

COURSE PROGRAM

Academic Year: 2024/2025

Identification and characteristics of the course													
Code	501107	ECTS Credits	6										
Course name (English)	INDUSTRIAL COMPUTING												
Course name (Spanish)	INFORMÁTICA INDUSTRIAL												
Degree programs	Degree in Electronics Engineering and Automation (Industrial Branch)												
Faculty/School	Industrial Engineering School												
Semester	7th	Type of course	Obligatory										
Module	Specific Technology of Industrial Electronics and Automation												
Matter	Automation and Control												
Lecturer/s													
Name	Office	E-mail	Web page										
José Ignacio Suarez Marcelo	D2.15	jmarcelo@unex.es	CVUEX										
Subject Area	Systems Engineering and Automation												
Department	Electrical, Electronics Engineering and Automation												
Coordinating Lecturer (If more than one)													
Competencies (see table at http://bit.ly/competenciasGrados)													
Basic Competences	Check With an " X"	General Competences	Check With an " X"	Transversal Competences	Check With an " X"	Specific Competences Basic Formation	Check With an " X"	Specific Competences Common to the Industrial Branch	Check With an " X"	Specific Competences Specific Technology	Check With an " X"	Specific Competences Specific Technology	Check With an " X"
CB1		CG1	X	CT1	X	CEFB1		CECRI1		CETE1		CETE11	
CB2		CG2	X	CT2	X	CEFB2		CECRI2		CETE2		CETE12	
CB3		CG3	X	CT3	X	CEFB3		CECRI3		CETE3		CETE13	
CB4		CG4	X	CT4	X	CEFB4		CECRI4		CETE4		CETE14	
CB5		CG5	X	CT5	X	CEFB5		CECRI5		CETE5		CETE15	
		CG6	X	CT6	X	CEFB6		CECRI6		CETE6		CETE16	
		CG7	X	CT7	X			CECRI7		CETE7		CETE17	
		CG8	X	CT8	X			CECRI8		CETE8		CETE18	
		CG9	X	CT9	X			CECRI9		CETE9		CETE19	
		CG10	X					CECRI10		CETE10	X	CETE20	
		CG11	X					CECRI11				CETFG	
		CG12						CECRI12					
Contents													
Course outline													
Embedded control systems: architecture and programming													
Course syllabus													

THEORY

Block I: Introduction to Embedded Control Systems

- **Unit I.1 – Introduction to Embedded Systems (1.5 h)**
 - Definitions and basic concepts. Embedded vs. automated system. MCU vs MPU vs PLC.
- **Unit I.2 – Internal Architecture of an MCU (2.5 h)**
 - Harvard architecture, ALU and operands, instruction execution, oscillator.
- **Unit I.3 – MCU Memory (3.5 h)**
 - Program memory, partitioning, exception vector table. Special registers. Data memory, bank management, specific and general purpose registers, addressing modes. Stack operation.

Block II: Basic programming of an MCU

- **Unit II.1 – In-circuit Programming and Debugging (1.5 h)**
 - ICD vs ICSP. Vendor ecosystem. Basic concepts (debug, release, debug executive). Configuration words
- **Unit II.2 – Programming in Assembler (2.5 h)**
 - Instruction set, classification, Computed-GOTO technique, creation and manipulation of variables, creation of program flow control structures.
- **Unit II.3 – I/O Ports (1.5 h)**
 - Internal diagram, operation and configuration of ports. Voltages, pull-ups, slew rate, open-drain. Pin remapping.
- **Unit II.4 – Interrupts (2.5 h)**
 - I/O techniques: interrupt vs. polling. Masks and flags. Interrupt service routine. Latency. Configuration and management of interrupts in assembly and C languages.

Block III: MCU Peripherals

- **Unit III.1 – Timers (2.5 h)**
 - Basic concepts, configuration, prescaler, postscaler. Role of the timer in the implementation of digital control algorithms. Timers and interrupts: creating precise timings, handling multiple tasks.
- **Unit III.2 – Data Converters (2 h)**
 - A/D converter: analog input model, configuration (channel selection, clock, format, automatic acquisition), conversion time. D/A converter: internal structure, configuration.
- **Unit III.3 – Signal Control and Generation Modules (1.5 h)**
 - CCP modules: operating modes and configuration. PWM modules: configuration, calculation of period and duty cycle, effective resolution.
- **Unit III.4 – Communication Modules (2 h)**
 - EUSART and MSSP modules: block diagrams, configuration, synchronous and asynchronous communications.

