COMILLAS
UNIVERSIDAD PONTIFICIA
ICAI ICADE CIHS

COURSE SYLLABUS 2025-2026

GENERAL INFORMATION

Course information	
Name	Internet of Things
Code	DEAC-MIINT-527
Main program	Máster Universitario en Ingeniería Industrial
Offered in	Máster Universitario en Ingeniería Industrial + Máster en Industria Inteligente [2nd year] Máster en Industria Inteligente [1st year]
Level	Official Master's Degree
Semester	2nd (Spring)
Credits	3.0 ECTS
Type	Elective (MII), Compulsory (MIINT)
Department	Electronics, Control and Communications
Coordinator	Néstor Rodríguez Pérez

Instructor	
Name	Néstor Rodríguez Pérez
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Instructor	
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COURSE SPECIFIC INFORMATION

Contextualization of the course

Contribution to the professional profile of the degree

With economies of scale for sensors and other devices and the steady improvement in communication infrastructure, in the new industrial operation practice many connected devices (IoT) report information from ubiquitous locations. The collected data are stored in databases and data warehouses which are increasingly more commonly hosted in the Cloud, where the information they contain is extracted and used to improve companies' efficiency.

This new context requires a fast, reliable, and secure communication concept. In this course, we will thoroughly review the most important concepts, protocols, and technologies so that students are able to understand and implement the IoT technology that supports the operation of a growing number of companies today.

By the end of the course, students will:

- Understand how industrial systems based on IoT work.
- Know the most important communication technologies, protocols and frameworks.
- Know today's IoT trends.

Prerequisites

Being familiar with the fundamentals of networking and the protocol stack.

Competences[1] – Objectives

Competences – Máster Universitario en Ingeniería Industrial

General

BA2. Be able to apply and integrate their knowledge, understanding, scientific foundation and problem-solving skills in new and imprecisely defined environments, including multidisciplinary contexts both in research and in highly specialized professional fields.

Saber aplicar e integrar sus conocimientos, la comprensión de estos, su fundamentación científica y sus capacidades de resolución de problemas en entornos nuevos y definidos de forma imprecisa, incluyendo contextos de carácter multidisciplinar tanto investigadores como profesionales altamente especializados.

CG1. Have adequate knowledge of the scientific and technological aspects of mathematical, analytical, and numerical methods in engineering, electrical engineering, energy engineering, chemical engineering, mechanical engineering, mechanics of continuous media, industrial electronics, automation, manufacturing, materials, quantitative management methods, industrial computing, urban planning, infrastructures, etc.

Tener conocimientos adecuados de los aspectos científicos y tecnológicos de: métodos matemáticos, analíticos y numéricos en la ingeniería, ingeniería eléctrica, ingeniería energética, ingeniería química, ingeniería mecánica, mecánica de medios continuos, electrónica industrial, automática, fabricación, materiales, métodos cuantitativos de gestión, informática industrial, urbanismo, infraestructuras, etc.

Competences – Máster en Industria Inteligente

General

CG1. Have acquired advanced knowledge and demonstrated, in a research and technological or highly specialized context, a detailed and well-founded understanding of the theoretical and practical aspects, as well as of the work methodology in one or more fields of study.

Haber adquirido conocimientos avanzados y demostrado, en un contexto de investigación científica y tecnológica o altamente especializado, una comprensión detallada y fundamentada de los aspectos teóricos y prácticos y de la metodología de trabajo en uno o más campos de estudio.

CG2. Know how to apply and integrate their knowledge, understanding, scientific rationale, and problem-solving skills to new and imprecisely defined environments, including highly specialized multidisciplinary research and professional contexts.

Saber aplicar e integrar sus conocimientos, la comprensión de estos, su fundamentación científica y sus capacidades de resolución de problemas en entornos nuevos y definidos de forma imprecisa, incluyendo contextos de carácter multidisciplinar tanto investigadores como profesionales altamente especializados.

CG5. Be able to transmit in a clear and unambiguous manner, to specialist and non-specialist audiences, results from scientific and technological research or state-of-the-art innovation, as well as the most relevant foundations that support them.

Saber transmitir de un modo claro y sin ambigüedades, a un público especializado o no, resultados procedentes de la investigación científica y tecnológica o del ámbito de la innovación más avanzada, así como los fundamentos más relevantes sobre los que se sustentan.

CG6. Have developed sufficient autonomy to participate in research projects and scientific or technological collaborations within their thematic area, in interdisciplinary contexts and, where appropriate, with a high knowledge transfer component.

Haber desarrollado la autonomía suficiente para participar en proyectos de investigación y colaboraciones científicas o tecnológicas dentro de su ámbito temático, en contextos interdisciplinares y, en su caso, con una alta componente de transferencia del conocimiento.

[1] Competences in English are a free translation of the official Spanish version.

