



COURSE DESCRIPTION CARD - SYLLABUS

Course name

Automatics and Robotics [S1FT2>AiR]

Course

Field of study

Technical Physics

Year/Semester

2/4

Area of study (specialization)

–

Profile of study

general academic

Level of study

first-cycle

Course offered in

Polish

Form of study

full-time

Requirements

compulsory

Number of hours

Lecture

30

Laboratory classes

15

Other (e.g. online)

0

Tutorials

0

Projects/seminars

0

Number of credit points

3,00

Coordinators

dr inż. Jarosław Warczyński

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Lecturers

Prerequisites

Knowledge of physics, mathematics and computer science (core curriculum for second year students): basic knowledge of mathematical analysis, matrix calculus, theory of mechanisms and computer science. The ability to describe problems in physics using differential equations, based on the acquired knowledge, the ability to obtain information from the indicated sources. Understanding the need to expand your competences, readiness to cooperate as part of the team.

Course objective

1. To acquaint students with the theoretical foundations and principles of operation of automatic control systems and robotic systems within the scope defined by the curriculum content appropriate for the field of study. 2. Developing the ability of students to solve problems in the field of control and to perform simple experiments and to analyze the results based on the acquired knowledge. 3. Shaping students' teamwork skills.

Course-related learning outcomes

Knowledge:

As a result of the conducted classes, the student will have knowledge in the following areas:

1. Can choose the type of mathematical model (dynamic, static; linear, non-linear; stationary, non-stationary; continuous, discrete; deterministic, stochastic) appropriate to solve the control task
2. Can use 3 methodologies for the description of dynamical systems: differential equations, state equations, operator transmittance
3. Can apply frequency analysis to dynamical systems, knows the types of frequency characteristics and can use them in the analysis of control systems
4. Has detailed knowledge of selected automation and robotics departments, allowing for understanding of the control process in selected, complex control and measurement systems and robotic manufacturing systems
5. Knows the basic algorithms and structures of automatic control, in particular robot control

Skills:

As a result of the course, the student will acquire the following skills:

1. Can apply mathematical knowledge to describe and create dynamic models of processes and structures of control systems, algorithmization of selected tasks of controlling dynamic objects.
2. Can formulate mathematical models of any linear dynamical systems and selected nonlinear systems
3. Is able to carry out numerical modeling and simulations of basic physical objects and their control processes with the use of standard software
4. Is able to identify a complex control problem, as well as propose a diagram of its analysis and / or solution, detailing its various technical aspects, and determining the degree of complexity and assessing its feasibility
5. Can use the acquired knowledge to describe processes, create models, write control algorithms; can use analytical methods to formulate and solve tasks in the field of control and analysis of control objects
6. Is able to develop programs controlling dynamic objects with the use of standard devices and software

Social competences:

As a result of the conducted classes, the student will acquire the following social competences:

1. Can actively engage in solving given problems, independently develop and expand their competences
2. Can cooperate within a team, fulfill the duties entrusted as part of the division of labor in a team, demonstrate responsibility for own work and co-responsibility for the results of the team's work
3. is able to properly define the priorities for the implementation of the task set by himself or others; is aware of the importance of behavior in a professional manner; knows the risks related to the consequences of errors in the operation of automatic control systems, eg loss of stability by the system

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

learning outcome (symbol) form of evaluation evaluation criteria

written test

3 50.1% -70.0%

4 70.1% -90.0%

5 from 90.1%

exercise report

3 the student is able to use the software laboratory, basic tools, which enables oral and written answers him to create simple models of physical objects and simulating them; the student is able to apply the basic methods laboratory, object identification, knows a variety of patterns oral and written answers of control systems and their parameters

4 the student is able to use the software fluently tools, is able to create various models physical objects and simulate simple processes control; the student is able to apply the basic methods control objects identification and make interpretation of the obtained results. Can, on the basis of obtained results, propose a circuit diagram control.

5 the student is fluent in operating the utility software, can create simple and complex models of objects physical and verify their correctness, can design a control system and simulate it action; the student is able to apply the basic methods identify control objects and interpret the obtained results. Can, on the basis of obtained results, propose a circuit diagram control and select its parameters. He can introduce alternative ways to control and define them advantages and disadvantages.

Colloquium

3 50.1% -70.0%

4 70.1% -90.0%

Programme content

The scope of the lecture includes the following program content:

Basic concepts of automation, review of basic automatic control structures, methods of analysis and modeling of dynamic control objects including transmittance models, frequency analysis, stability analysis of automatic control systems. The next block of issues are the principles of selecting controllers for continuous control systems and methods of implementing discrete control systems. In the field of robotics, the program content includes the basic issues of the design goals of robot manipulators, the specificity of their control, taking into account the tasks of direct and inverse kinematics, and the analysis of control issues on the example of the control system of a single kinematic node of a robot manipulator.