Block IV: Implementing controllers on an MCU

- **Unit IV.1 – Controller Discretization (2 h)**
 - Discretisation methods for analog controllers. Selection of sample time and its effects. Obtaining difference equations. Discretization of a PID.
- **Unit IV.2 – PID Controller Implementation on an MCU (3.5 h)**
 - Configuration and programming of the MCU interfaces in C language. Obtaining the sample time by configuring timers and interrupts. Implementation of the control algorithm. Generation of the output signal. Preparation for the next sampling period. Practical considerations. Preparation and handling of variables for real-time monitoring of the controller operation. Calculation of the execution time of the control algorithm.

PRACTICAL ACTIVITIES

The program of practical (laboratory) activities is designed to enable students to develop skills in the handling of (both HW and SW) the tools of a recognised manufacturer of 8-bit microcontrollers of with a very widespread in the Spanish and world markets. The program is divided into several sessions (LAB), in increasing order of complexity, which will allow, on the one hand, to consolidate the most important concepts of the subject and, on the other hand, to facilitate the development of the team work of the subject. The activities will be as follows:

- LAB1 – Simulation vs real-time execution (4 h)
- LAB2 – Implementing tables (4 h)
- LAB3 – Switch debouncing. Modular Programming (4 h)
- LAB4 – HW timing. Interrupts (4 h)
- LAB5 – Controller Implementation. Part I (4 h)
- LAB6 – Controller Implementation. Part II (2.5 h)

Educational activities

Student workload in hours by lesson		Lectures	Practical activities				Monitoring activity	Homework
Lesson	Total	L	HI	LAB	COM	SEM	SGT	PS
I.1	2,5	1,5						1
I.2	7,5	2,5		2				3
I.3	13	4		2				7
II.1	7,5	1,5		2				4
II.2	8,5	2,5		2				4
II.3	6,5	1,5		2				3
II.4	9,5	2,5		2				5
III.1	9,5	2,5		2				5
III.2	5	2						3
III.3	7,5	1,5		2				4
III.4	8	2		2				4
IV.1	8	2		2				4
IV.2	9,5	3		2,5				4
Team project	43						3	40
Assessment	4,5	1						3,5
Final Assessm. (OA2)	4,5	1						3,5
TOTAL	150	30		22,5	0	0	3	94,5

L: Lectures (85 students)

HI: Hospital internships (7 students)

LAB: Laboratory or field practices (15 students)

COM: Computer room or language laboratory practices (20 students)

SEM: Problem classes or seminars or case studies (40 students)

SGT: Scheduled group tutorials (educational monitoring, ECTS type tutorials)

PS: Personal study, individual or group work and reading of bibliography

Teaching Methodologies

Among the teaching methodologies included in the formative program, in this course the following are used:

Teaching methodology	Used methodologies labelled as "X"
1. Explanation and discussion of theoretical contents.	X
2. Resolution, analysis and discussion of support examples or previously proposed exercises.	
3. Exposition of related topics by students.	X
4. Development of case studies or demonstrations at laboratory, computer room, etc.	X
5. Resolution of specific doubts in small groups in order to identify potential problems in the teaching-learning process, and academic guidance for essays, case studies, practical works, demonstrations, etc.	X
6. Search for information prior to the development of the topics, or for complementary information once they are in progress.	X
7. Preparation of essays, either individually or in groups.	X
8. Study of each topic, which may consist of: content study, analysis of practical exercises or case studies, preparation for examinations, etc.	X

The subject will be developed according to the following activities:

- Big-Group: lectures of theoretical contents with a lot of slides and examples to clarify the subject concepts. The student will be **continuously involved** in such a way to make him **to think and question**, with a critical attitude, all the theoretical concepts.
- Laboratory sessions (LABs): students will use computer tools for learning the process of programming an embedded control system based on a microcontroller. The learning will be continuous and from less to greater difficulty. Practical concepts, complementary to those seen in theory, will be studied.
- Monitoring sessions: They will be used for monitoring the students team work, clearing up some doubts and proposing some solutions or alternatives. In addition, documents and information are provided to assist students in the realisation of the electronic design of an embedded control system.
- Practical team project: In small groups, students will develop a design project of an embedded control system, based on some technical requirements and under the supervision of the teacher. They will apply knowledge learnt in theoretical and practical sessions and will develop their profession skills. The methodology will be based on **Project Based Learning (PBL)**, which is very appropriate for their formation and future work in a company. Periodically, a short progress report on the progress and partial results of the project is requested. On the other hand, students will make an oral presentation of the project and a practical demonstration of the system operation which must show that it fulfils the given requirements. Students will also deliver a technical report which summarizes the adopted solutions and a description of the development of the work. The project **can only be developed and evaluated in the ordinary call**.
- Exams and quizzes: students will do some different theoretical-practical tests throughout the semester, either some quizzes on the virtual campus and / or a written exam.

