GDAŃSK UNIVERSITY OF TECHNOLOGY

Subject card

Subject name and code	Microcontrollers and sensors in chemistry, PG_00069262		
Field of study	Chemistry		
Date of commencement of studies	February 2025	Academic year of realisation of subject	2025/2026
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	3.0
Learning profile	general academic profile	Assessment form	assessment
Conducting unit	Department of Physical Chemistry -> Faculty of Chemistry -> Wydziały Politechniki Gdańskiej		
Name and surname of lecturer (lecturers)	Subject supervisor	dr hab. inż. Jarosław Wawer	
	Teachers		

Lesson types and methods of instruction

Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
Number of study hours	0.0	0.0	0.0	45.0	0.0	45
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	45	5.0	25.0	75

Subject objectives

The aim of the course is to familiarize students with the practical application of microcontrollers and sensors used for measuring physicochemical properties in industry or laboratory settings. Microcontrollers are single-chip computers that enable programmable and automatic data collection from sensors and device control. Their low cost and ease of use have made them increasingly popular. Students will learn how to program microcontrollers using the MicroPython language, integrate sensors, collect and analyze data, and design control systems using IoT technologies. The course aims to develop practical skills through project-based learning, such as building simple measurement and control devices, with a focus on energy efficiency.

Learning outcomes

Course outcome	Subject outcome	Method of verification
[K7_W03] recognizes and describes phenomena in the field of physics, including elements of quantum mechanics, solid state physics and nuclear physics, necessary to predict the course of physical phenomena and to solve technical problems	The student recognizes and is able to describe fundamental physical phenomena used in the operation of sensors applied in measurement and control systems, including phenomena from solid-state physics, nuclear physics, and, where applicable, quantum mechanics, which enables the proper selection and interpretation of measurement signals.	[SW1] Assessment of factual knowledge
[K7_K02] is able to cooperate and work in a group, taking on different roles	Acquisition by the student of the ability to work collaboratively in a project team, with the capacity to assume various roles, in the development of measurement and control systems based on microcontrollers and sensors.	[SK4] Assessment of communication skills, including language correctness [SK3] Assessment of ability to organize work
[K7_U02] prepares detailed documentation of the results of independently conducted experiments and analyzes the obtained results, uses professional vocabulary with understanding and prepares and communicates information	The student is able to independently search for and utilize technical documentation and programming libraries.	[SU2] Assessment of ability to analyse information [SU1] Assessment of task fulfilment

Subject contents	Modern modules such as Raspberry Pi Pico or ESP32 will be used during the classes. Programming will be carried out in MicroPython, an optimized dialect of the Python language for microcontrollers. The devices built in class will enable, among other things, the measurement of temperature, pressure, or gas detection. Sensor data will be transferred using various interfaces such as I2C, SPI, or one-wire. Based on the measurements, power regulation of devices such as heaters, motors, or stirrers will be implemented. Students will practice the implementation of solutions using wireless communication technologies such as Bluetooth, Wi-Fi, or LoRa, thereby realizing the basic principles of the Internet of Things (IoT). Active and continuous control of device operation will allow adaptation to changing conditions and needs, improving energy efficiency. Topics covered during the classes: introduction to microcontrollers: architecture, resources, GPIO, memory; MicroPython on Raspberry Pi Pico and ESP32: environment setup, code upload, debugger; sensor interfaces and protocols: I2C, SPI, UART, One-Wire (connections and libraries); example sensors: DS18B20 (temperature), BMP280 (pressure), MQ-XXX (gases); basics of control and power regulation for heaters and motors: PWM, ADC, DAC, relays; wireless communication: Bluetooth Low Energy, Wi-Fi, LoRa configuration, APIs; IoT elements: cloud data transmission, basics of MQTT/HTTP; optimization and sustainability: energy efficiency of systems; presentation and documentation of results: report, code repository, functional demonstration. Structure of the course: 6 introductory labs (3 hours each, total of 18 hours) mini-lectures and hands-on practice with example circuits, ending with a test; 9 project sessions (3 hours each, total of 27 hours) independent work on a chosen project topic, ongoing consultations, and final project evaluation.
Prerequisites and co-requisites	none

Assessment methods and criteria

Subject passing criteria	Passing threshold	Percentage of the final grade
ocena projektu i prezentacji	50.0%	70.0%
test	50.0%	30.0%

Recommended reading

Basic literature	Bell, Charles. "MicroPython for the Internet of Things." Apress: New York, NY, USA (2017). Tollervey, Nicholas H. Programming with MicroPython: embedded programming with microcontrollers and Python. " O'Reilly Media, Inc.", 2017.
Supplementary literature	Molloy, Derek. Exploring Raspberry Pi: interfacing to the real world with embedded Linux. John Wiley & Sons, 2016. Monk, Simon. Programming the Raspberry Pi: getting started with Python. McGraw-Hill Education TAB, 2021.
eResources addresses	

Example issues/ example questions/ tasks being completed	1. Build a simple UV-Vis spectrophotometer for measuring the absorbance of dye solutions. 2. Program a system to monitor and control the temperature in a chemical reactor using a DS18B20 sensor within the range of 10°C to +85°C. 3. Implement a gas detection system with notifications sent via Wi-Fi or remote monitoring via BLE and report submission to an MQTT server. 4. Create a control system for a heater based on data from a temperature sensor (implementing various PID algorithms). 5. Measure the concentration of carbon monoxide vapors (MQ-7) in a flow system.
Work placement	Not applicable

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