ANX-PR/CL/001-01

LEARNING GUIDE

SUBJECT

593000503 - Sensor Networks

DEGREE PROGRAMME

59AH - Master Universitario En Internet Of Things (iot)

ACADEMIC YEAR & SEMESTER

2022/23 - Semester 1

Index

Learning guide

1. Description

1.1. Subject details

Name of the subject	593000503 - Sensor Networks
No of credits	4.5 ECTS
Type	Compulsory
Academic year ot the programme	First year
Semester of tuition	Semester 1
Tuition period	September-January
Tuition languages	English
Degree programme	59AH - Master Universitario en Internet Of Things (Iot)
Centre	59 - Escuela Tecnica Superior De Ingenieria Y Sistemas De Telecomunicacion
Academic year	2022-23

2. Faculty

2.1. Faculty members with subject teaching role

Name and surname	Office/Room	Email	Tutoring hours *
Fco. Javier Ramirez Ledesma (Subject coordinator)	A4410	javier.ledesma@upm.es	Sin horario. TBD
Eduardo Juarez Martinez	A4204	eduardo.juarez@upm.es	Sin horario. TBD

Pedro Jose Lobo Perea	A4202	pedro.lobo@upm.es	Sin horario. TBD
Jesus Rodriguez Molina	A4415	jesus.rodriguezm@upm.es	Sin horario. TBD

* The tutoring schedule is indicative and subject to possible changes. Please check tutoring times with the faculty member in charge.

3. Prior knowledge recommended to take the subject

3.1. Recommended (passed) subjects

- Embedded Platforms And Communications For Iot

3.2. Other recommended learning outcomes

- Programming and debugging using the C++ or Java language

4. Skills and learning outcomes *

4.1. Skills to be learned

CB06 - Poseer y comprender conocimientos que aporten una base u oportunidad de ser originales en el desarrollo y/o aplicación de ideas, a menudo en un contexto de investigación

CB10 - Que los estudiantes posean las habilidades de aprendizaje que les permitan continuar estudiando de un modo que habrá de ser en gran medida autodirigido o autónomo.

CE.02 - Diseñar y desarrollar redes de sensores integrando nodos heterogéneos con diferentes sistemas de comunicación inalámbricas para desarrollar aplicaciones IoT

CE.03 - Programar dispositivos móviles en diferentes escenarios de aplicación en IoT en las que se recopilan datos del entorno a través de los sensores integrados en los dispositivos móviles.

CE.13 - Analizar el uso de dispositivos y servicios IoT en dominios de aplicación específicos y seleccionar los dispositivos más adecuados para el ecosistema IoT

CG01 - Los alumnos demostrarán tener una visión del estado actual, las necesidades y los problemas que se plantean en el mundo de la IoT, así como de las arquitecturas y estándares más utilizados

CG02 - Los alumnos serán capaces de aplicar métodos y tecnologías avanzadas que les permitan abordar necesidades y problemas en aplicaciones IoT

CT.01 - Capacidad de uso de la lengua inglesa para el trabajo en contextos internacionales

CT.02 - Capacidad para el trabajo en grupo y dirigir, organizar y supervisar equipos multidisciplinares.

4.2. Learning outcomes

RA39 - To combine the development tools for the integration of the components of a sensor network in IoT environments

RA37 - To build custom sensor nodes tailored to the processing requirements/needs of a given problem.

RA38 - To establish the criteria for the selection and integration into a hardware platform of the required wireless technologies and communication protocols for building IoT applications

* The Learning Guides should reflect the Skills and Learning Outcomes in the same way as indicated in the Degree Verification Memory. For this reason, they have not been translated into English and appear in Spanish.

5. Brief description of the subject and syllabus

5.1. Brief description of the subject

A sensor network is composed of several sensor nodes that communicate among them to build up homogeneous or heterogeneous networks, aiming at sensing information and acting accordingly in a wide physical environment. This course tackles the configuration and implementation of this type of networks, studying the most common technologies, protocols and architectures used. To do so, the building process of custom, high-performance sensor nodes and advanced wireless technologies for IoT are analyzed, considering performance and power consumption factors.

