COMILLAS
UNIVERSIDAD PONTIFICIA
ICAI ICADE CIHS

COURSE SYLLABUS 2024-2025

GENERAL INFORMATION

Course information	
Name	Data Modelling
Code	DTC-MIINT-513
Main program	Máster en Industria Inteligente
Offered in	Máster Universitario en Ingeniería Industrial + Máster en Industria Inteligente [1st year]
Level	Master's Degree
Semester	1st (Fall)
Credits	4.5 ECTS
Type	Compulsory
Department	Telematics and Computer Science
Coordinator	Gabriel Javier Maestroarena Rodas

Instructor	
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Lab Instructor	
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COURSE SPECIFIC INFORMATION

Contextualization of the course

Contribution to the professional profile of the degree

In the rapidly evolving landscape of intelligent industry, the ability to transform raw data into actionable insights is crucial. This course is designed to equip students with the foundational skills needed to model complex industrial processes and business systems, ensuring they can create and manage robust databases that drive informed decision-making.

By mastering these essential data modelling techniques, students will not only support advanced analytics and automation but also position themselves as key contributors to the future of smart manufacturing and Industry 4.0. This course lays the groundwork for a deep understanding of how data can be leveraged to optimize operations, enhance productivity, and innovate in the digital age.

Prerequisites

Students should be familiar with undergraduate-level Python programming or be simultaneously enrolled in a Python fundamentals course.

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

CE2. Conceptualize and develop comprehensive data models for complex industrial processes or businesses, create optimized databases to store critical information, and critically assess and refine their ability to query and manipulate the data to support decision-making.

Conceptualizar y desarrollar modelos de datos integrales para procesos industriales o negocios complejos, crear bases de datos optimizadas para almacenar información crítica, y evaluar y refinar críticamente su capacidad para consultar y manipular los datos de cara a la toma de decisiones capaces.

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

Learning outcomes	
RA1.	Identify appropriate data requirements and sources relevant to specific industrial or business scenarios.
RA2.	Design normalized data models that accurately represent industrial processes or business operations with appropriate simplifications.
RA3.	Construct efficient and scalable relational databases based on the developed data models.
RA4.	Apply advanced querying techniques to extract, analyze, and manipulate data from databases.
RA5.	Evaluate the effectiveness of data models and databases in meeting the specific needs of industrial and business applications.

CONTENTS

Contents
Theory
Unit 1. Conceptual and logical data model design
1.1 Data evolution: Structured vs. unstructured data 1.2 How to store data efficiently: DBMS/RDBMS 1.3 SQL vs NoSQL and new databases (vector, graph…) 1.4 Conceptual and logical data modelling
Unit 2. Physical data model design and SQL CRUD
2.1 Physical data modelling 2.2 Data manipulation with SQL: DML, DCL, and DDL 2.3 Implementation in MySQL
Unit 3. Using MySQL from Python code
3.1 Connecting Python with MySQL databases 3.2 CRUD operations in Python using MySQL
Laboratory
Lab 1. Logic data model design
Relational model and normalization.
Lab 2. Physical data model design and SQL CRUD
DDL and DML on a MySQL database.
Lab 3. Connecting Python and MySQL
Students will create a simple Python to query a MySQL database.
Final project
Each group will choose a different industrial process or business of their liking, build a data model to manage it (with the appropriate simplifications), deploy it to MySQL, and develop a Python application that exposes a REST API to interact with the database.

TEACHING METHODOLOGY

General methodological aspects	
Theory and practice will be combined along the course. The teacher will explain the basics of the subject and will go into depth in the more important issues with illustrative examples. Students will form groups to put the proposed methods and techniques in practice in a collaborative way.	
In-class activities	**Competences**
▪ **Lectures and problem-solving sessions:** 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 short application exercises to be solved in class either on paper or using a software package.	CG1, CG7, CE1, CE2
▪ **Lab sessions:** Under the instructor's 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 the development of smart solutions in the context of Industry 4.0.	CG1, CG2, CG5, CG6, CG7, CE1, CE2
▪ **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, CE1, CE2
▪ Lab session preparation, programming, and reporting.	CG1, CG2, CG5, CE2
▪ Development of a final project in small groups.	CG1, CG2, CG5, CG6, CG7, CE1, CE2

STUDENT WORK-TIME SUMMARY

IN-CLASS HOURS		
Lectures	**Lab sessions**	**Assessment**
16	26	3
OUT-OF-CLASS HOURS		
Self-study	**Lab preparation and report writing**	**Final project**
20	25	45
	ECTS credits:	**4.5 (135 hours)**

EVALUATION AND GRADING CRITERIA

Evaluation activities	Grading criteria	Weight
Continuous evaluation	▪ Understanding of the theoretical concepts. ▪ Application of these concepts to problem-solving.	10%
Design and SQL 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 model real industrial systems. ▪ Attitude and effort: Initiative and proactive work will be encouraged. ▪ Written communication skills. ▪ There will be an intra-group evaluation method to differentiate among team members.	30%
Final project	▪ Problem analysis and design ▪ Quality of the project implementation. ▪ Teamwork ▪ Oral presentation skills. ▪ There will be an intra-group evaluation method to differentiate among team members.	30%

Grading

Regular assessment

- **Theory** will account for 40%, of which:
  - Continuous evaluation: 10%
  - Design and SQL exam: 30%
- **Lab** will account for the remaining 60%, of which:
  - Lab assignments: 30%
  - Final project: 30%

In order to pass the course, both theory and laboratory marks must be greater or equal to 5 out of 10 points. Otherwise, the final grade will be the lower of the two marks. Although the exam will be held after the midterm break, students will have the chance to retake it during the official ordinary evaluation period. The mark obtained will replace that of the midterm regardless of the result obtained.

Retake
Lab marks will be preserved as long as the weighted average of the assignments and the final project results in a passing grade. Otherwise, a new project will have to be developed and handed in. In addition, all students will take a new design and SQL exam whose mark will replace that of the regular assessment period. The resulting grade will be computed as follows: ▪ **Theory** will account for 40%, of which: • Continuous evaluation: 10% • Design and SQL exam: 30% ▪ **Lab** will account for the remaining 60%, of which: • If the student passed the lab during regular assessment ▪ Lab assignments: 30% ▪ Final project: 30% • Otherwise ▪ Final project: 60% As in the regular assessment period, in order to pass the course, both theory and laboratory marks must be greater or equal to 5 out of 10 points. Otherwise, the final grade will be the lower 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).

WORK PLAN AND SCHEDULE

Activities	Date/Periodicity	Deadline
Continuous evaluation activities to review and study the concepts covered in the lectures	Periodically on demand	–
Design and SQL exam	Week 8	–
Lectures and lab sessions	Weekly	–
Review and self-study of the concepts covered in the lectures	Weekly	–
Final project development	From week 10	The last week of the semester

BIBLIOGRAPHY AND RESOURCES

Basic references

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

Complementary references

- R. Elmasri and S. B. Navathe, *Fundamentals of Database Systems*, 7th Ed., Pearson Education, 2016. ISBN-13: 978-1-292-09761-9
- E. Matthes, *Python Crash Course: A Hands-On, Project-Based Introduction to Programming*, 3rd Ed., No Starch Press, 2022. ISBN-13: 978-1-718-50270-3
- MySQL documentation, [Online]. Available: https://dev.mysql.com/doc/