

Pokhara University
Faculty of Science and Technology

Course Code: CMP 222

Course Title: Database Management System (3-1-3)

Nature of the Course: Theory and Practical

Level: Bachelor

Full Marks: 100

Pass Marks: 45

Total Lectures: 45 hours

Program: BE

1. Course Description

This course is designed to encompass the fundamental concepts of database management system. These concepts include the aspects of database design, database languages and database system implementation. This course presents the introductory concepts of database security, query processing and optimization, transactions and their concurrency control and recovery policies. This course also introduces the emerging new trended databases such as NoSQL and Blockchain databases. After completion of this course, students can design and implement a database system to develop a software application.

2. General Objective

- To acquaint the students with the knowledge of relational database design using ER Model.
- To develop the skills in students to design normalized relational database required for a specified application.
- To acquaint the students with the knowledge of database security, query processing and optimization, files and record organizations, transaction, concurrency control, data recovery mechanisms.
- To acquaint the students with basic concepts of NoSQL databases and Blockchain Databases.

3. Methods of Instruction

- Lecture, Tutorial/Discussion/Readings, Practical works and Project works.

4. Contents in Detail

| Specific Objectives | Contents |
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| <ul style="list-style-type: none">• Familiarize with basic concepts of database systems, and its architecture. | Unit 1: Introduction [4 hrs] <ol style="list-style-type: none">1. Database Management System purpose and applications,2. Database Systems vs File Systems3. View of Data- Data Abstraction (Physical, logical and view level, Data Independence)4. Instances and Schemas,5. Database Languages (DDL, DML and DCL)6. Database and Application Architecture- Database System Architecture and Database Application Architecture (two-tier and three-tier) |

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| <ul style="list-style-type: none"> Familiarize with ER Model and Relational Model and relational algebra. Design the relational database using ER model. | <p>Unit 2: ER and Relational Model [8 hours]</p> <ol style="list-style-type: none"> Introduction to ER Model: Entity sets, attributes and values, Relationship sets-participation, entity's role, descriptive attributes, degree of relationship set, Mapping Cardinalities, Attributes- simple, composite, single-valued, multi-valued, derived, Entity-Relationship (ER) Diagram, Specialization, Generalization, and Aggregation Key- Super key, Candidate key and Primary key, Strong and Weak Entity Sets Introduction to Relational Model Reducing ER diagrams to Relational Schema Structure of Relational Databases, Database Schema, Keys, Schema Diagrams Relational Algebra |
| <ul style="list-style-type: none"> Implement and write DDL and DML queries in the SQL. | <p>Unit 3: Structured Query Language [5 hours]</p> <ol style="list-style-type: none"> Structured Query Language (SQL)- SQL DDL and DML, Basic Structure of SQL Queries, DDL queries, Basic Operations (Rename, String, Attribute Specification in the select clause, order by, where-clause), Set Operations, Null values, Aggregate Functions, Nested Queries, Join Expressions (Natural Join, Join Conditions, Outer Joins), Modification of Database (delete, insert into, update), Views, Stored Procedures |
| <ul style="list-style-type: none"> Apply the integrity constraints to implement database securities. Normalize the database to a defined normal form. | <p>Unit 4: Relational Database Design [6 hrs]</p> <ol style="list-style-type: none"> Integrity constraints- Domain Constraints, Entity Integrity Constrains, Referential Integrity Constraints, Assertions and Triggers Features of Good Relational Designs Functional dependencies and Armstrong's Axioms Closure of a Set of Functional Dependencies and Closure of Attribute Sets Database Normalization and Normal Forms- 1NF, 2NF, 3NF and BCNF Denormalization for Performance |
| <ul style="list-style-type: none"> Understand the need of database security. Understand the role of access control, authorization, views and encryption mechanism to provide database security. | <p>Unit 5: Security [3 hrs]</p> <ol style="list-style-type: none"> Security and integrity violations Access control Authorization Security and Views |
| Understand the mechanism of query processing and need of query optimization. | <p>Unit 6 : Query Processing and Optimization [5 hrs]</p> <ol style="list-style-type: none"> Introduction to Query Processing Equivalence of Expressions Query Cost Estimation Query Optimization |

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| | 5. Query evaluation and execution plan |
| <ul style="list-style-type: none"> Familiarize with different file organization methods. | Unit 7 : Storage Management and Indexing [3 hrs] 1. File Organization- fixed length records, variable length records 2. Organization of Records in File- Heap, Sequential and Indexed sequential file organizations. 3. B+ Tree Index Files 4. Hash Indices |
| <ul style="list-style-type: none"> Understand the concepts of transactions, need of atomicity, durability and isolation, serial schedule. Familiarize with the need of Concurrency control. | Unit 8 : Transactions and Concurrency Control [4 hrs] 1. Transaction Concepts 2. Transaction Model and State Diagram 3. ACID properties of transaction 4. Serializability- conflict and view serializability 5. SQL Standard Isolation Levels 6. Concurrency Control- Lock-Based Protocols and Graph-Based Protocols |
| <ul style="list-style-type: none"> Understand the recovery algorithms and techniques to protect and recover the data from various failures. | Unit 9 : Crash Recovery [3 hrs] 1. Failure classification 2. Recovery and Atomicity- log records, database modification, concurrency control and recovery, transaction commit, Redo and Undo Transactions using Log, Check Points, 3. Recovery Algorithm Using Log Records- Transaction Rollback, Recovery After a System Crash, Optimizing Commit Processing 4. High Availability Using Remote Backup System |
| <ul style="list-style-type: none"> Understand the concepts of NoSQL, ODBMS, Distributed Databases | Unit 10 : Emerging Trend in Databases [4 hrs] 1. NoSQL Databases- Characteristics, Categories, Advantages 2. Object Oriented Database and ORM 3. Distributed Databases- 4. Distributed Ledged Technology: Blockchain, Cryptocurrency, Blockchain Properties |

