LEVEL 4

Databases

Student Guide

Modification History

Version	Date	Revision Description
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1. Unit Overview and Objectives

This unit aims to give the learner a thorough grounding in practical techniques for the design and development of database systems, and the theoretical frameworks that underpin them.

2. Learning Outcomes and Assessment Criteria

Learning Outcomes; The Learner will:	**Assessment Criteria;** The Learner can:
1. Understand the concepts associated with database systems	1.1 Summarise the common uses of database systems 1.2 Explain the meaning of the term database 1.3 Explain the meaning of the term database management system (DBMS) 1.4 Describe the components of the DBMS environment 1.5 Describe the typical functions of a DBMS 1.6 Summarise the advantages and disadvantages of a DBMS 1.7 Define the term security and describe examples of threats, and vulnerabilities that can compromise database security, together with their impact. 1.8 Explain strategies to control database security risks.
2. Understand the concepts associated with the relational model	2.1 Summarise the concept of the relational model. 2.2 Explain the terminology associated with the relational model 2.3 Explain the concept of relational integrity.
3. Understand how to design and develop a database system	3.1 Explain the goal of Entity Relationship (ER) modelling 3.2 Draw an ER diagram (ERD) using UML 3.3 Explain the concepts of an entity type, relationship and attribute 3.4 Interpret an ERD 3.5 Construct an ERD from a scenario. 3.6 Explain the purpose of primary and foreign keys 3.7 Recognise strong and weak entities 3.8 Identify and explain ways of solving problems in ER models
4. Be able to develop and enhance a logical database design	4.1 Explain the process of requirements gathering 4.2 Design a set of database tables from an entity model 4.3 Document the tables, columns and domains in a database using a data dictionary 4.4 Describe the features and use of CASE tools 4.5 Describe the concept of functional dependency 4.6 Recognise anomalies in relations 4.7 Explain and apply the normalisation process to produce a model in 3NF 4.8 Define the term Transaction . 4.9 Construct a CRUD matrix to analyse a transaction.

	4.10 Recognise potential performance issues 4.11 Identify the potential need for denormalisation
5. Be able to develop and enhance a database system using SQL	5.1 Explain the purpose of SQL 5.2 Create database tables based on a data dictionary 5.3 Use DDL commands to create, delete and modify a database 5.4 Explain and define integrity constrains on tables 5.5 Retrieve, Insert, update and delete table data. 5.6 Retrieve data from one or more tables using join 5.7 Retrieve data from one or more tables using sub-queries
6. Understand the principles behind Big Data and the NoSQL databases	6.1 Explain the limitations of relational databases 6.2 Explain the key features of Big Data 6.3 Outline basic techniques for handling Big Data 6.4 Describe the four main types of NoSQL data models including document, key-value pair, wide column, and graph
7. Understand the concepts and principles of Cloud database	7.1 Describe the characteristics of cloud databases 7.2 Explain the benefits of cloud database solutions

3. Syllabus

Syllabus Content		
Topic	**Proportion**	**Course coverage**
1. Introduction to the Unit and Database Fundamentals	1/12 2 hours of lectures 1 hour of laboratory 1 hour of tutorials	• Introduction to the unit • What are databases? • Data and information • Pre-database information systems • Database approach • Database management systems • The relational model and alternatives ***Learning Outcome: 1***

2. Entity Relationship (ER) Modelling (1)	1/12
	
	2 hours of lectures
	1 hour of laboratory
	1 hour of tutorials
		• Entity Relationship Modelling
		• Types of Notation
		• Basic concepts
		  • Entities
		  • Relationships
		  • Attributes
		• Identifying Entities
		Learning Outcome: 3

3. Entity Relationship (ER) Modelling (2)	1/12 2 hours of lectures 1 hour of laboratory 1 hour of tutorials	• Constructing ER models • Identifying Entities • Primary and Foreign keys • Strong and weak entities • Identifying problems in ER models • Problem solving in ER models ***Learning Outcome: 3***
4. The Relational Model	1/12 2 hours of lectures 1 hour of laboratory 1 hour of tutorials	• Aims of the relational model • Basic concepts of the relational model • Terminology ***Learning Outcome: 2***
5. Normalisation	1/12 2 hours of lectures 1 hour of laboratory 1 hour of tutorials	• Relational integrity • Anomalies • Functional dependency • The process of normalisation ***Learning Outcomes: 2,4***
6. SQL	1/12 2 hours of lectures 2 hours of laboratory 1 hour of tutorials	• Purpose of SQL • Basic concepts of SQL • Datatypes in SQL • Creating tables • More on the select statement • Fixing errors and optimisation. ***Learning Outcome: 2,5***
7. Database Design	1/12 2 hours of lectures 2 hours of laboratory 1 hour of tutorials	• Understanding requirements • Identifying a set of tables from an ER model • The data dictionary • Use of CASE tools ***Learning outcome: 4***

8. Supporting Transactions	1/12
	
	2 hours of lectures
	2 hours of laboratory
	1 hour of tutorials
		• Business rules
		• Identifying and documenting transactions
		  • ACID Criteria
		  • CRUD analysis
		• Views and de-normalisation
		Learning Outcome: 4

9. Database Implementation	1/12 2 hours of lectures 1 hour of laboratory 1 hour of tutorials	• The implementation environment • Creating tables • Enforcing integrity via constraints • Creating indexes • Inserting data at implementation • Oracle as an example implementation environment ***Learning Outcome: 5***
10. Database Security and Cloud Databases	1/12 2 hours of lectures 1 hour of laboratory 1 hour of tutorials	• Concepts of database security • Database security measures • Concepts of cloud databases • Advantages of cloud databases • Explore cloud database providers • Case studies ***Learning Outcome: 1,7***

11. Big Data and Post-Relational databases	1/12
	
	2 hours of lectures
	1 hour of tutorials
		• The limitations of the relational model
		• Introduction to Big Data
		• 3V model
		• NoSQL
		  • key-value pair, document, graph, wide column
		• Techniques for handling Big Data
		  • Hadoop, Spark
		Learning Outcome: 6

12. Summary	1/12 2 hours of lectures	• Summary of unit • Identifying links with other units/subject areas • Clarification of unit material and related issues as identified by students ***Learning Outcomes: ALL***

4. Related National Occupational Standards

The UK National Occupational Standards describe the skills that professionals are expected to demonstrate in their jobs in order to carry them out effectively. They are developed by employers and this information can be helpful in explaining the practical skills that students have covered in this unit.

Related National Occupational Standards (NOS)
Sector Subject Area: IT Users **Related NOS:** TECHDUDL1, TECHDUDW1, TECHDUOS1, ESKITU010, ESKITU011

5. Resources

Lecturer Guide: This guide contains notes for lecturers on the organisation of each topic, and suggested use of the resources. It also contains all of the suggested exercises and model answers.

PowerPoint Slides: These are presented for each topic for use in the lectures. They contain many examples which can be used to explain the key concepts. Handout versions of the slides are also available; it is recommended that these are distributed to students for revision purposes as it is important that students learn to take their own notes during lectures.

Student Guide: This contains the topic overviews and all of the suggested exercises. Each student will need access to this and should bring it to all of the taught hours for the unit.

5.1 Additional Hardware and Software Requirements

Hardware: Desktop computer or laptop with 8-16GB of RAM.

Software: This unit also makes use of SQL. You may choose which version of SQL is to be used but students will need to have access to this during laboratory and private study time. You may wish to consider MySQL. This is open source software which is available from http://www.mysql.com/downloads .

