IT2305 – Database Systems I

(Compulsory)

INTRODUCTION

This is one of the 4 modules designed for Semester 2 of Bachelor of Information Technology Degree program.

CREDITS: 04

LEARNING OUTCOMES

On completion of this course, students should be able to design and develop a database eliminating anomalies using a commercial database product applying fundamentals and concepts of database management systems.

MINOR MODIFICATIONS

When minor modifications are made to this syllabus, those will be reflected in the Virtual Learning Environment (VLE) and the latest version can be downloaded from the relevant course page of VLE. Please inform your suggestions and comments through the VLE. http://vle.bit.lk

ONLINE LEARNING MATERIALS AND ACTIVITIES

You can access all learning materials and this syllabus in the VLE: http://vle.bit.lk, if you are a registered student of BIT degree program. It is very important to participate in learning activities given in the VLE to learn this subject.

ONLINE ASSIGNMENTS

The assignments consist of two quizzes, assignment quiz 1 (It covers the first half of the syllabus) and assignment quiz 2 (It covers the second half of the syllabus). Maximum mark for a question is 10, minimum mark for a question is 0 (irrespective of negative scores). Final assignment mark is calculated considering 40% of assignment quiz 1 and 60% of assignment quiz 2. Pass mark for the online assignments in a course is 50. You are advised to do online assignments before the final exam of the course. It is compulsory to pass all online assignments to partially qualify to obtain year 1 certificate.

FINAL EXAMINATION

Final exam of the course will be held at the end of the semester. Each course in the semester 2 is evaluated using a two hour question paper which consists of 40-60 MCQs.

OUTLINE OF SYLLABUS

Topics	Hours
1. Introduction to DBMS	07

2. Relational Data Model	03
3. Data manipulation using Relational Algebra	06
4. Data manipulation using SQL	16
5. Data views	05
6. Data security	05
7. Database Design Process	12
8. Data Normalization process and the normal forms	06
TOTAL	**60**

REQUIRED MATERIALS

Main Reading:

Ref 1. Fundamentals of Database Systems by R. Elmasri and S.B. Navathe, 6th edition, Addison-Wesley, 2010.

Ref 2. Database Management Systems by R. Ramakrishnan and JGehrke, 3rd edition, McGraw-Hill, International Edition, 2003.

Ref 3. Database Systems by Thomas M. Connolly Connolly E.Begg, 3rd edition, Low Price Edition, 2004.

Supplementary Reading:

Ref 4. Database System Concepts by A. Silberschatz, H.F. Korth and S. Sudarshan, 6th edition, McGraw-Hill, International Edition, 2010.

Ref 5. An Introduction to Database Systems by C.J. Date, 8th edition, Addison-Wesley, Low Priced Edition, 2003.

Ref 6. Modern Database Management by R.F. McFadden and J.A. Hoffer,11th edition, Benjamin-Cummins, 2012.

Ref 7. A Guide to the SQL Standard , C.J. Date and H. Darwen, 4th edition, Reading, MA: Addison-Wesley, 1996.

DETAILED SYLLABUS

1 Introduction to DBMS (7 hrs)

Instructional Objectives

- Describe the role of a database system.
- Briefly describe the evolution of database systems and the limitations of conventional file processing systems.
- Describe the three-schema architecture for databases and explain the difference between conceptual, external and physical schemas.
- Define the functions of a database administrator.

Sub Topics

1.1 The Evolution of Database Technology

1.1.1. Data, information, database, database system, database management system; Data processing and data management, Increasing use of data as a corporate resource. [Ref 1: pg.3-9; Ref 2: pg.3-5, 9-10]

1.1.2. File oriented systems: Meeting the need for random access processing; Limitations of Traditional File Systems: Data redundancy, Inadequate data manipulation capabilities, program-data dependency; Data independence. [Ref 2: pg.8]

1.2 Database Architecture

1.2.1. Components of a Database Management System (DBMS): Data Dictionary (importance, contents), meta data; Data security and integrity; Concurrent access; User-oriented data query and reporting; Application development facilities [Ref 1: pg.29-33]