Course topics

1. Automation as a system field of knowledge - the genesis of automation development, specificity of automation as a system discipline, general, independent of the physical field, the nature of control problems, technical cybernetics. Characteristics of the subject of automation research.
2. Basic concepts - Signal, automation element, control object, disturbance, control, feedback, control device, control system, basic automatic control concepts: open loop control, closed loop control, disturbance compensation control, closed loop control with noise compensation. Classification of control systems. Static and dynamic linearization, linear dynamical systems.
3. Dynamics of control objects - Classification of control objects, methods of object dynamics description: differential equations, operator equations, operator transfer function, state equations, state space, state trajectory, time characteristics.
4. Frequency analysis - Spectral transmittance, frequency characteristics: amplitude-phase, logarithmic (Bode diagrams), logarithmic amplitude-phase characteristics.
5. Basic linear dynamic terms - equations, transfer functions, time characteristics, frequency characteristics, examples. Static and astatic objects.
6. Block diagrams of automatic control systems - Construction, substitute transfer functions of basic connections, conversion of diagrams.
7. Stability of systems - Second Lyapunov method of stability studies, necessary and sufficient condition of asymptotic stability of a linear system, stability criteria of linear systems: Hurwitz criterion, Nyquist criterion, logarithmic Nyquist criterion. Module and phase stability reserve.
8. Quality of control and regulation.
9. Linear regulators - The laws of regulation: P, PI, PD, PID. Regulators: P, PI, PD, PD-real, PID, PID-real. Selection and settings of regulators, Nichols card, Ziegler Nichols method of selecting regulator settings.
10. Discrete systems - Discrete function, difference equations, Z transform, solving difference equations, discrete transfer function, discrete time and frequency characteristics, Shannon sampling theorem, strobe phenomenon.
11. Linear digital control systems - A / C and C / A converters and their description: ideal pulser, zero-order extrapolator, digital control algorithms, digital controllers, PLC controllers.
12. Basic kinematic structures of manipulators. Denavit-Hartenberg notation. Workspace coordinates, orientation, configuration coordinates, coordinates and homogeneous transformations.
13. Simple and inverse manipulator kinematics: for position, velocity and acceleration, Jacobian. Model of manipulator dynamics. Elements of trajectory planning and robot programming
14. Robot control systems: Independent control of nodes. Point control. Continuous control. Inverse dynamics control, control with dynamic interaction compensation.

Teaching methods

1. Lecture: multimedia presentation, presentation illustrated with examples given on the blackboard.
2. Laboratory exercises: practical exercises, conducting experiments, taking measurements, discussion, team work.

Bibliography

Basic:

1. Lisowski, J.: Podstawy Automatyki. Uniwersytet Morski w Gdyni, Gdynia 2022
2. Craig, J.J. - Wprowadzenie do robotyki. Mechanika i sterowanie, WNT 1993
3. Czemplik A.: Modele dynamiki układów fizycznych dla inżynierów. Zasady i przykłady konstrukcji

- modeli dynamicznych obiektów automatyki. WNT, Warszawa, 2008.
4. Honczarenko, J.: Roboty przemysłowe: Budowa i zastosowanie. WNT, Warszawa, 2010.
 5. Jezierski, E.: Dynamika robotów. WNT, Warszawa, 2006.
 6. Słota, A.: Sterowanie układami ciągłymi. PWN, Warszawa 2022.
 6. Dębowski, A. Automatyka. Podstawy Teorii. PWN, WNT, Warszawa 2023
 7. Zdanowicz, R.: Podstawy robotyki. Wyd. Polit. Śląskiej. Gliwice, 2010.

Additional:

1. Fu, K.S., R.C. Gonzalez, C.S.G. Lee: Robotics: Control, Sensing, Vision, and Intelligence, McGraw-Hill Book Comp.1989.
2. Kaczorek T., A. Dzieliński, W. Dąbrowski, R. Łopatka: Podstawy teorii sterowania. WNT, Warszawa, 2006.
3. McKerrow, Ph. J.: Introduction to Robotics, Addison-Wesley 1991 Morecki, A., Knapczyk, J.: Podstawy robotyki. Teoria i elementy manipulatorów. WNT, Warszawa, 1999.
4. Paul, R.P.: Robot Manipulators: Mathematics, Control, and Programming, Boston MIT Press 1981.
5. Spong, M. W., M. Vidyasagar: Dynamika i sterowanie robotów WNT Warszawa 1997.
6. Zieliński T. P.: Cyfrowe przetwarzanie sygnałów: od teorii do zastosowań. Wydawnictwa Komunikacji i Łączności, Warszawa 2005.

Breakdown of average student's workload

	Hours	ECTS
Total workload	75	3,00
Classes requiring direct contact with the teacher	45	2,00
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	30	1,00