SYLLABUS

1. Information regarding the programme

1.1 Higher education institution	Babeș–Bolyai University
1.2 Faculty	Faculty of Mathematics and Computer Science
1.3 Department	Department of Computer Science
1.4 Field of study	Computer Science
1.5 Study cycle	Bachelor
1.6 Study programme / Qualification	Computer Science

2. Information regarding the discipline

2.1 Name of the discipline (en) (ro)	Microcontrollers Microcontroleri						
2.2 Course coordinator	Assoc. Prof. András Libál, PhD						
2.3 Seminar coordinator	Assoc. Prof. András Libál, PhD						
2.4. Year of study	3	2.5 Semester	6	2.6. Type of evaluation	C	2.7 Type of discipline	Optional DS
2.8 Code of the discipline	MLE9011						

3. Total estimated time (hours/semester of didactic activities)

3.1 Hours per week	4	Of which: 3.2 course	2	3.3 seminar/laboratory	2 LP

3.4 Total hours in the curriculum	56	Of which: 3.5 course	28	3.6 seminar/laboratory	28

Time allotment:	hours
Learning using manual, course support, bibliography, course notes	11
Additional documentation (in libraries, on electronic platforms, field documentation)	11
Preparation for seminars/labs, homework, papers, portfolios and essays	6
Tutorship	8
Evaluations	8
Other activities:	

3.7 Total individual study hours	44
3.8 Total hours per semester	100
3.9 Number of ECTS credits	4

4. Prerequisites (if necessary)

4.1. curriculum	none (Electronics is recommended but not required)
4.2. competencies	Basics of electronic circuits, C/C++ programming

5. Conditions (if necessary)

5.1. for the course	Projector, Board
5.2. for the seminar /lab activities	Projector, Board, a laboratory equipped with microcontrollers (Arduino, Node MCU) sensors, Arduino shields, components

6. Specific competencies acquired

Professional competencies	C2.1 Describing the structure and operation of hardware, software and communication components C5.2 Analysing, designing, executing and measuring of electronic circuits of low/ medium complexity C5.5 Designing electronic circuits of low / medium complexity and implementing them using CAD techniques
Transversal competencies	CT1 Honorable, responsible, ethical behavior, in the spirit of the law, to ensure the professional reputation CT3 Demonstrating initiative and pro-active behavior for updating professional, economical and organizational culture knowledge

7. Objectives of the discipline (outcome of the acquired competencies)

7.1 General objective of the discipline	Show students the basics of the operation of microcontrollers, how they are programmed both on a high level (using pre-written libraries) and low level (reading specifications and setting the correct bits in the registers in C language, utilizing the hardware to its full capability). Learning the use of different sensors, reading digital and analog signals or communicating with the sensors using a standard protocol. Understanding the analog-digital conversion. Being able to generate output and read input from different components using standard protocols (1W,I2C, SPI, ...).
7.2 Specific objective of the discipline	We will study the Arduino UNO board and platform, the Arduino IDE and language (libraries built on C) and in detail the design and capabilities of the Atmel Atmega 328P processor at the level of registers. We will read values from different sensors (liquid level, light intensity, temperature, acceleration, magnetic field etc) we will scan digital inputs (switches, keypads, tilt switches etc) and we will learn to use the most used communication protocols such as the UART serial port, 1W protocol, TWI (I2C) protocol, SPI and we will also talk about specific protocols related to some devices (for example LCD screens). We will also learn about controlling different types of motors such as DC, stepper and servo motors.

8. Content

8.1 Course	Teaching methods	Remarks
1. Introduction to Microcontrollers and Embedded Systems. Using GPIO ports to read/write digital	Presentation, demonstration	

information. Buttons, Touch sensors, keypad.		
2. Timer system, Normal Timer operation. Driving a seven-segment display. Sound generation.	Presentation, demonstration	
3. Timer system, CTC operation, Timer interrupts, event capture. Measuring time: ultrasonic sensors. IR communication, reading IR communication signals.	Presentation, demonstration	
4. Timer system. PWM operation. Controlling laser intensity with PWM. Different methods for generating PWM signals.	Presentation, demonstration	
5. Sensing. Different Sensors. Analog-Digital Conversion. Sampling Theorem. ADC with a microcontroller and external ADC unit.	Presentation, demonstration	
6. 1W protocol in detail. CRC check. DS18B20 thermometer. DS2431 EEPROM module. Non-standard one wire: Smart RGB LEDs and DHT11 temperature and humidity sensors.	Presentation, demonstration	
7. TWI (I2C) protocol. I2C EEPROM module, I2C real time clock. I2C interfacing of an LCD module. LCD module low-level programming (Hitachi HD44780U interfacing).	Presentation, demonstration	
8. SPI protocol. SPI stereo DAC. Writing SD cards in SPI mode. SPI LED dot matrix. SPI Bluetooth module. SPI RC522 RFID card-keyfob reader.	Presentation, demonstration	
9. UART protocol. Parity. Radio communication. Ethernet board, wireless communication with ESP8266 module. Introduction to IoT: the ESP8266 module, Node MCU, WeMOS boards	Presentation, demonstration	