6. Pedagogic Approach

Suggested Learning Hours						
Guided Learning Hours				Assessment	Private Study	Total
Lecture	Tutorial	Seminar	Laboratory			
24	11	-	13	30	72	150

The teacher-led time for this unit is comprised of lectures, laboratory sessions and tutorials. The breakdown of the hours is also given at the start of each topic, with 5 hours of contact time per topic.

6.1 Lectures

Lectures are designed to introduce students to each topic; PowerPoint slides are presented for use during these sessions. Students should also be encouraged to be active during this time and to discuss and/or practice the concepts covered. Lecturers should encourage active participation, help them construct mental models of the key concepts using examples and interaction, clarify complex concepts and inspire them to study further.

6.2 Tutorials

These are designed to deal with the questions arising from the lectures and private study sessions. For some topics these will be structured sessions with students engaging in tasks related to the

lecture. Other sessions will involve problem solving and trouble-shooting discussions related to the practical work.

The details of these tasks are provided in this guide and also in the Student Guide. They are also designed to deal with the questions arising from the lectures, laboratory sessions and private study sessions.

6.3 Laboratory Sessions

During these sessions, students are required to work through practical tutorials and various exercises. The bulk of the tutorial sessions will be related to gaining a sufficient level of mastery of the chosen database tool and the SQL language sufficient to implement the assessment task. Students will be introduced to SQL in the laboratory sessions and this learning will later be augmented by lecture and tutorial sessions. The details of these are provided in this guide and also in the Student Guide. It is recommended that tutors start lab sessions with a demonstration of the SQL that will be learned in that session; students can then undertake the exercises.

6.4 Private Study

In addition to the taught portion of the unit, students will also be expected to undertake private study. Exercises are provided in the Student Guide for students to complete during this time. Teachers will need to set deadlines for the completion of this work. These should ideally be before the tutorial session for each topic, when Private Study Exercises are usually reviewed.

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7. Assessment

This unit will be assessed by means of an assignment worth 60% of the total mark and an examination worth 40%. These assessments will cover the learning outcomes and assessment criteria given above. Sample assessments are available through the NCC Education Virtual Learning Environment (http://vle.nccedu.com/login/index.php) for your reference.

8. Further Reading List

A selection of sources of further reading around the content of this unit must be available in your Accredited Partner Centre's library. The following list provides suggestions of some suitable sources:

- Connolly, T. & Begg, C. (2015). *Database Systems: A Practical Approach to Design, Implementation, and Management, 6th Edition*. Addison Wesley.
  ISBN-13: 978-1292061849

- Hoffer, J., Ramesh, V. and Toppi, H. (2019). *Modern Database Management, 13th Edition.* Pearson Prentice Hall.
  ISBN-10: 1292263350
  ISBN-13: 978-1292263359

Topic 1: Introduction to the Unit and Database Fundamentals

1.1 Learning Objectives

This topic provides an overview of the unit syllabus and a general introduction to databases.

On completion of the topic, students will be able to:

- Summarise the common uses of database systems
- Explain the meaning of the term database
- Explain the meaning of the term database management system (DBMS)
- Describe the components of the DBMS environment
- Describe the typical functions of a DBMS
- Summarise the advantages and disadvantages of a DBMS

1.2 Pedagogic Approach

Information will be presented to the students during the lectures. Students will be encouraged to participate in activities during the lecture. They will then practise the skills during the tutorial session. The laboratory sessions will introduce SQL to enable students to begin creating some database structures that will be used in future topics. It is recommended that tutors should demonstrate the features of SQL used in the LAB before students attempt the exercises.

1.3 Timings

Lectures:	2 hours
Laboratory Sessions:	1 hour
Private Study:	6 hours
Tutorials:	1 hour

1.4 Laboratory Sessions

The laboratory time allocation for this topic is 1 hour.

Create Tables

Exercise 1

The following SQL scripts will create two tables. Create and run them. If possible learn how to save them in a file and run them from the SQL prompt. The mechanism for doing this will depend upon the version of SQL you are using.

```
CREATE TABLE department(
dept_no INTEGER  NOT NULL,
department_name VARCHAR(30),
location VARCHAR(3)
PRIMARY KEY dept_no
);

CREATE TABLE worker(
emp_no INTEGER  NOT NULL,,
first_name VARCHAR (30),
last_name VARCHAR (30),
job_title VARCHAR (30),
age INTEGER ,
dept_no INTEGER ,
PRIMARY KEY emp_no,
FOREIGN KEY (dept_no) REFERENCES department(dept_no)
)
```

Exercise 2

Examine the tables you have created. You do this using the **DESC <table_name>** command.

Insert Data

Exercise 3: Insert Statements

To insert data into a table, you need to use an INSERT statement. The structure of INSERT statements is:

```
INSERT INTO department VALUES ('1', 'Packing', 'Cairo');
```

Now use similar statements to insert the Accounts department in Lagos with reference number 2 and the Human Resources department in London with reference number 3.

Note: ‘ ‘ are used around text based fields and are not required for numeric fields.

Exercise 4

Now use INSERT statements to create the following workers:

Emp_no	First_name	Last_name	Job_title	Age	Dept_no
1	Lawrence	Surani	Manager	56	1
2	Jason	Argo	Manager	33	2
3	Emily	Villa	Manager	32	3
4	Ahmed	Mukani	Packer	23	1
5	Joe	Todj	Packer	24	1
6	Hattie	Smith	Accountant	56	2
7	Sally	Boorman	Admin Assistant	34	3

View Data

Exercise 5: Looking at the Data

To see the data in your table, you need to use a select statement. The structure of select statements is:

SELECT <column_name> FROM <table_name>

To see all the columns:

SELECT * FROM <table_name>

Use the select command to view the contents of your tables.

Simple queries

The SELECT statement is used to retrieve data from tables in the database. Whenever you want to retrieve some data, use the SELECT keyword followed by the name of the columns you want and the table (or tables) that those columns are in. The form on the SELECT statement is:

```
SELECT <column name>, <column name>
FROM <table name>
WHERE <Condition>
```

An example of a SELECT statement that gets the emp_no and the last_name from the worker table is:

```
SELECT emp_no,  last_name
FROM worker
WHERE dept_no = 1;
```

Try this and look at the results.

Exercise 6

Select the emp_no, first_name and last name from the worker table.

Exercise 7

Select the emp_no, first_name and last_name from the worker table for all the worker in department no 1.

Exercise 8

Select the first_name, last_name and job_title for all the managers in the worker table.

Exercise 9

Select the first_name and last_name for all the worker whose first names start with the letter 'J'.

Hint: The LIKE operator is used in a WHERE clause to search for a specified pattern in a column. There are two wildcards often used in conjunction with the LIKE operator:

- The percent sign % represents zero, one, or multiple characters
- The underscore sign _ represents one, single character
- E.g. 'P%' means any word beginning with the letter P, so combining it with the LIKE operator such as last_name LIKE 'P%' will match all last-names beginning withg P.

Exercise 10

Select all the columns from the worker table for workers over the age of 50.

HINT: SQL has the following operators for use in the WHERE clause

=	Equal
>	Greater than
<	Less than
>=	Greater than or equal
<=	Less than or equal
<>	Not equal. **Note:** In some versions of SQL this operator may be written as !=
BETWEEN	Between a certain range
LIKE	Search for a pattern
IN	To specify multiple possible values for a column

Exercise 11

Select the emp_no, first_name and last_name for all the manager who are under the age of 40.

1.5 Private Study

The time allocation for private study in this topic is expected to be approximately 6 hours.

