

**1. General information****Course:** MICROPROCESSOR-BASED SYSTEM DESIGN**Code:** 42335**Type:** CORE COURSE**ECTS credits:** 6**Degree:** 347 - DEGREE PROGRAMME IN COMPUTER SCIENCE ENGINEERING (CR)**Academic year:** 2022-23**Center:** 108 - SCHOOL OF COMPUTER SCIENCE OF C. REAL**Group(s):** 20**Year:** 3**Duration:** C2**Main language:** Spanish**Second language:** English**Use of additional languages:****English Friendly:** Y**Web site:** <https://campusvirtual.uclm.es>**Bilingual:** N**Lecturer:** JULIAN CABA JIMENEZ - Group(s): 20

| Building/Office | Department | Phone number | Email | Office hours |
|-----------------|---------------------------------------|--------------|---------------------|--|
| 3.05 | TECNOLOGÍAS Y SISTEMAS DE INFORMACIÓN | 6725 | julian.caba@uclm.es | Available at https://esi.uclm.es/index.php/grado-en-ingenieria-informatica/profesorado/ |

2. Pre-Requisites

This subject is based on the skills and knowledge acquired in the subjects:

- Computer Structure
- Computer Technology
- Computer Organization

3. Justification in the curriculum, relation to other subjects and to the profession

This subject begins from the subjects "*Computer Structure*" and "*Computer Technology*" and develops the ability to design systems based on microcontrollers and microprocessors, and the subject "*Embedded Systems*" complements this subject.

4. Degree competences achieved in this course**Course competences**

| Code | Description |
|-------|--|
| IC01 | Ability to design and build digital systems, including computers, based on microprocessors and communication systems. |
| IC02 | Ability to develop specific processors and embedded systems, along with the development and optimization of software in such systems. |
| IC05 | Ability to analyse, assess, and select the most adequate hardware and software platforms for the support of embedded and real time applications. |
| IC07 | Ability to analyse, assess, select, and set up hardware platforms for the development and execution of applications and digital systems. |
| INS02 | Organising and planning skills. |
| INS04 | Problem solving skills by the application of engineering techniques. |
| PER02 | Ability to work in multidisciplinary teams. |
| PER04 | Interpersonal relationship skills. |
| PER05 | Acknowledgement of human diversity, equal rights, and cultural variety. |
| SIS01 | Critical thinking. |
| SIS03 | Autonomous learning. |
| SIS05 | Creativity. |

5. Objectives or Learning Outcomes**Course learning outcomes****Description**

Ability to analyze, evaluate and select the most appropriate hardware platform based on the specific environment in which it is to be implemented.

Ability to recognize different types of parallel architectures.

Ability to design and build digital systems, as well as to develop and optimize software for such systems.

Ability to size and integrate systems using the most appropriate hardware and software platforms for the development and execution of computer applications and services.

Ability to use and correctly program multiprocessor architectures.

6. Units / Contents**Unit 1: Microcontrollers and Microprocessors****Unit 1.1** Introduction**Unit 1.2** Cortex-M Family Processors and STM32-F411RE**Unit 2: Basics of Embedded Software**

- Unit 2.1** Basics of Software Concurrency
- Unit 2.2** Exceptions and Interrupts
- Unit 2.3** Task Scheduling: a freeRTOS approach

Unit 3: Peripherals

- Unit 3.1** GPIO
- Unit 3.2** Watchdog and Timers
- Unit 3.3** Analog Interfacing
- Unit 3.4** Serial Communication
- Unit 3.5** DMA: Direct Memory Access
- Unit 3.6** FPU: Float-Point Unit

Unit 4: Communication Protocols

- Unit 4.1** MQTT: Message Queue Telemetry Transport

ADDITIONAL COMMENTS, REMARKS

The laboratory part is divided into labs that have an incremental character except the first one. In the labs we are going to use STM32-F411RE (Cortex-M4) and ESP-WROOM-32 (ESP32) boards.

