GDAŃSK UNIVERSITY OF TECHNOLOGY

Subject card

Subject name and code	Cobots, PG_00067982						
Field of study	Automatic Control, Cybernetics and Robotics						
Date of commencement of studies	October 2026			Academic year of realisation of subject		2028/2029	
Education level	first-cycle studies			Subject group		Optional subject group 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	3			Language of instruction		Polish	
Semester of study	5			ECTS credits		4.0	
Learning profile	general academic profile			Assessment form		exam	
Conducting unit	Department of Decision Systems and Robotics -> Faculty of Electronics Telecommunications and Informatics -> Faculties of Gdańsk University of Technology						
Name and surname of lecturer (lecturers)	Subject supervisor		dr inż. Marek Tatara				
	Teachers		dr inż. Marek Tatara				
Lesson types	Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
	Number of study hours	15.0	0.0	30.0	15.0	0.0	60
	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	60		4.0	36.0		100
Subject objectives	The course objective is for students to acquire the interdisciplinary knowledge and practical skills needed to design, program, and implement collaborative robotics systems (cobots).						

Learning outcomes	Course outcome	Subject outcome	Method of verification
	[K6_U04] can apply knowledge of programming methods and techniques as well as select and apply appropriate programming methods and tools in computer software development or programming devices or controllers using microprocessors or programmable elements or systems specific to the field of study	The student can create and implement software for cobots by selecting and applying appropriate programming methods and tools, including simulation environments.	[SU4] Assessment of ability to use methods and tools
	[K6_U11] can plan and organise individual and team work	The student can plan and organize the work of a project team to solve a complex problem in collaborative robotics, from defining requirements to the demonstration and evaluation of the final solution.	[SU5] Assessment of ability to present the results of task
	[K6_W03] knows and understands, to an advanced extent, the construction and operating principles of components and systems related to the field of study, including theories, methods and complex relationships between them and selected specific issues - appropriate for the curriculum	The student knows and understands the architecture and operating principles of collaborative robots, including the structure of their control systems, the role of key components (sensors, actuators), and the complex relationships between the system's design and its ability to interact safely and effectively with a human.	[SW1] Assessment of factual knowledge
	[K6_U12] can analyze the operation of components, circuits and systems related to the field of study, as well as measure their parameters and examine technical specifications, and plan and conduct experiments related to the field of study, including computer simulations and measurements, and interpret obtained results and draw conclusions	The student can plan and conduct experiments, including computer simulations, to analyze and evaluate the performance of a robotic system. The student can interpret the obtained results and draw conclusions regarding the safety and effectiveness of the human-robot interaction.	[SU1] Assessment of task fulfilment

Subject contents

Course content – lecture

1. Introduction to Cobots

- Definition and characteristics of cobots - what collaborative robots are and how their design philosophy distinguishes them from traditional industrial robots
- The ability of cobots to complement human skills to increase productivity and flexibility
- The interdisciplinary nature of cobots

2. Safety and Human-Robot Interaction
- Fundamentals of safe collaboration, types of safety measures
- Introduction to cobot design methods.
- Intent inference and shared autonomy
- Multimodal interfaces

3. Technical Foundations and Perception

- Robot kinematics and dynamics
- Sensors and perception
- Mechanical components

4. Programming Methods and Adaptability

- Cobot programming methods
- Motion planning and decision making
- Adaptation to a changing environment

5. Virtual Testing, System Integration, and Social Aspects

- The role of simulators
- Open-source software and integration platforms
- Ethical and social aspects of robotics

Course content – laboratory
1. Introduction to the programming and operating environment of collaborative robots.
2. Creating and testing robotic workcells in a simulation environment.
3. Configuration and verification of key safety functions for human-robot collaboration.
4. Defining tool coordinate systems and programming movements in Cartesian space.
5. Controlling cobot motion using a scripting language and an external computer.
6. Implementing tasks based on force control and programming arm compliance.
7. Integrating a virtual camera with a cobot in a simulator to perform vision-guided tasks.
8. Performing hand-eye calibration to determine the spatial relationship between the camera and the robot arm.
9. Implementing a pick-and-place task on a physical workcell using a 3D vision system.
10. Designing and implementing a simple scenario of safe human-robot collaboration.

Course content – project
The goal of the project is to design, implement, and demonstrate a complete robotic workcell based on a cobot. The project should address the issues presented in the project assignment. The project should include the following phases:

1. Analysis and specification of the problem and requirements.
2. Conceptual design and simulation.
3. Implementation on physical hardware.
4. Testing and validation.
5. Documentation and final demonstration.

Prerequisites and co-requisites

Knowledge of:

- linear algebra, specifically matrix-vector operations
- fundamentals of robotics
- programming fundamentals

Assessment methods and criteria

Subject passing criteria	Passing threshold	Percentage of the final grade
Exam	60.0%	30.0%
Laboratories	60.0%	40.0%
Project	60.0%	30.0%

Recommended reading

Basic literature	[1] Doulgeri, Z., & Dimeas, F. (Eds.). (2023). Human-Robot collaboration: Unlocking the potential for industrial applications (Vol. 134). IET. [2] Ramasamy, V., Balamurugan, S., & Peng, S. L. (Eds.). (2025). Intelligent Robots and Cobots: Industry 5.0 Applications. John Wiley & Sons.
Supplementary literature	[1] Wang, L., Wang, X. V., Váncza, J., & Kemény, Z. (Eds.). (2021). Advanced human-robot collaboration in manufacturing (pp. 74-84). Springer.
eResources addresses	

Example issues/ example questions/ tasks being completed	**Lecture** 1. Based on the definition of a collaborative robot, discuss the key differences in design philosophy and construction between a cobot and a traditional industrial robot, referring to the aspects of safety and human interaction. 2. Explain the motion planning problem in the context of cobots and the significance of environmental perception for this process. Describe how a cobot adapts its operation to a dynamically changing environment. 3. Explain the role and importance of simulators in the process of designing and deploying robotic workcells with cobots. Name three key benefits of virtual testing. **Laboratory** 1. Describe the step-by-step procedure for defining a new Tool Center Point (TCP) for a gripper mounted on the robot. Explain why its precise definition is crucial for the accuracy of movements in Cartesian space. 2. Present how to implement a task based on force control, e.g., following an object's contour. List what programming functions or blocks should be used and how to configure the force parameters to ensure the task is performed correctly and safely. 3. Explain the purpose and subsequent stages of the hand-eye calibration process. Describe what input data is needed, what the result of this procedure is, and why it is essential for implementing vision-guided "pick-and-place" tasks. **Project** 1. Justify the choice of concept for the implemented robotic workcell. Present what alternative solutions were considered and why the chosen approach was deemed optimal in the context of the project requirements. 2. Discuss the biggest technical challenge encountered during the project's implementation on physical hardware. Describe what the problem was, what steps were taken to solve it, and what conclusions were drawn from this experience. 3. Present the testing and validation methodology for the implemented system. Describe what test scenarios were conducted to verify the correctness of operation and safety of the workcell, and how it was assessed whether the project met the initial assumptions.
Practical activites within the subject	Not applicable