COMILLAS
UNIVERSIDAD PONTIFICIA
ICAI ICADE CIHS

COURSE SYLLABUS 2025-2026

GENERAL INFORMATION

Course information	
Name	Cloud Computing
Code	DTC-MIINT-522
Main program	Máster en Industria Inteligente
Offered in	Máster Universitario en Ingeniería Industrial + Máster en Industria Inteligente [2nd year] Máster en Industria Inteligente [1st year]
Level	Master's Degree
Semester	2nd (Spring)
Credits	3.0 ECTS
Type	Compulsory
Department	Computer Science and Artificial Intelligence
Coordinator	Enrique Alejo Álvarez

Instructor	
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COURSE SPECIFIC INFORMATION

Contextualization of the course

Contribution to the professional profile of the degree

Cloud computing has revolutionized the way businesses operate by offering scalable, on-demand computing resources. This transformation allows companies to leverage advanced technologies without the need for extensive on-premises infrastructure, which reduces operational overhead and allows them to focus on driving efficiency and innovation.

This course will allow students to understand traditional IT systems and their limitations, and how cloud computing helps solve these problems by accessing the latest technologies on demand through a network connection. The course will take a hands-on approach, delivery several laboratories to allow students to grasp the knowledge needed to deploy proof of concepts or simple applications in the cloud to bring their ideas to reality.

Prerequisites

Students willing to take this course should be familiar with the basics of version control systems (Git), undergraduate-level programming and have previous experience with Python and Bash. A basic understanding of networking and REST APIs is encouraged.

Competences[1] – Objectives

Competences

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.

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

CE7. Understand the role of cloud computing in modern IT ecosystems, its contribution to agile development and innovation, and acquire the ability to design and deploy basic cloud-based services.

Comprender el papel de la computación en nube en los ecosistemas de tecnológicos actuales, su contribución al desarrollo ágil y la innovación, y ser capaz de diseñar y desplegar servicios básicos en la nube.

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

Learning outcomes	
RA1.	Describe the evolution of IT systems and the impact of cloud computing.
RA2.	Differentiate between SaaS, PaaS, and IaaS, and understand the shared responsibility model.
RA3.	Identify and compare the characteristics, use cases, and limitations of virtual machines, containers, serverless architectures, and cloud scalability models.
RA4.	Compare key database and storage systems used in cloud environments and evaluate their advantages and limitations.
RA5.	Implement infrastructure as code solutions to manage cloud resources through automated, repeatable deployments.
RA6.	Identify and explain the key operational components surrounding a cloud-based application, including security, networking, monitoring, and system operations.
RA7.	Explain the role of cloud computing in enabling artificial intelligence innovation.

CONTENTS

Contents
Theory
Unit 1. Introduction to cloud computing
1.1 The evolution of IT systems 1.2 What has changed with the Cloud 1.3 SaaS, PaaS and IaaS 1.4 Understanding the shared responsibility model 1.5 Basic cloud concepts: Virtual Private Clouds, Identity Management 1.6 The basic three-tier application and distributed systems
Unit 2. Computing in the cloud
2.1 Virtual machines, containers and serverless architectures 2.2 Scaling in the cloud 2.3 Networking
Unit 3. Infrastructure as code (IaC)
3.1 Console actions vs. configuration 3.2 Terraform, CloudFormation and CDK 3.3 DevOps and GitOps
Unit 4. Storage and database services
4.1 Databases: SQL, NoSQL, distributed SQL and caches 4.2 Object and file storage
Unit 5. Data analytics
5.1 Big Data: Processing millions of data points 5.2 Data Lakes: Govern your data 5.3 Business Intelligence: Show your data
Unit 6. Generative AI
6.1 Accessing and fine-tuning Large Language Models 6.2 Retrieval augmented generation 6.3 Agents

