COMILLAS
UNIVERSIDAD PONTIFICIA
ICAI ICADE CIHS

COURSE SYLLABUS 2025-2026

GENERAL INFORMATION

Course information	
Name	Intelligent Process Automation
Code	DTC-MIINT-526
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	Luis Navarro Velasco

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COURSE SPECIFIC INFORMATION

Contextualization of the course

Contribution to the professional profile of the degree

In today's technological landscape, Generative Artificial Intelligence (GenAI) has evolved from being an experimental tool to becoming a strategic pillar for intelligent automation across industries. Large Language Models (LLMs), Vision-Language Models (VLMs), and autonomous agent systems are redefining how organizations design, execute and monitor their processes.

This course provides students with an applied and critical understanding of these technologies, preparing technical profiles capable of:

- Designing AI-based generative solutions for industrial environments.
- Integrating intelligent agents into automated workflows.
- Understanding ethical, regulatory, and sustainability challenges.

In a context where responsible AI and model governance are essential, after taking this course students will be prepared to lead intelligent automation projects with both technical and ethical judgment, contributing to the development of a more efficient, safe, and human-centered industry.

Prerequisites

Deep learning foundations.

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	
CE6.	Understand the current landscape of Generative AI and be able to apply it to the automation of production processes. *Entender el panorama actual de la IA Generativa y ser capaz de aplicarla a la automatización de procesos productivos.*

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

Learning outcomes	
RA1.	Apply prompt engineering techniques to effectively interact with Large Language Models (LLMs) and solve Natural Language Processing tasks.
RA2.	Use Vision Language Models (VLMs) to perform image comprehension tasks.
RA3.	Design and implement Retrieval-Augmented Generation (RAG) systems, managing the complete data lifecycle from processing and vectorization (chunking, embeddings) to retrieval from vector databases.
RA4.	Evaluate and optimize the performance of a RAG system using standard metrics and MLOps tools.
RA5.	Develop autonomous agents capable of performing complex tasks through tool calling.
RA6.	Understand the core protocols for Generative AI, focusing on model context handling and agent interaction.

CONTENTS

Contents

Theory

Unit 1. Introduction to Generative AI

1.1 State-of-the-art and current Generative AI landscape
1.2 Main Generative AI products and providers
1.3 Technical principles (tokenization, embeddings, fine-tuning…)
1.4 Open source vs. closed source
1.5 On-premises vs. in the cloud
1.6 Ethics, risks, and regulatory framework (EU AI Act)

Unit 2. Prompt engineering

2.1 Prompting guide
2.2 Prompting differences among models and providers
2.3 Security in LLMs

Unit 3. Multimodal Generative AI

3.1 Text to image
3.2 Image to text
3.3 Text to speech
3.4 Vision Language Models (VLMs)

Unit 4. Retrieval Augmented Generation (RAG)

4.1 What is a RAG system?
4.2 Processing and vectorization
4.3 Search methods
4.4 Limitations

Unit 5. LLMOps

5.1 Evaluations
5.2 Monitorization

Unit 6. Agents

6.1 What is an agent?
6.2 AI agent components
6.3 Types of agentic sytems
6.4 Agentic frameworks

Unit 7. Agent interoperability

7.1 What is Model Context Protocol (MCP)?
7.2 Main components
7.3 Agent-to-agent (A2A) communication protocols

Unit 8. AI workflow automation

8.1 Low-code automation
8.2 Zapier

Laboratory

Lab 1. Prompting, LLMs vs. NLP and Vision Language Models

- Types of messages to the models
- Provider(s) to be used
- Prompting on different platforms/providers
- Solving NLP problems using LLMs (classification, entity extraction…)
- Visual question answering
- Document understanding
- Image captioning

Lab 2. Retrieval Augmented Generation – Part 1: Retrieval

- Chunking techniques
- Embedding generation
- Ingestion into vector databases

Lab 3. Retrieval Augmented Generation – Part 2: Augmentation, Generation and Evaluation

- Search in vector databases
- Rerankers
- RAG prompting
- Evaluation of the RAG created

Lab 4. Agent without framework

Develop and agent from scratch.

Lab 5. Model Context Protocol (MCP)

Develop an MCP server that can be used from Claude Desktop (or a similar alternative).

Project. Agentic Retrieval Augmented Generation (RAG)

As a final project, the students will bring together all the knowledge acquired during the lab assignments to build a RAG solution using agents.

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 develop a robotics application by the end of the term. In every unit, after the initial explanation of each concept, the instructor will propose individual and group quizzes and activities (some of which will be graded) to test students' understanding. Once they are more confident with the material, 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, 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 online quizzes and short application exercises to be solved in class either on paper or using a software package.	CG1, CG7, CE6
▪ **Lab sessions:** Under the instructor's supervision, students, divided into small groups, will apply the concepts and techniques covered in the lectures to simulated versions of commercial mobile robots.	CG1, CG2, CG5, CG6, CG7, CE6
▪ **Tutorial sessions** will be organized upon request, both in groups and individually, to address any questions that arise after working through the different topics and to guide students in their learning process.	–
Out-of-class activities	**Competences**
▪ **Personal study.** Students are expected to carry out individual work after the lectures in order to understand and internalize the knowledge covered in every unit.	CG1, CG7, CE6
▪ **Laboratory sessions.** The lab sessions will require prior preparation and will conclude with the submission of a report.	CG1, CG2, CG5, CG6, CG7, CE6