- **Lab 1:** *Blinking LEDs (use of registers)*
- **Lab 2:** *Moore FSM*
- **Lab 3:** *Interrupts*
- **Lab 4:** *Timers*
- **Lab 5:** *PWM*
- **Lab 6:** *Serial Communications - Bluetooth and I2C*
- **Lab 7:** *MQTT - ESP32*

7. Activities, Units/Modules and Methodology

| Training Activity | Methodology | Related Competences (only degrees before RD 822/2021) | ECTS | Hours | As | Com | Description |
|--|--------------------------------------|---|----------|------------|----|-----|--|
| Class Attendance (theory) [ON-SITE] | Lectures | IC01 IC02 IC05 IC07 | 0.6 | 15 | N | - | Teaching of the subject matter by lecturer (MAG) |
| Individual tutoring sessions [ON-SITE] | Lectures | IC01 IC02 IC05 IC07 | 0.18 | 4.5 | N | - | Individual or small group tutoring in lecturer's office, classroom or laboratory (TUT) |
| Study and Exam Preparation [OFF-SITE] | Self-study | IC01 IC02 IC05 IC07 | 1.8 | 45 | N | - | Self-study (EST) |
| Other off-site activity [OFF-SITE] | Practical or hands-on activities | IC01 IC02 IC05 IC07 INS02 INS04 PER02 PER04 PER05 SIS01 SIS03 SIS05 | 0.9 | 22.5 | N | - | Lab practical preparation (PLAB) |
| Problem solving and/or case studies [ON-SITE] | Project/Problem Based Learning (PBL) | IC01 IC02 IC05 IC07 INS02 INS04 PER02 PER04 PER05 SIS01 SIS03 SIS05 | 0.6 | 15 | Y | Y | Worked example problems and cases resolution by the lecturer and the students (PRO) |
| Writing of reports or projects [OFF-SITE] | Self-study | IC01 IC02 IC05 IC07 INS02 INS04 PER02 PER04 PER05 SIS01 SIS03 SIS05 | 0.9 | 22.5 | Y | N | Preparation of essays on topics proposed by lecturer (RES) |
| Laboratory practice or sessions [ON-SITE] | Practical or hands-on activities | IC01 IC02 IC05 IC07 INS02 INS04 PER02 PER04 PER05 SIS01 SIS03 SIS05 | 0.72 | 18 | Y | Y | Realization of practicals in laboratory/computing room (LAB) |
| Final test [ON-SITE] | Assessment tests | IC01 IC02 IC05 IC07 INS02 INS04 SIS01 SIS05 | 0.3 | 7.5 | Y | Y | Partial test 1 of the first half of the syllabus of the subject (EVA) |
| Total: | | | 6 | 150 | | | |
| Total credits of in-class work: 2.4 | | | | | | | Total class time hours: 60 |
| Total credits of out of class work: 3.6 | | | | | | | Total hours of out of class work: 90 |

As: Assessable training activity

Com: Training activity of compulsory overcoming (It will be essential to overcome both continuous and non-continuous assessment).

8. Evaluation criteria and Grading System

| Evaluation System | Continuous assessment | Non-continuous evaluation* | Description |
|---|-----------------------|----------------------------|--|
| Assessment of active participation | 10.00% | 10.00% | Non-compulsory activity that can be retaken. To be carried out in the theory/laboratory sessions for the students of the continuous assessment mode. The students of non-continuous modality will be evaluated of this activity through an alternative method. [EVA] |
| Final test | 40.00% | 40.00% | Compulsory activity that can be retaken (rescheduling) to be carried out within the planned exam dates of the final exam call (convocatoria ordinaria). [EVA] [RES] |
| Assessment of problem solving and/or case studies | 25.00% | 25.00% | Non-compulsory activity that can be retaken. To be carried out before end of teaching period [EVA] [PRO] |
| Laboratory sessions | 25.00% | 25.00% | Compulsory activity that can be retaken. To be carried out during lab sessions [LAB] |
| Total: | 100.00% | 100.00% | |

According to art. 4 of the UCLM Student Evaluation Regulations, it must be provided to students who cannot regularly attend face-to-face training activities the passing of the subject, having the right (art. 12.2) to be globally graded, in 2 annual calls per subject, an ordinary and an extraordinary one (evaluating 100% of the competences).

