Course guide
205082 - 205082 - Iot Engineering

Last modified: 30/05/2025

Unit in charge: Terrassa School of Industrial, Aerospace and Audiovisual Engineering
Teaching unit: 710 - EEL - Department of Electronic Engineering.

Degree: MASTER'S DEGREE IN AUTOMATIC SYSTEMS AND INDUSTRIAL ELECTRONICS (Syllabus 2012). (Optional subject).
MASTER'S DEGREE IN INDUSTRIAL ENGINEERING (Syllabus 2013). (Optional subject).
MASTER'S DEGREE IN AERONAUTICAL ENGINEERING (Syllabus 2014). (Optional subject).
MASTER'S DEGREE IN SPACE AND AERONAUTICAL ENGINEERING (Syllabus 2016). (Optional subject).
MASTER'S DEGREE IN RESEARCH IN MECHANICAL ENGINEERING (Syllabus 2021). (Optional subject).
MASTER'S DEGREE IN MECHANICAL ENGINEERING RESEARCH (Syllabus 2024). (Optional subject).
MASTER'S DEGREE IN INDUSTRIAL ENGINEERING (Syllabus 2025). (Optional subject).

Academic year: 2025 **ECTS Credits:** 3.0 **Languages:** English

LECTURER

Coordinating lecturer: JOSE ANTONIO SORIA PEREZ

Others:

PRIOR SKILLS

As introductory subject, lectures can be followed without any relevant skills. However, an average knowledge of hardware programming languages â□□â□□(such as C++ and Python) as well as Windos and Linux BASH, and experience in the assembly of electronic prototypes is recomended.

REQUIREMENTS

Be a graduate student in one of the engineering degrees offered by the UPC (or equivalent, when accessing from other university) and enrolled in one of the masters affiliated to either ESEIAAT or UPC

TEACHING METHODOLOGY

The classes combine theoretical explanations with activities with real IoT devices. The activities are guided through the UPC Atenea campus and are taught entirely in the laboratory in English. At the end of the course activities, a project (IoTP) based on an IoT application is proposed that the group will implement in the laboratory. This project will be documented in an article (DOC), IEEE format that the group will submit as a conclusion of the subject.

At the end of the course, a multiple-choice questionnaire (QIoT) will be conducted to assess the general concepts acquired during the course

LEARNING OBJECTIVES OF THE SUBJECT

- Understanding of the fundamentals of IoT: its architectures, technologies, and applications in different fields.
- Design and implemention of IoT sensor networks with MCUs and SBC server board platforms for data visualization and remote control over the Internet.
- Become acquinted with the various Internet-based communication protocols, network models, and architectures that enable interoperability between IoT agents.
- Understanding the impact of IoT ecosystems on everyday life and industry, including social, ethical, and security/data integrity issues.

STUDY LOAD

Type	Hours	Percentage
Hours large group	18,0	24.00
Hours small group	9,0	12.00
Self study	48,0	64.00

Total learning time: 75 h

CONTENTS

1. Hardware for IoT

Description:
In this section, the studeint will learn the main hardware elements and tools (ESP8266/32, STM32, Raspberry Pi or similar) and practice with them to develop IoT applications in the laboratory.

Content of section 1:

1.1. Fundamentals of the Internet of Things (IoT)
1.1.1 Definition, History and Applications
1.1.2 Classic MCU Architecture vs IoT Architecture
1.1.3 Devices: Sensors and Actuators
1.1.4 OSI Communication Models: Client-Server, Publish-Subscribe, P2P, MultiCast, etc
1.2 Embedded Systems: IoT MCUs (MicroCOntroller Units) and SBCs (Single Board Computers) for network servers
1.2.1 Introduction to ESP8266/32, Raspberry Pico/Pi, STMN32, etc.
1.2.2 Programming with ArduinoIDE, MicroPython, PlatformIO and PiArduino
1.2.3 Wired Communications: 1-Wire, SPI, I2C
1.2.4 LPWM and High-Speed â□□â□□Wireless Communications: RF, Zigbee, LoRaWan, BLE and WiFi

Specific objectives:
- Knowing the key elements of an IoT system (sensors, actuators, network, processing, interface).
- Configuring and programming microcontrollers (ESP8266, ESP32, Raspberry Pi, Raspberry Pi Pico) to interact with sensors and actuators.

Related activities:
- IoT Laboratory (LAB)
- IoT Test (QIoT)
- IoT Project (IoTP)

Full-or-part-time: 14h
Theory classes: 3h 22m
Laboratory classes: 1h 40m
Self study : 8h 58m

2. Introduction to Web Servers

Description:
This section introduces the fundamental concepts required for implementing web applications.

Content of section 2:

2.1 Introduction to IoT protocols: HTTP, SMTP, FTP, MQTT i CoAp
2.2 Synchronous Servers (HTTP polling)
2.2.1 Introduction to TCP/IP and HTTP packets
2.2.2 BOM (Browser Object Model: Basic introduction to the creation of web pages (HTML, CSS and JavaScript, etc.)
2.2.3 "Hello World" application with ESP8266 Server
2.2.4 HTTP REST: GET and POST commands
2.2.5 Secure HTTPS web servers
2.2.6 Format de dades JSON

Specific objectives:
- Learning to implement a basic HTTP client-server communication with ESP8266/32 and Raspberry Pi.
- Acquisition and sending of data (JSON format) to sensor/actuator nodes using GET/POST commands.
- Developing web interfaces or dashboards for data visualization from IoT devices.

