

**BIRLA INSTITUTE OF TECHNOLOGY & SCIENCE, PILANI**

**WORK INTEGRATED LEARNING PROGRAMMES**

**COURSE HANDOUT**

**Part A: Content Design**

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| **Course Title** | Database Design and Applications |
| **Course No(s)** | CSI ZG518/ SE ZG518/ SS ZG518 |
| **Credit Units** | 5 (1 unit for lecture, 2 for self-study, 2 for lab / assignment / work integrated activities) |
| **Course Author** | R. Gururaj |
| **Version No** | 1.1 |
| **Date** |  |

**Course Objectives**

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| **No** | **Course Objective** |
| **CO1** | To enable students to Design and Develop robust databases & applications |
| **CO2** | Provide knowledge about the internals of Database Management Systems. |
| **CO3** | To provide skills to operationalize Database Systems, like maintaining consistency and integrity, improving performance, etc. |

**Text Book(s)**

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| T1 | Ramez Elmasri & Shamkant B. Navathe, Fundamentals of Database Systems, Pearson Education, 7th Edition, 2017 |

**Reference Book(s) & other resources**

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| R1 | Abraham Silberschatz, Henry F Korth and S Sudarshan, Database System Concepts, McGraw Hill, 6th Ed., 2013 |
| R2 | Date C.J., An Introduction to Database Systems, Addison Wesley, 8th Ed., 2006. |
| R3 | Raghu Ramakrishnan & Johannes Gehrke, Database Management Systems, McGraw-Hill Education, 3e, Indian Edition 2014 |

**Modular Content Structure**

1. Introduction to Database Management Systems (DBMS) Concepts and Architecture
   1. Database Management Systems Introduction
      1. Basics and advantages of storing data using DBMS
      2. Database systems environment
   2. Database Management System Architecture
      1. Abstraction and Three-schema architecture
      2. Basic modules of DBMS
      3. DBMS Users
2. Data Modeling
   1. Database Design and ER Modeling
      1. Steps in database Design Process
      2. Concepts and notations
      3. Relationships and constraints
      4. Examples
   2. Relational Data Model concepts
      1. Relational data model fundamentals
      2. Constraints in Relational data model
      3. Representation of schemas
   3. ER to Relational Mapping
      1. Mapping rules/guidelines for mapping ER constructs
      2. Mapping rules/guidelines for mapping hierarchies
      3. Examples
3. Relational Query Languages
   1. Relational Algebra
      1. Basic Relational operations
      2. Other operations and Joins
   2. SQL
      1. Introduction to SQL
      2. SQL features
      3. SQL join operations
      4. SQL Grouping operations
      5. SQL views
4. Schema Refinement
   1. Functional Dependencies
      1. Functional dependencies
      2. Inference rules
   2. Normalization and Decomposition
      1. First and Second Normal forms
      2. Third and BCNF normal forms
      3. Decomposition and desirable properties
      4. Lossless join decomposition
      5. Dependency preserving decomposition
5. Data storage, Hashing and Indexing
   1. Disk storage
      1. Disk features
      2. Storage capacity
      3. File and Record organization
      4. Types of File organizations
      5. Types of record organizations
   2. Hashing Techniques
      1. Static external Hashing
      2. Dynamic hashing schemes
   3. Indexing Techniques
      1. Introduction to indexing
      2. Primary and secondary indexing
      3. Multilevel indexing
      4. B+ tree indexing
6. Transaction processing, concurrency control and recovery
   1. Transaction model
      1. Transaction significance
      2. States of a transaction
      3. Schedules- serial and concurrent
   2. Concurrency Control
      1. Need for Concurrency control
      2. Lock based concurrency control and Deadlocks
      3. Time-stamp based concurrency control
   3. Database Recovery
      1. Log based recovery techniques
      2. Checkpointing
      3. Shadow paging
7. Database Security and Database Programming
   1. Database security
      1. Introduction to Database Security
      2. Access Control Mechanisms
      3. Statistical Database Security
      4. Flow Control
      5. Other Security Challenges
8. Additional Topics
   1. Query optimization and Tuning
      1. Query execution steps
      2. Query trees
      3. Heuristics
      4. Database tuning concepts
   2. Database Design methodology and UML
      1. Role of information systems
      2. Design process
      3. UML and tools in Database
   3. XML data model
      1. Basics of XML
      2. DTD and schemas
      3. XML storage
      4. XML query languages- XPath and XQuery
   4. Database programming
      1. Accessing databases from programming languages
      2. Triggers
      3. Stored procedures
   5. Distributed Databases and Client Server Architecture
      1. Purpose of Distributed databases
      2. Managing distributed databases
      3. Overview of 3-tier client server architecture
   6. Recent trends in databases
      1. NoSQL Databases
      2. Hadoop

NoSQL Database

<https://www.thoughtworks.com/insights/blog/nosql-databases-overview>

Hadoop

<https://www.mssqltips.com/sqlserverauthor/77/dattatrey-sindol/>

**Note:** Due to time constraints, all topics listed under module 8 may not be covered. Instructor may decide on some topics from module 8 to be covered as a part of the course.

