BCS THE CHARTERED INSTITUTE FOR IT

BCS HIGHER EDUCATION QUALIFICATIONS
BCS Level 5 Diploma in IT

DATABASE SYSTEMS

Monday 22nd April 2024 - Morning

Answer any FOUR questions out of SIX. All questions carry equal marks.

Time: TWO hours

Answer any Section A questions you attempt in Answer Book A
Answer any Section B questions you attempt in Answer Book B

The marks given in brackets are **indicative** of the weight given to each part of the question.

Calculators are **NOT** allowed in this examination.

Section A
Answer any Section A questions you attempt in Answer Book A

A1.

a) Define **each** of the following relational database concepts using examples from the STUDENT relation given in Fig A1.1

i. Tuple.
(1 mark)

ii. Cardinality.
(1 mark)

iii. Degree.
(1 mark)

iv. Attribute.
(1 mark)

v. Schema.
(2 marks)

vi. Domain.
(2 marks)

vii. Composite key.
(2 marks)

Fig A1.1 Relation STUDENT

ROLL	NAME	CITY	PHONE	AGE
1	SUJIT	DELHI	454370295	18
2	RAMESH	KARACHI	757567744	18
3	SAMI	LONDON	91562532	20
4	SURESH	LEEDS		34

b) Explain the importance of the ANSI-SPARC database architecture in supporting data independence in a Database Management System (DBMS) and supporting database design.
(5 marks)

c) Relational Algebra uses operators to manipulate a Relation. An operator can be either Unary or Binary. Consider the following Depositor and Borrower relations below:

Fig A1.2 `Depositor`

ID	Name
1	a
2	b
3	c

Fig A1.3 `Borrower`

ID	Name
2	b
3	a
5	d

i. Give examples of **TWO** Unary Relational Algebra (RA) operators that operate only on the Depositor **or** the Borrower relations.
(4 marks)

ii. Give examples of **THREE** Binary Relational Algebra operators that operate on both the Depositor and Borrower Relations given above (Fig A1.2 and Fig A1.3).
(6 marks)

B6.

a) Consider the following example of two concurrent transactions (Tx1 and Tx2) and answer the questions below.

Tx1	Tx2
`Read (x)`	
`x := x - 5`	
`Write (x)`	
	`Read (x)`
	`x := x + 5`
	`Write (x)`
`ROLLBACK`	
	`COMMIT`

i. What problem occurs in the example? **(2 marks)**

ii. Explain the concept of 2 phase locking and show how 2 phase locking prevents the problem in part i. above.

(8 marks)

b) Briefly explain the concept of a recovery strategy at business level and why a business would have one. Your answer should mention **TWO** options available for recovery strategies.

(4 marks)

c) A database auditor detected both login changes and user permission changes to your database. Why should you be concerned?

(4 marks)

d) Authorisation in SQL databases can be granted to users and roles. It controls how/whether they can access data in the database. Answer the following questions related to authorisation:

i. What is the effect of the following SQL statement?

```
GRANT DELETE on amy.Student TO Prof_Smith;
```

(2 marks)

ii. What are the advantages in the use of roles?

(2 marks)

iii. How can views help with database security in conjunction with granting permissions?

(3 marks)

END OF EXAMINATION

A2.

Normalisation to Third Normal Form (3NF) is one the most important objectives of database design.

Consider the following table in Fig A2, that holds data about players of a computer game. This table records the `PlayerID` and `Playername` and the types of weapons a player uses in the game. For example, Moeen uses a sword and an axe. A weapon may be assigned to a player and/or removed from a player at any time.

Each player has a rating and a skill level and is assigned a unique `PlayerID`. The `Skill level` of a player is on a numeric scale related to the player rating such as a Beginner has a skill level of either 1 or 2; Intermediate has skill level of either 3 or 4; Advanced level has either 5 or 6.

Fig A2 Games Table

PlayerID	**PlayerName**	**Weapon**	**PlayerRating**	**Skill Level**
1	JB	dagger, sword	Beginner	2
2	JonT	crossbow	Intermediate	4
3	Moeen	sword, axe	Beginner	1
4	Liam	dagger	Advanced	5

a) With reference to Fig A2 Games Table as a source of examples, describe the problems that can arise if a table is not fully normalised to 3NF.