Exercise 1: Databases in Organisations

Consider at least 2 organisations that you are familiar with; for example: your college, place of work, somewhere you shop or an organisation you are involved with during your leisure time. For each of them make notes on the following:

- Do they have databases at the moment? If so, what are they used for?
- What sort of data would they be interested in collecting?
- How might they breakdown the data they are interested in into different categories? These might be types of people, objects for sale, courses etc.

Exercise 2

Many organisations that collect data that will eventually go into a database begin the collection process with paper forms. Example of this might be a passport or driving license application, a job application or application to join a library.

Collect some examples of such paper forms and a turn each into a list of the data that could then be input into a database.

Exercise 3

Revise the topics that were discussed in the lecture. Ensure that you understand examples of databases in use, the definitions of databases that were given, types of data, the difference between data and information, metadata, and DBMS.

If anything remains unclear after you have revised the topic, make a list of your questions and bring it to the tutorial session.

1.6 Tutorial Sessions

The time allowance for tutorials in this topic is 1 hour.

Exercise 1: Group Discussion of Private Study Activities

In small groups, discuss your findings to Private Study Exercises 1 and 2. You should collate your findings and report back to the class.

Exercise 2: **Data and Information**

Answer the following questions:

1. What is the difference between ‘data’ and ‘information’?

2. Identify in the materials you have collected as part of the Private Study: what is data and what is information?

Topic 2: Entity Relationship Modelling 1

2.1 Learning Objectives

This topic provides an overview of databases and database management systems

On completion of the topic, students will be able to:

- Explain the goal of Entity Relationship (ER) modelling
- Draw an ER diagram (ERD) using UML
- Explain the concepts of an entity type, relationship and attribute
- Interpret an ERD
- Construct an ER model from a scenario

2.2 Pedagogic Approach

Information will be presented to the students during the lectures. Students will be encouraged to participate in activities during the lecture. They will then practise the skills during the tutorial session. The laboratory sessions will concentrate on SQL exercises.

2.3 Timings

Lectures:	2 hours
Laboratory Sessions:	1 hour
Private Study:	6 hours
Tutorials:	1 hour

2.4 Laboratory Sessions

The laboratory time allocation for this topic is 1 hour.

Selecting from More Than One Table

When we want to get information from more than one table, this involves what is known as a join between the two tables. This basically means using the WHERE part of the SELECT statement to do an equality operation between the columns that join the two tables.

For example, the workers and departments tables are joined in our data model by the fact that dept_no is a foreign key on workers. This shows in which department each worker is. If we want to select the department_name from departments and the first_name and last_name of the workers from the workers table, the SELECT statement will look like this:

```
SELECT department.department_name, worker.first_name, worker.last_name
FROM department, worker
WHERE department.dept_no = worker.dept_no;
```

We can make this a bit easier to write out by giving each of our tables an alias, usually a letter so we do not have to keep writing the whole name for the table each time we refer to it:

```
SELECT d.department_name, w.first_name, w.last_name
FROM department d, worker w
WHERE d.dept_no = w.dept_no;
```

Exercise 1

Make sure you can write and run the above query using the table aliases.

Exercise 2

Try the following exercises that all use similar statements:

1. Select the department_name from department and the first_name, last_name and job_title from worker.

2. Select the department_name and location from department and the first_name and last_name from worker.

3. Select the department_name and location from department and the first_name and last_name from worker. Only select workers who are in the ‘Packing’ department.

4. Select the department_name and location from department, and the first_name, last_name and job_title from worker, for just the managers that work in Cairo.

5. Select the job_title, age and location for all the worker who work in London.

Exercise 3

The ORDER BY statement is a way of specifying the order in which you want your selected data to appear. For example, to retrieve the emp_no and first_name of workers, we could order by emp_no or order by first_name:

To order by emp_no:

```
SELECT emp_no, first_name
FROM worker
ORDER BY emp_no;
```

To order by first_name

```
SELECT emp_no, first_name
FROM worker
ORDER BY first_name;
```

1. Select the department_name from department, the first_name, last_name and age from worker. Order by the age.

2. Select the first and last names of the workers who work in Cairo and order them by their age.

2.5 Private Study

The time allocation for private study in this topic is expected to be 6 hours.

Exercise 1

In the Private Study session for Topic 1, you were asked to collect paper data input forms from an organisation, such as a library or government department or any other organisation.

Examine these forms and specify what entities and attributes might be needed in a database to capture the data that they collect.

Bring both the paper forms and your analysis to the tutorial for discussion.

Exercise 2

Examine the library system diagram on Slide 24. Identify the missing multiplicities for Book to Loan and Loan to Borrower.

Exercise 3

Revise the topics studied in the lecture. Make notes on the following topics and make sure you understand the concepts:

- Entity Type
- Entity Occurrence
- Relationship Type
- Relationship Occurrence
- Attributes
- Multiplicity

2.6 Tutorial Sessions

The time allowance for tutorials in this topic is 1 hour.

Exercise 1: Group Discussion of Private Study Activity

In small groups, discuss your findings to Private Study Exercises 1 and 2. You should collate your findings and report back to class.

Exercise 2

Use this time to raise questions regarding the material. In small groups, discuss the concepts listed below and report your findings back to the class.

Do you understand the following concepts? :

- Entity Type
- Entity Occurrence
- Relationship Type
- Relationship Occurrence
- Attributes
- Multiplicity

Topic 3: Entity Relationship Modelling 2

3.1 Learning Objectives

This topic is the continuation from Topic 2: Entity Relationship Modelling.

On completion of the topic, students will be able to:

- Construct an ERD from a scenario
- Explain the purpose of primary and foreign keys
- Recognise strong and weak entities
- Identify and explain ways of solving problems in ER models

3.2 Pedagogic Approach

Information will be presented to the students during the lectures. Students will be encouraged to participate in activities during the lecture. They will then practise the skills during the tutorial session. The laboratory sessions will concentrate on SQL exercises.

3.3 Timings

Lectures: 2 hours

Laboratory Sessions: 1 hour

Private Study: 6 hours

Tutorials: 1 hour

3.4 Laboratory Sessions

The laboratory time allocation for this topic is 1 hours.

Exercise 1: Inserting Data

The INSERT statement allows us to add new data to our tables.

The basic structure of the INSERT statement was introduced in the first laboratory session.

```
INSERT INTO department VALUES (1,'Packing','Cairo');
```

There is some variation on this. For example, to insert into the table but only particular fields, we specify the columns in the insert statement. So, if we wanted to insert a new row into departments, but did not yet know where it would be located, we would write:

```
INSERT INTO department (dept_no, department_name) VALUES (4, 'Marketing');
```

Run this insert statement.

1. Insert another new department 'Public Relations'. Its dept_no will be 5. Its location is Madrid.

2. Insert another new department 'Research and Development'. Its dept_no is 6. Its location is unknown at the moment.

3. A new employee has joined Research and Development. Their first_name is 'Jonas', their last_name is 'McKenzie'. They are 38 years old. Their emp_no is 8. They are 38 years old, but currently their job_title has not been decided. Insert data into the workers table for them.

IMPORTANT: Make sure you commit your work by writing the command: commit;

Exercise 2: Updating Data

The UPDATE statement allows us to change data that already exists.

For example, we might have a script that changes someone's age.

```
UPDATE worker
SET age = age + 1
WHERE emp_no = 1;
```

This will add one to the age of worker one.

Try this Update script.

1. It has now been decided where the new Research and Development department should be located. Write an update script that sets the location of this department to 'Berlin'.

2. Write an update script to set the job_title of the employee McKenzie to 'Manager'.

Exercise 3: Deleting Data

The DELETE statement allows us to get rid of data from our database.

