



INTERNATIONAL  
CAMPUS OF  
EXCELLENCE

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LEARNING ACTIVITIES  
PR/CL/001



E.T.S. de Ingeniería y Sistemas  
de Telecomunicación

# ANX-PR/CL/001-01

## LEARNING GUIDE

### SUBJECT

**595310047 - Embedded Systems Design Raspberry Pi**

### DEGREE PROGRAMME

59ET - Doble Grado en Ing.electrónica de Comunicaciones y en Ing.telemática

### ACADEMIC YEAR & SEMESTER

2020/21 - Semester 2

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## 1. Description

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### 1.1. Subject details

<b>Name of the subject</b>	595310047 - Embedded Systems Design Raspberry Pi
<b>No of credits</b>	4.5 ECTS
<b>Type</b>	Optional
<b>Academic year of the programme</b>	Fifth year
<b>Semester of tuition</b>	Semester 10
<b>Tuition period</b>	February-June
<b>Tuition languages</b>	English
<b>Degree programme</b>	59ET - Doble Grado en Ing.electronica de Comunicaciones y en Ing.telematica
<b>Centre</b>	59 - Escuela Tecnica Superior de Ingenieria y Sistemas de Telecomunicacion
<b>Academic year</b>	2020-21

## 2. Faculty

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### 2.1. Faculty members with subject teaching role

<b>Name and surname</b>	<b>Office/Room</b>	<b>Email</b>	<b>Tutoring hours *</b>
Mariano Ruiz Gonzalez	A4206	mariano.ruiz@upm.es	Sin horario.
Sergio Esquembri Martinez (Subject coordinator)	A4206	s.esquembri@upm.es	Sin horario.

\* 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

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#### 3.1. Recommended (passed) subjects

The subject - recommended (passed), are not defined.

#### 3.2. Other recommended learning outcomes

- Basic computer networks knowledge

### 4. Skills and learning outcomes \*

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#### 4.1. Skills to be learned

CE EC01 - Capacidad de construir, explotar y gestionar sistemas de captación, transporte, representación, procesado, almacenamiento, gestión y presentación de información multimedia, desde el punto de vista de los sistemas electrónicos.

CE EC03 - Capacidad de realizar la especificación, implementación, documentación y puesta a punto de equipos y sistemas, electrónicos, de instrumentación y de control, considerando tanto los aspectos técnicos como las normativas reguladoras correspondientes.

CE EC04 - Capacidad para aplicar la electrónica como tecnología de soporte en otros campos y actividades, y no sólo en el ámbito de las Tecnologías de la Información y las Comunicaciones.

CE EC05 - Capacidad de diseñar circuitos de electrónica analógica y digital, de conversión analógico-digital y digital-analógica, de radiofrecuencia, de alimentación y conversión de energía eléctrica para aplicaciones de telecomunicación y computación.

CE EC07 - Capacidad para diseñar dispositivos de interfaz, captura de datos y almacenamiento, y terminales para servicios y sistemas de telecomunicación.

CE EC08 - Capacidad para especificar y utilizar instrumentación electrónica y sistemas de medida.

CG 02 - Capacidad de búsqueda y selección de información, de razonamiento crítico y de elaboración y defensa de argumentos dentro del área.

CG 03 - Capacidad para expresarse correctamente de forma oral y escrita y transmitir información mediante documentos y exposiciones en público.

CG 04 - Capacidad de abstracción, de análisis y de síntesis y de resolución de problemas.

## 4.2. Learning outcomes

RA492 - Conectar un circuito electrónico básico en uno de los interfaces digitales de la RaspBerry PI.

RA487 - Identificar la funcionalidad de cada uno de los interfaces digitales y analógicos que incluye la RaspBerry-PI.

RA489 - Conocer los elementos integrantes de una distribución de Linux para un sistema empujado.

RA495 - Redactar documentos técnicos presentando los pasos seguidos y las conclusiones obtenidas en la realización de una aplicación.

RA493 - Desarrollar una aplicación software básica utilizando los interfaces de la RaspBerry PI.

RA494 - Presentar y defender en público propuestas técnicas para resolver problemas.

RA491 - Documentar el desarrollo de una aplicación con RaspBerry-PI y presentarla en público.

RA488 - Instalar un sistema operativo Linux y aplicaciones software en la RaspBerry Pi.

RA490 - Configurar y construir una distribución del sistema operativo Linux utilizando la herramienta Buildroot para la plataforma RaspBerry-PI.

