GDAŃSK UNIVERSITY OF TECHNOLOGY

Subject card

Subject name and code	Mathematic Fundamentals of Computer Control, PG_00067975		
Field of study	Automatic Control, Cybernetics and Robotics		
Date of commencement of studies	October 2026	Academic year of realisation of subject	2028/2029
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	3	Language of instruction	Polish
Semester of study	5	ECTS credits	2.0
Learning profile	general academic profile	Assessment form	assessment
Conducting unit	Department of Decision Systems and Robotics -> Faculty of Electronics Telecommunications and Informatics -> Faculties of Gdańsk University of Technology		
Name and surname of lecturer (lecturers)	Subject supervisor	dr inż. Marek Tatara	
	Teachers	dr inż. Marek Tatara	

Lesson types	Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
	Number of study hours	15.0	15.0	0.0	0.0	0.0	30
	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	30	2.0	18.0	50

Subject objectives	To master the knowledge of the mathematical foundations of discrete-time computer-controlled systems and to acquire skills in the analysis and design of control algorithms for these systems.

Learning outcomes	Course outcome	Subject outcome	Method of verification
	[K6_U01] can apply mathematical knowledge to formulate and solve complex and non-typical problems related to the field of study and perform tasks, in an innovative way, in not entirely predictable conditions, by:n- appropriate selection of sources and information obtained from them, assessment, critical analysis and synthesis of this information,n- selection and application of appropriate methods and toolsn	The student can formulate and solve complex problems in the analysis and synthesis of computer control systems by selecting and applying appropriate mathematical methods and tools.	[SU3] Assessment of ability to use knowledge gained from the subject
	[K6_W01] knows and understands, to an advanced extent, mathematics necessary to formulate and solve simple issues related to the field of study	The student knows and understands advanced mathematical methods, including linear algebra, difference equations, and the Z-transform, to a degree that enables describing, analyzing, and solving fundamental problems in the field of discrete-time control systems.	[SW1] Assessment of factual knowledge
	[K6_W03] knows and understands, to an advanced extent, the construction and operating principles of components and systems related to the field of study, including theories, methods and complex relationships between them and selected specific issues - appropriate for the curriculum	The student knows and understands the architecture of a digital control system and the role of its components. The student can explain the complex relationships between the structure of the mathematical model (e.g., pole locations, properties of the state-space model matrices) and the resulting dynamic behavior of the system (e.g., its stability).	[SW1] Assessment of factual knowledge

Subject contents	Course content – lecture **Lecture** 1. Introduction to Computer Control Systems • Characteristics of discrete-time signals and systems • Architecture and operating principles of a classical digital control loop • Relation of classical control systems to cyber-physical systems 2. Mathematical Modeling of Discrete-Time Systems • Description using difference equations • Fundamental properties of discrete systems: linearity, time-invariance, causality • Recursive and non-recursive models • The impulse response of a system • State-space representation 3. System Analysis using the Z-Transform • Introduction to the unilateral and bilateral Z-transform • Properties of the Z-transform • Inverse Z-transform (partial fraction expansion, residue method, polynomial division) • Relationship of the transfer function to the impulse response, difference equations, and state-space models 4. Stability of Discrete-Time Systems • Definition of BIBO stability for the general and LTI case • Stability conditions in the complex z-plane • Methods of stability analysis 5. Control Systems Design • Design methods for discrete-time controllers • The PID controller and its tuning methods (manual, Ziegler-Nichols method) 6. State-Space Analysis • Controllability, reachability, observability, and reconstructibility • Identity transformations • Diagonalization of the state matrix and canonical forms **Exercises** 1. Modeling and Property Analysis of Discrete-Time Systems • Operators in difference equations • Discretization of differential equations • Analysis of the properties of discrete-time systems • Step and impulse response of a system 2. The Z-Transform - Forward and Inverse • Calculating the Z-transform • Methods for calculating the inverse transform (polynomial division, partial fraction expansion, residue method) 3. State-Space Representation • The relationship between the discrete-time description, transfer function, and state-space model; transitions between models • Eigenvalues of the state-transition matrix 4. Stability Analysis • Pole locations • Jury's criterion 5. Controller Design • Selection of parameters for a digital PID controller • Discretization of continuous-time controllers 6. State-Space System Properties • Analysis of controllability, reachability, observability, and reconstructibility • Identity transformations • Diagonalization and canonical forms
Prerequisites and co-requisites	Knowledge of: • mathematical analysis, including differential and integral calculus, series, and complex numbers • linear algebra, including operations on matrices and vectors, and the ability to solve systems of linear equations • basics of control theory for continuous-time systems, including the concepts of transfer function, feedback, and basic stability criteria
Assessment methods and criteria	see table below

Assessment methods and criteria

Subject passing criteria	Passing threshold	Percentage of the final grade
Lecture assessment	60.0%	60.0%
Two class tests	60.0%	40.0%

<table>
<tr><td rowspan="3">Recommended reading</td><td>Basic literature</td><td>1. Franklin, Gene F., et al. Digital Control of Dynamic Systems / Gene F. Franklin, J. David Powell, Michael L. Workman. 3rd ed., Addison-Wesley, 1998.
2. Brogan, William Lloyd. Modern Control Theory / William L. Brogan. 3rd ed., Prentice Hall, 1991.
3. Ogata, Katsuhiko. Modern Control Engineering / Katsuhiko Ogata. Prentice Hall, 1970.</td></tr>
<tr><td>Supplementary literature</td><td>1. Ogata, Katsuhiko, and Prentice Hall International Wydawca. Discrete-Time Control Systems / Katsuhiko Ogata. Prentice-Hall, 1987.
2. Levine, W. S. Control System Fundamentals. 2nd ed., CRC Press, 2011.</td></tr>
<tr><td>eResources addresses</td><td></td></tr>
<tr><td>Example issues/
example questions/
tasks being completed</td><td colspan="2">Lecture

1. Discuss the concepts of linearity and time-invariance in discrete-time systems, including the relevant formulas, assumptions, and the notation of the symbols used

2. Discuss the relationships between different methods of describing discrete-time systems

3. Discuss the concept of stability in discrete-time systems, considering the general case and the LTI case

Exercises

1. For a given state-space model, analyze its stability and controlability

2. Find the impulse response of the system based on the given transfer function

3. Examine the linearity, time-invariance, and causality of the given systems</td></tr>
<tr><td>Practical activites within the subject</td><td colspan="2">Not applicable</td></tr>
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