Subject (course) name: **Embedded Systems**		
Programme: **Computer Science** Specialty:		Subject code: **9K** Title graduate: **Engineer**
Type of course: **obligatory**	Course level: **First-cycle studies**	Year: **II** Semester: **IV** Semester: **summer**
Form of classes: **Lectures, Classes, Labs, Seminar, Project**	Number of hours per week: **1L, 0, 2Lab, 0, 0**	Credit points: **3 ECTS**

GUIDE TO SUBJECT

SUBJECT OBJECTIVES

C1. General knowledge in microcontrollers and embedded systems.

C2. General ability to design embedded systems for industrial application.

C4. General programming skills of embedded systems.

SUBJECT REQUIREMENTS

1. General knowledge in logical devices, computer architecture, programming in high-level languages.
2. General ability to work independently and ability to work in a group.
3. General ability to independently search in literature and online resources.

LERNING OUTCOMES

EK 1 - Student lists and describes the rule of operation of the typical microcontroller's elements.

EK 2 - Student lists and describes the internal devices working with the microcontroller.

EK 3 - Student explains the rules of operation of external I/O devices and can design embedded systems for industrial application.

EK 4 - Student explains the rule of operation of demo software and can develop the software for embedded systems unaided.

SUBJECT CONTENT

Form of classes – lectures

Topic	Hours
W1 – Introduction to embedded systems – definition, application, etc. Overview and comparison of 8/16/32 bits architectures of microcontrollers.	**1**
W2 – Architecture of x51 core, embedded circuits: timers, interrupts, watchdog, ADC converter	**1**
W3 – ANSI C syntax: data types, constants, declarations, arithmetic and logical operators, type conversion	**1**
W4 – Commercial and open-source programming environments, mixed programming, libraries, debugging, JTAG	**1**
W5 – ANSI C syntax: inc/dec operators, bitwise operators, assignment operators, conditional expressions, priority queue	**1**
W6 – ARM architecture, programming model, instruction set architecture	**1**
W7 – ANSI C syntax: statements, structure of C program	**1**
W8 – ANSI C syntax: variables, pointers and arrays, preprocessing directives, header files, macros	**1**

W9 – Serial interfaces USART, SPI, 1Wire	**1**
W9 – ANSI C syntax: Structures and unions, functions, pointers and address operators	**1**
W12 – Serial buses I^2C, USB	**1**
W10 – ANSI C syntax: character and formatted I/O, math functions	**1**
W11 – Error detection and correction techniques	**1**
W12 – Real time systems	**1**
Final test	**1**
Total	**15**

Form of classes – laboratory

Topic	Hours
Introduction	**0,5**
L1 – KEIL μVision IDE for x51 cores. The program development in μVision. An example - driving I/O port lines	**1,5**
L2 – Timers and counters – configuration and application	**2**
L3 – Interrupts - configuration and application	**2**
L4 – RS 2323 serial transmission – embedded circuit and software emulation with CRC coding	**2**
L5 – The program development for ARM based core. Examples of driving I/O port lines: buttons, joy, LEDs	**2**
L6 – ADC and DAC conversions – potentiometer and buzzer	**2**
L7 – Graphical LCD control	**2**
L8 – Touch panel control	**2**
L9 – SD card control and FAT implementation	**2**
L10 – Real time system implementation	**2**
L11-14 – Realization of individual projects in teams of two students, eg.: RTC, magnetic card reader, serial transmission with SPI, I2C, USB, etc.	**9**
Examination of programming tasks	**1**
Total	**30**

STUDY METHODS

1. Lectures using multimedia presentations and computer arithmetic tasks
2. Discussion during the course and in addition during individual consultations
3. Laboratory – analysis of the operation and development of software - teamwork

EDUCATIONAL TOOLS

1. Audiovisual equipment, black(white)board, lectures in electronic version
2. Laboratory equipped with PC computers with software for compilation, programming and debugging
3. Embedded systems (development kits) based on 8 bits microcontrollers
4. Embedded systems (development kits) based on 16/32 bits microcontrollers