10.Actuating. Different Motor, Motor Drivers, transistor decoupling, Relays, H Bridge, L293D, Motor Shields, DC, servo and stepper motors. PWM for motor driving.	Presentation, demonstration	
11. Introduction to robotics. and, basics of mechatronics, PID control. Controlling a robotic arm. Driving brushless motors with feedback.	Presentation, demonstration	
12. Other embedded systems, future outlook (Arduino Mega, Arduino Due, new Arduino boards with embedded wifi, FPGA and image processing capabilities, particle Photon)	Presentation, demonstration	
13. The Node MCU board, Internet of Things. Communicating with a backend server. Firebase connection. Creating a webpage that communicates with the microcontroller system.	Presentation, demonstration	
14. Courses and platforms for further learning in embedded, IoT and robotics systems. User communities, platforms and conferences with documentation and project descriptions. Major hardware platform developers and their open resources.	Presentation, demonstration	
Bibliography Horowitz, Hill - The Art of Electronics Scherz, Monk - Practical Electronics for Inventors Richard G. Lyons - Understanding Digital Signal Processing Bezhad, Razavi - Fundamentals of Microelectronics		
8.2 Seminar / laboratory	Teaching methods	Remarks
1. Simple Digitial I/O, LED, Switches, Touch Sensors, Keypads	Presentation, demonstration, teamwork in groups of 2-3	

2. Timer generated outputs, seven-segment display, Sound generation with multiple Timer modes, normal, CTC, illustrating flags and interrupts	Presentation, demonstration, teamwork in groups of 2-3	
3. Timed inputs: ultrasonic distance measurement, handling event capture, IR communication decoding (remote control). Designing our own IR protocol.	Presentation, demonstration, teamwork in groups of 2-3	
4. Reading analog signals, configuring the ADC, interpreting different sensor values, multiplexing at the input with CD4051.	Presentation, demonstration, teamwork in groups of 2-3	
5. Communication with multiple bits. DHT11 sensor, driving a Smart RGB LED. One Wire protocol, illustrated with the DS18B20 temperature sensor.	Presentation, demonstration, teamwork in groups of 2-3	
6. Two Wire (I2C) protocol: (RTC clock, I2C EEPROM, I2C external ADC unit. I2C DAC driving.	Presentation, demonstration, teamwork in groups of 2-3	
7. Two Wire (I2C) protocol continued: I2C LCD backpack, using the LCD Hitachi driver. I2C radio module.	Presentation, demonstration, teamwork in groups of 2-3	
8. SPI protocol: 8x8 LED matrix. 8x8 seven-segment display driving, RFID reading and writing with the RC522 module	Presentation, demonstration, teamwork in groups of 2-3	
9. SPI protocol continued: configuring and using a Bluetooth module, SD card interfacing with SPI, adding a file system to the Microcontroller	Presentation, demonstration, teamwork in groups of 2-3	
10. Motors: motor driver shield, driving DC, stepper, and servo motors. PWM: demonstrating PWM on a laser module and on DC and servo motors. Aliasing wheel.	Presentation, demonstration, teamwork in groups of 2-3	
11. Application of motor driving to simple robots with ultrasonic sensing and driving DC motors (obstacle avoidance).	Presentation, demonstration, teamwork in groups of 2-3	

12. Spinning up a brushless HDD motor with optical feedback. Application of motor driving to a robotic arm. PID control, demonstrating the importance of PID control.	Presentation, demonstration, teamwork in groups of 2-3	
13. Simple IoT project with Node MCU, interfacing the Node MCU with the Arduino and having two-way communication with SPI and TWI protocols.	Presentation, demonstration, teamwork in groups of 2-3	
14. Pre-built IoT project with custom made PCB for controlling the environment in an office (light, AC, motor driven blinds with sensing for temperature and ambient light). Writing a program for the controller, demonstrating a web app to control the system.	Presentation, demonstration, teamwork in groups of 2-3	

Bibliography

Jeremy Blum: Exploring Arduino
Simon Monk: Programming Arduino
Han-Way Huang: The Atmel AVR MIcrocontroller
Hayes, Horowitz - Learning the Art of Electronics, A Hands-On Lab course

9. Corroborating the content of the discipline with the expectations of the epistemic community, professional associations and representative employers within the field of the program

The material of the course is something students can use in their embedded and IoT projects, it is being refreshed every year to correspond to current trends and new hardware available. It is relevant for students who will participate in any embedded, IoT or robotic projects in the future.

10. Evaluation

Type of activity	10.1 Evaluation criteria	10.2 Evaluation methods	10.3 Share in the grade (%)
10.4 Course	Every class beings with a simple quiz from the last lecture with 5 questions (10 minutes) At the first course, the presence counts. Quizzes cannot be recovered later.	All quizes count the same 10 points. Towards the end of the semester there is a superquiz that counts extra and is worth 30 points.	30% from the final grade

10.5 Seminar/lab activities	Every Lab students work together in groups of 2-3 people to complete the lab assignment. One Lab can be recovered late in the semester.	All labs count 20 points with the possibility to earn extra +2 or +4 points for some additional work	30% from the final grade
10.6 Minimum performance standards			
Average of all the quizzes (including the super quiz) has to be a minimum of 3.0, quizzes cannot be recovered at a later date. Average of all the quizzes and the labs has to be a minimum of 5.0, one lab can be recovered during the semester at a specified date. The University criteria is to be present at 75% of all Labs so 4/6 presence is required. If either of these criteria is not met the student is ineligible to take the exam and has failed. The written exam has to be a minimum of 5.0. The written exam can be re-taken in the second exam period with the rest of the grade from Quizes and Labs remaining the same.			

Date	Signature of course coordinator	Signature of seminar coordinator
2022.04.22.		Li

Date of approval	Signature of the head of department
24.05.2022	