UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 4 Examination in Engineering: November 2022

Module Number: EE4202 **Module Name: Database Systems**

[Three Hours]

[Answer **all questions**, each question carries **10 Marks**]

Q1 a)

(i) State four (4) fundamental functions of a database management system.

[1.0 Mark]

(ii) List down three (3) advantages of using a database management system.

[1.5 Marks]

(iii) What is meant by Physical Data Independence in three schema architecture?

[1.0 Mark]

(iv) Compare the two main types of database architectures.

[1.5 Marks]

b) In a database schema called "FILM" of a flim production company ABC, a relation MOVIE ('Title', 'Launched_Year', 'Duration', 'Rank') is defined, where 'Title' is a 20 letter string, 'Duration' and 'Rank' are intergers. Both 'Title' and 'Year' cannot be NULL. The 'Duration' needs to be set as 4 hours if there is no input from the user.

(i) Write SQL statements to create the relation MOVIE in FILM Schema.

[0.5 Marks]

(ii) Write SQL statements to constraint the 'Duration' of the movie to be no less than 2 hours and no longer than 5 hours.

[0.5 Marks]

(iii) The relation MOVIE is in a relationship with ACTOR in the same schema. Write SQL statements to implement a referential integrity constraint between these two relations.

[2.0 Marks]

(iv) The company ABC also has DIRECTORS for their films. However, the company doesn't allow their directors to act in films. Write SQL statements only for relations, MOVIE and DIRECTOR, to implement this relationship in FILM schema.

[2.0 Marks]

Q2 a) Consider the partially completed Entity Relationship (ER) diagram for the Electrical and Information Engineering Department (DEIE) shown in Figure Q2.

Some specific criteria are highlighted below.

- DEIE Lecturers play the roles of Academic Advisor, Teacher, and Module Coordinator, but only senior lecturers coordinate the modules.
- DEIE offers modules with number of credits 1, 2, and 3 with total lecture hours of 14, 28, and 42, respectively.

- Each Lecture hall has a maximum class size which is the number of seats available.
- On a given date, only one lecturer will conduct the lectures of a particular module.

(i) Complete the ER diagram by including four relationships to connect the given entities appropriately.

[1.0 Mark]

(ii) Represent the relationships with the maximum cardinality ratios (You can put the ratios in the same diagram drawn in (i)).

[1.0 Mark]

(iii) State one derived attribute for each of the relations, STUDENT and LECTURES.

[0.5 Marks]

(iv) Some modules may contain QUIZ as an assessment component. Implement QUIZ as a weak entity in the given schema and illustrate it (including weak entity, strong entity and identifying relationship) by using notations, while including participation constraint and maximum cardinality ratio. Propose a key for QUIZ. Note: Redraw only the corresponding entites and relationships.

[1.5 Marks]

(v) Implement a recursive relationship for DEIE schema. Note: Redraw only the corresponding entites and relationships.

[0.5 Marks]

(vi) Identify and illustrate the functional dependency types exist between MODULE and LECTURER using the usual notations. Note: Redraw only the corresponding entites and relationships.

[0.5 Marks]

(vii) Propose a key for LECTURES relation.

[0.5 Marks]

b) Illustrate the table structure with all the dependencies for tables which undergo normalization for the following questions. Also, you need to show the referential integrity constraints and candidate keys, using the usual notations.

(i) Normalize STUDENT entity to Relational model in First Normal form (1NF).

[1.5 Marks]

(ii) Normalize LECTURES entity to Relational model in Third Normal form (3NF).

[1.5 Marks]

(iii) Normalize MODULE entity to Relational model in Third Normal form (3NF).

[1.5 Marks]

Q3 a)

(i) Prove that SELECT operation in relational algebra is commutative by using an appropriate example.

[0.5 Marks]

(ii) Explain the DIVISION operation in relational algebra by using an appropriate example, and prove that DIVISION operation is not commutative by using the same example.

[1.0 Mark]

(iii) Briefly explain a method to simulate DIVISION operation by using other relational algebra operations.