METHODS OF ASSESMENT (F – Forming, P – Summary)

F1. assessment of self preparation for laboratory classes – oral answer
F2. assessment of the correctness and timeliness of presentation software created
P1. lecture – written test of the theory
P2. laboratory – assessment of ability to software analysis and software development

STUDENT WORKLOAD

Form of activity	Averaged workload (hours)		
	[h]	∑ [h]	ECTS
Participation in class activities lecture laboratory consultation	15 30 2	47	2
Preparation for tutorials (reading literature)	10	28	1
Preparation for test	10		
Familiarizing yourself with the software	8		

Total		**75**	**3**

A. BASIC READING

1. Banahan M., Brady D., Doran M.: The C Book: Featuring the ANSI C Standard, 2nd Edition, Addison-Wesley Pub (Sd); 2 edition (August 1991); eBook (2003)
2. Ball S.R.: Embedded Microprocessor Systems: Real World Design, Elsevier Science, 2002.
3. Chowdary Venkateswara Penumuchu: Simple Real-time Operating System. A Kernel Inside View for a Beginner, Trafford Publishing, Victoria (Canada) 2007.
4. Documentation of RS232, 1Wire, SPI, I2C, USB.
5. User's guide of IDE tools.

B. FURTHER READING

1. Valvano J.: Embedded Systems: Introduction to Arm® Cortex (TM) - M Microcontrollers, 2014.
2. ARM®v7-M Architecture Reference Manual, ARM, 2010
3. Journals, e.g..: IEEE Transactions on Embedded Systems, ACM Transactions on Embedded Computing.

Learning objectives	In relation to the learning outcomes specified for the field of study	Subject objectives	Study methods	Methods of assessment
EK1	K_W07 K_W15	C1,C2	lectures, discussion	P1
EK2	K_W07 K_W15	C1,C2	lectures, discussion	P1
EK3	K_U02 K_U21	C2	discussion, laboratory	F1,P2
EK4	K_U02 K_U21	C3	discussion, laboratory	F1,F2,P2

II. EVALUATION

Grade	Outcome
EK1	**Student lists and describes the rule of operation of the typical microcontroller's elements**
2 (F)	Student can not list and describes the rule of operation of the typical microcontroller's elements
3 (E)	Student lists and describes the rule of operation of the chosen microcontroller's elements
4 (C)	Student lists and describes the rule of operation of the most typical microcontroller's elements
5 (A)	Student lists and describes the rule of operation of the typical microcontroller's elements
EK2	**Student lists and describes the internal devices working with the microcontroller**
2 (F)	Student can not list and describe the internal devices working with the microcontroller
3 (E)	Student lists and describes the chosen internal devices working with the microcontroller
4 (C)	Student lists and describes the most internal devices working with the microcontroller
5 (A)	Student lists and describes the internal devices working with the microcontroller
EK3	**Student explains the rules of operation of external I/O devices and can design embedded systems for industrial application**
2 (F)	Student can not explain the rules of operation of external I/O devices and can not design embedded systems for industrial application
3 (E)	Student explains the rules of operation of external I/O devices and can design simply embedded system
4 (C)	Student explains the rules of operation of external I/O devices and can design simply embedded system for industrial application
5 (A)	Student explains the rules of operation of external I/O devices and can design embedded systems for industrial application
EK4	**Student explains the rule of operation of demo software and can develop the software for embedded systems unaided**
2 (F)	Student can not explain the rule of operation of demo software and can not develop the software for embedded systems unaided

3 (E)	Student explains the rule of operation of demo software can develop the simple software for embedded systems supervised by teacher
4 (C)	Student explains the rule of operation of demo software and can develop the software for embedded systems supervised by teacher
5 (A)	Student explains the rule of operation of demo software and can develop the software for embedded systems unaided

III. OTHER USEFUL INFORMATION

1. All information for students on the schedule are available on the notice board and on the website: www.el.pcz.pl
2. Information on the consultation shall be provided to students during the first lecture and will be placed on the website www.el.pcz.pl
3. Terms and conditions of credit courses will be provided to students during the first lecture