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5. Practical Works

Laboratory work of 45 hours per group of maximum 24 students should cover the database design, use of database languages and database system implementation using any relational database management system such as MS SQL or MySQL or Oracle etc. Students should complete the following tasks in laboratory:

| S N | Tasks to Complete |
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| 1 | Introduction to MS SQL (or any RDBMS), its datatypes and its installation. |

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| 2 | All SQL DDL operations studied in Unit 2 such as creating database, creating tables, delete database, drop table, alter etc. |
| 3 | All SQL DML operations studied in Unit 2 such as database modification operation- insert into, delete, update etc. |
| 4 | Implementing Join Expressions (Natural Join, Join Conditions, Outer Joins) |
| 5 | Implementing Stored Procedures. |
| 6 | Illustration and implementation of Views. |
| 7 | Implementing Integrity constraints (Domain Constraints, Entity Integrity Constrains, Referential Integrity Constraints) |
| 8 | Implementing Assertions and Triggers. |
| 9 | Implementation of Database Security and Privileges: Grant and Revoke Commands, Commit and Rollback Commands. |
| 10 | Connecting database with connection string using any standard programming language and executing SQL queries. |

Students should submit a project work that uses all the knowledge obtained from this course to design and implement a database system for any application that students chose. The students should design the database using ER model and present using ER diagram which are then reduced to relational schema. The students should apply the constraints studied in this course including triggers. The database should be in at least 3NF. The marks for the practical evaluation must be based on the project work submitted by students.

6. List of Tutorials

The various tutorial activities that suit your course should cover all the content of the course to give students a space to engage more actively with the course content in the presence of the instructor. Students should submit tutorials as assignments or class works to the instructor for evaluation. The following tutorial activities of 15 hours per group of maximum 24 students should be conducted to cover the content of this course:

A. Discussion-based Tutorials: (3 hrs)

- Evolution of database systems- traditional file systems and need of database system (Class discussion)
- Semi-Structured Data Model and Object-Based Data Model (Class discussion).
- Concurrency Control- Lock-Based Protocols and Timestamp-Based Protocols (Oral Presentation).

B. Problem solving-based Tutorials: (6 hrs)

Suppose you are given a task to design a database of a university or college or library, or any real world system that you know very well. Use ER model to design the database for the system you chose, reduce it into the relational schema, represent in Database diagram, normalize the database, implement the integrity constraints, apply some level of security using Grant and Revoke Commands, Commit and Rollback Commands, and develop a

mini project. You can combine this tutorial with your lab project stated in Practical Works section.

C. Review and Question/Answer-based Tutorials: (6 hrs)

- a. Case study on any NoSQL Database.
- b. Case study on using Blockchain Database.
- c. Students ask questions within the course content, assignments and review key course content in preparation for tests or exams.

1. Evaluation System and Students' Responsibilities

Evaluation System

The internal evaluation of a student may consist of assignments, attendance, internal assessment, lab reports, project works etc. The internal evaluation scheme for this course is as follows:

| Internal Evaluation | Weight | Marks | External Evaluation | Marks |
|----------------------------------|--------|-------|--------------------------|-------|
| Theory | | 30 | Semester-End examination | 50 |
| Attendance & Class Participation | 10% | | | |
| Assignments | 20% | | | |
| Presentations/Quizzes | 10% | | | |
| Internal Assessment | 60% | | | |
| Practical | | 20 | | |
| Attendance & Class Participation | 10% | | | |
| Lab Report/Project Report | 20% | | | |
| Practical Exam/Project Work | 40% | | | |
| Viva | 30% | | | |
| Total Internal | | 50 | | |
| Full Marks: 50 + 50 = 100 | | | | |

Student Responsibilities

Each student must secure at least 45% marks separately in internal assessment and practical evaluation with 80% attendance in the class in order to appear in the Semester End Examination. Failing to get such a score will be given NOT QUALIFIED (NQ) to appear for the Semester-End Examinations. Students are advised to attend all the classes, formal exam, test, etc. and complete all the assignments within the specified time period. Students are required to complete all the requirements defined for the completion of the course.

8. Prescribed Books and References

Text Books

1. Silberschatz, A., Korth, H. F., & Sudarshan, S. (2011). *Database system concepts*. McGraw Hill.

References

1. Majumdar, A. K., & Bhattacharyya, P. (1996). *Database Management Systems*. McGraw-Hill.
2. Elmasri, R., & Navathe, S. B. (1994). *Fundamentals of Database Systems* Benjamin Cummings. *Redwood City, CA*.
3. Everest, G. C. (1986). *Database management*. McGraw-Hill, Inc..