Library Copy (8)

University of Ruhuna - Faculty of Technology

Bachelor of Information & Communication Technology Honours Degree
Level 1 (Semester II) End Semester Examination, June/July 2026
Academic Year 2024/2025

Course Unit: ICT 1212 – Database Management Systems
(Theory)

Duration: 02 Hours

IMPORTANT INSTRUCTIONS:

1. The medium of this examination is **English**.
2. This is a **Closed Book** examination.
3. This Examination consists of **four (04) questions** that are given equal marks.
4. This examination paper contains **five (05) pages** including this instruction page.
5. You must **answer all four (04) questions** in this examination.

Question 01 **[100 marks]**

Imagine that you are in the process of developing an information system for a national airline company. Part of the requirements used to design the database is given below.

The airline company operates several operational divisions such as Flight Operations Division, Cabin Crew Division, Cargo Division, and Customer Service Division. Each division has a unique division ID, division name, office location, and multiple contact numbers.

The system stores details about employees working in the airline company. Each employee has a unique employee ID, name, date of birth, gender, address, salary, and job position (such as pilot, flight attendant, ground officer, or operational manager). Each employee is assigned to exactly one division, where as a division can have multiple employees. An employee cannot exist without being assigned to a division, and every division must have at least one employee.

Each division is managed by an operational manager. An operational manager can manage only one division, while every division must have exactly one operational manager. The start date and end date of the manager's assignment to the division must be recorded.

The airline company operates multiple flights. Each flight has a unique flight number, destination, departure airport, arrival airport, departure time, and arrival time. A flight is controlled by only one division, while a division can control multiple flights. There cannot be any flights without divisions.

Employees can be assigned to multiple flights managed by their respective division, and the number of working hours spent on each flight assignment must be recorded. Each flight must have multiple employees assigned, although an employee may not be assigned to any flight.

Each employee reports to a senior employee within the same division. Each employee has exactly one reporting employee, whereas a senior employee can supervise many employees. There cannot be any employees without a reporting employee, however some senior employees may not be supervised by anyone.

For emergency situations, the system stores details about employees' emergency contacts. An emergency contact's name, address, contact number, and relationship to the employee are recorded. An employee can have multiple emergency contacts, while each emergency contact belongs to only one employee. Emergency contacts cannot exist without employees.

a) Draw an **ER diagram** that captures the above requirements by indicating relevant **attributes** along with the **key attributes**. Also specify **cardinality ratios** and **participation constraints**. State any assumptions you have made.

[70 marks]

b) Map the ER diagram you obtained in part (a) into a set of relations. Specify all primary keys and foreign keys of each relation.

[30 marks]

Question 02 **[100 marks]**

a) Briefly explain the concept of **closure property** in Relational Algebra.

[10 marks]

b)

i. Explain the difference between **Unary** and **Binary** Relational Algebra operations.

[10 marks]

ii. List down **two (02)** Unary operations and **two (02)** Binary operations in Relational Algebra.

[8 marks]

c) A vehicle rental company maintains the following relations in its database system. Answer the following questions based on given relations.

CUSTOMER (**cid**, cname, city, license_no)
VEHICLE (**vid**, vname, type, daily_rate)
BOOKING (**bid**, cid, vid, bdate, returndate)

CUSTOMER
• cid – unique ID of the customer • cname – name of the customer • city – Residence of the customer • license_no – Driving license number of the customer
BOOKING
• bid – unique ID of the vehicle booking • cid – ID of the customer • vid – ID of the vehicle • bdate – date of the vehicle booking • returndate – vehicle return date to the company
VEHICLE
• vid – unique ID of the vehicle • vname – name of the vehicle • type – vehicle type • daily_rate – daily charges for the vehicle

Express the following queries in **Relational Algebra**.

i. List the names of customers who live in "Colombo". [8 marks]

ii. List the names of vehicles whose type is "SUV". [8 marks]

iii. List the names of customers who booked vehicles after "2025-01-01". [12 marks]

iv. List the names of customers together with the vehicle names they have booked.

[12 marks]

v. List the names of vehicles that have not been booked by any customer. [12 marks]

d) **"Relational Calculus is considered as a declarative language"**. Do you agree with this statement? Justify your answer by providing **two (02)** reasons.

[20 marks]

Question 03 **[100 marks]**

a) Write down **two (02)** reasons why redundant data in a relation is undesirable.

[12 marks]

b) List down **two (02)** objectives of normalization in relational database design.

[12 marks]

c) State the requirements for a relation to be in **Fourth Normal Form (4NF)**.

[12 marks]

d) Answer the following questions using the **"library_management"** relation and the details given below.

memID	memName	category	libID	libName	bookID	bookTitle	issueDate
M001	Nimal	Undergraduate	L101	Mrs. Silva	B201	Database Systems	2026-05-02
M002	Kavindi	Postgraduate	L102	Mr. Fernando	B205	Computer Networks	2026-05-05
M003	Amaya	Undergraduate	L103	Ms. Peris	B210	Software Engineering	2026-05-08
M004	Dhanuka	External	L104	Mr. Gamage	B220	Data Structures	2026-05-11

Relation: **library_management**

- memID: Unique membership ID of a library member
- memName: Name of the library member
- category: Membership category
- libID: ID of the librarian handling the issue
- libName: Name of the librarian
- bookID: Unique ID of the book
- bookTitle: Title of the book
- issueDate: Date the book was issued

i. Is the library_management relation in 1NF? Justify your answer. [10 marks]

ii. Briefly describe the **Transitive dependency** by giving example from above relation.

[10 marks]

iii. By indicating the intermediate steps clearly, normalize the "library_management" relation into **Third Normal Form (3NF)**.

[44 marks]

Question 04 **[100 marks]**

a) A company currently stores employee details, salary records, and attendance information using separate spreadsheet files maintained by different departments. The higher management of the company decides to move on to the DBMS instead of a traditional file system. Briefly describe **two (02)** advantages of using a DBMS instead of this traditional file system.

[8 marks]

b)

i. What is **data independence**? [5 marks]

ii. Differentiate between **logical** and **physical** data independence. [10 marks]

c)

i. Briefly explain the difference between a **database schema** and a **database state**. [10 marks]

ii. Define the following terms related to the database state. [12 marks]

A. Empty State
B. Initial State
C. Valid State

d) A software company is developing a database system for a university to manage its employees. The university employs several categories of staff members and each employee is uniquely identified by EmployeeID, Name, Address, Salary, and DateOfJoin. Employees are categorized as Lecturers, Administrators, Technicians and Managers. In addition, some employees may serve as Managers. Lecturers are assigned to departments and have a ResearchArea. It is also possible for a Lecturer to simultaneously serve as a Manager. Technicians possess a specific SkillType, and Administrators are assigned an OfficeNumber. Managers receive an additional ManagementAllowance. Furthermore, every employee must belong to at least one employee category.

i. Identify the superclass, all subclasses and one shared subclass. [12 marks]

ii. Briefly explain the concept of attribute inheritance in the above scenario with examples.

[15 marks]

iii. Differentiate between **disjoint** and **overlapping constraints** using examples from the scenario.

[20 marks]

iv. Discuss **two (02)** advantages of using EER modeling instead of basic ER modeling in this scenario.

[8 marks]

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