STUDENT WORK-TIME SUMMARY

IN-CLASS HOURS	
Lectures	**Lab sessions**
12	18
OUT-OF-CLASS HOURS	
Self-study	**Lab sessions**
20	40
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
Quizzes	▪ Understanding of the theoretical concepts.	10%
Final exam	▪ Understanding of the theoretical concepts. ▪ Application of these concepts to problem-solving. ▪ Critical analysis of the numerical results. ▪ Written communication skills.	30%
Lab assignments	▪ Understanding of the theoretical concepts. ▪ Application of these concepts to problem-solving. ▪ Ability to use and develop software for mobile robots. ▪ Critical analysis of the experimental results. ▪ Oral and written communication skills.	40%
Project	▪ Ability to use and develop software for mobile robots. ▪ Critical analysis of the experimental results. ▪ Working robustness. ▪ Autonomy and problem-solving skills. ▪ Teamwork. ▪ Oral and written communication skills.	20%

Grading

Regular assessment

- **Theory** (40%)
  - Quizzes: 10%
  - Final exam: 30%
- **Laboratory** (60%)
  - Lab assignments: 40%
  - Final project: 20%

The final grade will be computed according to these **restrictions**:

- The mark of the final exam must be greater or equal to 4 out of 10 points.
- The laboratory weighted average must be at least 5 out of 10.

If all the restrictions are met, the final grade of the course will be determined according to the weights indicated above. Otherwise, it will be the minimum of the two restrictions.

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.
- According to Article 168, section 2.e) of the General Regulations of Universidad Pontificia Comillas, a serious offense is defined as *"any action aimed at falsifying or defrauding the systems used to assess academic performance."* If any irregularity is detected in an academic activity, the work will be graded with a zero (0.0), and disciplinary proceedings may be initiated. In laboratory assignments and the final project, the following will be considered irregularities: the total or partial copying of source code or answers from other students, whether from the current academic year or previous years. The literal or paraphrased reproduction of content from external sources without proper citation will also be considered an attempt of plagiarism. This includes content generated using generative artificial intelligence models, which must comply with the guidelines outlined in the following section.

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
Quizzes	In every lecture	–
Final exam	After the lecture period	–
Lab sessions	From week 2	–
Self-study of the concepts covered in the lectures	After each lesson	–
Lab preparation	Before every lab session	–
Lab report writing	–	One week after the end of each session

BIBLIOGRAPHY AND RESOURCES

Basic references

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

Complementary references

- OpenAI, *GPT-4 Technical Report*, arXiv, Mar. 2024, [Online]. Available: https://arxiv.org/abs/2303.08774
- Gemini Team, Google, *Gemini: A family of highly capable multimodal models*, May 2025, [Online]. Available: https://arxiv.org/abs/2312.11805
- Anthropic, *Introducing the Model Context Protocol*, Nov. 2024, [Online]. Available: https://www.anthropic.com/news/model-context-protocol
- IBM Research, Scale trusted AI with watsonx.governance, 2025, [Online]. Available: https://www.ibm.com/products/watsonx-governance
- European Commission, *AI Act – Regulation of Artificial Intelligence*, Official Journal of the EU, Jun. 2024, [Online]. Available: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32024R1689

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[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.

	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 (1.5h)			2	Self-study (2h)			RA1
	2	Unit 2. Prompting (1h) Unit 3. Multimodal Generative AI (1h)			2	Self-study (2h)			RA1, RA2
2	2		Lab 1. Prompting, LLMs and VLMs (2h)		4		Lab preparation (1h) Report writing (3h)		RA1, RA2
	2	Unit 4. Retrieval Augmented Generation (2h)			2	Self-study (2h)			RA3
3	2	Unit 4. Retrieval Augmented Generation (1h) Unit 5. LLMOps (1h)			2	Self-study (2h)			RA3, RA4
	2		Lab 2. RAG - Part 1 (2h)		4		Lab preparation (1h) Report writing (3h)		RA3
4	2		Lab 3. RAG - Part 2 (2h)		4		Lab preparation (1h) Report writing (3h)		RA3, RA4
	2	Unit 6. Agents (2h)			2	Self-study (2h)			RA5
5	2		Lab 4. Agents (2h)		4		Lab preparation (1h) Report writing (3h)		RA5
	2	Unit 7. Agent interoperability (1h)	Lab 5. MCP (1h)		6	Self-study (2h)	Lab preparation (1h) Report writing (3h)		RA6
6	2	Unit 8. AI workflow automation (1h)	Project (1h)		6	Self-study (2h)		Project development (4h)	RA1 – RA6
	2		Project (2h)		4			Project development (4h)	RA1 – RA6
7	2		Project (2h)		4			Project development (4h)	RA1 – RA6
	2		Project (2h)		4			Project development (4h)	RA1 – RA8
8	2		Project (2h)		4			Project development (4h)	RA1 – RA8
				Final exam Project[3]	6	Final exam preparation (6h)			RA1 – RA8

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