For example, if we wanted to delete all the managers from the database, we would write the following (do **NOT** run this; it is an example):

```
DELETE FROM worker
WHERE job_title = 'Manager';
```

1. Use the INSERT statement to insert yourself in the workers table with an ID of 10. Then write a DELETE statement to get rid of yourself from the database.

3.5 Private Study

The time allocation for private study in this topic is expected to be 6 hours.

Review Material on ER Modelling

Please review all the materials for Topic 2 and 3 before going on to the exercises below. You should make note of anything that you feel requires further clarification and bring your questions to the tutorial for this topic.

Drawing ER Models

ER diagrams are one of the most important techniques used in database development. You will need to master this technique in order to complete your assignment. Almost any work in the database field requires an understanding and ability to construct ER diagrams.

The following are a series of short scenarios. Draw an ER diagram for each.

Exercise 1

A customer records systems for a mail order beauty products company.

> A customer is assigned to one and only one geographical region. A customer may be interested in a number of different product lines. A region may have many customers.
>
> Any particular product line must belong to one product category that may contain many product lines.

Exercise 2: A Boat Rental System

A boat is rented to a customer for a set period of time. Any damage to the boat is recorded for that particular rental.

NB This is a brief scenario, which does not fully specify the relationships, you must therefore make assumptions, and list these. This is no unusual in real situations.

Exercise 3: A Personnel Database

Employees can be members of one or more than one department.

Exercise 4: A Database for a Private Collection of Books

Each author may have written one or more books. A book might have one or more authors. Each book belongs to one category.

Exercise 5: A Plane Ticket System

Each ticket is for one flight and one customer. A customer may book many flights. A flight has many customers.

Exercise 6: A Film Rental Shop

The shop needs to keep track of rentals. A member can rent films. A film can be rented by many members. A film can be rented by the same member more than once.

3.6 Tutorial Session

The time allocation for this topic is 1 hour.

Exercise 1: Review of ER Modelling

Ask your tutor any questions you have with regard to Topic 2 and 3 on Entity Relationship Modelling.

Exercise 2: Review of Private Study Exercises

Work in a small group and review your answers to Private Study Exercises 1-6. Discuss the decisions you took in drawing each ER diagram.

Exercise 3

Answer the following questions in your own words:

a. Give an explanation of a fan trap using examples.

b. Give an explanation of a chasm trap using examples.

c. Why is it important to resolve many-to-many relationships into one-to-many relationships?

d. Give examples of entities, from any system or example system, which represent the following: people, events, concepts, physical objects.

e. Define the following: simple attribute; composite attribute and single-valued attribute.

Topic 4: The Relational Model

4.1 Learning Objectives

On completion of the topic, students will be able to:

- Summarise the concept of the relational model
- Explain the terminology associated with the relational model

4.2 Pedagogic Approach

Information will be presented to the students during the lectures. Students will be encouraged to participate in activities during the lecture. They will then practise the skills during the tutorial session. The laboratory sessions will concentrate on SQL exercises.

4.3 Timings

Lectures: 2 hours

Laboratory Sessions: 1 hour

Private Study: 6 hours

Tutorials: 1 hour

4.4 Laboratory Sessions

The laboratory time allocation for this topic is 1 hour.

More on Creating and Modifying Tables

The basic format for creating tables was shown in Topic 1:

```
CREATE TABLE department
(dept_no INTEGER NOTNULL,
department_name VARCHAR(30),
location VARCHAR(30)
PRIMARY KEY dept_no);
```

Be aware of variations depending on which database product you use. The variations are usually to do with where you specify primary keys and foreign keys.

```
CREATE TABKE department
(dept_no INTEGER NOT NULL PRIMARY KEY,
department_name VARCHAR(30),
location VARCHAR(3));
```

In the exercises for this laboratory session, we will look at creating a table from another table and modifying an already existing table.

If we wanted to create a table which stored the unique names for the different types of jobs that are available in our firm, we could create it in the conventional way. However, since all the values we want already exist in the workers table, it would be easier to create the table with the data from the existing workers table. This is done like this:

```
CREATE TABLE job_type as
(SELECT DISTINCT job_title FROM worker);
```

Exercise 1

Run the above script and use a SELECT statement to look at the results.

Exercise 2

Our new table only has one attribute and no primary key. Therefore, we should modify this with the ALTER TABLE statement as follows:

Add a column for the salary of that job_title:

```
ALTER TABLE job_type
ADD salary FLOAT;
```

Note that ‘Float’ designates the floating point data type. It is also known as REAL.

Run this script to alter the table.

Exercise 3

We now need to add the primary key for this table. The primary key will be the job_title field.

```
ALTER TABLE job_type
ADD PRIMARY KEY (job_title);
```

Run this script.

Exercise 4

We must now enforce the fact that job_title in the workers table is now a foreign key to the job_type table. We do this in a similar way using the ALTER table statement.

```
ALTER TABLE worker
ADD FOREIGN KEY (job_title) REFERENCES job_type(job_title);
```

Run this script.

Be aware that different vendors' versions of SQL may implement these constraints slightly differently.

Exercise 5

You will notice that the salary field is blank. Update the job_type table to set the salaries as follows:

- Managers earn 30000
- Packers earn 20000
- Admin Assistants earn 15000
- Accountants earn 28000

Exercise 6

You should now be confident enough to be able to create tables of your own design.

1. Design a table that keeps your personal details. This should include your name, address and date of birth. Create this table using SQL with an appropriate primary key.

2. Design a table that keeps a list of your qualifications. This will have a foreign key to the table with your personal details. Create this table using SQL with the appropriate primary and foreign keys. You should include information about the name of the qualification, the level of the qualification (e.g. Level 4), the name of the institution the qualification was taken at and the final grade.

4.5 Private Study

The time allocation for private study in this topic is expected to be 6 hours.

Exercise 1

Look at the following table of data from a hair-care product supplier:

Customer ID	Customer Name	Customer Products	Product Prices
C1	Manjeet Islam	Hair dryer Shampoo Specialist comb set	$35 $7 $8
C4	Tolu Amusia	Hair net	
C2	Sid James	Specialist comb set Hair dryer	$7 $35
C6	Ambereen Reeza	Clippers	

1. Identify why you think this table is not a relation.
2. Is the price of the hair net the same as the price of the clippers?
3. What are the prices of the hair net and the clippers?
4. Should the row for customer C2 be put before that of C4?
5. Redraw the table as a single table so that it qualifies as a relation.

Name: Customers

Customer ID	Customer Name	Customer Products	Product Prices
C1	Manjeet Islam	Hair dryer	$35
C1	Manjeet Islam	Shampoo	$7
C1	Manjeet Islam	Specialist Comb set	$8
C4	Tolu Amusia	Hair net	
C2	Sid James	Specialist Comb set	$7
C2	Sid James	Hair dryer	$35
C6	Ambereen Reeza	Clippers	

Exercise 2

Looking at the single table you have produced for Question 5 of the Exercise 1 above where you were asked to redraw the table as a single table. There will still be a number of problems with it. What issues are there with duplication and the primary key?

Exercise 3

Redraw the single table as three separate tables that have less duplication. You should be guided in this by the example shown in the lecture for this topic.

Exercise 4

Identify the primary and foreign keys for each of your new relations.

Exercise 5

Review the content of this topic and conduct any further reading you need to undertake in order to ensure that you understand the material. You should make note of anything that you still feel requires further clarification and bring your questions to the tutorial for this topic

4.6 Tutorial Sessions

The time allowance for tutorials in this topic is 1 hour.

