# COMP 356E Database Systems Technology

## Course Description

This course is an introduction to database systems. We will explain how to query database systems via languages such as SQL. Then, we will see how database systems work internally, how they store and index data, how they process and optimize queries, and how they process transactions while providing guarantees such as isolation, atomicity, and durability (ACID guarantees).

Different database systems such as distributed DBMS, In-Memory databases and NoSQL databases will also be introduced.

## Course Goals

It is expected that students get to know how a database works under different situations and with different technologies. Focus will be placed on the correct design of a database. This knowledge should help students to understand and solve different practical problems that can come up in their future professional career.

In addition, students will be introduced to different database types to provide them with an overview about benefits and drawbacks of each one.

Finally, we will briefly explain how data can be uploaded to and fetched from a database so it can be added to a regular calculation procedure in a programming language.

## Methodology

This course consists of 26 face-to-face sessions where both theoretical knowledge and practical sessions will be taught.

Students will be given both comprehensive documentation and slides for each session. It is recommended that students look at the documentation in advance.

Class attendance and participation will be mandatory as, at the end of each topic, there wil be practical exercises. Presentations or discussions among students will be included so everyone can learn from others' experience and conclusions.

## Technical Requirements

This course will require students to bring their laptop for the classes that require running databases examples. (Databases will not be running on tablets or smartphones). We will install/access MS Access, MS Excel, SQLite, DB Browser for SQLite, and MongoDB.

## Course Materials

Textbooks are not required for this course as course materials will be provided in advance.

**Complementary Bibliography**

1. Fundamentals of database systems. Ramez Elmasri, Shamkant B. Navathe. Pearson
2. Database Systems. Thomas Connolly, Carolyn Begg. Pearson
3. Database Design for Mere Mortals: 25th Anniversary Edition, 4th Edition. Michael J. Hernandez. Addison-Wesley

**Note**: It is not expected students buy any of these books. Topics in this subject are built from them. Students will be given the information already prepared by the teacher for them to study. Besides this, these books will be available at CUID's library for reference (not at UPO's library).

## Course Requirements and Grading

Your final grade will be calculated as follows:

- Class participation: 25%
- Practical exercises and in-class presentations: 35%
- Mid-term exam: 10%
- Project: 20%
- Final exam: 10%

During the course, students will be given some questions or practical exercises to be solved and then presented and commented in class in a "learning by doing" approach. If a student is confident enough to provide other students with an explanation, this will mean the knowledge is mastered. Therefore, it is highly recommended for students to attend not only lectures but also presentations and discussions.

It is mandatory to pass the exams to pass the subject.

Exams and every other assignment will be marked following the Spanish numerical range. Here is a table to illustrate differences in conversion between the Spanish, U.S. and Standard European grading systems:

| SPAIN | 10 | 9,9 - 9,5 | 9,4 - 9 | 8,9 - 8,5 | 8,4 - 8 | 7,9 - 7,5 | 7,4 - 7 | 6,9 - 6,5 | 6,4 - 6 | 5,9 - 5,5 | 5,4 - 5 | 4,9 - 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| USA | A+ | A | A- | B+ | B | B | B- | C+ | C | C | C- | F |
| ECTS | A | B | B | C | C | C | C | D | D | E | E | F |

## General Course Policies

Each student is expected to be familiar with the course syllabus. Students are expected to focus their full attention on the class, arrive on time, and stay until class ends. Leaving the classroom repeatedly is disturbing to both your professor and your classmates and may adversely affect your participation grade. Please make use of the 10-minute breaks in between classes to fill up your water bottle, use the restroom, etc.

Students are expected to listen and respect other points of view. Phone calls, social media, email, or Internet browsing at any time during class are not acceptable except for specific class-related activities expressly approved by your instructor. You are responsible for any course material covered in class, announcements, and/or handouts if you are not present for any reason. Students will be held responsible to be up to date by attending class regularly and checking both email and the Blackboard site of the course frequently (monitor your email and Blackboard announcements at least once every 24 hours).

Communicating with the instructor: Please allow at least 48 hours for your instructor to respond to your emails. The weekend is not included in this timeframe. If you have an urgent request or question for your professor, be sure to send it during the week.

## Student Engagement Policy

Student's engagement will account for at least 20% of the final grade for every course, thus highlighting its significance for high-impact learning.

Students will receive two engagement grades: a mid-term grade (at least 10%) and an end-of-semester grade (at least 10%).

An engagement rubric is provided to ensure transparent and consistent grading (final page).

Absences and lack of engagement

Absences during the add/drop period do not count against students' engagement grade, but may impact their performance in the course.

As a consistent lack of academic engagement may raise concerns about a student's overall academic performance, the following steps will be taken in order to support students' success:

**Initial outreach – after missing 3 classes***
E-mail from professor reiterating engagement policy and consequences for additional absences.

**Second outreach – after missing 4 classes***
E-mail from professor and notification of academic staff at the International office.

**Academic probation – after missing 6 classes***
Student is called in for a meeting with academic staff at the International office. Automatic notification of home institution and further academic consequences.

Any additional absences will result in a failing grade.

## Academic Honesty

Academic integrity is a guiding principle for all academic activity at Pablo de Olavide University. Cheating on exams and plagiarism (which includes copying from the Internet) are clear violations of academic honesty. A student is guilty of plagiarism when they present another person's intellectual property as their own. The penalty for plagiarism and cheating is a failing grade for the assignment/exam and a failing grade for the course. The International Center may also report this to your home university. Avoid plagiarism by citing sources properly, using footnotes and a bibliography, and not cutting and pasting information from various websites when writing assignments.