RA486 - Conocer las características hardware básicas de un sistema electrónico embebido como la RaspBerry PI basado en un System On Chip

\* 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

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### 5.1. Brief description of the subject

Embedded Systems Design with Raspberry Pi is a sixth-semester elective course for the Communications Electronics Engineering B. Eng. program. This course introduces the students to the use of embedded electronic systems for practical application development. During the course, students will learn to develop and embed their own Linux-based operating system in a very low-cost embedded system like the Raspberry Pi. The course is organized as laboratory assignments introduced by theory lessons. The laboratory assignments are designed to emphasize application development and integration skills, as well as the presentation of results in an oral and written manner.

### 5.2. Syllabus

1. Introduction to Raspberry Pi: Architecture and hardware resources
2. Raspberry Pi Linux Application development
  - 2.1. Raspberry Pi Operating System installation
  - 2.2. Linux basic use tutorial
  - 2.3. (Optional) Install and configure Ubuntu Virtual Machine
  - 2.4. Connecting sensors and actuators to Raspberry Pi
  - 2.5. C application development for Raspberry Pi
3. Generation of custom embedded Linux systems
  - 3.1. Embedded Linux System Fundamentals
  - 3.2. Embedded Linux System generation tools: Buildroot
4. Embedded Linux Application development
  - 4.1. Environment configuration for remote connection, development, deployment, testing, and debug
5. IoT Application development using Raspberry Pi and Embedded Linux
  - 5.1. IoT fundamentals: Protocols and use cases
  - 5.2. Raspberry Pi for IoT

## 6. Schedule

### 6.1. Subject schedule\*

Week	Face-to-face classroom activities	Face-to-face laboratory activities	Distant / On-line	Assessment activities
1	<p><b>Course presentation</b> Duration: 01:00</p> <p><b>Introduction to Raspberry Pi: Architecture and hardware resources Raspberry Pi Operating System Installation</b> Duration: 02:00</p>			
2	<p><b>Linux basic use tutorial</b> Duration: 00:30</p> <p><b>Connecting Sensors and actuators to Raspberry Pi</b> Duration: 00:30</p>	<p><b>Raspberry Pi Operating System Installation</b> Duration: 00:30</p> <p><b>C application development for Raspberry Pi</b> Duration: 01:30</p>		
3		<p><b>C application development for Raspberry Pi</b> Duration: 03:00</p>		
4		<p><b>Raspberry Pi Linux Application Development: Result presentation and alumni knowledge sharing</b> Duration: 03:00</p>		
5	<p><b>Embedded Linux System Fundamentals</b> Duration: 03:00</p>			
6	<p><b>Embedded Linux System Generation Tools: Buildroot</b> Duration: 01:30</p>	<p><b>Tutorial: Build custom embedded Linux system for Raspberry Pi</b> Duration: 01:30</p>		
7		<p><b>Tutorial: Build custom embedded Linux system for Raspberry Pi</b> Duration: 03:00</p>		
8	<p><b>Environment configuration for remote connection, development, deployment and testing</b> Duration: 01:00</p>	<p><b>Tutorial: Environment configuration for remote connection, development, deployment and testing</b> Duration: 02:00</p>		

9	IOT Application Development using Raspberry Pi and Embedded Linux Duration: 02:00	IoT application development Duration: 01:00		
10				<p><b>Generation of Custom Embedded Linux_ Questionary</b></p> <p>Continuous assessment Presential Duration: 00:05</p> <p><b>Generation of Custom Embedded Linux Systems: Alumni presentations and questions by instructors</b></p> <p>Continuous assessment Presential Duration: 02:55</p>
11		IoT application development Duration: 03:00		
12		IoT application development Duration: 03:00		
13				<p><b>IoT Application Development: Questionary</b></p> <p>Continuous assessment Presential Duration: 00:05</p> <p><b>IoT Application development: Alumni presentations and questions by instructors</b></p> <p>Continuous assessment Presential Duration: 02:55</p>
14				
15				
16				
17				<p><b>Final Assesment</b></p> <p>Continuous assessment Presential Duration: 01:00</p> <p><b>Application desing and development during days previous to the exam. Oral and writing exam. The exam will be conditioned to the necessary to the completion of the application proposed.</b></p> <p>Final examination Presential Duration: 03:00</p>