CG7.	Being able to take responsibility for their own professional development and their specialization in one or more fields of study. *Ser capaces de asumir la responsabilidad de su propio desarrollo profesional y de su especialización en uno o más campos de estudio.*
Specific	
CE4.	Have an overview of the characteristics of the IoT technologies, as well as the ability to design solutions for particular applications or services, having the ability to select the most suitable technologies among the different available technological solutions. *Tener una visión general de las características de las tecnologías IoT, así como la capacidad de diseñar soluciones para aplicaciones o servicios particulares, teniendo la capacidad de seleccionar las tecnologías más idóneas entre las diferentes soluciones tecnológicas disponibles.*
Learning outcomes	
RA1.	Design an IoT solution based on local data processing.
RA2.	Analyze and select the most appropriate communication technology depending on the target application or service.
RA3.	Understand and distinguish between different options for communication protocols for IoT.
RA4.	Understand the different blocks and processes that make up a framework for IoT communication and information processing.
RA5.	Be aware of the existing risks in terms of information security on an IoT environment.

CONTENTS

Contents

Theory

Unit 1. Introduction

1.1 Motivation. Overview of the current impact of IoT in industry
1.2 Overview of the protocol stack
1.3 Communications paradigms: Client-Server vs Publish-Subscribe

Unit 2. Hardware platforms for IoT

2.1 Raspberry Pi
2.2 Arduino
2.3 Other available solutions (ESP32, PIC, Particle)
2.4 Hardware platform comparison. Use cases and design exercises

Unit 3. Communication technologies

3.1 IEEE 802.15.4/Zigbee
3.2 Bluetooth
3.3 Wi-Fi (IEEE 802.11)
3.4 Ethernet (IEEE 802.3)
3.5 PLC (Power Line Communications)
3.6 LPWAN Technologies (LoRa, NB-IoT, LTE-M)
3.7 Communication technologies comparison. Use cases and design exercises

Unit 4. Communication protocols

4.1 MQTT
4.2 COAP
4.3 HTTP RESTful API
4.4 DLMS/COSEM
4.5 OPC UA
4.6 Communication protocols comparison. Use cases and design exercises

Unit 5. Virtualization and "Dockerization"
5.1 Concept, purpose, and historical evolution 5.2 Virtualization vs Docker: pros and cons 5.3 Use cases
Unit 6. Outlook and industry trends
6.1 SDN 6.2 NFV 6.3 5G 6.4 Edge/Fog Computing
Laboratory
Lab assignments. IoT connectivity
In this block of laboratories, the students will gain hands-on experience with common IoT hardware platforms, such as Raspberry Pi, Arduino, or SONOFF, communications technologies, such as Wi-Fi or LPWAN, and communications protocols, such as MQTT or RESTful API, as well as with widely used networking tools, such as Wireshark, and virtualization using Docker.
Final project
This block aims to promote and foster students' initiative, autonomy, and creativity. Students will devise, design, and develop their own IoT project shared with the Cloud Computing course, putting together the knowledge and skills acquired in both subjects. This project will have to meet technical requirements (e.g., involve sensors and actuators, basic local data processing, and connection to the Cloud for control and data processing). In addition, the project will have to also address service and business perspectives.

TEACHING METHODOLOGY

General methodological aspects	
Theory and practice will be combined along the course. The professor will explain the basics of the subject and will go in depth in the more important issues with illustrative examples. The students will be grouped in pairs in order to put in practice the proposed methods and techniques in a collaborative way.	
In-class activities	**Competences**
▪ **Lectures**: The lecturer will introduce the fundamental concepts of each chapter, along with some practical recommendations, and will go through worked examples to support the explanation. Active participation will be encouraged by raising open questions to foster discussion and by proposing short application exercises to be solved in class.	CG1, CG2, CG3, CG4, CG5, CG6, CG7, CE4
▪ **Lab sessions:** Under the instructors' supervision, students, divided in small groups, will apply the concepts and techniques covered in the lectures to real problems and will become familiar with technologies used in development of smart solutions in the context of Industry 4.0.	CG1, CG2, CG3, CG4, CG6, CE4
▪ **Tutoring** for groups or individual students will be organized upon request.	–
Out-of-class activities	**Competences**
▪ Personal study of the course material and resolution of the proposed exercises.	CG1, CG2, CE4
▪ Lab session preparation, programming, and reporting.	CG1, CG2, CE4
▪ Development of the final project	CG1, CG2, CE4

STUDENT WORK-TIME SUMMARY

IN-CLASS HOURS		
Lectures	**Lab sessions**	**Assessment**
18	8	4
OUT-OF-CLASS HOURS		
Self-study	**Lab preparation and report writing**	**Project Development**
15	15	30
	ECTS credits:	**3.0 (90 hours)**

EVALUATION AND GRADING CRITERIA

The use of AI to produce entire assignments or significant parts of them, without citing the source or tool used, or without explicit permission in the assignment description, will be considered plagiarism and will be subject to the University's General Regulations.