Learning outcomes

The expected learning outcomes (RA) are as follows:

- RA1 – Knowledge of basic concepts of digital computers architecture.
- RA2 – Knowledge and skills related to basic I/O programming techniques used in digital computers.
- RA3 – Knowledge of the fundamentals of microcontrollers and their basic architecture.
- RA4 – Knowledge and skills related to microcontroller programming in assembly language and the associated tools.
- RA5 – Knowledge and skills related to the fundamentals of designing embedded control systems based on microcontrollers.

Assessment systems

Assessment criteria:

- CR1 – To understand basic concepts of microcontrollers: basic architectures, I/O basic techniques, start-up, debugging, etc. (related to competences CG[1,3,5,7,8,11] and CT[1,7]).
- CR2 – To show skills for programming in assembly and C languages by using the software and hardware tools and the vendor MCU datasheets (related to competences CG[1,3,5,7,8,11], CT[1,4,5,7] and CETE[10]).
- CR3 – To show skills for understanding and carrying out design projects of embedded control systems based on MCUs (related to competences CG[1,2,4,6-8,11], CT[2,4,8,10], CETE[10] and **ENAAE transversal competences CTE[1,2,3]**).
- CR4 - To show skills for planning and allocating the tasks in a team work by presenting and submitting results and knowledge (related to competences CG[1,2,4,5,6,8-11], CT[2,3,5-9], CETE[10] and **ENAAE transversal competences CTE[1, 2]**).

Assessment activities:

Among the assessment activities included in the formative program, in this course the following are used:

	Range fixed	Ordinary call	Extraordinary call	Global assessment
1. Final exam and/or partial examinations.	0%–80%	15 % + 15 %	15 % + 60 %	50 %
2. Practical activities in: classroom, lab, computers room, visits, etc	0%–50%	25 %	25 %	50 %
3. Solution and submission of activities (cases, exercises, assignments, projects, etc.), individually and/or in groups	0%–50%	10 % + 35 %		
4. Active participation in the learning activities.	0%–10%			
5. Attendance to the learning activities.	0%–10%			

IMPORTANT NOTICE

*In order to make the most of the contents of the subject, it is recommended to have passed the following subjects: **Automatic Control, Digital Electronics and Power Electronic Systems.***

Description of the assessment activities:

CONTINUOUS EVALUATION (Ordinary Call)

Examination Activities of type 1:

- **Ordinary Activity 1 (OA1) – Quizzes of theoretical contents (CR[1,2])**
 - 15%. **Rating** from 0 to 10.
 - NOT RECOVERABLE and IT IS SAVED for the extraordinary call.
 - During the semester there will be several short quizzes on the virtual campus related to the contents of the units.
 - OA1 is calculated as the arithmetic mean of the quizzes grade.
- **Ordinary Activity 2 (OA2) – Oral defence and practical demonstration of team project (CR[3,4])**
 - 15%. **Rating** from 0 to 10.
 - NOT RECOVERABLE and NOT SAVED for the extraordinary call.
 - The students will present orally the results of the practical project carried out in a group. At any time, the teacher may ask related questions addressed to one or all members of the group.

Examination Activities of type 2:

- **Ordinary Activity 3 (OA3) – Laboratory Sessions (LABs) (CR[1,2])**
 - 25%. **Rating** from 0 to 10.
 - NOT RECOVERABLE and IT IS SAVED for the extraordinary call.
 - OA3 is calculated as the mean of the individual grades of each LAB, weighted by the **percentage of attendance (PA)**. Each LAB will be graded from 0 to 10, answering related questions through quizzes on the virtual campus. It is compulsory for the student to show the teacher that the practice works correctly; Otherwise, the individual grade will be 0, regardless of the grade of the quiz of the Virtual Campus.
Example:
LAB mean grade = 7; PA = 60%; OA3 = 7 x 0.6 = 4.2
 - The attendance control will be carried out by taking student signed or oral register in every laboratory session. The unsigned registers cannot be recovered.