1.2.2. Database Systems; ANSI/SPARC Three-level Architecture: Conceptual model, Logical model, Physical model, External view, Conceptual view, Internal view of data. [Ref 1: pg.33-35;Ref 2: pg.12-16]

1.2.3. Data specification and access mechanisms: Data Definition Language (DDL), Sub-Schema DDL, Data Manipulation Language (DML); Users: End users, Database Administrator (DBA); DBMS: Functions, Capabilities, Advantages and disadvantages. [Ref 1: pg.36-38; Ref 2: pg.131-132]

1.3. Users of a Database

1.3.1. Users and practitioners of a Database System [Ref 1: 14-16]

1.3.2. Data administrator, Database Administrator (DBA), Functions of a DBA. [Ref 1: pg.15; Ref 2:21-22]

1.3.3. Roles of a DBA with respect to Database Integrity, Transaction Processing, Concurrency Control, Database Security and Database Recovery. [Ref 2:21-22,714-715]

2. Relational Data Model (3 hrs)

Instructional Objectives

- Explain basic facts about the historical development of database management systems.
- Define the following key terms: Relation, Attribute, tuple, domain, instance, cardinality, degree, schema.
- Explain the fundamental concepts of the relational model, including relations, attributes,

domains, keys, foreign keys, entity integrity and referential integrity.

Sub Topics

2.1 Introduction Data Models: Review of database models, Definition of Relation, Attribute, tuple, domain, instance, cardinality, degree, schema, Constrains. [Ref 1: pg. 60-67; Ref 2:pg. 59-62]
2.2 Concepts of keys: Candidate key, Primary key, Alternate key, Composite key, Surrogate key, Foreign key. [Ref 1: pg.69, 73-74,84; Ref 2: pg.29]
2.3 Fundamental integrity rules: entity integrity, referential integrity: Domain constraints, Key constraints. [Ref 1: pg.68-70,73-74; Ref 2: pg.32-34,61,70]

3. Data Manipulation using Relational Algebra (6 hrs)

Instructional Objectives

- List the operations of relational algebra and show how they can be used to create new relations from existing relations.
- Formulate solutions to specific types of queries in relational algebra.

Sub Topics

3.1 Relational algebra (RA): Traditional Set Operations (Union, Intersection, Difference, Cartesian Product)4, Special Relational Operations (Select or Restrict, Project, Join, Different types of join (theta join, equi-join, natural join, outer joins), Division), Minimal set of operations, Simple and Complex queries using RA. [Ref 1: pg.145-186; Ref 2: pg.100-116]

4. Data Manipulation using SQL (16hrs)

Instructional Objectives

- Define a relational database schema in SQL.
- Explain basic elements in the structure of an SQL information schema.
- Formulate SQL queries of varying complexity.
- Insert, update and delete data in a relational database through SQL commands.

Sub Topics

4.1 Structured Query Language (SQL)

Introduction to SQL standards: SQL86, SQL89 and SQL92. [Ref 1: pg.87-90; Ref 2: pg.58,130-133]

4.2 Creating SQL Databases and Tables

4.2.1 Creating a Database: CREATE DATABASE, Creating a database schema; Database options: Connect, Disconnect, Select, Close, Create, Drop.

4.2.2 Defining tables: CREATE TABLE, ALTER TABLE, DROP TABLE. [Ref 1: pg.90-92; Ref 2: pg.62-63]

4.2.3 Specifying integrity constraints: PRIMARY KEY, UNIQUE, NOT NULL, CHECK, Referential Integrity constraints (Cyclic, Self-referencing, Multiple path) FOREIGN KEY (CASCADE, RESTRICT, NULL, DEFAULT.) []Ref 1: pg. 94-97; Ref 2: pg.69-73]