[0.5 Marks]

(iv) Prove that SET DIFFERENCE operation in relational algebra is not commutative by using an appropriate example.

[1.0 Mark]

b) Write relational algebra and the resultant relation in each of the steps, for the following scenarios by using the relations denoted in Figure Q3.

(i) Obtain the teacher tuples who were "born after 1994.01.01 and married" or whose "subject is Maths and salary is greater than 30,000".

[0.5 Marks]

(ii) Obtain student first_name and reg_no who were born before 2006.01.01 and city is Galle.

[0.5 Marks]

(iii) Retrieve the number of teachers and their average salary.

[0.5 Marks]

(iv) Retrieve the number of teachers in each subject who were joined after 2019.01.01 and city is Matara.

[0.5 Marks]

c) Write MySQL queries for the following scenarios by using relations denoted in Figure Q3.

(i) STUDENT $\bowtie_{reg\_no = stu\_rep}$ CLASS

[0.5 Marks]

(ii) $\pi_{(class\_name)}(\sigma_{(last\_name=Perera)}(CLASS*studentClassRelation* STUDENT))$

[0.5 Marks]

(iii) Retrieve class_name and number of students for each class.

[0.5 Marks]

(iv) Retrieve reg_no, first_name and number of classes for each student.

[0.5 Marks]

(v) Retrieve the teacher_ID, subject and dob of teachers who are either doing project Prj_02 or have 'Andromeda' as a class.

[1.0 Mark]

(vi) Retrieve the first_name, joined_date of teachers who are doing both project Prj_01 and have 'Proxima' as a class.

[1.0 Mark]

(vii) Retrieve the last_name and town of teachers who are having 'Sagittarius' as the class but not doing Prj_01.

[1.0 Mark]

Q4 a)

(i) What are the two types of ordered indices? Explain them using a diagram.

[0.5 Marks]

(ii) What are the differences and similarities between the two types of ordered indices?

[0.5 Marks]

(iii) State three (3) situations where indices are adversely affected to the

performance of the database.

[0.5 Marks]

(iv) Write five (5) SQL tuning guidelines that can be used to enhance the performance of the database.

[0.5 Marks]

b) A file contains 45,436 fixed length records of size 134 bytes stored on a disk with a block size of 1024 bytes. This file is stored as an unordered file in terms of the secondary index field having 25,745 distinct values for the unordered field. A block pointer of the index file pointing to intermediate blocks will be 8 bytes in size. An unordered secondary index is created with an index field of size 16 bytes. Assume that when using the index, there will be on average 3 intermediate block accesses.

(i) Calculate the average block accesses needed without the index for searching the unordered index field.

[0.5 Marks]

(ii) Calculate the average block accesses needed with the index for searching the unordered index field.

[0.5 Marks]

(iii) Did the secondary index improve the performance of the database? Explain the reason.

[0.2 Marks]

c)

(i) Write a MySQL query to analyze the complexity of the following query.
SELECT * FROM Teacher WHERE salary > 25000;

[0.5 Marks]

(ii) Write the definition of five (05) parameters that can be observed in complexity analysis query output.

[1.0 Mark]

d) Write MySQL query for the following.

(i) Visualize all the indices available in Teacher table in Figure Q3.

[0.5 Marks]

(ii) Create unique index named 'teacher_uindex' by combining both attributes last_name and dob in Teacher table in Figure Q3.

[0.8 Marks]

(iii) Delete the index 'teacher_uindex' in Teacher table in Figure Q3.

[0.5 Marks]

e)

(i) Briefly explain three (3) access control methods used in databases.

[1.5 Marks]

(ii) Write MySQL queries for the following scenario.
Create two users 'user01' with the password 'user01pwd' and 'user02@localhost' with the password 'user01pwd'. Then, change the password of user02 to 'PWD02' and the password lifetime to 90 days. After

that, provide SELECT privilege on all schemas and all tables to user02. Subsequently, visualize the privileges provided for user02. Finally, remove provided privileges from user02 and delete user02.

[2.0 Marks]

Q5 a)

(i) Compare Relational databases and NoSQL databases by stating five (05) key differences.

