 2 environment in the upper equilibrium position under impulse destabilising disturbances of large magnitude: synthesis of regional linear PID controllers and LQ controllers, synthesis of global nonlinear controller as Takagi – Sugeno fuzzy system build up from the regional controllers, application of Matlab LMI toolbox to determine the membership function and regional controller parameters, implementation of the control system and further tuning its parameters in order to robustly meet the requirements on the return time and overshoot.
Prerequisites and co-requisites	Pre-Requisites: Control engineering, Control engineering - laboratory

Assessment methods and criteria

Subject passing criteria	Passing threshold	Percentage of the final grade
Midterm colloquium	50.0%	60.0%
Tutorials	50.0%	20.0%
Practical exercise	50.0%	20.0%

Recommended reading

Recommended reading	Basic literature	1. Franklin G. F., Powell J.D., Abbas Emami-Naeini: Feedback Control Dynamic Systems. Sixth Edition, Pearson, Upper Saddle River, 2010. 2. Byrski W.: Obserwacja i sterowanie w systemach dynamicznych. Uczelniane Wydawnictwa Naukowo – Dydaktyczne Akademii Górniczo – Hutniczej w Krakowie, 2007.
	Supplementary literature	1. Piegat A.: Modelowanie i sterowanie rozmyte, Akademicka Oficyna Wydawnicza EXIT, 1999. 2. Nise N.S.: Control System Engineering. 3th edition. John Wiley & Sons, 2000.
	eResources addresses	

Example issues/ example questions/ tasks being completed	• DC motor position control • chemical process control including disturbance impact
Work placement	Not applicable