GDAŃSK UNIVERSITY OF TECHNOLOGY

Subject card

Subject name and code	, PG_00058632						
Field of study	Mechatronics						
Date of commencement of studies	February 2024		Academic year of realisation of subject	2024/2025			
Education level	second-cycle studies		Subject group				
Mode of study	Full-time studies		Mode of delivery	at the university			
Year of study	1		Language of instruction	Polish			
Semester of study	2		ECTS credits	2.0			
Learning profile	general academic profile		Assessment form	assessment			
Conducting unit	Zakład Technologii Maszyn i Automatyzacji Produkcji -> Institute of Manufacturing and Materials Technology -> Faculty of Mechanical Engineering and Ship Technology						
Name and surname of lecturer (lecturers)	Subject supervisor		dr hab. inż. Mariusz Deja				
	Teachers						
Lesson types and methods of instruction	Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
	Number of study hours	15.0	0.0	15.0	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		0.0		0.0	30
Subject objectives	Learning the capabilities of systems that control technological devices						

Learning outcomes

Course outcome	Subject outcome	Method of verification
[K7_W01] has extended knowledge in terms of selected areas of mathematics, including discrete and applied mathematics, optimisation methods, mathematical and numerical methods essential for: 1) modelling and analysis of nonstationary mechatronics, continuous and discrete time systems as well as physical phenomena; 2) description and analysis of mechatronic systems that include programmable devices 3) description and analysis of signal processing algorithms 4) synthesis of non-stationary mechatronic systems	Monitoring of technological processes	[SW3] Assessment of knowledge contained in written work and projects
[K7_U04] is able to utilise known methods and mathematical models, as well as computer simulations for analysis and evaluation of non-stationary continuous and discrete mechatronic systems and processes	Ability to conduct simulations of technological device control	[SU1] Assessment of task fulfilment
[K7_W10] knows development trends and most important new achievements in technical sciences and science disciplines: Mechanical Engineering, Automation, Electronics and Electrical Engineering and related: Informatics and Materials Engineering	Knowledge of the directions of development of control systems for technological devices	[SW3] Assessment of knowledge contained in written work and projects
[K7_W06] has detailed, supported by the theory knowledge in terms of mechatronic design, mechatronic systems and machines, devices and process where they are used	Practical use of mechatronic design	[SW2] Assessment of knowledge contained in presentation

Subject contents	1. Introduction to Control Systems for Machine Tools • Definition and history of the development of numerically controlled machine tools. • Classification of machine tools (lathes, milling machines, drills) and their basic operating principles. • Traditional machine tools vs. CNC (Computer Numerical Control) machine tools key differences and advantages. 2. Basics of Numerical Control (CNC) • The principle of operation of numerical control the role of NC (Numerical Control) programs. • Structure of CNC systems controllers, drives, sensors, and user interfaces. • Principles of creating NC programs: G-code and M-code basic commands and their applications. • Computer-Aided Manufacturing (CAM) and its integration with CNC systems. 3. Kinematics and Geometry of Machine Tools • Motion axes in CNC machine tools (X, Y, Z, and additional rotary axes) and their significance in the machining process. • Calibration of machines setting the zero point of the machine and reference systems (WCS Work Coordinate System). • Control of linear interpolation, circular interpolation, and 5-axis machining how machines perform complex motions. 4. Drive Control in CNC Machine Tools • Electric drives used in CNC machines servo drives and stepper motors. • Principles of controlling spindle speed and torque. • Integration of drives with CNC control systems feedback and positioning accuracy. 5. Principles of CNC Programming • Basics of programming in G-code: motion functions (G01 linear motion, G02 circular motion), tool changes, and auxiliary operations (coolant, spindle rotation). • Creating tool paths for operations such as turning, milling, and drilling. • Machining simulations and verification of NC programs before running them on the machine. 6. Automatic Tool Change Systems (ATC) • Operating principles of ATC (Automatic Tool Changer) systems in CNC machines. • Tool management in CNC programs and automation of the tool change process. • Monitoring tool wear and tool diagnostics. 7. Measuring Systems in CNC Machine Tools • Position sensors and optical systems for monitoring tool and workpiece movements. • Tool and workpiece measurement systems probing systems, tool calibration, and workpiece measurement. • In-process measurements during machining increasing accuracy and automating quality control. 8. Integration of CAD/CAM with CNC Systems • The process of creating CAD (Computer-Aided Design) models and generating tool paths using CAM (Computer-Aided Manufacturing) software. • Information flow between CAD, CAM, and the CNC machine. • Optimization of tool paths and machining simulations in the CAM environment. • Importing and exporting data to CNC machines. 9. Diagnostics and Maintenance of Control Systems for Machine Tools • Diagnostic methods for CNC systems analysis of positioning errors, mechanical wear, and electronic failures. • Predictive maintenance in machine tools monitoring machine condition and preventing failures. • Software updates for control systems and machine calibration. 10. Safety Principles in CNC Systems • Safety standards for CNC machine tools operator and machine protection. • Safety systems: emergency stop buttons, safety barriers, and mechanical locks. • Monitoring the condition of tools and workpieces to prevent machine and component damage. 11. Automation of Machining Processes in Industry • Application of CNC machine tools in batch and mass production. • Automatic machining lines, robots cooperating with CNC machines (cobots), and material feeding and unloading systems. • Examples of modern applications: additive manufacturing technologies (3D printing) and their integration with CNC machines.
Prerequisites and co-requisites	Technical drawing, CAD

<table>
<tr><td>Assessment methods and criteria</td><td colspan="3"><table>
<tr><th>Subject passing criteria</th><th>Passing threshold</th><th>Percentage of the final grade</th></tr>
<tr><td>Laboratory</td><td>60.0%</td><td>50.0%</td></tr>
<tr><td>Colloquium</td><td>60.0%</td><td>50.0%</td></tr>
</table></td></tr>
<tr><td rowspan="3">Recommended reading</td><td>Basic literature</td><td colspan="2">Adam Zalewski, Mariusz Deja, Krzysztof Jarosz, Adam Ruszaj: CNC machine tools. Basics of operation and programming. Subtractive, additive and hybrid processes.. PWN, Warszawa, 2024.</td></tr>
<tr><td>Supplementary literature</td><td colspan="2">Selected scientific papers</td></tr>
<tr><td>eResources addresses</td><td colspan="2">Adresy na platformie eNauczanie:</td></tr>
<tr><td>Example issues/ example questions/ tasks being completed</td><td colspan="3">1. What is the main difference between traditional machine tools and CNC (Computer Numerical Control) machine tools?Explain how CNC technology enhances machining capabilities compared to traditional methods.2. What are G-code and M-code, and how are they used in CNC programming?Provide examples of common commands found in G-code and M-code.3. What is the purpose of an Automatic Tool Change (ATC) system in CNC machines?Describe how ATC systems improve machining efficiency.4. What is the significance of calibration in CNC machine tools, and how is it typically performed?Explain the process of setting a zero point and its importance for accurate machining.5. How do measuring systems enhance the accuracy and quality control in CNC machining?Discuss the role of in-process measurement and tool wear monitoring in improving machining results.</td></tr>
<tr><td>Work placement</td><td colspan="3">Not applicable</td></tr>
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