## About using Artificial Intelligence (AI)

The use of AI tools such as grammar checkers, ChatGPT, etc. and automatic translation tools is prohibited unless expressly permitted by the instructor to enhance the students' learning experience. Plagiarism includes, but is not limited to, the unacknowledged use of these tools to create content submitted as one's own. If the use of any of these tools is suspected, the instructor may request notes and other materials used in preparing assignments. Students must retain these materials until final grades are posted. Failure to produce these materials when requested may negatively impact the student's grades.

## Learning Accommodations

If you require special accommodations or have any other medical condition you deem may affect your class performance, you must stop by the International Center to speak to Marta Carrillo (mcaroro@acu.upo.es) to either turn in your documentation or to confirm that our office has received it. Marta will explain the options available to you.

## Behavior Policy

Students are expected to show integrity and act in a professional and respectful manner at all times. A student's attitude in class may influence his/her participation grade. The professor has a right to ask a student to leave the classroom if the student is unruly or appears intoxicated. If a student is asked to leave the classroom, that day will count as an absence regardless of how long the student has been in class.

## Course Contents

### **Unit 1.** Introduction to databases

- Introduction
- History of Database Applications
- Databases vs File system
- Characteristic of the database approach
- Summary

### **Unit 2.** SQL review

- Entity-Relation model
- Data Definition Language (DDL)
- Data Manipulation Language (DML)
- Cardinality restrictions
- Summary
- Examples

### **Unit 3.** Transaction Management

- Introduction
- ACID concept
- Properties
- Concurrency of users
- Sequentially and interference
- Isolation level
- Failure recovery
- Roles on DBMS
- Summary and review questions

### **Unit 4.** Query Processing

- Translating SQL into linear algebra
- Algorithms for external sorting
- Algorithms for SELECT and JOIN operations
- Implementing Aggregate Operations and OUTER JOINs
- Pipelining
- Summary and review questions

### **Unit 5.** Index structures

- Disk storage, basic file structure and hashing
- Single-Level ordered Indexes
- Multilevel indexes
- Dynamic multilevel Indexes using B/B*-Trees and B+-Trees
- Summary and review questions

### **Unit 6.** Query Optimization

- Heuristic query optimization
- Selectivity and Cost Estimates in query optimization
- Semantic query optimization
- Summary and Review questions

### **Unit 7.** Distributed DBMS

- Differences between distributed database systems, distributed processing, and parallel database systems
- Advantages and disadvantages of distributed DBMS
- Problems of heterogeneity
- Basic networking concepts
- Summary

### **Unit 8.** In-Memory databases

- Description
- Advantages and disadvantages
- ACID support
- Hybrids with on-disk databases
- Summary
- SQL Lite exercises

## **Unit 9.** Alternative database models

- NoSQL vs SQL
- Architecture
- Advantages and disadvantages
- noSQL systems
- Document oriented database: MongoDB
- Columnar Database: MariaDB
- Graph oriented database: Neo4j
- Exercises

## **Unit 10.** Connection to programming languages

- JPA
- ADO
- SQLAlchemy
- Exercises

## Student Engagement Rubric (each item is equally weighted)

| Criteria | Exemplary (9-10) | Proficient (7-8) | Passing (5-6) | Poor (0-4) |
|---|---|---|---|---|
| **Attendance** | Arrives on time and stays for the entire duration of class. No absences, or if absent once, demonstrates knowledge of course material missed. | Misses no more than two sessions or is occasionally late. Demonstrates knowledge of course material missed. | Misses 3 or 4 sessions or frequently arrives late/leaves early; exhibits little knowledge/interest regarding course material missed. | Misses 5 or more sessions and does not demonstrate knowledge of course material missed. |
| **Preparation** | Consistently well-prepared; demonstrates deep understanding of readings and completes assignments. | Usually prepared; completes readings with some understanding and usually completes assignments. | Occasionally prepared. Demonstrates limited understanding of materials and occasionally completes assignments. | Rarely prepared; minimal effort to engage with course materials. |
| **Participation** | Actively participates in discussions with thoughtful comments/questions; demonstrates knowledge of the material and critical thinking skills. | Participates often demonstrating knowledge of material and critical thinking skills. | Participates once in a while or contributions lack depth or relevance. | Does not participate or is disruptive during discussions. |
| **Attentiveness & Respect** | Fully engaged and attentive during all sessions; respectful to professor and fellow students. Use of laptop/tablet for notetaking only; no cellphone use. | Generally attentive, with very infrequent lapses in focus and use of electronic devices for non-class related purposes. Respectful to professor and fellow students. | Occasionally inattentive or disengaged. Use of electronic devices for non-class related purposes thus showing disrespect towards professor and fellow students. | Rarely attentive, focused or responsive. Repeated use of electronic devices for non-class related purposes thus showing disrespect towards professor and fellow students. |
| **Collaboration & Feedback** | Effectively collaborates with peers in group or in-class activities following professor's instructions. Incorporates feedback to improve learning & performance. | Collaborates frequently with peers or in in-class activities. Incorporates feedback and makes moderate efforts to improve learning & performance. | Occasionally works well with peers but does not contribute substantially to in-class or group assignments. Responds to feedback inconsistently with minimal improvement. | Does not collaborate with peers, does not complete in-class or group assignments. Ignores feedback. |