**Learning Outcomes:**

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| **No** | **Learning Outcomes** |
| LO1 | Students can design databases that minimizes duplication of data and one that provides fast access to data |
| LO2 | Students can develop database applications that maintains integrity of data |
| LO3 | Students are aware of techniques to tune the Database Systems and Applications for improved performance, response-time, etc. |

**Part B: Contact Session Plan**

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| **Academic Term** | First Semester 2024-2025 |
| **Course Title** | Database Design and Applications |
| **Course No** | CSI ZG518/ SE ZG518/ SS ZG518 |
| **Lead Instructor** | Uma Mahshwari Ganesan and Manjunath N |

**Course Contents**

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| **Contact Session**  **(2Hrs)** | **List of Topic Title**  **(from content structure in Part A)** | **Topic #**  **(from content structure in Part A)** | **Text/Ref Book/external resource** |
| 1 | * Introduction to Database Management Systems * Advantages of using DBMS * Three-schema architecture and Data independence * DBMS Architecture * Database Users | 1.1, 1.2 | T1-Chapter 1  *Sections:*  1.1-1.6,  T1-Chapter 2  2.1 to 2.4 |
| 2 | * Database Design Process * ER Modelling concepts * EER Concepts | 2.1 | T1-Chapter 3  *Sections:*  3.1 to 3.7  T1 Chapter 4  *Sections:*  4.1-4.3 |
| 3 | * Relational model concepts * Relational data model constraints * Mapping ER Constructs to relations * Mapping Class hierarchies | 2.4, 2.3 | T1-Chapter 5  *Sections:* 5.1- 5.3  T1-Chapter  *Sections:* 9.1, 9.2 |
| 4 | * Relational algebraic expressions * Relational Algebraic operations * Introduction to TRC | 3.1 | T1-Chapter 8  *Sections:*  8.1- 8.6 |
| 5 | * Introduction to SQL * Queries in SQL * Aggregate and GROUPING * INSERT/DELETE/UPDATES * Views in SQL | 3.2 | T1-Chapter 6  *Sections:*  6.1-6.4  T1-Chapter 7  *Sections:*  7.1-7.4 |
| 6 | Tutorial on   * ER/EER Modelling * ER/EER to Relational Mapping * SQL Queries |  |  |
| 7 | * Guidelines for database design * Functional dependencies * Normal forms and their conditions * Decomposition and properties | 4.1, 4.2 | T1-Chapter 14  *Sections:*  14.1-14.5  T1-Chapter 15  *Sections:*  15.1-15.3 |
| 8 | * Secondary storage devices * Files, records, blocks on disks * Revision(1 hour) | 5.1 | T1-Chapter 16  *Sections:*  16.1-16.7 |
| 9 | * Hashing techniques(internal & external) * Types of Indexes; Sparse and Dense indexing * Multilevel indexes * Dynamic indexing with B-Trees and B+ Trees | 5.2, 5.3 | T1-Chapter 16  *Sections:*  16.8  T1-Chapter 17  *Sections:*  17.1 – 17.3 |
| 10 | * Introduction to transactions * States of a transaction * Desirable properties of a transaction * Schedules * Concurrent transactions * Serializability | 6.1 | T1-Chapter 20  *Sections:*  20.1- 20.5 |
| 11 | * Need for Concurrency Control in database systems * Lock-based protocols * Two-phase locking techniques for concurrency control * Deadlock situation * Timestamp-based protocols | 6.2 | T1-Chapter 21  *Sections:*  21.1, 21.2 |
| 12 | Database Recovery   * Recovery concepts * Introduction to log-based recovery techniques * Database recovery based on Shadow paging | 6.3 | T1-Chapter 22  *Sections:*  22.1- 22.4 |
| 13 | Database Security   * Introduction to Database Security * Access Control * Statistical Database Security * Flow Control * Other Challenges | 7.1 | T1-Chapter 30 |
| 14,15 | Some topics from module 8 to be covered as decided by the instructor. |  |  |
| 16 | Revision Lecture |  |  |

Tutorial session:

1. ER & EER diagram: Faculty will provide a real life comprehensive scenario in the class. The students will draw an EER diagram for the same. The faculty will clarify students’ doubts as they try to draw the diagram. Estimated duration 40 min.
2. Mapping EER to Relational model: For the same scenario described above, the students will convert the EER diagram to Relational model. Faculty will clarify doubts of students. Estimated duration 40 min.
3. Writing SQL statements: For the same scenario described above, the faculty will provide queries in plain English. The students will have to write these queries in SQL. Estimated time is 40 min.