[0.5 Marks]

(ii) Briefly explain the meaning of Aggregate Data Model.

[0.5 Marks]

(iii) What are the two (02) types of database scaling methods? Explain each of them briefly.

[0.5 Marks]

(iv) State the CAP theorem.

[0.5 Marks]

(v) What are the two (2) main types of conflicts that can occur in NoSQL database systems? Briefly explain each of them.

[0.5 Marks]

(vi) Explain a method to avoid above mentioned (Q5 (a) v) conflicts in NoSQL peer to peer distribution systems.

[0.5 Marks]

(vii) Briefly explain the term Map-Reduce that used in NoSQL databases using an example.

[1.0 Mark]

b) Write MQL (MongoDB Query Language) queries for the following.

(i) Create a collection named 'student' and insert a document containing your name, index number and specialization.

[0.5 Marks]

(ii) Retrieve only index number of all documents.

[0.5 Marks]

(iii) Update your specialization (i.e. created in Q5 b) (i)) to a different field.

[0.5 Marks]

(iv) Delete your document (i.e. created in Q5 b) (i)).

[0.5 Marks]

c) Write queries using Cypher Query Language (used in Neo4j) for the following.

(i) Create all the nodes given in Table Q5-1 to create a graph database.

[0.5 Marks]

(ii) Delete node 'Kasun'.

[0.25 Marks]

(iii) Create the relations given in Table Q5-2.

[0.5 Marks]

(iv) Show only 'Supun' and 'Ruhuna' nodes.

[0.5 Marks]

(v) Update the age of 'Supun'' to 26.

[0.5 Marks]

(vi) Update the relation status of 'Hasini -> Ruwan' to 'Normal'.

[0.5 Marks]

(vii) Delete node 'Supun'.

[0.5 Marks]

d) Briefly explain the terms replication factor and consistency level used in Cassandra NoSQL databases.

[0.75 Marks]

