GDAŃSK UNIVERSITY OF TECHNOLOGY

Subject card

Subject name and code	Mathematical Modelling Methods, PG_00067434					
Field of study	Automatic Control, Cybernetics and Robotics					
Date of commencement of studies	October 2025		Academic year of realisation of subject		2026/2027	
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	2		Language of instruction		Polish	
Semester of study	3		ECTS credits		2.0	
Learning profile	general academic profile		Assessment form		exam	
Conducting unit	Department of Decision Systems and Robotics -> Faculty of Electronics Telecommunications and Informatics -> Wydziały Politechniki Gdańskiej					
Name and surname of lecturer (lecturers)	Subject supervisor		prof. dr hab. inż. Zdzisław Kowalczuk			
	Teachers		prof. dr hab. inż. Zdzisław Kowalczuk			
Lesson types and methods of instruction	Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
	Number of study hours	30.0	0.0	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	Celem tego przedmiotu jest zapoznanie się i opanowanie wiedzy w zakresie matematycznych metod modelowania procesów dynamicznych (autonomicznych i nieautonomicznych).					

Learning outcomes

Course outcome	Subject outcome	Method of verification
[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 at an advanced level the mathematical methods used in the process of modeling and simulating dynamic systems, including the concepts of ordinary differential equations, state variables, systems of state equations, and the principles of normalization and scaling. The student is able to use selected analytical methods (e.g. congruent, canonical, nested integration, instrumental methods) to create and transform mathematical models representing real physical and technical processes. The student understands the role of mathematical structures such as sequential machines, potential and current variables, the principles of continuity and compatibility, and is able to use them to describe the behavior of automation and robotics systems. Thanks to this knowledge, the student is able to independently formulate a mathematical model for a given system, identify key variables, and analyze the behavior of the model in time - both in continuous and discrete terms.	[SW1] Assessment of factual knowledge
[K6_W21] knows and understands the basic methods of decision making as well as methods and techniques of design and operation of automatic regulation and control systems, computer applications for controlling and monitoring dynamic systems.	The student knows and understands the concept of modeling and the methodology of simulating dynamic processes, is able to distinguish and build different types of mathematical and formal models - both for autonomous and non-autonomous systems. Understands the role of simulation as a tool supporting decision-making in the process of designing, analyzing and optimizing control systems and automatic regulation. During the course, the student acquires knowledge in the field of creating continuous, synthetic, two-terminal models and structurally described systems, and also learns about the methods of their discretization and computer implementation. Is able to build a prototype simulation procedure and use methods for assessing the correctness and fidelity of the representation of the behavior of dynamic systems.	[SW1] Assessment of factual knowledge

Subject contents

Modeling and Simulation Concepts; M&S Methodology and Model Types; Modeling and Simulation Relationships; Modeling Validity; Aspects of Simulation Fidelity with Respect to Levels/Systems of the Modeling Process; Integrated Model Construction by Reduction of the Basic Model; Interaction Rules; Prototype Simulation Procedure; Formal Description; Sequential Machines; Autonomous Systems; Non-autonomous Systems; Structure and Response; State Variables; State Equations; Example - Neuron Model; Pseudo-Random Number Generators; Congruent Methods; Shaping Probability Density Distributions; Learning Tasks; Modeling Tasks; Analytical Modeling; Two-terminal Systems; Intensity and Potential Variables; Continuity and Compatibility Principles. Examples; Synthetic Modeling. Examples; Modeling and Simulation of Continuous Processes; Solving Differential Equations; Integral and Structural Modeling of Systems; Structuring of Continuous Description; General Method; Canonical methods: nested integration and instrumental variable. Examples; Normalization of variables and time base; Evaluation of maximum values. Method of equal coefficients and natural vibrations; Complete scaling procedure. Examples; Computer simulation of continuous-time systems; Discretization with respect to the independent variable; Fundamental construction of simulation programs; Summary.

Prerequisites and co-requisites

Mastering basic knowledge of academic mathematics.

Assessment methods and criteria

Subject passing criteria	Passing threshold	Percentage of the final grade
Written exam	50.0%	100.0%

Recommended reading	Basic literature	J. M. Smith: Mathematical modelling and digital simulation for scientists and engineers. Wiley, New York, 1977. H. Orłowski, J. Hawryluk: Modelowanie cyfrowe. WNT, Warszawa, 1971. Yang, Bingen, and Inna Abramova. Dynamic Systems: Modeling, Simulation, and Analysis. Cambridge University Press, 2022. Witelski, Thomas, and Mark Bowen. Methods of mathematical modelling. Springer, 2015.
	Supplementary literature	Z. Kowalczuk: Discrete models in the design of control systems, Zesz. Nauk. PG, vol. 78, no. 493, 1992 Banasiak, Jacek, and Katarzyna Szymańska-Dębowska. Układy dynamiczne w modelowaniu procesów przyrodniczych, społecznych i technologicznych. PWN, 2023.
	eResources addresses	
Example issues/ example questions/ tasks being completed	1. What is the postulate of economical modeling (Rissanena)? 2. What is the basis of time? 3. Provide an interpretation of the interaction rules occurring in the prototype simulation procedure. 4. Provide a variance of even distribution in the range with a given width. 5. What is the interpretation of the time scaling coefficient than one? 6. Can variables be found in a set of output variables? 7. Can the principle of balance of d'Alambert power be assigned to the principles of compatibility? 8. Can the White Box be in the form of Armax? 9. Can the IIR/Noi system be excited with a non -rekursive model/Fir/Max? 11. For a given electrical system, provide steps to the procedure leading to the development of the required In-Out model.	
Work placement	Not applicable	