COURSE DESCRIPTION CARD - SYLLABUS

Course name
Control Theory

Course

Field of study	Year/Semester
Automatic Control and Robotics	1/1
Area of study (specialization)	Profile of study
Vision systems	general academic
Level of study	Course offered in
Second-cycle studies	Polish
Form of study	Requirements
full-time	compulsory

Number of hours

Lecture	Laboratory classes	Other (e.g. online)
30	0	0
Tutorials	Projects/seminars	
15	15	

Number of credit points

4

Lecturers

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

Prerequisites

Knowledge: The student starting this course should have basic knowledge of differential and integral calculus, algebra and the description of dynamical systems using Lagrange equations and in the state space

Skills: Should have the ability to solve basic problems in the field of designing automatic control systems for linear systems, testing their stability and the ability to obtain information from indicated sources. They should also understand the need to expand their competences / be ready to cooperate within the team

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 basic knowledge on the description of nonlinear systems, their controllability, linearization and stability.

2. Developing students' skills in solving difficult control design problems for nonlinear systems and applying basic mathematical tools to solve them (these tools do not go beyond the basic integral and differential apparatus known to the student, taught in mathematics at technical universities).

3. Shaping students' ability to work in a small team.

Course-related learning outcomes

Knowledge

1. has extended and in-depth knowledge of selected mathematics departments necessary to formulate and solve complex tasks in the field of control theory and modeling complex automation systems; - [K2_W1]

2. has an ordered, theoretically founded, detailed knowledge of methods of analysis and design of nonlinear control systems; - [K2_W7]

3. has theoretically founded detailed knowledge related to nonlinear control systems; - [K2_W11]

4. has knowledge of development trends and the most important new achievements in the field of non-linear automation and robotics systems and related scientific disciplines; - [K2_W12]

Skills

1. can make critical use of literature information, databases and other sources in Polish and in a foreign language; - [K2_U1]

2. can simulate and analyze the operation of complex automation systems described by myelinear differential equations; - [K2_U9]

3. can designate models of complex systems and processes, and use them for the purposes of analysis and design of automation and robotics systems; - [K2_U10]

4. is able to formulate and verify by simulation hypotheses related to engineering tasks and difficult research problems in the field of automation and robotics; - [K2_U15]

5. can make a critical analysis of the operation of control systems or robotics systems; - [K2_U19]

6. can critically assess and select appropriate methods and tools to solve a task in the field of automation and robotics, in particular modern mathematical tools; - [K2_U22]

Social competences

1. has the ability to work responsibly in a small team to solve tasks - [K2_K3]

2. is aware of the need to combine mathematical knowledge with technical knowledge for professional solving of technical problems - [K2_K4]

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Formative assessment:

a) in the field of lectures:

based on answers to questions about the material discussed in previous lectures,

b) in terms of exercises and design:

based on the assessment of the current progress in the implementation of tasks,

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 demonstrated in the problem-based written exam, which are signaled during the lecture.

ii. discussion of exam results,

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

i. assessing the student's preparation by solving tasks during the exercises,

ii. assessment of knowledge and skills related to the implementation of exercises through 2 short tests per semester,

c) in terms of the project previous

Programme content

The lecture program covers the following topics:

1. Description of nonlinear systems in the state space and tools used for their linearization. Basic concepts such as derivative and Lie parenthesis and their basic properties will be introduced, which are illustrated by appropriate computational examples.

2. Definition of the dipheomorphic transformation of state variables and the relative order for a system described by linear differential equations into spatial state and non-linear systems of the SISO type (single input single output?

3. Definition of the relative order for a MIMO (multiple input multiple output) system together with an example illustrating the description of manipulator dynamics with n degrees of freedom.

4. Definition of zero dynamics for dynamical systems of SISO and MIMO type with a calculation example.

5. Definition of the concept of involuntary distribution and distribution. Definition of the codistribution and its annihilator. Illustration of concepts with simple calculation examples.

6. Discussion of the Frobenius theorem concerning integrity of distribution with constructive proof of the sufficiency condition. Carrying out a simple calculation example.

7. Discussion of linearization through linear approximation and stability conditions resulting from the first Lapunov principle with practical calculation examples.

8. Discussion of linearization through the pure transformation of state variables, giving the Krener condition of local linearization with calculation examples.

9. Discussion of linearization through feedback with a proof of a sufficient condition for SISO systems with a calculation example.

10. Overview of linearization through feedback for a MIMO type system with a computational example.

11. Determination of the linearization conditions by dynamic feedback with the specification of the sufficient and sufficient conditions.

12. Overview of practical methods of linearization determination for objects with one input, together with illustrative examples.

13. Discussion of practical methods of linearization determination for objects with many inputs, together with illustrative examples.

14. Overview of the DC motor rotation stabilization task with its full nonlinear dynamics model with the use of zero dynamics and the speed-dependent output function. Determination of the relative order of the system along with the conditions of asymptotic stability of the system.

15. Presentation of the manipulator dynamics model with one cell controlled by a DC motor with a gear and an elastic element. Definition of the output function, calculation of the relative order of the system, zero dynamics and linearization of the tested system.

As part of the calculation exercises, students solve computational examples illustrating the content of the above-mentioned 15 lectures. Examples of non-linear objects analyzed are, among others, a two-wheeled robot with a differential drive, a car-type robot, a manipulator with two degrees of freedom, a jumping robot with two degrees of freedom, and a two-legged robot with three and five degrees of freedom. As the calculation examples are very complicated, parts of the calculations are carried out in an analytical form and the more complicated ones with the symbolic expression processor, eg Maple. These tasks are carried out by students in groups of no more than two and they constitute project tasks carried out within the subject. Matlab and Simulink will be used to solve simpler numerical examples.

Teaching methods

1. lecture: conducted using the traditional method, illustrated with numerous examples given on the board.

2. calculating exercises: conducted using the traditional method and solving numerous calculation examples on the blackboard.

3. project: students receive more complex computational examples to solve using tools such as the symbolic expression processor and numerical packages. The largest group of students is two people, but if possible, each student is recommended to solve one more complex problem on his own.

Bibliography

Basic

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

2. Linearyzacja przez sprzężenie zwrotne w syntezie algorytmów regulacji dla obiektów termoenergetycznych, W.Bolek, T. Wi-śniewski, Oficyna Wydawnicza Politechniki Wrocławskiej, 2006

Additional

1. Applied Nonlinear Control, J.E. Slotine, W. Li, Prentice Hall, 1991

2. Nonlinear Dynamical Systems, N. Nijmeijer, A.J. van der Schaft, Springer, 1990

3. Robot Modeling and Control, M. Spong, S. Hutchinson, M. Vidyasagar, John Wiley and Sons, Inc., 2006

Breakdown of average student's workload

	Hours	ECTS
Total workload	100	4,0
Classes requiring direct contact with the teacher	69	3,0
Student's own work (literature studies, preparation for laboratory classes/tutorials, preparation for tests/exam, project preparation) [1]	31	1,0

[1] delete or add other activities as appropriate