5.2. Syllabus

1. General Communication Model Introduction
   1.1. Context description
   1.2. Challenges
   1.3. Existing models
   1.4. Communications commercial IoT solutions overview
2. Low-power wide-area wireless communications
   2.1. Lora/LoraWAN
   2.2. Sigfox
   2.3. Others (LTE-MTC, NB-IoT, Weightless SIG...)
3. Network interoperability
   3.1. Interoperability models.
   3.2. Gateways
4. Short-range wireless communications
   4.1. IEEE 802.15.4, ZigBee, 6LoWPAN, routing protocols (RPL, AODV)
   4.2. Others (Bluetooth LE,...)
5. Sensor networks practical design methodology
   5.1. Processing requirements
   5.2. Node type, platform and network selection
   5.3. Interoperability requirements
   5.4. Development and test tools
6. Project 1. Embedded wireless sensor design and integration use case
7. Project 2. Short-range wireless communications and interoperability use case

6. Schedule

6.1. Subject schedule*

Week	Classroom activities	Laboratory activities	Distant / On-line	Assessment activities
1	**Lesson1. General Communication Model Introduction** Duration: 02:00 **Lesson 2. Low-power wide-area wireless communications** Duration: 03:00	**Project 1. Embedded wireless sensor design and integration use case** Duration: 02:00		
2	**Lesson 3. Network interoperability** Duration: 02:00	**Project 1. Embedded wireless sensor design and integration use case** Duration: 01:30		
3		**Project 1. Embedded wireless sensor design and integration use case** Duration: 07:00		
4	**Lesson 4. Sort-range wireless communications** Duration: 03:00			**Multiple Choice Test 1** Continuous assessment Presential Duration: 00:30 **Project 1. Embedded wireless sensor design and integration use case assessment** Continuous assessment Presential Duration: 03:30
5	**Lesson 4. Sort-range wireless communications** Duration: 02:00	**Project 2. Short-range wireless communications and interoperability use case assessment** Duration: 03:30		
6	**Lesson 5. Sensor networks practical design methodology** Duration: 01:30	**Project 2. Short-range wireless communications and interoperability use case assessment** Duration: 04:00		
7		**Project 2. Short-range wireless communications and interoperability use case assessment** Duration: 03:30		

8		**Project 2. Short-range wireless communications and interoperability use case assessment** Duration: 01:30		**Challenge/Use case design. Non-retakeable assessment.** Continuous assessment Presential Duration: 02:00
9		**Project 2. Short-range wireless communications and interoperability use case assessment** Duration: 01:00		**Project 2. Short-range wireless communications and interoperability use case assessment. Design, development and deployment of a sensors network.** Continuous assessment Presential Duration: 03:00 **Multiple Choice Test 2** Continuous assessment Presential Duration: 00:30
10				
11				
12				
13				
14				
15				
16				
17				

Depending on the programme study plan, total values will be calculated according to the ECTS credit unit as 26/27 hours of student face-to-face contact and independent study time.

* The schedule is based on an a priori planning of the subject; it might be modified during the academic year, especially considering the COVID19 evolution.

7. Activities and assessment criteria

7.1. Assessment activities

7.1.1. Assessment

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
4	Multiple Choice Test 1		Face-to-face	00:30	9%	0 / 10	CT.01 CE.13 CB10 CG01
4	Project 1. Embedded wireless sensor design and integration use case assessment		Face-to-face	03:30	35%	5 / 10	CT.01 CT.02 CE.13 CB10 CE.03 CG01 CB06 CG02 CE.02
8	Challenge/Use case design. Non-retakeable assessment.		Face-to-face	02:00	10%	5 / 10	CT.01 CT.02 CE.13 CB10 CG01 CG02
9	Project 2. Short-range wireless communications and interoperability use case assessment. Design, development and deployment of a sensors network.		Face-to-face	03:00	35%	5 / 10	CE.13 CB10 CE.03 CG01 CB06 CG02 CE.02 CT.01 CT.02
9	Multiple Choice Test 2		Face-to-face	00:30	11%	0 / 10	CB10 CG01 CT.01 CE.13

7.1.2. Global examination

No se ha definido la evaluacion sólo por prueba final.

7.1.3. Referred (re-sit) examination

Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
Course projects exam		Face-to-face	04:00	70%	5 / 10	CT.01 CT.02 CE.13 CB10 CE.03 CG01 CB06 CG02 CE.02
Multiple choice exam		Face-to-face	01:00	20%	0 / 10	CT.01 CE.13 CB10 CG01

7.2. Assessment criteria

The final mark for each student in this course will be a number between 0 and 10 points. The course is passed if the mark is equal or above 5 points.