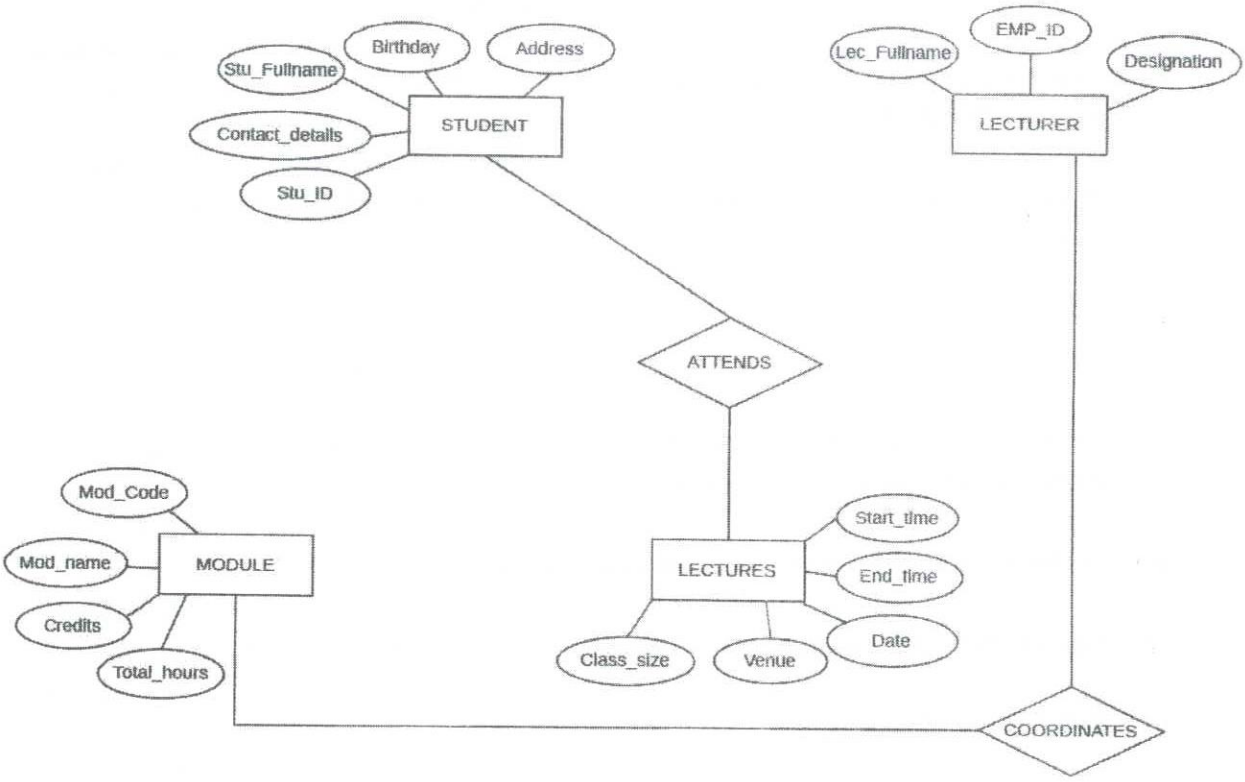
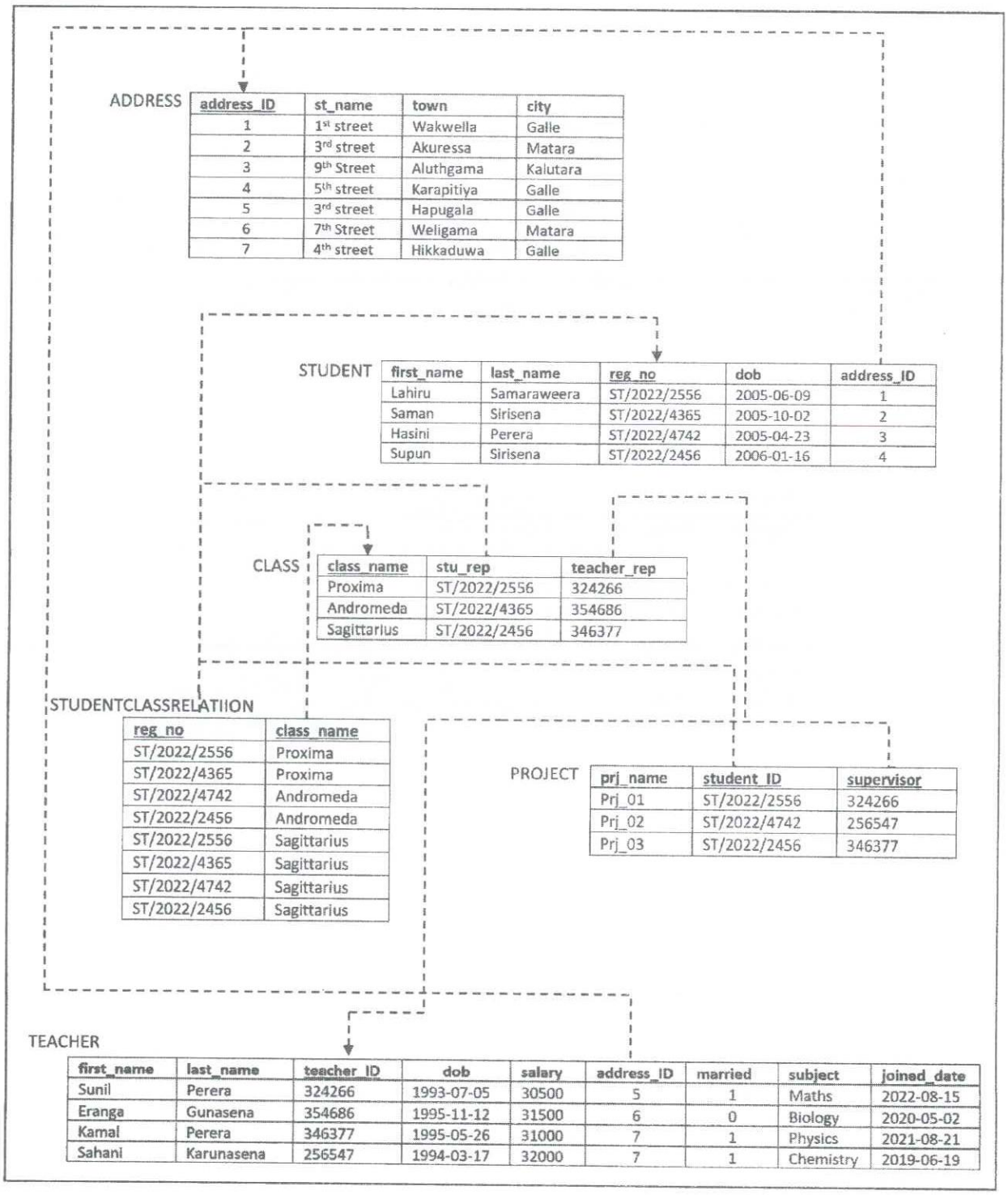