Laboratory
Lab 1. Virtual Machine in a Virtual Private Cloud
Students will become familiar AWS by deploying a simple Virtual Private Cloud (VPC) to contain a virtual machine which they will be able to SSH to and set up a basic web server. Once this is setup, they will repeat the process using infrastructure as code.
Lab 2. Complete REST API
Students will already understand infrastructure as code, computation, and databases within the cloud and will be able to deploy a complete REST API. They will add basic monitoring functionality to this application to track its usage and status.
Final project
In the final lab, students will build on their final project in the Internet of Things course. They will build a cloud-based solution that ingests IoT device data, stores it in the cloud, and exposes it through a REST API in near real time. They will also explore a batch processing job for data post-processing and create a text-to-SQL engine powered by an LLM, accessible via an API.

TEACHING METHODOLOGY

General methodological aspects	
Inspired by the "learn by doing" paradigm, this course is designed to provide students with the tools they require to understand the benefits of cloud computing compared to traditional IT systems and have the skills to develop applications in the cloud. Once students are confident after the theory sessions, they will be asked to implement what they have learned in a lab session where they will start building blocks that will help them advance in their final project.	
In-class activities	**Competences**
▪ **Lectures:** The lecturer will introduce the fundamental concepts of each unit, along with some practical recommendations. Active participation will be encouraged by raising open questions to foster discussion and by proposing short application exercises to be solved in class either on paper or using a software package.	CG1, CG7, CE7
▪ **Lab sessions:** Under the instructor's supervision, students, divided into small groups, will apply the concepts and techniques covered in the lectures using AWS Cloud.	CG1, CG2, CG5, CG6, CG7, CE7
▪ **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, CG7, CE7
▪ Lab session preparation to make the most of in-class time.	CG1
▪ Lab work to finish all necessary activities.	CG1, CG2, CE7
▪ Lab results analysis and report writing.	CG2, CG5, CE7

STUDENT WORK-TIME SUMMARY

IN-CLASS HOURS		
Lectures	**Lab sessions**	
14	16	
OUT-OF-CLASS HOURS		
Self-study	**Lab preparation, work and report writing**	**Final project**
15	25	20
	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
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. ▪ Use and develop functional solutions using a cloud provider. ▪ Written communication skills. ▪ Teamwork.	35%
Final project	▪ Application of theoretical concepts to real problem-solving. ▪ Use and develop functional solutions using a cloud provider. ▪ Written communication skills. ▪ Teamwork.	35%

Grading

Regular assessment

- **Theory** will account for 30%, of which:
  - Final exam: 30%
- **Lab** will account for the remaining 70%, of which:
  - Lab assignments 1 and 2: 17.5% each
  - Final project: 35%

In order to pass the course, the weighted average mark must be greater or equal to 5 out of 10 points, the mark of the final exam must be greater or equal to 4 out of 10 points, and the laboratory mark (the weighted average of the assignments and the final project) must be at least 5 out of 10 points. Otherwise, the final grade will be the lower of the three marks.

Retake

There will be a retake exam that will replace the final exam of the regular assessment period. As long as the laboratory has a passing grade, all the remaining marks will be preserved; otherwise, a new individual project will have to be developed, and all failed lab assignments repeated. The final grade will be computed as in the regular assessment period and under the same restrictions.

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 procedures will follow (cf. Article 168 of the General Regulations (Reglamento General) of Comillas Pontifical University).

Guidelines for the use of generative artificial intelligence (AI)

- **Exams.** The use of generative artificial intelligence models or programming assistants is strictly prohibited in the exams. These activities must reflect exclusively the student's own knowledge and individual work.
- **Laboratory.** The use of AI-based programming assistants and generative language models is permitted under the following conditions:
  - These tools may be used as support for understanding technical concepts, obtaining suggestions on how to approach the proposed exercises, and generating code snippets or initial drafts of reports.
  - Their use must always be complementary and must not replace the student's individual work. Submitting automatically generated content as one's own, without proper understanding, review, and adaptation, is not allowed.
  - Any relevant content generated wholly or partially using these tools must be explicitly cited, clearly indicating which parts were generated with AI and which tools were used. The sequence of prompts must be included as an annex at the end of the report.
  - Instructors reserve the right to ask oral questions regarding content generated with AI assistance to assess the student's understanding. Failure to explain or justify such content may negatively impact the grade for the activity.
- The responsible use of these tools is encouraged as a means of supporting individual study (e.g., to clarify concepts, generate additional exercises, or receive feedback). However, students should be aware that responses generated by AI models may contain errors, and it is their responsibility to critically assess and verify the information provided.