Exercise 1: Group Discussion of Private Study Activity

In small groups, discuss your findings to Private Study Exercises 1-4. Your tutor will then lead a class feedback session, during which you can also raise any questions you have about the material covered in this topic.

Exercise 2: Questions

Answer these questions in your own words.

a. What is meant by the concept of data independence?

b. What was System R and what was its importance in the development of the relational model?

c. What is meant by the term NULL and why can't a primary key contain a NULL value?

d. What are the properties of a relation?

e. What is the purpose of foreign keys in a relational database?

f. Look at the following tables that form part of a database from a library system:

Book
- BookID
- BookName
- AuthorID
- BookTypeCode
- ISBN

BookType
- BookTypeCode
- BookTypeDescription

Author
- AuthorID
- AuthorName
- NationalityCode

Country
- NationalityCode
- CountryName

Borrower
- BorrowerID
- BorrowerName

Loan

BorrowerID
BookID
LoanStartDate

LoanEnd Date

Idenfity the primary and foreign keys in the above schema.

Topic 5: Normalisation

5.1 Learning Objectives

This topic provides an overview of further aspects of the relational model.

On completion of the topic, students will be able to:

- Explain the concept of relational integrity;
- Describe the concept of functional dependency;
- Recognise anomalies in relations;
- Explain and apply the normalisation process to produce a model in 3NF

5.2 Pedagogic Approach

Information will be presented to the students during the lectures. Students will be encouraged to participate in activities during the lecture. They will then practise the skills during the tutorial session. The laboratory sessions will concentrate on SQL exercises.

5.3 Timings

Lectures:	2 hours
Laboratory Sessions:	1 hour
Private Study:	6 hours
Tutorials:	1 hour

5.4 Laboratory Sessions

The laboratory time allocation for this topic is 1 hour.

Exercise 1

Create a table called Student. The table should have the following attributes all of type varchar:

- student_id
- first_name
- last_name
- gender

student_id is the primary key for the Student table. The Student table is attached to the table Course in a one-to-many relationship where Student is the many part of the relationship. The primary key of the Course table is course_id. You will also need to create the Course table.

Exercise 2

Insert the following person into the Student table created in Exercise 1. The student's first name is 'Chris', his last_name is 'Peters', he is an 18 year old male and his student ID will be NCC001. Chris will be on course DB001 Databases. You will also need to update the Course table.

Exercise 3

Update the Course table to show that the course name for course DB001 has changed from Databases to Database Systems. Then update the Student table to show that student NCC001 no longer wishes to take course DB001, they now wish to take course SE001 Software engineering. You will also need to update the course table.

Exercise 4

Delete the student with the ID NCC001 from the Student table.

5.5 Private Study

The time allocation for private study in this topic is expected to be 6 hours.

Exercise 1

Draw the ER diagram for the set of relations produced in Slide 22.

Exercise 2: Normalisation

Product Number: 009

Product Name: Wall Bracket

Product Type Code: HF

Product Type Name: Home Fitting

Supplier Number	Suppliers Name	Supplier's Product Ref No	Price	Main Supplier Y/N ?
099	Gibbons	WB09	£3	Y
0100	Jarrold's Fittings	98383	£3.50	N
0101	H Drammond	B010	£3.75	N
098	Crambornes	Br 7	£3.99	N
078	Jamison	8383	£3.99	N

Above is a form used by a firm to keep track of the different suppliers that supply them the same part. Supplier's Product Ref No is the reference number given to the part by the supplier. Main Supplier Y/N indicates whether this is their preferred supplier of the part.

Using the techniques discussed in the lecture, break this document down into a set of third normal form relations.

Exercise 3

Review the content of this topic and conduct any further reading you need to undertake in order to ensure that you understand the material. You should make note of anything that you still feel requires further clarification and bring your questions to the tutorial for this topic.

5.6 Tutorial Notes

The time allowance for tutorials in this topic is 1 hour.

Exercise 1: Review of Private Study Exercises

In small groups, discuss your findings to Private Study Exercises 1 & 2. Your tutor will then lead a class feedback session, during which you can also raise any questions you have about the material covered in this topic.

Exercise 2: Questions

Answer these questions in your own words.

a. Give a definition for first, second and third normal form.

b. What is the purpose of normalisation? Why is it necessary to split data into separate tables

c. Why do you think Entity Diagrams are usually referred to as a ‘top-down’ approach and normalisation as a ‘bottom-up’ approach?

d. Describe the concept of functional dependency.

e. What role does functional dependency play in the process of normalisation?

Topic 6: SQL

6.1 Learning Objectives

This topic provides an overview of SQL (Structured Query Language).

On completion of the topic, students will be able to:

- Explain the purpose of SQL
- Create database tables based on a data dictionary.
- Use DDL commands to create, delete and modify a database.
- Retrieve, Insert, update and delete table data.
- Retrieve data from one or more tables using join
- Retrieve data from one or more tables using sub-queries.

6.2 Pedagogic Approach

Information will be presented to the students during the lectures. Students will be encouraged to participate in activities during the lecture. They will then practise the skills during the tutorial session. The laboratory sessions will concentrate on SQL exercises.

6.3 Timings

Lectures:	2 hours
Laboratory Sessions:	2 hours
Private Study:	6 hours
Tutorials:	1 hour

6.4 Laboratory Sessions

The laboratory time allocation for this topic is 2 hours.

Exercise 1

In Topic 5, you should have designed and created your own personal details tables. Gather details of at least 8 of your fellow students. You should get data for both tables. Insert the data into the tables.

Exercise 2

Write a query that shows all the qualifications for a named person. This could be yourself.

Exercise 3

Write a query that shows which institution each student has attended. Order this by the students' last name.

Exercise 4

Show all those people who have achieved a Level 3 qualification.

Exercise 5

Write a query that shows how many qualifications you have.

Exercise 6

If there is not one already there then add a column to the personal_detail to record a persons' age.

Exercise 7

Update the personal_detail table with each person's age.

Exercise 8

Write a query to show all first names, last names and the level 2 qualifications for students who are under the age of 20;

Exercise 9

Create a new table called 'qualification_type' using the 'as' statement that shows all the qualifications that exist. There should be one row for each qualification without duplications.

Exercise 10

Add a column to the qualification_type table to show the level the qualifications is at.

Exercise 11

Update the qualification_type with the correct level for each qualification.

Exercise 12

Once the qualification_type table is updated with the level then the level can be deleted from the qualification table. Use the drop column scripts as shown below:

```
ALTER TABLE qualification
DROP COLUMN qual_level;
```

Exercise 13

Make the qualification attribute the primary key of qualification_type;

Exercise 14

Now create a foreign key between qualification and qualification_type using the qualification attribute.

Exercise 15

Rewrite the query from Exercise 4. Show all those people who have achieved a Level 3 qualification. You will now need to include all three tables.

6.5 Private Study

The time allocation for private study in this topic is expected to be 6 hours.

Exercise 1

The following tables are for a garden products database.

customer

Customer ID	Customer Name
C1	Arthur Smith
C4	Samson Odogo
C2	Jagpal Singh
C6	Jenkins Watson

product

Product	Price
Land mower	£100
Slug Repellent	£5
Trowel	£8
Weed killer	
Knee rest	

customer_product

Customer ID	Product
C1	Lawn Mower
C1	Slug Repellent
C1	Trowel
C4	Weed Killer
C2	Weed Killer
C2	Lawn Mower
C6	Trowel

Use these tables to complete the exercises below.

Exercise 1

Write an SQL statement that returns the names of all the customers.

Exercise 2

Write an SQL statement that returns the names of all the customers who have bought a lawn mower.