4.2.4 Creating indexes: CREATE INDEX, DROP INDEX. [Ref 1: 110-111]

4.3 Selecting Data

4.3.1 Queries: SELECT Statement. [Ref 1: pg.97-100; Ref 2: pg.73-74,133-141]

4.3.2 Single Table: all columns (*), selecting specific columns (RA project operation), unique values (DISTINCT), Executing multiple statements (;), WHERE clause (RA select operation), Including or excluding rows (=, !=), Relational Operators (=, !=, >, >=, <, <=), Identifying Null values (IS NULL), Where clause keywords (AND, OR, [NOT] BETWEEN, [NOT] IN, IS [NOT] NULL, [NOT] LIKE, ORDER BY) Arithmetic Operators (+, -, *, /), Expressions, Display Labels, Aggregate Functions: (COUNT, SUM, AVG, MAX, MIN, GROUP BY, HAVING.) [Ref 1: pg.98-100; Ref 2: pg.138-164]

4.3.3 Multiple Table: RA join and product operations, Natural Join, Multiple Table Joins, Aliases for table names, Outer Join, UNION. [Ref 1: pg.123-124, 152-157; Ref 2: pg.107-109,141-144,164-165]

4.3.4 Functions: Arithmetic (ROUND, TRUNC), String (TO_CHAR, UPPER, LOWER, Sub strings, Concatenation, TRIM), Date and Time (DAY, MONTH, YEAR, DATE, CURRENT). [Ref 1: pg.92-94,105-106; Ref 2: pg.139-141]

4.3.5 Sub queries: Nested Select Statement, Values returned by sub queries (single value, a list of values), EXISTS, Correlated nested queries. [Ref 1: pg.107; 119-122; Ref 2: pg.144-151]

4.4 Data Insertion, Updating and Deletion

4.4.1 Inserting Data: INSERT INTO [VALUES|SELECT] including a column list, null values; obtaining values from a SELECT. [Ref 1: pg. 107-109; Ref 2: pg.62-63,69-70]

4.4.2. Updating Data: UPDATE (selected columns, selected rows, with a sub query). [Ref 1: pg. 109-110; Ref 2: pg.63,70]

4.4.3. Deleting Data: DELETE (all data, selected data, with a sub query). [Ref 1: pg. 109; Ref 2: pg.69,70]

5. Data Views (5hrs)

Instructional Objectives

- Define the view concept in database systems.
- Formulate data views in SQL.
- Define the limitations in updating views.
- Define the concept of view materialization.

Sub Topics

5.1. What is a view? [Ref 1: pg.133-134; Ref 2: pg.86-88]
5.2. Views using SQL
  5.2.1. Creating view (CREATE VIEW) [Ref 1: pg.134-135; Ref 2: pg.88-89]
  5.2.2. Dropping view (DROP VIEW) [Ref 1: pg.135; Ref 2: pg.92-94]
5.3. View Updatability and WITH CHECK OPTION in SQL [Ref 1: pg.135-137; Ref 2: pg.88-91]
5.4. View Materialization [Ref 1: pg.135-136; Ref 2: pg.874-878]

6. Data Security (5hrs)

Instructional Objectives

- Describe types of security and threats to database systems.
- Define discretionary access control.

Sub Topics

6.1. Types of Security and Threats to Database Systems [Ref 1: pg.836-837; Ref 2: pg.692-694]
6.2. Discretionary Access Control
  6.2.1. Types of Discretionary Privileges [Ref 1: pg.842-844; Ref 2: pg.694-703]
    6.2.1.1. System Privileges
    6.2.1.2. Object Privileges
  6.2.2. Granting and Revoking Privileges [Ref 1: pg 842-.844; Ref 2: pg.704-705]
  6.2.3. Propagation of Privileges [Ref 1: pg.844-846]

7. Database design process (12hrs)

Instructional Objectives

- Describe the steps in the database development life cycle and their interrelationships.
- Demonstrate how information needs that occur frequently in businesses can be addressed by using these data modeling concepts.
- Map conceptual model into relational schema.

