



Subject card

Subject name and code	Physical basis of microcontroller measurement systems, PG_00051072						
Field of study	Technical Physics						
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		
Mode of study	Full-time studies	Mode of delivery			at the university		
Year of study	3	Language of instruction			Polish		
Semester of study	6	ECTS credits			3.0		
Learning profile	general academic profile	Assessment form			assessment		
Conducting unit	Division of Theoretical Physics and Quantum Informaton -> Institute of Physics and Applied Computer Science -> Faculty of Applied Physics and Mathematics -> Faculties of Gdańsk University of Technology						
Name and surname of lecturer (lecturers)	Subject supervisor		dr inż. Paweł Syty				
	Teachers						
Lesson types	Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
	Number of study hours	15.0	0.0	0.0	30.0	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 structure and basic methods of designing and programming simple embedded systems based on microcontrollers, i.e. specialized IT systems responsible for performing strictly defined tasks - mainly related to monitoring and control. The physical basis of the functioning of sensors (receptors) and actuators (effectors / actuators) as the basic components of this type of systems will be discussed.						
Learning outcomes	Course outcome		Subject outcome		Method of verification		
	[K6_W02] possesses structured knowledge of the fundamentals of physics, including mechanics, thermodynamics, electricity and magnetism, optics, atomic and molecular physics, solid-state physics, and nuclear and particle physics.		The student is able to explain, from a physics perspective, how selected electronic components (sensors and actuators) used in microcontroller-based embedded systems work.		[SW1] Assessment of factual knowledge [SW3] Assessment of knowledge contained in written work and projects		
	[K6_U05] is able, individually or in a team, to design and construct simple devices, measuring instruments or technical systems using appropriately selected methods, techniques, tools and materials.		The student is able to design, build and program simple, specialized embedded systems based on selected microcontrollers.		[SU1] Assessment of task fulfilment [SU2] Assessment of ability to analyse information [SU4] Assessment of ability to use methods and tools [SU5] Assessment of ability to present the results of task		
	[K6_U06] is able to identify and assess risks, economic efficiency and the applicability of proposed engineering solutions, including critical evaluation taking into account non-technical factors such as ethical aspects.		The student is able to estimate the technical and economic feasibility of building an embedded system.		[SU2] Assessment of ability to analyse information [SU3] Assessment of ability to use knowledge gained from the subject		
	[K6_W06] has knowledge of technical sciences related to physics, including electronics or energy engineering, and understands their application in the design and implementation of technological processes.		The student is able to describe the functioning of an embedded system on the basis of electronics.		[SW1] Assessment of factual knowledge [SW3] Assessment of knowledge contained in written work and projects		

