University of Ruhuna - Faculty of Technology

Bachelor of Information & Communication Technology Honours Degree
Level 1 (Semester II) End Semester Examination, November/December 2025
Academic Year 2023/2024

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

Duration: 02 Hours

This examination paper contains **five (05)** pages including this instruction page.

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. You must **answer all four (04) questions** in this examination.

1.
Imagine that you are in the process of developing an information system for the Sri Lanka police department as your group project. Part of the requirements which is used to design the database is given below.

The police department is divided into divisions such as the Terrorist Investigation Division (TID), Traffic Police Division (TPD), Financial Crimes Investigation Division (FCID), etc. Each division has a unique name, location, and multiple contact numbers.

The system needs to store details about officers working in the police department. Each officer has a unique employee number, along with their name, date of birth, gender, address, salary, and rank (such as Constable, Sub Inspector (SI), or DIG). An officer is assigned to only one division, and each division can have multiple officers. There cannot be any officers without a division, nor any divisions without officers. A Deputy Inspector General (DIG), who is a ranked officer of the police, will manage each of these divisions. A DIG can manage only one division, and each division is managed by exactly one DIG. There cannot be any divisions without an assigned DIG. The start date and end date of a DIG's assignment to a division must be recorded in the system.

Each division initiates special missions. Every mission has a unique id, name, start date, and end date. A mission is controlled by only one division, while a division can have multiple missions initiated at the same time. There cannot be any divisions without missions or any missions without divisions.

An officer can be assigned to multiple missions that are controlled by their respective division, and the time spent by each officer on each mission is recorded. Each mission has multiple officers assigned. There cannot be any missions without officers assigned, but there can be officers who are not assigned to any mission. Every officer has a reporting officer who is a higher-ranked officer within the same division. An officer has only one reporting officer, while a reporting officer can have multiple officers reporting to him or her. There cannot be any officers without a reporting officer, although there may be higher-ranked officers who do not have any subordinates reporting to them.

To be used in emergency situations, the system keeps track of each officer's dependents details. A dependent's name, address, contact number, and the relationship to the officer are getting recorded in the system. An officer can have multiple dependents, but each dependent can be related to only one officer. There cannot be any officers without dependents, or there cannot be any dependents without officers. Dependents cannot exist in the system without an associated officer.

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 (1) (a) into a set of **relations**. Specify all **primary keys** and **foreign keys** of each relation.

[30 marks]

2. Answer the following questions based on the "student" relation given below.

regno	name	course	grade	lecturer	contact
TEC123	Nimal Perera	DBMS Networks	A B+	Dr. Sunil Fernando Ms. Saumya Silva	077-1234567 071-9876543
TEC124	Sahan De Silva	DBMS Programming	A- B	Dr. Sunil Fernando Mr. Ruwan Jayasena	077-1234567 075-4567890
TEC125	Dilini Fernando	Networks Programming	B+ A	Ms. Saumya Silva Mr. Ruwan Jayasena	071-9876543 075-4567890

Table 01: student relation

regno: Registration number of the student, Primary Key of the relation
name: Name of the student
course: Courses which are enrolled by the student
grade: Grade taken for each course by the student
lecturer: Lecturer who teaches the course
contact: Contact number of the lecturer

i. Is the **student** relation in 1NF? Justify your answer.

[10 marks]

ii. By indicating the intermediate steps clearly, normalize the **student** relation into **Third Normal Form (3NF).** For each relation, clearly specify the **primary key** and any **foreign key/s**.

[50 marks]

iii. By referring to the examples from student relation or its normalized forms briefly describe the following concepts.

- Super key
- Insertion anomaly
- Functional dependency
- Transitive dependency

[40 marks]

3.

a. Write down **one (01) similarity** and **one (01) difference** between ***tuple relational calculus*** and ***domain relational calculus***.

[10 marks]

b. Consider the following relations representing doctors, departments, surgeries conducted by each department, and doctors' involvement in these surgeries in the hospital. Answer the following questions based on these relations.

DOCTOR(**did**, dname, dgen, dspe, depid)
DEPARTMENT(**depid**, depname)
SURGERY(**sid**, depid, sname, scost, sdate)
PARTICIPATE(**depid**, **sid**, **did**, hours)

DOCTOR	SURGERY
• did - unique ID of the doctor • dname - name of the doctor • dgen - gender of the doctor • dspe - specialization of the doctor • depid - ID of the department the doctor belongs to	• sid - unique ID of the surgery • depid - ID of the department conducting the surgery • sname - name of the surgery • scost - cost of the surgery • sdate - date of the surgery
DEPARTMENT	**PARTICIPATE**
• depid - unique ID of the department • depname - name of the department	• depid - ID of the department • sid - ID of the surgery • did - ID of the doctor • hours - number of hours the doctor contributed to the surgery

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

  i. Retrieve the *names* of all **female** doctors who specialize in **Psychology**.
  [10 marks]

  ii. Retrieve the *names* of doctors who have **not participated in any surgery**.
  [15 marks]

  iii. Retrieve the *names* of all **male** doctors who have contributed **more than 10 hours** to the surgery **Heart Bypass** conducted by the **Cardiology** department.
  [15 marks]

- Express the following queries in **Tuple Relational Calculus.**

  iv. Retrieve the *surgery names* and their respective *department names* for **surgeries conducted after 2025-01-01**.
  [10 marks]

  v. Retrieve the *names* of doctors who **do not participate in any surgeries**.
  [15 marks]

- Express the following queries in **Domain Relational Calculus.**

  vi. Retrieve the *name*, *date* and the *cost* of the **Neuro Repair** surgery conducted by the **Neurology** department.
  [10 marks]

  vii. Retrieve the *names* of doctors who have **participated in at least one surgery** conducted by the **Cardiology** department.
  [15 marks]

4. a.

i. Briefly describe **two (02)** differences between **controlled** and **uncontrolled redundancy** in a relational database environment.

[10 marks]

ii. Briefly describe **two (02)** differences between a **Database Schema** and a **Database State**.

[10 marks]

iii. Briefly describe **two (02)** differences between **RAID Level 0** and **RAID Level 1** used in a DBMS environment.

[10 marks]

iv. Write down **one (01) advantage** and **one (01) disadvantage** of usage of **Stored Procedures** in Relational Databases.

[10 marks]

b. Consider a magnetic disk with a **sector size of 1024 bytes**, **1000 tracks** per surface, **50 sectors per track**, and **five double-sided platters**. The disk has an average **seek time of 8 milliseconds** and rotates at **7200 revolutions per minute (rpm)**. A database **file containing 100,000 records**, **each 100 bytes long**, is to be stored on this disk. A **block size of 2048 bytes (2 KB)** is chosen, and it is required that **no record spans two blocks and no block spans two tracks**.

i. What is the total **capacity** of the disk?

[06 marks]

ii. Write down **two (02) valid block sizes** and **two (02) invalid block sizes** for the disk.

[08 marks]

iii. What is the **average rotational delay** for the disk.

[08 marks]

iv. If **one track** of data can be **transferred per revolution**, what is the **transfer rate** for the disk?

[08 marks]

v. If the given database file is stored **sequentially** on the disk, calculate the **total number of cylinders required** to store it.

[15 marks]

vi. Estimate the **total time needed to read the stored database file** sequentially from the disk, assuming it takes **1 millisecond to move between adjacent cylinders.**

[15 marks]

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