Evaluation criteria for the final exam:

Continuous assessment:

In compulsory activities, a minimum mark of 40% is required in order to pass that activity and have the possibility to therefore pass the entire subject. The evaluation of the activities will be global and therefore must be quantified by means of a single mark. In the case of the activities that may be retaken (i.e., rescheduling), an alternative activity or test will be offered in the resit/retake exam call (convocatoria extraordinaria).

The final exam will be common for all the theory/laboratory groups of the subject and will be evaluated by the lecturers of the subject in a serial way, i.e., each part of the final exam will be evaluated by the same lecturer for all the students.

A student is considered to pass the subject if she/he obtains a minimum of 50 points out of 100, taking into account the points obtained in all the evaluable activities, and also has passed all the compulsory activities.

For students who do not pass the subject in the final exam call (convocatoria ordinaria), the marks of activities already passed will be conserved for the resit/retake exam call (convocatoria extraordinaria). If an activity is not recoverable, its assessment will be preserved for the resit/retake exam call (convocatoria extraordinaria) even if it has not been passed. In the case of the passed recoverable activities, the student will have the opportunity to receive an alternative evaluation of those activities in the resit/retake exam call and, in that case, the final grade of the activity will correspond to the latter grade obtained.

The mark of the passed activities in any call, except for the final exam, will be conserved for the subsequent academic year at the request of the student, provided that mark is equal or greater than 50% and that the activities and evaluation criteria of the subject remain unchanged prior to the beginning of that academic year.

The failure of a student to attend the final exam will automatically result in her/him receiving a "Failure to attend" (no presentado). If the student has not passed any compulsory evaluation activity, the maximum final grade will be 40%.

Non-continuous evaluation:

Students may apply at the beginning of the semester for the non-continuous assessment mode. In the same way, the student may change to the non-continuous evaluation mode as long as she/he has not participated during the teaching period in evaluable activities that together account for at least 50% of the total mark of the subject. If a student has reached this 50% of the total obtainable mark or the teaching period is over, she/he will be considered in continuous assessment without the possibility of changing to non-continuous evaluation mode.

Students who take the non-continuous evaluation mode will be globally graded, in 2 annual calls per subject, an ordinary and an extraordinary one (evaluating 100% of the competences), through the assessment systems indicated in the column "Non-continuous evaluation".

In the "non-continuous evaluation" mode, it is not compulsory to keep the mark obtained by the student in the activities or tests (progress test or partial test) taken in the continuous assessment mode.

Specifications for the resit/retake exam:

Evaluation tests will be conducted for all recoverable activities.

Specifications for the second resit / retake exam:

Same characteristics as the resit/retake exam call.

| 9. Assignments, course calendar and important dates | |
|--|-------|
| Not related to the syllabus/contents | |
| Hours | hours |
| General comments about the planning: The subject is taught in 3 x 1,5 hour sessions per week. | |
| Unit 1 (de 4): Microcontrollers and Microprocessors | |
| Activities | Hours |
| Class Attendance (theory) [PRESENCIAL][Lectures] | 2 |
| Individual tutoring sessions [PRESENCIAL][Lectures] | .5 |
| Study and Exam Preparation [AUTÓNOMA][Self-study] | 11 |
| Other off-site activity [AUTÓNOMA][Practical or hands-on activities] | 3 |
| Writing of reports or projects [AUTÓNOMA][Self-study] | 3 |
| Laboratory practice or sessions [PRESENCIAL][Practical or hands-on activities] | 3 |
| Final test [PRESENCIAL][Assessment tests] | 2 |
| Teaching period: 2 weeks | |
| Unit 2 (de 4): Basics of Embedded Software | |
| Activities | Hours |
| Class Attendance (theory) [PRESENCIAL][Lectures] | 4 |
| Individual tutoring sessions [PRESENCIAL][Lectures] | 1 |
| Study and Exam Preparation [AUTÓNOMA][Self-study] | 12 |
| Other off-site activity [AUTÓNOMA][Practical or hands-on activities] | 4 |
| Problem solving and/or case studies [PRESENCIAL][Project/Problem Based Learning (PBL)] | 4.5 |
| Writing of reports or projects [AUTÓNOMA][Self-study] | 4.5 |
| Laboratory practice or sessions [PRESENCIAL][Practical or hands-on activities] | 4.5 |
| Final test [PRESENCIAL][Assessment tests] | 3 |
| Unit 3 (de 4): Peripherals | |
| Activities | Hours |
| Class Attendance (theory) [PRESENCIAL][Lectures] | 6 |
| Individual tutoring sessions [PRESENCIAL][Lectures] | 2 |
| Study and Exam Preparation [AUTÓNOMA][Self-study] | 18 |
| Other off-site activity [AUTÓNOMA][Practical or hands-on activities] | 11.5 |
| Problem solving and/or case studies [PRESENCIAL][Project/Problem Based Learning (PBL)] | 9 |