Related activities:
- IoT Laboratory (LAB)
- IoT Test (QIoT)
- IoT Project (IoTP)

Full-or-part-time: 35h
Theory classes: 8h 24m
Laboratory classes: 4h 12m
Self study : 22h 24m

3. Asynchronous IoT Protocols

Description:
This section introduces the main communication protocols used in IoT and develops communication applications with several devices.

Content of section 3:

3.1 Asynchronous Web Server
3.1.1 Synchronous HTTP vs. Asynchronous HTTP
3.1.2 WebSockets and Socket.io
3.1.3 SSE (Server-Sent Events)
3.2 IoT Networks
3.2.1 Types: Star, Mesh, P2P, etc.
3.2.2 MQTT (Message Queuing Telemetry Transport).
3.2.3 ESP-MESH with ESP-NOW.

Specific objectives:
- Distinguishing the different IoT network communication models (client-server, publish-subscribe, M2M, etc.).
- Knowing and implementing the main asynchronous communication protocols, and associated technologies (MQTT, Websockets, Server-Sent-Events, LoRaWAN, etc.) with ESP8266/32 and Raspberry Pi.
- Providing web interfaces or dashboards with the mechanisms for displaying real-time data from IoT devices.
- To Integrate IoT solutions web tools such as Node-RED.

Related activities:
- IoT Laboratory (LAB)
- IoT Test (QIoT)
- IoT Project (IoTP)

Full-or-part-time: 25h
Theory classes: 6h
Laboratory classes: 3h
Self study : 16h

4. Advanced IoT

Description:
Content of Block 4:

4.1 Cloud IoT Platforms: ThgingSpeak, The Things Network AWS IoT Core, Azure IoT Hub, etc.
4.2 Web Design Tools: Node-Red, Drafana, FreeBoard.io, ThingsBoard, etc.
4.3 Web Servers on SBCs: Flask, LAMMP, XAMPP, etc.
4.4 Databases: SQL, Influx DB, TimeScale DB
4.5 IoT Security:
4.5.1 Common Threats: DDoS Attacks, Sniffing, Spoofing, Man-in-the-Middle, etc.
4.5.2 Protection Mechanisms: TLS/SSL Certificates, Authentication, AES Encryption, Hardware Protection, etc.
4.6 USe cases: Agriculture, Smart cities, Domotics, Industry 4.0, medicine, etc

Specific objectives:
- Designing projects that solve a problem using IoT: environmental monitoring, Smart-homes, smart cities, Smart-agriculture, etc.
- Integrating IoT solutions within cloud platforms such as ThingSpeak, Blynk, Ubidots, Azure, or AWS IoT.
- Learn to store collected data from sensors in local or cloud databases: SQL, SQLite, InfluxDB, Firebase, etc.
- To apply basic security principles in the design of IoT systems: authentication, encryption, API protection, etc.

Related activities:
- IoT Laboratory (LAB)
- Test IoT (QIoT)
- IoT Project (IoTP)
- Technical Report (DOC)

Full-or-part-time: 1h
Theory classes: 0h 14m
Laboratory classes: 0h 07m
Self study : 0h 39m

GRADING SYSTEM

Final Mark = 0.35·LAB + 0.35·IoTP + 0.2·DOC + 0.1·QIoT

with the following items:

- LAB: Selfguided activities for assembling IoT prototypes in the laboratory
- IoTP: Development of an IoT sensors/actuators system of two or more devices operating in a network
- DOC: Technical report of the development in the IoTP section
- QIoT: Multiple-choice questionare related to the field of IoT engineering

EXAMINATION RULES.

- In order to recieve assessment for the project (IoTP), the student must demonstrate its operation in the laboratory prior to the completion of the technical report (DOC).
- The technical report must be an article, in IEEE format with two columns, no more than 15 pages long and written in English.

BIBLIOGRAPHY

Basic:
- Domínguez Mínguez, Tomás. Desarrollo de aplicaciones IoT en la nube para Arduino y ESP8266. Barcelona: Marcombo, 2020. ISBN 9788426728456.
- Hillar, Gastón Carlos. Hands-on MQTT programming with Python: work with the lightweight IoT protocol in Python. Birmingham: Packt Publishing, 2018. ISBN 9781789138542.
- Smart, Gary. Practical Python programming for IoT: build advanced lo T projects using a Raspberry Pi 4, MQTT, RESTful APIs, WebSockets, and Python 3. Birmingham: Packt Publishing, 2020. ISBN 9781838982461.

Complementary:
- Boswarthick, D.; Elloumi, O.; Hersent, O. M2M communications: a systems approach. Chichester, West Sussex, U.K: John Wiley & Sons, 2012. ISBN 9781119994756.
- Veneri, Giacomo; Capasso, Antonio. Hands-on industrial Internet of Things: create a powerful industrial IoT infrastructure using industry 4. 0 [on line]. Birmingham: Packt Publishing, 2018 [Consultation: 20/05/2025]. Available on: https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?pq-origsite=primo&docID=5608194. ISBN 9781789538304.
- Lea, Perry. IoT and edge computing for architects [on line]. Birmingham: Packt Publishing, 2020 [Consultation: 20/05/2025]. Available on: https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?pq-origsite=primo&docID=6130759. ISBN 9781839214806.

RESOURCES

Other resources:
Basic
- http://www.arduino.cc – Arduino programming
- https://www.raspberrypi.org/documentation/ - Raspberry programming
Complementary
- https://randomnerdtutorials.com/ />- https://lastminuteengineers.com/