(5 marks)

b) Explain and justify the process of normalising the Fig A2 Games table to third normal form (3NF) by working through the following steps.

Step1: UNF->1NF;
Step2: 1NF->2NF;
Step3: 2NF->3NF;

(12 marks)

c) Suppose there is a new requirement:

A player can have the use of more than one weapon of the same type (for example another 2 axes). Therefore, it is required to record a count of the weapons used (for example Moeen uses 3 axes).

Explain how you would modify the 3NF table(s) in your answer in part b) to accommodate the above requirement. Illustrate your answer with sample data.

(4 marks)

d) Show all the functional dependencies that now exist, including the modification to your design in part c).

(4 marks)

[Turn Over]

A3.

Consider the following Tables (Fig A3.1 and A3.2) below and SQL script (Fig A3.3) on page 5.

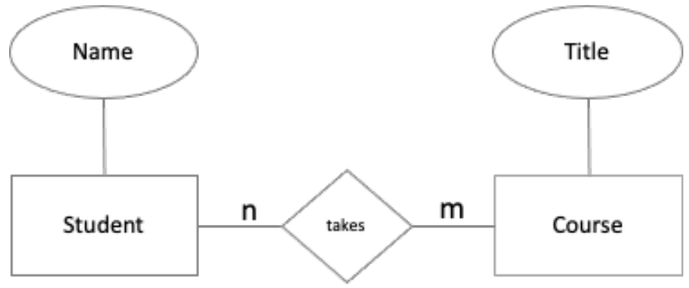
Fig A3.1 Table Borrower

BORROWERID	BORROWERFNAME	BORROWERLNAME
874	Leon	Small
875	Gary	Lowe
876	Marik	Ahmed
877	Clywd	Morgan

Fig A3.2 Table Loan

LOANID	BOOKID	BORROWERID	LOANDATE	DUEDATE	RETURNDATE
122	3932	874	15-NOV-2022	14-DEC-2022	24-JAN-2023
123	3944	874	23-DEC-2022	24-JAN-2023	24-JAN-2023
124	3906	874	23-DEC-2022	03-JAN-2023	30-DEC-2022
125	3944	876	29-JAN-2023	28-FEB-2023	-
126	3932	874	25-JAN-2023	21-FEB-2023	-
127	3945	876	25-JAN-2023	21-FEB-2023	-

c) Consider the following ERD model. Map the model into the relevant physical design. Add keys as required. You do not need to provide sample data.



(8 marks)

d) Consider the `NOT NULL` constraint in SQL. Explain what it means and provide a simple SQL DDL statement in which you use it.

(4 marks)

[Turn Over]

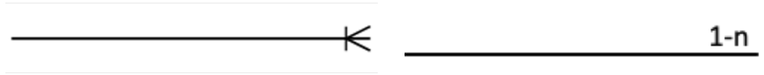
B5.

a) Consider the following notations used in entity Relationship Diagrams (where they differ, both Chen's notation and the Crow's foot version are provided) and explain their meaning.

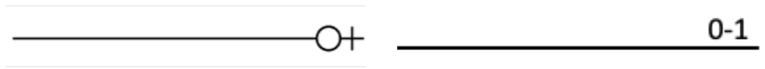
i.

ii.

iii.



iv.



(6 marks)

b) Consider the following SQL Data Definition Language extract. Identify suitable key constraints (both foreign and primary) and add the respective SQL statements to implement the keys.

```
CREATE TABLE Student (
      Name VARCHAR(50),
      DoB DATE,
      Studid INT NOT NULL
);
CREATE TABLE Course (
      Name VARCHAR(50),
      Courseid INT NOT NULL
);
CREATE TABLE Enrolment (
      StudID INT NOT NULL,
      CourseID INT NOT NULL
);
```

(7 marks)