WORK PLAN AND SCHEDULE[2]

Activities	Date/Periodicity	Deadline
Final exam	After the lecture period	–
Lab sessions	Weeks 3 and 5	–
Review and self-study of the concepts covered in the lectures	After each lesson	–
Lab preparation	Before every lab session	–
Lab report writing	–	One and a half weeks after the end of each session
Final project	From week 6	Before the final exam

[2] A detailed work plan of the subject can be found in the course summary sheet (see following page). Nevertheless, this schedule is tentative and may vary to accommodate the rhythm of the class.

BIBLIOGRAPHY AND RESOURCES

Basic references

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

Complementary references

- Amazon Web Services, *Overview of Amazon Web Services*, 2024. [Online]. Available: https://docs.aws.amazon.com/whitepapers/latest/aws-overview/introduction.html
- T. Golding, *Building Multi-Tenant SaaS Architectures: Principles, Practices and Patterns Using AWS*, 1st Ed., O'Reilly Media, 2024. ISBN: 978-1-098-14064-9
- G. Kim, J. Humble, P. Debois, and J. Willis, *The DevOps Handbook: How to Create World-Class Agility, Reliability & Security in Technology Organizations*, 1st Ed., IT Revolution Press, 2021. ISBN-13: 978-1-950-50840-2
- A. Wiggins, *The Twelve-Factor App*, 2017. [Online]. Available: https://12factor.net/

	In-class activities				Out-of-class activities				Learning outcomes
Week	Time [h]	Lecture	Laboratory	Assessment	Time [h]	Self-study	Lab preparation and report writing	Other activities	Code
1	2	Course overview (0.5h) Unit 1. Introduction to cloud computing (1.5h)			1	Review and self-study (1h)			RA1, RA2
	2	Unit 1. Introduction to cloud computing (1h) Unit 2. Computing in the cloud (1h)			1	Review and self-study (1h)			RA1, RA2, RA3
2	2	Unit 2. Computing in the cloud (2h)			1.5	Review and self-study (1.5h)			RA2, RA3
	2	Unit 3. Infrastructure as code (2h)			3.5	Review and self-study (1.5h)	Lab preparation (2h)		RA5
3	2		Lab 1. VM in a VPC (2h)		3			Lab work (3h)	RA2, RA3
	2		Lab 1. VM in a VPC (2h)		4			Lab work (4h)	RA2, RA3, RA5
4	2	Unit 4. Storage and database services (2h)			4.5	Review and self-study (1.5h)	Report writing (3h)		RA2, RA4
	2	Unit 5. Data analytics (2h)			3.5	Review and self-study (1.5h)	Lab preparation (2h)		RA6, RA7
5	2		Lab 2. Complete REST API (2h)		3			Lab work (3h)	RA2 – RA6
	2		Lab 2. Complete REST API (2h)		4			Lab work (4h)	RA7
6	2	Unit 6. Generative AI (2h)			5	Review and self-study (1h)	Report writing (3h) Lab preparation (1h)		RA2 – RA7
	2		Final project (2h)		5			Final project development (5h)	RA2 – RA7
7	2		Final project (2h)		5			Final project development (5h)	RA2 – RA7
	2		Final project (2h)		5			Final project development (5h)	RA2 – RA7
8	2		Final project (2h)		5			Final project development (5h)	RA2 – RA7
				Final exam[3]	6	Final exam preparation (6h)			RA1 – RA4, RA6, RA7

[3] The final exam will be held the week after the lecture period.