COURSE DESCRIPTION CARD - SYLLABUS

Course name

Control theory

Course

Field of study	Year/Semester
Automatic control and robotics	3/5
Area of study (specialization)	Profile of study
	practical
Level of study	Course offered in
First-cycle studies	polish
Form of study	Requirements
full-time	compulsory

Number of hours

Lecture	Laboratory classes	Other (e.g. online)
30	15	
Tutorials	Projects/seminars	
15		

Number of credit points

6

Lecturers

Responsible for the course/lecturer:	Responsible for the course/lecturer:
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Prerequisites

Knowledge: The student starting this subject should have basic knowledge of subjects such as Fundamentals of Automation, Mathematical Analysis, General Mechanics.

Skills: Should have the ability to solve basic problems covered by the required knowledge and the ability to obtain information from the indicated sources. He should also understand the need to expand his competences.

Social competences In addition, in terms of social competences, the student must present attitudes such as honesty, responsibility, perseverance, cognitive curiosity, creativity, personal culture, respect for other people.

Course objective

1. Provide students with knowledge of control theory, in particular knowledge related to various automation systems, in order to prepare them substantively for issues related to their stability as well as synthesis and analysis of their control.

2. Developing students' skills in solving problems related to the concept of stability in terms of Lyapunov and applying it to a wide class of automation systems. In addition, students will have the ability to construct various observers widely used in technology, optimization of control systems and dynamic programming.

Course-related learning outcomes

Knowledge

1.has extended and in-depth knowledge of mathematics including algebra, geometry, analysis, probability and elements of discrete mathematics and logic, including mathematical methods and numerical methods necessary for the description and analysis of the properties of linear and basic nonlinear dynamic and static systems, description and analysis complex quantities, - [K1_W1]

2.description of random processes and uncertain quantities, description and analysis of combinational and sequential logic systems, description of control algorithms and analysis of the stability of dynamic systems, description, analysis and methods of signal processing in the time and frequency domains, numerical simulation of dynamic systems in the domain of continuous and time discreet; - [K1_W1]

3. has ordered knowledge of the theory of linear dynamical systems, including selected modeling methods and the theory of stability; knows and understands the basic properties of linear dynamic elements in the time and frequency domain and the properties of selected non-linear elements; knows and understands the design techniques of linear control systems using the description in the state space - [K1_W14]

4. is familiar with the current state and the latest development trends in the field of automation and robotics; - [K1_W21]

Skills

1. obtain information from literature, technical documentation and other sources, also in English; - [K1_U1]

2. can check the stability of linear and selected nonlinear objects and dynamical systems; - [K1_U12]

3. can design simple control systems for processes with one input and one output; can consciously use standard functional blocks of automation systems and shape dynamic properties of measurement paths; - [K1_U29]

Social competences

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Formative assessment:

a) in the field of lectures: on the basis of answers to questions about the material discussed in previous lectures,

b) in terms of exercises: based on the assessment of the current progress of the tasks being solved,

Summative assessment:

a) in the field of lectures, verification of the assumed learning outcomes is carried out by:

i. assessment of the knowledge and skills shown in the written exam in the subject, which consists of 10 tasks for which 20 points can be obtained (2 points per task).

ii. assessment of knowledge and skills on the basis of individual discussion of written results (additional control questions),

b) in the field of exercises, verification of the assumed learning outcomes is carried out by:

i. assessment of the student's preparation for individual auditorium exercises and assessment of skills related to the implementation of laboratory exercises,

ii. continuous assessment during each class (oral answers) - rewarding the increase in the ability to use the learned rules and methods,

iii. assessment of knowledge and skills related to the implementation of learning outcomes through two written tests.

Obtaining additional points for activity during classes, especially for:

i. discuss additional aspects of the issue,

ii. effectiveness of applying the acquired knowledge while solving a given problem, iii. comments related to the improvement of teaching materials,

iv. identifying students' perceptual difficulties enabling ongoing improvement of the teaching process.

Programme content

The lecture program covers the following topics:

1. Definition of stability in the sense of Lyapunov:

a) BIBO stability (limited input, limited output type),

b) asymptotic stability,

c) exponential stability,

d) definition of the Lyapunov function positively, negatively, half-positive, and half-negative defined with examples for linear and nonlinear systems,

e) differential error equation for a nonlinear system.

2. Discussion of the second law of stability of systems according to Lapunov:

a) theorems of local and global stability,

b) the concept of an invariant set,

c) LaSalle theorem,

d) practical application examples of LaSalle theorem.

e) folding shifts and turns.

3. Observers for linear systems:

a) description of the Luenberger observer structure for the discrete rope system,

b) examples of applications of the Luenberger observer in practice.

4. Kalman filter:

a) definition of stochastic, ergodic, stationary and white noise processes,

b) passing the stochastic process and white noise through the linear system,

c) definition of filtration and prediction,

d) construction of the Klaman filter,

e) examples of practical applications of the Kalman filter.

5. The problem of decoupling for linear systems:

a) definition of the input-output type decoupling,

b) definition of a controllable output system and a necessary condition for the controllability of the system,

c) design of the decoupling algorithm for a linear system,

d) computational examples illustrating the decoupling algorithm.

6. Quadratic optimization of discrete systems using Lagrange multipliers:

a) Elements of discrete minimization of functions of several variables with equality constraints,

b) definition of the Hamiltonian and Lagrange multipliers,

c) necessary and sufficient conditions for quadratic optimization,

d) design of the optimization algorithm,

e) Riccati's equation and its analysis,

f) Pontryagin maximum rule.

7.dynamic programming:

a) description of the dynamic programming method for discrete systems,

b) quadratic optimization of discrete systems using dynamic programming,

c) an example illustrating a dynamic programming method.

Auditorium classes are conducted in the form of fifteen 2-hour classes, during which students solve accounting tasks covering the content provided during the lecture. The exercises discuss in detail the problem of stability in terms of Lyapunov, the construction of various observers, and the input-output decoupling of linear systems. Then the quadratic optimization for the class of discrete systems with Lagrange multipliers is analyzed. The subject of calculations are also dynamic programming algorithms and the practical elements of Pontryagin's maximum principle are discussed.

Teaching methods

1. Lecture: traditional presentation on the board illustrated with examples.

2. Auditorium exercises: solving problems, case studies.

Bibliography

Basic

1. T. Kaczorek, Teoria układów regulacji automatycznej, Wydawnictwa Naukowo - Techniczne, 1974

2. P. De Larminat, Yves Thomas, Automatyka - układy liniowe, tom 2, Sterowanie, Wydawnictwa Naukowo - Techniczne, 1983

3. P. De Larminat, Yves Thomas, Automatyka - układy liniowe, tom 3, Sterowanie, Wydawnictwa Naukowo - Techniczne, 1983

4. Jean-Jacques E. Slotine, Weiping Li, Applied Nonlinear Control, Prentice Hall, 1995

5. R. C. Dorf, R. H. Bishop, Modern Control Systems, tenth edition, Pearson Educational International, Prentice Hall, 2005

Additional

1. A. Isidori, Nonlinear Control Systems, Springer Verlag, 1995

Breakdown of average student's workload

	Hours	ECTS
Total workload	150	6,0
Classes requiring direct contact with the teacher	60	3,0
Student's own work (literature studies, preparation for laboratory classes/tutorials, preparation for tests/exam, project preparation) [1]	90	3,0

[1] delete or add other activities as appropriate