Examination Activities of type 3:

- **Ordinary Activity 4 (OA4) – Delivery of project progress reports (CR[1-4])**
 - 10%. **Rating** from 0 to 10.
 - NOT RECOVERABLE and NOT SAVED for the extraordinary call.
 - Periodically, each working group will be asked to deliver on the virtual campus a small progress report indicating the progress, activities and partial results achieved so far, in order to evaluate the progress of the practical project.
- **Ordinary Activity 5 (OA5) – Delivery of the project final report (CR[1-4])**
 - 35%. **Rating** from 0 to 10.
 - NOT RECOVERABLE and NOT SAVED for the extraordinary call.
 - Students will submit a final report of the practical project, as well as the original source codes.

Final grade of the ordinary call (FGO)

- *It is compulsory to submit all reports (OA4) and to pass each of them (except 1st one) with a grade of at least 7. In case of not fulfilling this requirement, OA2 and OA5 rating will be graded as zero.*

The final grade is obtained as follows:

$$- \text{FGO} = 0,15 \cdot \text{OA1} + 0,15 \cdot \text{OA2} + 0,25 \cdot \text{OA3} + 0,10 \cdot \text{OA4} + 0,35 \cdot \text{OA5}$$

CONTINUOUS EVALUATION (Extraordinary Call)

In the extraordinary call, the saved grades of OA1 (quizzes) and OA3 (LABs) are used. In addition, the following activity must be carried out:

Examination Activity of type 1:

- **Extraordinary Activity 1 (XA1) – Exam of theoretical contents (CR[1,2])**
 - 60%. **Rating** from 0 to 10. Minimum rating 4. If rating is lower than 4, XA1 = 0.

Final grade of the extraordinary call (FGX)

The final grade is obtained as follows:

$$- \text{FGX} = 0,15 \cdot \text{OA1} + 0,60 \cdot \text{XA1} + 0,25 \cdot \text{OA3}$$

GLOBAL EVALUATION

The global evaluation test shall consist of the following parts:

Examination Activity of type 1:

- **Global Activity 1 (GA1) – Exam with contents related to theory and practice (CR[1,2])**
 - 50%. **Rating** from 0 to 10. Minimum rating 5. If rating is lower than 5, GA1 = 0.

Examination Activity of type 2:

- **Global Activity 2 (GA2) – Practical exam with the laboratory equipment (CR[1,2])**
 - 50%. **Rating** from 0 to 10. Minimum rating 5. If rating is lower than 5, GA2 = 0.

Final Grade of Global Evaluation (FGG)

The final grade is obtained as follows:

$$- \text{FGG} = 0,5 \cdot \text{GA1} + 0,5 \cdot \text{GA2}$$

Bibliography (basic and complementary)

Basic Bibliography:

- [B1] Subject slides and resources (*available on the virtual campus*) and notes taken in class.
- [B2] Vendor MCU datasheets and help documents (*available on the virtual campus*).

Complementary Bibliography:

- [C1] T. Wilmshurst, "Designing Embedded Systems with PIC Microcontrollers", Newnes (2010). (*Available as an electronic resource at the UEx Library Service*).
- [C2] G.F. Franklin, J. D. Powell, A. Emami-Naeini, "Feedback Control of Dynamics Systems" (7th Ed.), Pearson, 2014. (*Previous versions available at the School Library and at the Central Library of the Badajoz campus*).
- [C3] M. Etxeberria Isuskiza, "Microcontroladores PIC: teoría y práctica", Creaciones Copyright (2011). (*Available at the Central Library of the Badajoz campus*).
- [C4] J. M. Angulo Usategui, S. Romero Yesa, I. Angulo Martínez, "Microcontroladores PIC. Diseño Práctico de Aplicaciones (2ª parte)", McGraw-Hill Interamericana (2006). (*Available at the School Library and at the Central Library of the Badajoz campus*).
- [C5] G. Sen Gupta, S. Chandra Mukhopadhyay, "Embedded Microcontroller Interfacing", Springer Berlin Heidelberg (2010). (*Available as an electronic resource at the UEx Library Service*).
- [C6] B. Borowik, "Interfacing PIC Microcontrollers to Peripheral Devices", Springer Netherlands (2011). (*Available as an electronic resource at the UEx Library Service*).

Other resources and complementary educational materials

- **Microchip Developer Help** (<https://www.microchip.com/en-us/education/developer-help>). Resources, tutorials and courses from the vendor to get started with its SW and HW tools for the design of embedded systems based on its microcontrollers.