**Detailed Plan for Lab work**

Install SQLite & SQLiteBrowser on your laptop for carrying out the lab exercises

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| **Lab No** | **Topic** | **Lab Objective** |
| 1 | Basics of SQL | Understand installation of DBMS such as SQLite and SQLiteBrowser and explore its features |
| 2 | Data Definition Language (DDL) | Understand how to CREATE tables |
| 4 | Data Manipulation Language(DML) | Basics of SQL: SELECT & JOIN |
| 5 | DML | Understand usage of Aggregate functions |
| 6 | DML | Understand how to use UPDATE and DELETE operations |

**Assignment**

1. Think of a web-based software application (with a central database), that you think will be useful to many people (1 week)
2. Write a brief description of the application (1 week)
   * Who will be the users?
   * What are the benefits of this application?
   * List of functions & features of the application
   * How many users will use it simultaneously?
3. Draw ER diagram for the application(2 weeks)
4. Convert ER model to relational model (2 weeks)
5. Write SQL queries to fulfil the end user needs (2 weeks)
6. Design indices to enhance the performance of queries and justify your choice of indices

**Work Integrated activities** (8 weeks)

(Applicable when students are working on projects involving databases)

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| **Activity No** | **Topic** | **Description** |
| 1 | Conceptual model | Draw ER diagram of the database used by your application |
| 2 | Logical database model | Study the tables of your application & determine if it satisfies 3rd Normal Form. Recommend improvements if any, to the table design |
| 3 | Physical design | Study the indexes of your application & suggest improvements if any. |
| 4 | Database administration | Talk to your DBA and find out what their challenges are. Think of ways to address these challenges and discuss your suggestions with them. What is the outcome of these discussions? |
| 5 | Security | What security features of DBMS are implemented in your application (set of applications). Give examples of situations where these features are used. |

**Evaluation Scheme**

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| **Evaluation Component** | **Name** | **Type** | **Weight** | **Duration** | **Day, Date, Session, Time** |
| **EC – 1** | Quiz | \* | 10% | - | September 1-10, 2024 |
| Lab or Assignment or Work Integrated activities |  | 15% | - | October 10-20, 2024 |
| **EC - 2** | Mid-Semester Test | Closed Book | 30% | 2Hr | Sunday, 22/09/2024 (AN) |
| **EC - 3** | Comprehensive Exam | Open Book | 45% | 3Hr | Sunday, 01/12/2024 (AN) |

***Note*** *- Evaluation components can be tailored depending on the proposed model.*

**Important Information**

Syllabus for Mid-Semester Test (Closed Book): Topics in Weeks 1-7

Syllabus for Comprehensive Exam (Open Book): All topics given in plan of study

Evaluation Guidelines:

1. EC-1 consists of either two Assignments or three Quizzes. Announcements regarding the same will be made in a timely manner.
2. For Closed Book tests: No books or reference material of any kind will be permitted. Laptops/Mobiles of any kind are not allowed. Exchange of any material is not allowed.
3. For Open Book exams: Use of prescribed and reference text books, in original (not photocopies) is permitted. Class notes/slides as reference material in filed or bound form is permitted. However, loose sheets of paper will not be allowed. Use of calculators is permitted in all exams. Laptops/Mobiles of any kind are not allowed. Exchange of any material is not allowed.
4. If a student is unable to appear for the Regular Test/Exam due to genuine exigencies, the student should follow the procedure to apply for the Make-Up Test/Exam. The genuineness of the reason for absence in the Regular Exam shall be assessed prior to giving permission to appear for the Make-up Exam. Make-Up Test/Exam will be conducted only at selected exam centres on the dates to be announced later.

It shall be the responsibility of the individual student to be regular in maintaining the self-study schedule as given in the course handout, attend the lectures, and take all the prescribed evaluation components such as Assignment/Quiz, Mid-Semester Test and Comprehensive Exam according to the evaluation scheme provided in the handout.

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| **Date** | **Revision #** | **Revised by** | **Key changes** |
| July 2, 2015 | 1.0 | R Gururaj | First release |
| June 30, 2016 | 1.1 | Viswanathan Hariharan | * Created lab sheet * Added assignment * Added Work integrated activity * Revised Evaluation components weight * Added topics   + Using DB from applications   + Recent trends |
| Mar 3, 2017 | 1.2 | Viswanathan Hariharan | * Introduced tutorial session before mid sem exam * Removed topics – Query optimization, Role of information systems, Implementation of database, UML, XML model, XML querying * Introduced ‘Student presentation’ session |
| June 22, 2017 | 1.3 | Viswanathan Hariharan | * Increased weightage for assignment from 10% to 15% and reduced weightage of compre exam from 50% to 45% |
| May, 2018 | 1.4 | Ashish Narang, Prof. TV Rao | * Added topics-Query optimization and tuning, Database Design Methodology and UML, XML Data Model and Distributed Databases as part of module 8. * Recent trends and Database programming have been shifted to module 8. * All topics listed under module 8 may not be covered. Some topics (decided by instructor) from module 8 will be covered in CS 14 and CS 15. * CS 16 has been made as revision lecture. |