| | |
|--|-----------------------------|
| Writing of reports or projects [AUTÓNOMA][Self-study] | 12.5 |
| Laboratory practice or sessions [PRESENCIAL][Practical or hands-on activities] | 9 |
| Final test [PRESENCIAL][Assessment tests] | 1.5 |
| Group 20: | |
| Initial date: 08-03-2022 | End date: 24-04-2022 |
| Unit 4 (de 4): Communication Protocols | |
| Activities | Hours |
| Class Attendance (theory) [PRESENCIAL][Lectures] | 3 |
| Individual tutoring sessions [PRESENCIAL][Lectures] | 1 |
| Study and Exam Preparation [AUTÓNOMA][Self-study] | 4 |
| Other off-site activity [AUTÓNOMA][Practical or hands-on activities] | 4 |
| Problem solving and/or case studies [PRESENCIAL][Project/Problem Based Learning (PBL)] | 1.5 |
| Writing of reports or projects [AUTÓNOMA][Self-study] | 2.5 |
| Laboratory practice or sessions [PRESENCIAL][Practical or hands-on activities] | 1.5 |
| Final test [PRESENCIAL][Assessment tests] | 1 |
| Teaching period: 2 weeks | |
| Global activity | |
| Activities | hours |
| Individual tutoring sessions [PRESENCIAL][Lectures] | 4.5 |
| Class Attendance (theory) [PRESENCIAL][Lectures] | 15 |
| Study and Exam Preparation [AUTÓNOMA][Self-study] | 45 |
| Other off-site activity [AUTÓNOMA][Practical or hands-on activities] | 22.5 |
| Problem solving and/or case studies [PRESENCIAL][Project/Problem Based Learning (PBL)] | 15 |
| Writing of reports or projects [AUTÓNOMA][Self-study] | 22.5 |
| Laboratory practice or sessions [PRESENCIAL][Practical or hands-on activities] | 18 |
| Final test [PRESENCIAL][Assessment tests] | 7.5 |
| Total horas: 150 | |

| 10. Bibliography and Sources | | | | | | |
|------------------------------|---|-------------------|------|-------------------|------|-------------|
| Author(s) | Title/Link | Publishing house | Citv | ISBN | Year | Description |
| A.K. Ganguly | Embedded Systems: Design, Programming and Applications | | | 978-1-84265-782-9 | 2014 | |
| Joseph Yiu | The Definitive Guide to ARM Cortex-M3 and Cortex-M4 Processors | Elsevier | | 978-0-12-408082-9 | 2014 | |
| Alexander G. Dean | Embedded Systems Fundamentals with ARM Cortex-M based Microcontrollers | ARM | | 978-1911531036 | 2017 | |
| Angulo y otros | Microcontroladores PIC, Diseño Práctico de Aplicaciones | Mc Graw-Hill | | | | |
| Yifeng Zhu | Embedded Systems with ARM Cortex-M3 Microcontrollers in Assembly Language and C | E-Man Press | | 978-0982692622 | 2014 | |
| Elliot Williams | Make: AVR Programming | Maker Media, Inc. | | 978-1-4493-5578-4 | 2014 | |
| Richard Barry | Using the FreeRTOS Real Time Kernel | | | | 2009 | |