FIGURE Q2



ADDRESS

address_ID	st_name	town	city
1	1st street	Wakwella	Galle
2	3rd street	Akuressa	Matara
3	9th Street	Aluthgama	Kalutara
4	5th street	Karapitiya	Galle
5	3rd street	Hapugala	Galle
6	7th Street	Weligama	Matara
7	4th street	Hikkaduwa	Galle

STUDENT

first_name	last_name	reg_no	dob	address_ID
Lahiru	Samaraweera	ST/2022/2556	2005-06-09	1
Saman	Sirisena	ST/2022/4365	2005-10-02	2
Hasini	Perera	ST/2022/4742	2005-04-23	3
Supun	Sirisena	ST/2022/2456	2006-01-16	4

CLASS

class_name	stu_rep	teacher_rep
Proxima	ST/2022/2556	324266
Andromeda	ST/2022/4365	354686
Sagittarius	ST/2022/2456	346377

STUDENTCLASSRELATIION

reg_no	class_name
ST/2022/2556	Proxima
ST/2022/4365	Proxima
ST/2022/4742	Andromeda
ST/2022/2456	Andromeda
ST/2022/2556	Sagittarius
ST/2022/4365	Sagittarius
ST/2022/4742	Sagittarius
ST/2022/2456	Sagittarius

PROJECT

prj_name	student_ID	supervisor
Prj_01	ST/2022/2556	324266
Prj_02	ST/2022/4742	256547
Prj_03	ST/2022/2456	346377

TEACHER

first_name	last_name	teacher_ID	dob	salary	address_ID	married	subject	joined_date
Sunil	Perera	324266	1993-07-05	30500	5	1	Maths	2022-08-15
Eranga	Gunasena	354686	1995-11-12	31500	6	0	Biology	2020-05-02
Kamal	Perera	346377	1995-05-26	31000	7	1	Physics	2021-08-21
Sahani	Karunasena	256547	1994-03-17	32000	7	1	Chemistry	2019-06-19

FIGURE Q3

Table Q5-1: Labels and Properties of Nodes

Node	Label	Properties
Supun	Student	{name: "Supun", reg_no: "EG/2019/2345", age:23}
Hasini	Student	{name: "Hasini", reg_no: "EG/2019/3455", age:24}
Ruwan	Student	{name: "Ruwan", reg_no: "EG/2019/4566", age:22}
Kasun	Student	{name: "Kasun", reg_no: "EG/2019/3456", age:22}
Ruhuna	University	{name: "Ruhuna", location: "Galle"}
Moratuwa	University	{name: "Moratuwa", location: "Colombo"}

Table Q5-2: Relationship Between Nodes

Related Nodes	Relationship
Supun -> Ruhuna	STUDIED_AT
Hasini -> Ruhuna	STUDIED_AT
Ruwan -> Moratuwa	STUDIED_AT
Supun -> Hasini	FRIENDSHIP {status: "Special"}
Hasini -> Supun	FRIENDSHIP {status: "Normal"}
Hasini -> Ruwan	FRIENDSHIP {status: "Enemy"}
Ruwan -> Hasini	FRIENDSHIP {status: "Special"}