GDAŃSK UNIVERSITY OF TECHNOLOGY

Subject card

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|---|---|---|---|
| Subject name and code | Control of Continuous Processes, PG_00038108 | | |
| Field of study | Automation, Robotics and Control Systems | | |
| Date of commencement of studies | October 2024 | Academic year of realisation of subject | 2026/2027 |
| Education level | first-cycle studies | Subject group | Obligatory subject group in the field of study<br>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 | 3 | Language of instruction | Polish |
| Semester of study | 5 | ECTS credits | 4.0 |
| Learning profile | general academic profile | Assessment form | assessment |
| 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 | | |

Lesson types and methods of instruction

| Lesson type | Lecture | Tutorial | Laboratory | Project | Seminar | SUM |
|---|---|---|---|---|---|---|
| Number of study hours | 30.0 | 15.0 | 15.0 | 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 | 4.0 | 36.0 | 100 |

Subject objectives

The aim of this course is to present an advanced classical and basic modern approach to modelling, analysis and synthesis of control systems, together with the development of skills in the selection of control technology, in control tasks primarily of continuous systems based on their linear (linearised), stationary, deterministic, lumped models and the use of modern computer tools for the purpose of the above.

Learning outcomes

| Course outcome | Subject outcome | Method of verification |
|---|---|---|
| [K6_U07] can build and analyze models of systems and systems in the field related to control systems and automation | The student derives models of dynamic plants both in the form of input-output models and state-space models using the basic knowledge of physics of these plants. He/she analyses basic properties of dynamic plants: stability, controllability, observability. The student explains structures and properties of PID family controllers and determines their parameters as well as structures with state feedback, also in the situation of unmeasured state variables and occurrence of constant and slow variable disturbances. He/she designs basic control systems satisfying quality requirements in the time domain and state observers using the pole allocation and LQ methods. | [SU3] Assessment of ability to use knowledge gained from the subject |
| [K6_W10] has basic knowledge related to mechatronics and robotics systems | The student models mechanical dynamic plants of the inverted pendulum type, electrical objects of the R, L, C type, DC electric motors, thermal and hydraulic plants, using basic knowledge of the physics of these plants, and then analyses their properties. | [SW1] Assessment of factual knowledge |

<table>
<tr><td>Subject contents</td><td colspan="2">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: 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. Integral control of MIMO systems under slowly varying disturbance inputs. Methods for discretising continuous time controllers. Introduction to nonlinear system dynamics. 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 linearisation, 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 preparation for implementation 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.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.</td></tr>
<tr><td>Prerequisites and co-requisites</td><td colspan="2">Pre-Requisites: Fundamentals of Control Engineering I, Fundamentals of Control Engineering II and Matrix Algebra.</td></tr>
<tr><td>Assessment methods and criteria</td><td colspan="2">

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

</td></tr>
<tr><td rowspan="3">Recommended reading</td><td>Basic literature</td><td>1. Kaczorek T. Teoria układów regulacji automatycznej, Wydawnictwa Naukowo-Techniczne, Warszawa, 1974.<br>2. Nise N.S. Control System Engineering. 3th edition. John Wiley & Sons, 2000.<br>3. Ogata K. Modern Control Engineering. 4th edition. Prentice Hall, 2002.<br>4. Mitkowski W.: Zarys teorii sterowania, Wydawnictwa AGH, Kraków, 2019.<br>5. Astrom K.J., Murray R.M.: Feedback Systems - An Introduction for Scientists and Engineers, Princeton University Press, 2008.<br>6. Ljung L., Glad T.: Modelling of Dynamic Systems, Prentice Hall, 1994.<br>7. Slotine J-J. E., Li. W.: Applied nonlinear control, Prentice Hall, Englewood Cliffs, New Jersey, US 1991.</td></tr>
<tr><td>Supplementary literature</td><td>1. Franklin G. F., Powell J.D., Abbas Emami-Naeini: Feedback Control Dynamic Systems. Sixth Edition, Pearson, Upper Saddle River, 2010.<br>2. Dorf R.C., Bishop R.H. Modern Control Systems. Addison Wesley & Sons Inc., 1998.<br>3. Ostertag E.: Mono- and Multivariable Control and Estimation, Springer Verlag, 2011.</td></tr>
<tr><td>eResources addresses</td><td>Adresy na platformie eNauczanie:</td></tr>
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| Example issues/ example questions/ tasks being completed | • DC motor position control<br>• chemical process control including disturbance impact |
| Work placement | Not applicable |