Subject contents	<p>Course content – lecture</p> <p>Discussion of the physical basis of operation of basic measurement systems based on selected microcontrollers.</p> <p>Detailed programme</p> <p>A. Hardware platforms:</p> <p>a. Arduino (Uno, Mega, Nano, Pro Mini, etc.) - a platform based on 8-bit microcontrollers from the Atmel AVR family</p> <p>b. Raspberry Pi - a family of 32/64-bit single board minicomputers based on microprocessors from the ARM family (11, Cortex)</p> <p>c. ESP8266 / ESP32 - 32-bit RISC microcontroller with built-in WiFi / Wifi+Bluetooth transmission, making it convenient to connect the system to the Internet</p> <p>d. Raspberry Pi Pico - a microcontroller board based on the Raspberry Pi RP2040 chip</p> <p>e. STM32 - a family of 32-bit microcontrollers from the ARM Cortex family</p> <p>B. Programming languages:</p> <p>a. C/C++ - in the context of programming for Arduino / ESP8266 / STM32</p> <p>b. Python - a general-purpose scripting language, particularly convenient for programming for the Raspberry Pi</p> <p>c. MicroPython - a version of Python for microcontrollers</p> <p>C. Programming tools and support hardware:</p> <p>a. Arduino IDE - a development environment for Arduino and ESP8266, including the necessary libraries</p> <p>b. NodeMCU - a framework/circuit software to facilitate ESP8266 programming in the context of the Internet of Things</p> <p>c. Sensors (e.g. temperature, pressure, distance, rain, motion, colour, sound), motors, LCD/LED displays, GPS, GSM, RFID devices, camera support, etc.</p> <p>d. Web services for the collection and presentation of measurement data</p> <p>D. Description and mechanisms of sensors</p> <ul style="list-style-type: none"> <li>• Inductive and Hall sensor</li> <li>• Potentiometer sensor and thermistors</li> <li>• Tensometric sensors</li> <li>• Capacitance and piezoelectric sensors</li> <li>• Ultrasound, radar and lidar sensors</li> <li>• Photoelectric sensors</li> <li>• Electrolytic-resistive sensor</li> </ul> <p>Most topics will be illustrated with a demonstration of the operation of a particular device / hardware / programming language.</p>											
	<p>Course content – project</p> <p>During the first weeks, students will learn, under the supervision of the instructor, how to work with the hardware and will build and program basic systems (e.g. control of LEDs, buzzer, motor, relay, measurement of temperature, atmospheric pressure, distance, recognition of movement, rain, colour, use of GPS, GSM and RFID devices, etc.).</p> <p>Then, students will present self-prepared prototypes of embedded systems projects for the chosen platform (including implementation), e.g.</p> <ul style="list-style-type: none"> <li>- internet radio with remote control (Raspberry Pi + WiFi + remote control / infrared sensor / Python)</li> <li>- room access control system (Arduino + RFID / C++)</li> <li>- weather station with WWW reporting (Arduino + selected sensors + ESP8266 / C++)</li> <li>- room monitoring with WWW reporting (Arduino + selected sensors + ESP8266 / C++)</li> <li>- wheeled self-driving robot (Arduino + distance and obstacle sensors + robot platform with motors and wheels / C++)</li> <li>- home automation (Arduino or Raspberry Pi + sensors + effectors / C++ or Python)</li> <li>- webcam with object recognition (Raspberry Pi + camera / Python + OpenCV library)</li> </ul> <p>Hardware (microcontroller boards, sensors, effectors, etc.) will be made available to students for the duration of their projects. It is also possible to design the system in TinkerCad or an equivalent service.</p>											
Prerequisites and co-requisites	<p>Basic knowledge of programming</p> <p>Basic knowledge of electronics</p>											
Assessment methods and criteria	<table border="1"> <thead> <tr> <th>Subject passing criteria</th> <th>Passing threshold</th> <th>Percentage of the final grade</th> </tr> </thead> <tbody> <tr> <td>Completion of the project</td> <td>50.0%</td> <td>80.0%</td> </tr> <tr> <td>Passing the theoretical part</td> <td>50.0%</td> <td>20.0%</td> </tr> </tbody> </table>			Subject passing criteria	Passing threshold	Percentage of the final grade	Completion of the project	50.0%	80.0%	Passing the theoretical part	50.0%	20.0%
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Completion of the project	50.0%	80.0%										
Passing the theoretical part	50.0%	20.0%										
Recommended reading	<p>Basic literature</p> <p>Supplementary literature</p> <p>eResources addresses</p>	<p>Michael J. McGrath, Clíodhna Ní Scanaill, Sensor Technologies. Healthcare, Wellness, and Environmental Applications. Apress, 2013</p> <p>Andy King, Programming the Internet of Things. O'Reilly Media, 2021</p> <p>Vedat Ozan Oner, Developing IoT Projects with ESP32. Packt Publishing, 2021</p> <p>Husan Mahey, Robotic Process Automation with Automation Anywhere. Packt Publishing, 2020</p>										

<p>Example issues/ example questions/ tasks being completed</p>	<ul style="list-style-type: none"> <li>- Internet radio with remote control (Raspberry Pi + WiFi + remote control / infrared sensor / Python)</li> <li>- room access control system (Arduino + RFID / C ++ ) weather station with reporting on the website (Arduino + selected sensors + ESP8266 / C ++ )</li> <li>- room monitoring with reporting on the website (Arduino + selected sensors + ESP8266 / C ++ )</li> <li>- wheeled self-propelled robot (Arduino + distance and obstacle sensors + robot platform with motors and wheels / C ++ )</li> <li>- home automation (Arduino or Raspberry Pi + sensors + effectors / C ++ or Python)</li> <li>- webcam with object recognition (Raspberry Pi + camera / Python + OpenCV library)</li> </ul>
<p>Practical activities within the subject</p>	<p>Not applicable</p>

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