Evaluation activities	Grading criteria	Weight
Continuous evaluation	▪ Understanding of the theoretical concepts. ▪ Ability to search, analyze, sort and structure information. ▪ Oral communication skills.	20%
Final exam	▪ Understanding of the theoretical concepts. ▪ Application of these concepts to problem-solving.	30%
Lab assignments	▪ Application of theoretical concepts to real problem-solving. ▪ Ability to use and develop lab software. ▪ Written communication skills.	20%
Final project	▪ Quality of the project implementation. ▪ Oral communication skills.	30%

Grading

Regular assessment

- **Theory** will account for 50%, of which:
  - Continuous evaluation: 20%
  - Final exam: 30%
- **Lab** will account for the remaining 50%, of which:
  - Lab assignment reports/tests: 20%
  - Final project development: 30%

In order to pass the course, the mark of the Lab must be greater or equal to 5 out of 10 points and the mark of the Theory must be greater or equal to 5 out of 10 points. Otherwise, the final grade will be the lowest of the two marks.

Retake

The retake exam will account for 40% of the final mark and continuous evaluation will account for 10%. If the Lab needs to be retaken, a new individual project, with similar complexity to the regular final project, will be delivered. It will account for 50%.

As in the regular assessment period, in order to pass the course, the mark of the Lab must be greater or equal to 5 out of 10 points and the mark of the Theory must be greater or equal to 5 out of 10 points. Otherwise, the final grade will be the lowest of the two marks.

Course rules
▪ Class attendance is mandatory according to Article 93 of the General Regulations (Reglamento General) of Comillas Pontifical University and Article 6 of the Academic Rules (Normas Académicas) of the ICAI School of Engineering. Not complying with this requirement may have the following consequences: - Students who fail to attend more than 15% of the lectures may be denied the right to take the final exam during the regular assessment period. - Regarding laboratory, absence to more than 15% of the sessions can result in losing the right to take the final exam of the regular assessment period and the retake. Missed sessions must be made up for credit. ▪ Students who commit an irregularity in any graded activity will receive a mark of zero in the activity and disciplinary procedure will follow (cf. Article 168 of the General Regulations (Reglamento General) of Comillas Pontifical University).
Guidelines for the use of generative artificial intelligence (AI)
▪ The use of AI is not permitted in the exams of this course. ▪ AI may be used in laboratory practices (including the final project) for activities that complement the main task, such as preliminary research, planning, synthesis, idea generation, or debugging. AI-based code generation assistants may be used as an assistant tool in laboratory practices and final project, but their use is strictly prohibited in exams. This must always be combined with the student's personal study of the bibliographic references and the materials provided in the course. ▪ For other course assignments, AI may be used for activities that complement the main task such as preliminary research, planning, synthesis or idea generation. However, students are required to provide the prompts introduced to the AI when submitting the assignment. ▪ In all cases, students are required to critically evaluate and/or modify the outputs suggested by AI, thereby demonstrating their understanding and assuming the responsibility for what is finally submitted or presented for grading. In all cases, the use of AI in any graded assignment must be explicitly cited, and the sources independently verified by the student.

WORK PLAN AND SCHEDULE

Activities	Date/Periodicity	Deadline
Continuous evaluation activities to review and self-study of the concepts covered in the lectures	Periodically on demand	–
Final exam	After the lecture period	–
Lab sessions	Weekly	–
Review and self-study of the concepts covered in the lectures	Weekly	–
Project preparation	–	Last week

BIBLIOGRAPHY AND RESOURCES

Basic references

- Slides prepared by the lecturer (available in Moodle).

Complementary references

- A. S. Tanenbaum and D. J. Wetheral, *Computer Networks*, 5th Ed., Pearson, 2013. ISBN-13: 978-8-131-78757-1
- J. Kurose and K. Ross, *Computer Networking: A Top-Down Approach*, 7th Ed., Pearson, 2016. ISBN-13: 978-0-133-59414-0
- U. Raza, P. Kulkarni, and M. Sooriyabandara, "Low Power Wide Area Networks: An Overview," in *IEEE Communications Surveys & Tutorials*, vol. 19, no. 2, pp. 855-873, 2017.
- V. Karagiannis, P. Chatzimisios, F. Vázquez-Gallego, and J. Alonso-Zarate, "A survey on application layers protocols for the Internet of Things", in *Transaction on IoT and Cloud Computing*, vol. 3, no. 1, pp. 9-18, 2015.
- O. Liberg, et al., *Cellular Internet of Things: From Massive Deployments to Critical 5G Applications*, 2nd Ed., Academic Press, 2019. ISBN-13: 978-0-081-02902-2