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. Continuous assessment

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
10	Generation of Custom Embedded Linux_ Questionary		Face-to-face	00:05	5%	/ 10	CG 02 CG 03 CG 04
10	Generation of Custom Embedded Linux Systems: Alumni presentations and questions by instructors		Face-to-face	02:55	25%	5 / 10	CG 04 CE EC01 CE EC03 CG 02 CG 03 CE EC05
13	IoT Application Development: Questionary		Face-to-face	00:05	10%	/ 10	CG 02 CG 03 CG 04
13	IoT Application development: Alumni presentations and questions by instructors		Face-to-face	02:55	45%	5 / 10	CG 02 CG 03 CG 04 CE EC03 CE EC04 CE EC05 CE EC07 CE EC08
17	Final Assesment		Face-to-face	01:00	15%	/ 10	CG 03 CG 04 CE EC01 CE EC04 CE EC07

#### 7.1.2. Final examination

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
17	Application desing and development during days previous to the exam. Oral and writing exam. The exam will be conditioned to the necessary to the completion of the application proposed.		Face-to-face	03:00	100%	5 / 10	CG 04 CE EC01 CE EC03 CE EC04 CE EC05 CE EC07 CE EC08 CG 02 CG 03

### 7.1.3. Referred (re-sit) examination

Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
Application desing and development during days previous to the exam. Oral and writing exam. The exam will be conditioned to the necessary to the completion of the application proposed.		Face-to-face	03:00	100%	5 / 10	CG 02 CG 03 CG 04 CE EC01 CE EC03 CE EC04 CE EC05 CE EC07 CE EC08

### 7.2. Assessment criteria

The following lists present the evaluation indicators that will be used for both the continuous assessment. The criteria used for the final examination and the referred (re-sit) examination will also be the same. For the last cases, the students will be asked to generate a custom Linux operating system and develop an application for Raspberry Pi during the 3 (three) hours of the exam, as well as completing a short writing exam.

Evaluation indicators:

- The student identifies the main hardware components of a Raspberry Pi.
- The student identifies the main characteristics of a BCM2835 chip or equivalent.
- The student identifies the functionalities of the different hardware interfaces available in the Raspberry Pi
- (Optional) The student is capable of installing and configuring a virtual machine with all the components required software packages.
- The student is capable of searching, downloading, installing, and booting a commercial operating system for Raspberry Pi.
- The student identifies the main functional blocks necessary for building an embedded Linux system.
- The student identifies the tools necessary for using Buildroot.
- The student identifies the main configuration parameters for building an embedded Linux system using Buildroot.
- The student knows the purpose and functionality of a bootloader.
- The student knows the purpose and functionality of the Linux kernel

- The student knows the purpose and functionality of a filesystem.
- The student knows the purpose and functionality of Busybox inside an embedded Linux system.
- The student is capable of configuring the host system for building an embedded Linux system using Buildroot
- The student is capable of booting a custom embedded Linux operating system with the Raspberry Pi
- The student is capable of changing the Buildroot configuration parameters to adapt to their specific requirements.
- The student is capable of identifying and fixing errors derived from the start-up of a custom embedded Linux system.
- The student identifies and understands the characteristics of electronic sensors and actuators with a digital interface
- The student is capable of connecting sensors and actuators to the proper Raspberry Pi interfaces.
- The student is capable of configuring the host system for remote connection, development, deployment, testing, and debugging of applications for the Raspberry Pi.
- The student is capable of design, develop and debug a C application for Raspberry Pi using sensors and actuators.
- The student is capable of design, develop and debug an IoT application based on Raspberry Pi.
- The student is capable of presenting the Raspberry Pi characteristics and set-up to his peers.
- The student is capable of explaining how basic applications can be developed and executed in the Raspberry Pi.
- The student is capable of presenting the configuration, development, deployment and start-up cycle of a custom embedded Linux system for Raspberry Pi.
- The student is capable of preparing formal documentation detailing the steps followed and the decisions taken to develop an embedded Linux System for Raspberry Pi.
- The student is capable of preparing detailed documentation about the development and deployment of an IoT application using Raspberry Pi
- The student is capable of team working for joint project development.

## 8. Teaching resources

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### 8.1. Teaching resources for the subject

Name	Type	Notes
Raspberry Pi Board	Equipment	Raspberry development board
Host Computer	Equipment	Personal computer with Windows operating System. It will require the installation of an Ubuntu Virtual Machine
Moodle	Web resource	UPM Course Moodle with the course support materials
Raspberry Pi Foundation	Web resource	<a href="http://www.raspberrypi.org">http://www.raspberrypi.org</a>
VMWare	Web resource	<a href="http://www.wmware.com">http://www.wmware.com</a>
Unix Tutorial	Web resource	<a href="http://www.ee.surrey.ac.uk/Teaching/Unix">http://www.ee.surrey.ac.uk/Teaching/Unix</a>
Buidlroot	Web resource	<a href="http://buildroot.uclibc.org/">http://buildroot.uclibc.org/</a>