**NATIONAL UNIVERSITY**
**of Computer & Emerging Sciences, Lahore**

# FAST School of Computing

## CS2005 – Database Systems

## Spring 2024


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**Course Information**
**Program:** BS **Credit Hours:** 3 **Type:** Core
**Pre-requisites (if any):** CS2001 - Data Structures
**Course Website (if any)**:
**Class Meeting Time**

**Course Description**
This course is an introduction to relational databases management Systems. The course will cover fundamental concepts of databases with an emphasis on modeling, designing and implementation of database systems. The theory will be augmented with hands-on exercises on database system. A project will be conducted in the database system lab that runs in parallel with the course. In project, the students will develop a data-centric application with complete set of business transactions and appropriate user interface using a popular programming language and a popular database management system.

**Learning Outcomes**
At the end of the course, you will be able to:
- Describe how databases store and retrieve information using the basic concepts and terminology of relational databases.
- Create an ER diagram (semantic model) about an enterprise (e.g., retail industry, airport, school, library) that correctly describes the entities, attributes, and relationships among the entities, for some of its major business functions.
- Create a logical data model from an ER diagram to design a set of DB relations.
- Normalize a set of attributes to eliminate update anomalies or redundancies from a set of relations.
- Implement a logical data model using a DBMS.
- Write queries using formal query languages such as relational algebra.
- Write SQL statements to query a set of tables in a DBMS involving multiple conditions, ordering, aggregate functions, grouping, group selection, set operations, joins, and nested queries.
- Write SQL statements to insert, delete and update a set of tables in a DBMS.
- Write SQL statements to create, alter, drop, rename a set of tables in a DBMS.
- Write SQL statements to add and drop constraints on a set of tables in a DBMS.
- Comprehend the ACID properties of Transactions and recoverability schedules.

**Textbook:** Ramez Elmasri, *Fundamentals of Database Systems* (7th Edition)

**Reference Books**
- Raghu Ramakrishnan, *Database Management Systems* (3rd Edition)
- C. J. Date, *An Introduction to Database Systems* (8th Edition)

**Grading Scheme**
Midterms (30%), Quizzes/Class Participation (10%), Assignments (10%), Final (50%)

**Grading**

- Minimum eligibility to pass this course is to get 50% marks.
- Academic integrity is expected of all the students. Plagiarism or cheating in any assessment will result in at least an **F** grade in the course, and possibly more severe penalties.

**Project**

Students will design, implement, demonstrate, and document a database system. The project is to be done in groups of 3/4 students. Pick your partner as soon as possible. The groups are self-policing (e.g., each group is responsible for its own division of labor, scheduling, etc.). A separate handout will be provided describing the project requirements in the 2nd week of the classes.

**Tentative Course Outline and Lecture Plan**

| Week | Topics to be covered | Topics Detail | | Readings (Textbook) | No of Lec. | Asst. |
|---|---|---|---|---|---|---|
| 1 | Introduction to Databases | • Databases and Database Users<br>• Characteristics of the Database Approach<br>• Advantages of Using the DBMS Approach<br>• Data Models, Schemas, Instances<br>• Architecture and Components of a DBMS | | Ch 1,2 | 2 | |
| 2-3 | Relational Data Model | RA | SQL | Ch 5, 6 | 4 | A1 |
| | | • Relational Model Concepts<br>o Domain, Attributes, Tuples, Relations<br>o Characteristics of Relations<br>• Relational Model Constraints<br>o Domain, Keys, Integrity<br>• Update Operations and Dealing with Constraint Violation | • Data Definition Statements (DDL)<br>o Create, Alter, Drop, Rename<br>• Specifying Constraints<br>o Attribute, Key, Referential Integrity, Tuple-Based Using CHECK<br>• Data Modification Statements (DML)<br>o Insert, Update, Delete | | | |
| 4-6 | Formal Query Language: Relational Algebra and The Database Language: SQL | RA | SQL | Ch 6, 7, 8 | 6 | A2, A3 |
| | | o Unary Relational Operations<br>o SELECT, PROJECT, RENAME | o Retrieval Queries<br>o Basic Queries: SELECT-FROM-WHERE<br>o Ordering, Arithmetic Operations, Substring Comparison | | | |
| | | o Binary Operations<br>o Union, Intersection, Difference, Division | o Set Operations | | | |
| | | o Cartesian Product, JOIN<br>o Outer Join, Outer Union, Full | o Joining, Full, outer, inner, Cross | | | |
| | | o Aggregate Functions and Grouping | o Aggregate Functions and Grouping | | | |
| | | Query Tree | o Nested Queries<br>o Correlated Nested Queries | | | |
| | | -- | o Views (Virtual Tables), Stores Procedures, Assertions and Triggers | | | |
| 7-9 | Database Design Theory and Normalization | • Design Anomalies<br>• Informal Design Guidelines for Relational Databases<br>• Functional Dependencies (FDs)<br>o Convert Business statements into Dependencies<br>o Armstrong's Inference Rules for FDs<br>o Algorithm for computing Attribute Closure<br>o Minimal Cover of FDs<br>o Equivalence of Sets of FDs<br>• Normalization for Relational databases<br>o Normalization and De-Normalization<br>o Normal Forms: 1NF, 2Nf, 3NF, BCNF, 4NF, 5NF<br>• Overview of Relational Database Design Algorithms | | Ch 14, 15 | 6 | A4 |

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| 10-12 | Data Modeling Using Entity-Relationship (ER) Model | • Entity Types, Entity Sets, Attributes, Keys<br>• Relationship Types, Relationship Sets, Roles<br>• Constraints on Relationship Types<br>• Relationship Types of Degree Higher than Two<br>• Enhanced Entity-Relationship (EER) Model Concepts<br>• Subclasses, Superclasses, Inheritance<br>• Specialization and Generalization<br>• Constraints and Characteristics of Specialization and Generalization<br>• Shared and UNION Type subclasses | Ch 3, 4 | 5 | A5 |
| 12-13 | Relational Database Design by ER- and EER-to-Relational Mapping | • Mapping ER Model Constructs to Relations<br>• Mapping EER Model Constructs to Relations | Ch 9 | 2 | |
| 13-14 | Transaction Processing Concepts | • Issues in Transaction Processing<br>• Why Concurrency Control is Needed<br>• Why Recovery is Needed<br>• Transaction States and Operations, System Log, Commit Point of a Transaction<br>• ACID Properties of Transactions<br>• Characterizing Schedules based on Recoverability<br>• Characterizing Schedules based on Serializability<br>• Transactions Isolation Levels and Possible Violations<br>• Basic Two-Phase Locking Technique for Concurrency Control | Ch 20 | 3 | |