Exercise 3

Write an SQL statement that finds the average price for all the products.

Exercise 4

Write an SQL statement that sets the price of weed killer to £5.

Exercise 5

Write a query that gives the total spent by each customer.

Exercise 6

Review all the material for Topic 6 SQL. You should make sure that you understand the following concepts and be prepared to raise any questions about them in the next tutorial:

- The purpose of SQL
- Data definition language (DDL)
- Date manipulation language (DML)
- How to update data on a database
- How to retrieve data on a database using the select statement
- How to create and modify tables using SQL

6.6 Tutorial Sessions

The time allowance for tutorials in this topic is 1 hour.

Exercise 1: Review of Private Study Exercises

In small groups, discuss your findings to Private Study Exercise 1, asking your tutor for clarification when needed.

Exercise 2: Questions

Answer the following questions which relate to aspects of SQL.

a. SQL has two major components, DDL and DML. What are these components and what are their functions?

b. What are the disadvantages of the CHAR data-type and how does the VARCHAR data-type overcome these?

c. What is the purpose of the ROLLBACK statement?

d. What are the advantages of using the ALTER TABLE statement as opposed to creating a new table from scratch when changes are needed?

e. What is the purpose of the GROUP BY clause?

Exercise 3

Clarify any questions you have from Private Study Exercise 2 with your tutor.

Topic 7: Database Design

7.1 Learning Objectives

This topic provides an overview of database design.

On completion of the topic, students will be able to:

- Explain the process of requirements gathering
- Design a set of database tables from an entity model
- Document the tables, columns and domains in a database using a data dictionary
- Describe the features and use of CASE tools

7.2 Pedagogic Approach

Information will be presented to the students during the lectures. Students will be encouraged to participate in activities during the lecture. They will then practise the skills during the tutorial session. The laboratory sessions will concentrate on SQL exercises.

7.3 Timings

Lectures:	2 hours
Laboratory Sessions:	2 hours
Private Study:	6 hours
Tutorials:	1 hour

7.4 Laboratory Sessions

The laboratory time allocation for this topic is 2 hours.

Grouping

In the previous laboratory session we looked at aggregation. You were asked to find the minimum, maximum, average and the sum of the age all the packers in the workers table.

The suggested solution was like this:

```
SELECT MIN(age), MAX(age), AVG(age), SUM(age)
FROM worker
WHERE job_type = 'Packer';
```

But what if we want to provide a query that shows us the maximum age for each of the different types of workers? SQL provides a group by clause that allows us to do this.

```
SELECT job_title, MAX (age)
FROM Workers
GROUP BY job_title;
```

Exercise 1

Run the above query and study the results.

Exercise 2

Write a query that finds the average age for the employees in 'Cairo'. Group this by job_title.

Exercise 3

Write a query that shows the age of the eldest workers in each department. Group this by the dept_no. You do not have to show the department name.

Exercise 4

Find the departments that have an average age of over 40. You do not need to show the department name.

Exercise 5

Find the maximum age, the minimum age, the average age and the job title for those jobs where the average age is above 35. Group this by the job title.

Exercise 6

As part of the laboratory exercises in Topic 5, you created two tables that kept personal information about yourself and the qualifications that you have. In Topic 6 you should have added some new rows about your friends and their qualifications to these tables.

Now use the aggregate functions from Topic 6's Laboratory Session and the 'Group By' clause from Topic 7's Laboratory Session to create a set of useful queries using these tables.

7.5 Private Study

The time allocation for private study in this topic is expected to be 6 hours.

This topic's private study time involves practising some database design based on elaboration of a previous private study exercise.

Exercise 1

In Topic 3, you were asked to draw an ERD for a boat rental system. The requirements were the following:

- You should be able to record that a boat is rented to a customer for a set period.
- Any damage to the boat is recorded against the particular rental.
- A boat should have a name.
- All boats are of the same type (yacht).
- Damage is classified as being hull, interior or other.

Using the ERD for this system, produce a data dictionary specifying the base relations (tables), attributes and domains. The data dictionary should be in the format given in the lecture.

Exercise 2

Find some examples of CASE tools online. What are their features? For how much of the database development process do they cater? What might be their disadvantages?

Prepare a brief written discussion for the tutorial.

Exercise 3

Investigate a systems development methodology such as SSADM. Each stage or step has what is known as a set of 'deliverables'. These are the outcomes of that stage which will form the basis of work in the next stage.

What are the deliverables from analysis, design and implementation stages for the methodology that you have investigated?

Exercise 4

Review the content of this topic and conduct any further reading you need to undertake in order to ensure that you understand the material. You should make note of anything that you still feel requires further clarification and bring your questions to the tutorial for this topic.

7.6 Tutorial Sessions

The time allowance for tutorials in this topic is 1 hour.

Exercise 1: Review of Private Study Exercises

In small groups, discuss your findings to the Private Study Exercises, asking your tutor for clarification when needed.

Exercise 2

Answer the following questions, which relate to approaches to development.

1. What is the difference between analysis and design?
2. Why is the traditional systems development approach called the Waterfall Model?
3. What stages in a traditional waterfall lifecycle do you think overlap with the conceptual, logical and physical stages of database design?
4. What is prototyping and what are its advantages?

Exercise 3

Outline the difference between Conceptual, Logical and Physical Design.

Topic 8: Supporting Transactions

8.1 Learning Objectives

This topic provides an overview of supporting transactions.

On completion of the topic, students will be able to:

- Define the term Transaction.
- Construct a CRUD matrix to analyse a transaction.
- Recognise potential performance issues
- Identify the potential need for denormalization

8.2 Pedagogic Approach

Information will be presented to the students during the lectures. Students will be encouraged to participate in activities during the lecture. They will then practise the skills during the tutorial session. The laboratory sessions will concentrate on SQL exercises.

8.3 Timings

Lectures:	2 hours
Laboratory Sessions:	2 hours
Private Study:	6 hours
Tutorials:	1 hour

8.4 Laboratory Sessions

The laboratory time allocation for this topic is 2 hours.

Nested Sub-queries

When we need to find the result of some complex enquiry on our database, we can put one query inside another. This is known as nesting.

Consider the following example:

```
SELECT d.department_name, d.location
FROM department d, worker w
WHERE d.dept_no = w.dept_no
AND w.age =
(SELECT MAX(w2.age)
FROM worker w2);
```

Use of the worker, department and job_type Tables

Exercise 1

Run the above query. What information is it telling us?

Exercise 2

Modify the above query to select the department and its location that has the youngest manager.

Exercise 3

Write a query using a nested sub-query to find those department IDs where the average age of the workers is less than the average age for all the workers in the company.

Exercise 4

Note that the result above produces multiple repeating values. Use the ‘Group By’ clause after the closing brackets to group by department ID.

Exercise 5

Make this query more user-friendly by changing the department ID to the department name.

Exercise 6

Using a nested sub-query, get the first names of all those workers who have the maximum age for the whole company. Remember to use Group By if you are getting repeating values.

Using the personal_detailss, qualifications and qualification_type Tables

The following exercises use the personal_detail, qualification and qualification_type tables.

Exercise 7

Show the first name and last name of all the people who have qualifications at level 3 and are older than the average age.

Exercise 8

Show a count of those people who have got a higher grade than the average for their level 2 qualification.

8.5 Private Study

The time allocation for private study in this topic is expected to be 6 hours.

Exercise 1

Write the SQL for creating the view for the following transaction:

List the details for damage: to which boats, during which hire periods and for which customers.

Exercise 2

Explain what you think the purpose and effect of this view would be for the Boat Hire system.