Sub Topics

7.1. Database Design Approach
  7.1.1. Introduction: Benefits, Critical success factors, Where it fits into the application development process, Approach [Ref 2: pg.26-28]
  7.1.2. Data requirement analysis: Gain an understanding of the business; Conceptual modeling: Identify the principal data objects, Diagram the data objects using the entity-relationship (ER) approach, Resolve the conceptual data model, Determine attribute specifications and data types, Verify the conceptual data model through normalization; Logical model; Physical model; Database Design tools. [Ref 1: pg.199-200]
7.2. ER Concepts and Terminology Graphics accelerator cards
  7.2.1. The Role of ER Diagrams. [Ref 1: pg.199-200; Ref 2: pg.26-28]
  7.2.2. Three classes of objects: Entities, Relationships and Attributes. [Ref 1: pg.203-207; Ref 2: pg.28-29]

7.2.3. Entities: Entity, Entity instance, Subtype and Super-type Entities, Strong and weak entities, Generalization, specialization and aggregation. [Ref 1: pg. 207-209;Ref 2: pg.28-29,35-42]

7.2.4. Relationships: Connectivity (binary, n-array), (1:1, 1:N, M:N), Determining the connectivity, Cardinality, Existence dependency (mandatory, optional). [Ref 1: pg.212-218; Ref 2: pg.29-34]

7.2.5. Attributes: Identifying attributes, Attribute types (identifier, descriptor), Derived data, Domain, Composite attributes. [Ref 1: pg.203-207; Ref 2: pg.59-62]

7.3. Mapping Conceptual model into relational schema

7.3.1. Regular, weak, generalized and specialized entities, Relationship types, Multi-valued attributes. [Ref 1: pg.191-205, 212-220; Ref 2: pg.40-42]

7.3.2. Resolve the conceptual data model; Redundant Relationships; Recursive Relationships; Resolving Relationships: 1:1, M:N. [Ref 1: pg. 212-218; Ref 2: pg.42-46]

7.4. Attribute Specifications and Data types

7.4.1. Attribute names, Naming conventions, Avoid Synonyms and Homonyms, Null Values, Entity integrity, Unique Requirement. [Ref 1:100-102,206, 221-222,317]

7.4.2. Categories of Data Types: Character, Numeric, Variable Character, Date, Serial, Money, Date-time, Interval. [Ref 1: 92-94]

7.4.3. Character: CHARACTER (CHAR); Numeric: INTEGER (INT), SMALLINT, FLOAT, SMALLFLOAT, DECIMAL; Variable Character: CHARACTER VARYING (VARCHAR); Binary Large Object (BLOB): Text, Byte. [Ref 1: 92]

8. Data normalization process and the normal forms(6hrs)

Instructional Objectives

- Translate a relational data model into efficient database structures, including knowing when and how to de-normalize the logical data model.
- Demonstrate how relations can be normalized. The normalization process requires an understanding of first through 3rd normal forms, functional dependencies and multi-valued dependencies.

Sub Topics

8.1. Introduction to data normalization and normal forms [Ref 1: pg.501-519; Ref 2: pg.615-619, 622-629]

8.1.1. What is normalization, Benefits of normalization, Normalization Rules

8.1.2. 1NF, 2NF, 3NF and Higher NF.

8.2. First Normal Form [Ref 1: pg.519-523]

8.2.1. 1NF, Why convert to 1NF, Conversion to 1NF;

8.3. Second Normal Form [Ref 1: pg.523; 526-527]

8.3.1. 2NF, Functional Dependence and Fully Functional Dependence, Why convert to 2NF, Conversion to 2NF

8.4. Third Normal Form [Ref 1: pg.523-525;528; Ref 2: pg.617-619]

8.4.1. 3NF, Transitive Dependence, Why convert to 3NF, Conversion to 3NF.

8.5. Normalization considerations [Ref 1: pg 531-535,519; Ref 2: pg 609,619-628,634-636,638,

672-674]

8.5.1. Good and bad decompositions

8.5.2. De-normalization

8.5.3. Multi-valued dependencies, Join dependencies

PLATFORM

Any standard PC (Pentium) with a standard commercial relational database management system (e.g. MS Access, MySQL) that allows the student to develop small applications involving menu design, screen design, data validation in data entry screens, report design.

Note: **Students are expected to achieve a level of competence in at least one of the standard commercial relational database management system and to be able to develop small applications involving menu design, screen design, data validation in data entry screens, report design and an overview of GUI design. Students are expected to acquire some of these skills in semester 1 Application Packages course. The students must also acquire skills for independently designing on-line database applications.**