Continuous Assessment

The continuous assessment will be carried out based in the following components:

- Two multiple choice exams, Test 1 and Test 2, evaluating:
  - Test 1: Lessons 1, 2 and 3 and the preliminary concepts used in Project 1.
  - Test 2: Lessons 4 and 5 and the preliminary concepts used in Project 2.

- Two projects:
  - Project 1: Embedded wireless sensor design and integration use case. Students will have to integrate the Platform use case developed in the subject Embedded Platforms and Communications for IoT in the previous two-month period.
  - Project 2: Short-range wireless communications and interoperability use case. Students are going to develop and deploy a sensors network.
- A "challenge/use case design". This component consists of a work in group, and is going to be presented and discussed in class.

The course grade will be composed of the following elements:

- Multiple choice exams: 20% (2 points)
    - Test 1: 9% (0.9 points)
    - Test 2: 11% (1.1 points)

- Assessment of the course Projects: 70% (7 points)
    - Project 1: 35% (3.5 points)
    - Project 2: 35% (3.5 points)
- A challenge/use-case design: 10% (1 point). This component is carried out in group work mode and will be presented and discussed in class. Some aspects presented by the students could be included as questions in test 2. Due to its characteristics, **this assessment cannot be retaken**. If it is not taken on the scheduled date, students will be marked out of 9.0 points in the ordinary and extraordinary assessment.

Global examination

- **Ordinary**

- In addition to the assessmentof test 2 and project 2 which, together with the previosly obtained grade from 'Challenge/use-case design' (non-retakeable) assessment, account for more than 51% of the grade for the course, the assessment of project 1 can be made up, as this assessment requires a minimum grade**.**

- **Extraordinary**

The final extraordinary examination will consist of the following components:

- Course projects exam: it is a practical exam of the two developed projects.
- A multiple choice exam, evaluating all the contents of the two continuous assessment multiple choice tests (Test 1 and Test 2). It may also include questions related to the contents exposed/discussed at the

challenge/use-case design assessment.

The grade will be composed of the following elements:

- Course projects exam: 70% (7 points)
- Multiple choice exam: 20% (2 points)
- Challenge/use-case design assesment (non-retakeable assessment: obtained on the day scheduled for this assessment): 10% (1 point).

8. Teaching resources

8.1. Teaching resources for the subject

Name	Type	Notes
Personal computer	Equipment	Personal computer with Internet connection for carrying out practical exercises.
Subject Moodle based web site	Web resource	UPM web site based on Moodle where short technical documents, bibliographic resources, practical exercises instructions and subject slides will be published. Several educational forums will be also available for discussions.
Networked sensors (IoT Platform)	Equipment	The sensors and communication platform previously studied in the subjects "Embedded systems and IoT devices"
Perry Lea. Internet of Things for Architects	Bibliography	Perry Lea, Internet of Things for Architects. Packt Publishing Ltd. 2018
David Hanes et al. "IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things".	Bibliography	David Hanes et al. "IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things". Cisco Press. 2017

Libelium Waspmote node, and sensors, and communication modules	Equipment	Equipment used in Project 2. http://www.libelium.com/products/waspmote/
Designing Embedded Systems and the Internet of Things (IoT) with the ARM mbed. Perry Xiao	Bibliography	Designing Embedded Systems and the Internet of Things (IoT) with the ARM mbed. Perry Xiao. 2018 First Edition. ISBN: 978-1119364047

9. Other information

9.1. Other information about the subject

The information contained in this document is of an orientative nature. Thus, it is subject to change due to errors, omissions or if the circumstances occurring during the course duration advise to do so.

Publication of the solutions to the assessment tests

The solutions to the theoretical tests will not be published, as this part of the exams is based on a bank of questions (which is revised each year) and each student may receive different questions. Therefore, it is not feasible to publish the solution of this part of the exam, as it may be different for each student. The solution of the laboratory practicals will not be published, since the practicals are usually used for several consecutive courses, and the publication of a reference solution would most likely negatively affect the performance of the students in subsequent years. In any case, any interested student can consult and obtain feedback on the solution of any part of his or her exam or specific practical work, either in personal tutorials or in the exam revision process.