Exercise 3

Use online resources to look for jobs advertised for database development work. What sorts of skills are being required for the jobs? What software is involved?

Exercise 4

One of the definitions of a transaction is that it should possess four basic properties, usually remembered by the abbreviation ACID:

- **A**tomicity
- **C**onsistency
- **I**solation
- **D**urability

Research and give a definition for each of these properties.

Exercise 5

Review all the material from this topic and prepare any questions for the tutorial session.

8.6 Tutorial Notes

The time allowance for tutorials in this topic is 1 hour.

Exercise 1: Review of Private Study Exercises

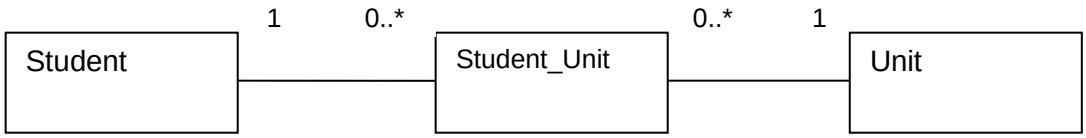
In groups, review the work you carried out during your private study.

Exercise 2

Give an explanation as to your understanding of a business rule. Using a system you are familiar with, from an example in the course materials or through personal experience, specify business rules that apply to that system.

Exercise 3

A student record system consists of three tables: Student, Unit, Student_Unit and the ER shown below:



Data dictionary

Student
student_id (PK)
student_first_name
student_last_name
student_address
student_age

Student_Unit
student_id(PK)(FK)
unit_code(PK)(FK)
semeseter
year
result

Unit
unit_code(PK)
unit_name

Complete a CRUD matrix for the following transactions:

a. Insert a new student.
b. List a student's personal details and results for all of the units they have taken. Include the unit name.
c. List details of all the units.
d. Insert a new unit.
e. Allocate a student to a unit.
f. Assign a result to a student for a unit.

Exercise 4

A number of business rules have been defined for this student records system:

1. All students should have an enrolment date recorded for them and a final completion date. All students should be deleted from the system three years after their completion date.
2. Secondly, students should be classified as being ‘Home’ or ‘Overseas’.
3. Students should be allowed to retake a unit that they fail.

Discuss how each of these business rules might be enforced on the system. This might require the creation of new attributes or other database structures.

Topic 9: Database Implementation

9.1 Learning Objectives

This topic provides an overview of database implementation.

On completion of the topic, students will be able to:

- Explain and define integrity constrains on tables
- Insert multiple rows of data in SQL
- Explain some of the features of the Oracle RDBMS

9.2 Pedagogic Approach

Information will be presented to the students during the lectures. Students will be encouraged to participate in activities during the lecture. They will then practise the skills during the tutorial session. The laboratory sessions will concentrate on SQL exercises.

9.3 Timings

Lectures:	2 hours
Laboratory Sessions:	1 hour
Private Study:	6 hours
Tutorials:	1 hour

9.4 Laboratory Sessions

The laboratory time allocation for this topic is 1 hour.

Views

A view can be thought of as a virtual table. It is the result of an SQL select operation and, to the user, looks like a table with rows and columns. However, unlike a table, it does not necessarily exist permanently in the database.

The syntax to create a view is similar to a select statement, but with a 'Create View' added. For example:

```
CREATE VIEW worker_over_thirty
AS SELECT emp_no, first_name, last_name
FROM worker
WHERE age > 30;
```

Exercise 1

Run the above script and then run a select statement to see all the data from it.

Exercise 2

Create a view that will contain the last name and the job title for all the workers in Cairo.

Exercise 3

Create a summary view that includes the emp_no, first_name, last_name, department_name, location, the job type and the salary (from the job type table).

Exercise 4

Now recreate the summary view from Exercise 4, but make it only for Workers who earn more than 25000.

Note: You will have to give it a different name from the previous summary.

Indexes

Exercise 5

An index is a structure in a database that helps queries run more quickly. Indexes can be unique, meaning that they will prevent a duplicate value from being added to that column, or they can be non-unique.

The syntax to create a unique index for the Workers table column emp_no is:

```
CREATE UNIT INDEX emp_no_Index on worker(emp_no);
```

Run this script.

If you need to get rid of this index, the syntax is:

```
DROP INDEX emp_no_index;
```

Constraints

Exercise 6

As well as having constraints to enforce primary and foreign keys, constraints can also be added to enforce a business rule. This will be discussed in more detail in a coming lecture. The example below enforces a rule that all our workers must be 70 or younger.

```
ALTER TABLE worker
ADD CONSTRAINT valid_age
CHECK (age < 71);
```

Run this script and then see what happens if you try to update someone's age to over 70.

9.5 Private Study

The time allocation for private study in this topic is expected to be 6 hours.

Exercise 1

You should prepare a short presentation on the database architecture of the vendor that you used to implement your assignment. Focus should be on the logical structure and the physical structure. The degree of detail that you will need to present should be guided by the lecture slides, i.e. it should be an overview in your own words rather than a detailed technical paper.

Exercise 2

Your lecturer will assign one of the following topics, concerning bulk loading facilities, to you. Prepare a short report about the features and the facilities of the tool that you are assigned to investigate.

Bulk insert in SQL server

https://learn.microsoft.com/en-us/sql/t-sql/statements/bulk-insert-transact-sql?view=sql-server-ver16

Oracle SQL loader

https://docs.oracle.com/en/database/oracle/oracle-database/19/sutil/oracle-sql-loader-concepts.html#GUID-DD843EE2-1FAB-4E72-A115-21D97A501ECC

MySQL ‘LOAD DATA’

https://dev.mysql.com/doc/refman/8.0/en/load-data.html

9.6 Tutorial Sessions

The time allowance for tutorials in this topic is 1 hour.

Exercise 1: Vendor Presentation

Give your presentation on the database architecture of the vendor you have chosen to the rest of the group.

Takes notes on interesting points while other students are speaking. Your tutor will also lead a discussion to summarise the findings of the class at the end of the presentations.

Exercise 2

Work in a small group with other students who have written a report on the **same** topic during private study time.

Discuss the information you have found. You should take the opportunity to add any additional information to your own notes.

Now prepare to present your information to students who have worked on the other report. You should work together as group to prepare a short (5 minutes), informal presentation which will give the other students a summary of the main information you have found.

Exercise 3

Work with your group to present your information to students from the other groups. You should also answer any questions they might have.

Now listen to their presentations and take notes.

Topic 10: Database Security and Cloud Databases

10.1 Learning Objectives

This topic provides an overview of database security and cloud databases.

On completion of the topic, students will be able to:

- Define the term security and describe examples of threats, and vulnerabilities that can compromise database security, together with their impact.
- Explain strategies to control database security risks
- Describe the characteristics of cloud databases
- Explain the benefits of cloud database solutions

10.2 Pedagogic Approach

Information will be presented to the students during the lectures. Students will be encouraged to participate in activities during the lecture. They will then practise the skills during the tutorial session. The laboratory sessions will concentrate on SQL exercises.

10.3 Timings

Lectures:	2 hours
Laboratory Sessions:	1 hour
Private Study:	6 hours
Tutorials:	1 hour

10.4 Laboratory Sessions

The laboratory time allocation for this topic is 1 hour.

Exercise 1:

Roles and permissions are fundamental components of database security, serving as mechanisms to control access and activities within the database environment.

Roles are predefined sets of privileges that can be assigned to users, determining what operations they can perform, such as querying, updating, or deleting data.

Permissions are the specific rights granted to roles or users to access and manipulate database objects. They define what actions a user is allowed to perform on the database, such as reading (SELECT), writing (INSERT, UPDATE), or deleting (DELETE) data.

