Course guide
330729 - ARDS - Advanced Relational Database Systems

Last modified: 03/09/2025

Unit in charge: Manresa School of Engineering
Teaching unit: 750 - EMIT - Department of Mining, Industrial and ICT Engineering.

Degree: MASTER'S DEGREE IN MACHINE LEARNING AND CYBERSECURITY FOR INTERNET-CONNECTED SYSTEMS (Syllabus 2024). (Optional subject).

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

LECTURER

Coordinating lecturer: Domingo Manubens Gil

Others:

TEACHING METHODOLOGY

AF1. Attendance and participation in master class. Presentation in class of new content and description of the study materials by the teacher and questions by the students to the teacher in relation to the content that he is explaining or presenting in the master class.
AF2. Attendance and participation in participatory class. Presentation of problems, challenges or case studies that students solve individually or in groups, with the teacher's assistance.
AF3. Carrying out laboratory practice. Completion in the laboratory and under the supervision of the teacher of tasks and experiments defined in the practice script, related to the implementation of the contents of the subject. It normally requires the preparation of a prior study and the preparation of a subsequent report. Possible field trips are considered within this typology.
AF4. Completion of tasks related to project-based learning. Students meet and manage the development of a complex project, organizing and distributing the necessary tasks and resources.
AF5. Presentation and defense of works. Students present to the rest of the class and the teacher how they have carried out the proposed tasks, be it solving problems, carrying out practices or developing projects.
AF6. Autonomous study carried out by the student outside of class hours. The student, autonomously, studies the content taught by the teacher, through notes and other materials provided by the teacher or obtained by the student himself.
AF7. Autonomous work carried out by the student outside of class hours. Tasks carried out autonomously, either individually or in a team, consisting of problem solving, exercises or the development of practices.
AF8. Attendance at tutoring session. Meeting of the student with the teacher or tutor to resolve specific doubts about content and tasks and assess the student's own progress.

LEARNING OBJECTIVES OF THE SUBJECT

Upon completion of the course, the student will be able to:

M.10.4 (S). Use entity relationship modeling, relational database design, and SQL to efficiently store, retrieve, and update data in a database.
M.10.5 (S). Develop a system design based on the provided system requirements using advanced tools for a clear and structured design.

CONTENTS

TOPIC 1: DBMS Internals

Description:
Covers the structure and operation of storage engines, buffer/caching strategies, and metadata management in PostgreSQL/MySQL.

Keywords: storage models, buffer, metadata

Specific objectives:
- Distinguish between row-store and column-store models
- Query internal catalogs (e.g., pg_catalog, information_schema)
- Understand DBMS memory usage and storage segments

Related activities:
All relevant labs and study materials.

Full-or-part-time: 11h
Theory classes: 2h
Laboratory classes: 1h
Self study : 8h

TOPIC 2: SQL Optimization

Description:
Advanced SQL tuning through query plan analysis, indexing, and rewriting strategies.

Keywords: execution plan, cost-based optimization, index types

Specific objectives:
- Interpret execution plans (EXPLAIN, EXPLAIN ANALYZE)
- Design and apply efficient indexing strategies
- Rewrite queries to enhance performance

Related activities:
Lab on large dataset optimization with PostgreSQL.

Full-or-part-time: 21h
Theory classes: 4h
Laboratory classes: 2h
Self study : 15h

TOPIC 3: Transactions and Concurrency

Description:
Exploration of ACID properties, isolation levels, locking mechanisms, and MVCC.

Keywords: ACID, locking, deadlocks, MVCC

Specific objectives:
- Simulate concurrent transactions and deadlocks
- Configure and test isolation levels
- Explore MVCC mechanisms in PostgreSQL

Related activities:
Deadlock simulation and resolution lab.

Full-or-part-time: 16h
Theory classes: 3h
Laboratory classes: 2h
Self study : 11h

TOPIC 4: Distributed Databases

Description:
Covers replication, sharding, clustering, and fault tolerance in distributed DBMSs.

Keywords: replication, sharding, failover

Specific objectives:
- Set up replication between DBMS nodes
- Simulate failover scenarios
- Understand sharding for horizontal scalability

Related activities:
Lab using Docker for replication and failover.

Full-or-part-time: 13h
Theory classes: 3h
Laboratory classes: 2h
Self study : 8h

TOPIC 5: NoSQL vs NewSQL

Description:
Comparison of document, key-value, and NewSQL systems.

Keywords: MongoDB, Redis, CockroachDB, polyglot persistence

Specific objectives:
- Evaluate use cases for relational vs NoSQL vs NewSQL
- Design hybrid data models using PostgreSQL and MongoDB
- Understand trade-offs of polyglot persistence

Related activities:
Hybrid modeling lab using PostgreSQL and MongoDB.

Full-or-part-time: 14h
Theory classes: 3h
Laboratory classes: 2h
Self study : 9h

ACTIVITIES

LECTURES

Description:
Face-to-face theoretical instruction and guided discussion of core concepts.

Material:
Lecture slides, PDF documents, practical examples.

Delivery:
In class. Occasionally, quizzes will be conducted. The grades obtained in these activities corresponds the variable QUIZ.

Full-or-part-time: 15h
Theory classes: 15h

LABORATORY WORK

Description:
Students perform hands-on tasks using Dockerized DBMS environments, including query tuning, replication setup, and polyglot integration.

Delivery:
Lab reports and working code. The evaluation determines the LAB parameter of the final grade.

Full-or-part-time: 9h
Laboratory classes: 9h

IINDEPENDENT STUDY

Description:
Autonomous review of videos, readings, and exercises.

Material:
Lecture notes, practice exercises, lab setup guides.

Full-or-part-time: 43h
Self study: 43h

EXAM

Description:
Final individual written exam covering all modules, closed book.

Delivery:
Written answers submitted on paper. The exam grade corresponds to the course grade variable FIN.

Full-or-part-time: 8h
Self study: 8h

GRADING SYSTEM

The final grade is calculated with the following weights:

Overall grade = 0.3 * FIN + 0.3 * QUIZ + 0.4 * LAB

EXAMINATION RULES.

The activities will be carried out following the uses and customs of academic work and, in particular, the following guidelines will be respected:

- Those activities that are explicitly declared as individual, whether they are face-to-face or not, will be carried out without any collaboration by other people.
- The dates, formats and other delivery conditions established will be mandatory.
- If any of the activities of the subject is not carried out, it will be considered graded with zero.
- The completion of laboratory activities is a necessary condition to pass the course.
- The use of the computer laboratory will be reserved exclusively for academic activities and in no case may abusive use be made.

BIBLIOGRAPHY

Basic:
- Peter Bailis, Joseph M. Hellerstein, Michael Stonebraker (Eds.). Readings in database systems [on line]. 5th Edition. Redbook, 2015 [Consultation: 08/10/2025]. Available on: http://www.redbook.io/.
- Ramakrishnan, Raghu; Gehrke, Johannes. Database management systems. 3rd ed., international ed. Boston [etc.]: McGraw-Hill, cop. 2003. ISBN 0071151109.