By carefully assigning roles and permissions, organisations can ensure that individuals only have access to the data and actions necessary for their job functions, significantly reducing the risk of unauthorised data exposure or modification.

The following SQL commands are used to create three user roles in a database, ‘read_only’, ‘data_entry’, and ‘admin’.

```
CREATE Role read_only;

CREATE Role data_entry;

CREATE Role admin;
```

Exercise 2:

Assign permissions to each role on the table . ‘read_only’ should only select, ‘data_entry’ should insert and update, ‘admin’ should have all privileges.

```
GRANT SELECT ON department TO read_only;

GRANT INSERT, UPDATE ON department TO data_entry;

GRANT ALL PRIVILEGES ON department TO admin;
```

Exercise 3:

Test the roles with the correct assigned permissions.

First, create test users with passwords.

```
CREATE USER test_read_only IDENTIFIED BY ‘password1’;

CREATE USER test_data_entry IDENTIFIED BY ‘password2’;

CREATE USER test_admin IDENTIFIED BY ‘password3’;
```

Next, assign the previously created roles to these users.

```
GRANT read_only TO test_read_only;

GRANT data_entry TO test_data_entry;

GRANT admin TO test_admin;
```

Exercise 4:

In the following exercises, you need to log in as each test user. Ask your tutor if you don’t know how to do this.

Exercise 5:

Testing permissions.

As ‘test_read_only’, attempt to SELECT from the table department, then try to INSERT or UPDATE the department table. What happened?

Exercise 6:

As ‘test_data_entry’, attempt to INSERT data into the table department and UPDATE the table department, then try to ALTER the table department. What happened?

Exercise 7:

As ‘test_admin, attempt to SELECT, INSERT, UPDATE, DELETE, and ALTER TABLE on the table department. What happened?

Exercise 8:

Reflecting on the exercises you’ve just completed. Consider the database mechanisms like roles and permissions. How unauthorised actions are prevented based on the role assigned?

10.5 Tutorial Sessions

The time allowance for tutorials in this topic is 1 hour.

Group Discussion of Private Study Activities

In small groups, discuss your findings to Private Study Exercises 2, 4, and 5. You should collate your findings and report back to the class.

10.6 Private Study

The time allocation for private study in this topic is expected to be 6 hours.

Exercise 1:

Explain each of the following terms.

a) Theft and fraud
b) Loss of confidentiality
c) Loss of privacy
d) Loss of integrity
e) Loss of availability
f) Discretionary access control
g) Mandatory access control
h) Role-based access control
i) Data masking
j) Authentication
k) Backup and recovery
l) Self-managed database
m) Managed database
n) DBaaS

Exercise 2:

Research the recent database security breaches and write a reflective piece on how these could have been prevented with proper security measures (200 words)

Exercise 3:

Read the provided cloud database case studies. Discuss their challenges and the impact on the organisations.

Exercise 4:

Conduct a detailed comparison of AWS RDS, Azure Cosmos DB, and Google Cloud Spanner, focusing on their database type, scalability options, pricing models, and management features. Consider the ease of use, support provided, and any additional services that affect the overall value of each platform.

Exercise 5:

Look up on-premises databases online and make sure you understand what they are. List the advantages and disadvantages of using on-premises databases compared to could databases. Focus on aspects such as control, security, cost, maintenance, and scalability.

Exercise 6 (option):

Follow the video to set up a trial account with Google Cloud Spanner, and explore the interface of their database service. Create a simple database and run basic queries to understand the workflow.

Topic 11: Big Data and Post-Relational Databases

11.1 Learning Objectives

This topic begins with the introduction of Big Data and post-relational databases.

On completion of the topic, students will be able to:

- Explain the limitations of relational databases
- Explain the key features of Big Data
- Outline basic techniques for handling Big Data
- Describe the four main types of NoSQL data models including document, key-value pair, wide column, and graph

11.2 Pedagogic Approach

Information will be presented to the students during the lecture. They will then consolidate their learning during the tutorial and private study. Note that there are no laboratory session for this topic.

11.3 Timings

Lectures:	2 hours
Private Study:	6 hours
Tutorials:	1 hour

11.4 Tutorial Sessions

The time allowance for tutorials in this topic is 1 hour.

Discuss the assignment, the time-constrained assessment, and suitable revision techniques with students.

11.5 Private Study

The time allocation for private study in this topic is expected to be 6 hours.

Exercise 1:

Note down important things from the lecture and where you required further explanation. Raise these with your tutor in the tutorial session.

Exercise 2:

Investigate the evolution of databases from flat-file systems to relational and then to NoSQL databases. Reflect on the driving factors behind this evolution.

Write a brief history of database technologies (approx. 400 words). List the key limitations of each database type that led to the development of the next (approx. 300 words). Reflect on current data challenges that NoSQL databases are well-equipped to handle (approx. 200 words).

You may find the following resources helpful.

Silberschatz, A. (2020). *Database system concepts*. New York Mcgraw-Hill Education. Section 1.13.

Presentation on NoSQL

Exercise 3:

Data modelling for a book store

You are tasked with designing a data model for an online bookstore that focuses primarily on managing an inventory of books and the authors who wrote them. The key elements to consider include:

Books

Each book in the bookstore has a title, an identifier (such as an ISBN), a publication year, and a genre. Books are the central entities in your database, and you'll need to store details about each one.

Authors: Authors are individuals who have written books. For each author, the bookstore wants to keep track of their name, a unique identifier, and possibly a short biography.

You need to create a database structure that efficiently organises this information, allowing for easy access to book details, finding all books by a specific author, and potentially exploring relationships between authors and genres.

You will explore how to model this scenario using both

- a traditional relational database approach, which might involve tables for books and authors with relationships defined between them, and
- a NoSQL approach, specifically JSON document.

Exercise 4:

Review of All Topics

Review the materials for all the topics up to this week and prepare questions for the final overview lecture in Topic 12.

Topic 12: Summary

12.1 Learning Objectives

This topic provides a summary of the whole unit.

On completion of the topic, students will be able to:

- Recognise the key concepts they have studied on the unit
- Have clarification of the unit material
- Recognise links to other subject areas

12.2 Pedagogic Approach

Information will be presented to the students during the lectures.

12.3 Timings

Lectures: 2 hours

Private Study: 6 hours

12.4 Private Study

The time allocation for private study in this topic is expected to be 6 hours.

Exercise 1

You are now at a point where you should be revising for the time-constrained assessment. The lists below, although not exhaustive, indicate things that you should understand, be able to describe and be able to produce, in order to do well in the time-constrained assessment.

Understand

- Metadata
- Fan traps
- Chasm traps
- The concepts associated with SQL
- Constraints on data

In order to make sure that you can show your understanding of the above, read through the lecture slides and make short notes on each of the points. Revise from these notes. You can also ask your tutor for guidance.

Describe

- Entity types
- The relational model
- The database development process
- How databases are used
- How databases are deployed

In order to make sure that you can describe the above, read through the lecture slides and make detailed notes on each of the points. Revise from these notes. You can also ask your tutor for guidance.

Produce

- An ER Diagram from a scenario
- SQL SELECT statements from information given to you
- SQL CREATE statements from information given to you
- SQL INSERT statements from information given to you
- CRUD Matrices from information given to you
- Normalised tables from information given to you

In order to make sure that you can produce the above, go through the appropriate laboratory, tutorial and private study exercises and make sure that you can answer the questions. If you are having difficulties answering the questions, you may need to either revisit the lecture slides or ask your tutor for guidance.