Fig A3.3 SQL script

```
/* an extract of the script that created and populated the above Loan Table and
a Borrower Table) */

CREATE TABLE Borrower(
                      BorrowerID INT
                     ,BorrowerFname VARCHAR(12)
                     ,BorrowerLname VARCHAR(12));

CREATE TABLE Loan(
                   LoanID INT
                  ,BookID INT
                  ,BorrowerID INT
                  ,LoanDate DATE
                  ,Duedate DATE
                  ,Returndate DATE);

/* COMMENT  current date = 29-JAN-2023 */
INSERT INTO Loan
      VALUES(122,3932, 874
      , CAST('15-NOV-2022' AS DATE)
      , CAST('14-DEC-2022' AS DATE)
      , CAST('24-JAN-2023' AS DATE));
INSERT INTO Loan
      VALUES(123,3944, 874
      , CAST('23-DEC-2022' AS DATE)
      , CAST('24-JAN-2023' AS DATE)
      , CAST('24-JAN-2023' AS DATE));
INSERT INTO Loan
      VALUES(124,3906, 874
      , CAST('23-DEC-2022' AS DATE)
      , CAST('03-JAN-2023' AS DATE)
      , CAST('30-DEC-2022' AS DATE));
INSERT INTO Loan
      VALUES(125,3944, 876
      , CAST('29-JAN-2023' AS DATE)
      , CAST('28-FEB-2023' AS DATE)
      , NULL);
INSERT INTO Loan
       VALUES(126,3932, 874
      , CAST('25-JAN-2023' AS DATE)
      , CAST('21-FEB-2023' AS DATE)
      , NULL);
INSERT INTO Loan
       VALUES(127,3945, 876
      , CAST('25-JAN-2023' AS DATE)
      , CAST('21-FEB-2023' AS DATE)
      , NULL);

INSERT INTO Borrower
       VALUES(874,'Leon','Small');
INSERT INTO Borrower
      VALUES(875, 'Gary', 'Lowe');
INSERT INTO Borrower
      VALUES(876, 'Marik', 'Ahmed');
INSERT INTO Borrower
      VALUES(877, 'Clywd', 'Morgan');

/* end of script extract  */
```

[Turn Over]

The below questions refer back to (Fig A3.1 and A3.2) on page 4 and SQL script (Fig A3.3) on page 5.

a) Refer to the SQL script. Both the `Borrower` and `Loan` tables are not constrained by entity integrity.

   i. Define entity integrity and briefly explain how entity integrity may be compromised when more data is inserted into these tables.

   (4 marks)

   ii. Write the SQL statement necessary to enforce entity integrity in the `Borrower` table. (Approximate SQL syntax /pseudocode is acceptable)

   (2 marks)

b) Refer to the SQL script. The relationship between `Borrower` and `Loan` is not constrained by referential integrity.

   i. Define referential integrity and briefly explain how data integrity might be compromised when a row of data is deleted from either the `Loan` or `Borrower` tables.

   (4 marks)

   ii. Write the SQL statement that would enforce referential integrity between `Borrower` and `Loan`. (Approximate SQL syntax /pseudocode is acceptable).

   (2 marks)

c) There is at least one further type of constraint that should be added to the table `Loan` in the script. Identify a constraint that needs enforcing and show how you would alter the SQL statement that creates the `Loan` table to enforce this constraint.

(3 marks)

d) Refer to the `Borrower` and `Loan` tables. Write a SQL statement and show the output it generates when returning the `BorrowerID`, `BorrowerLname` and `BorrowerFname` of those borrowers that have not borrowed a book.

(5 marks)

e) There are many ways in which a user can interact with a database. For example, the script shown in Fig A3.3 was developed using a Command Line interface.

Describe the key differences between the following types of user interface, contrasting the different needs of users and the way users interact with an underlying database.

- Command Line (Text based)
- Forms based (GUI)

(5 marks)

Section B
Answer any Section B questions you attempt in Answer Book B

B4.

You are employed as a consultant by a bus transport company. They want you to advise on the next database system for their operations in the context of new government regulation requiring publication of timetables, bus locations and fares. Specifically, their CEO is very keen to employ some new technology in the form of a graph database as they have heard that they are very flexible. Read the following description of their system needs and answer the questions below.

The database will be queried by route planning software and a web application for users that allows them to identify departure times at specific stops and for specific destinations. It will also identify any delays to the bus service. The information to be stored in the database are:

- Bus timetables: a bus timetable is a list of stops together with arrival and departure times at each stop; each bus route has two timetables (weekday and weekend), and the operator runs in the order of 10 bus routes.
- Bus locations: each bus sends updated information to the database when it arrives at or leaves a stop.

Note that both arrival and departure times for stops are recorded to allow for scheduled breaks as well as tracking where buses consistently arrive earlier than anticipated.

a) Briefly describe the concept of a Graph Database.

(4 marks)

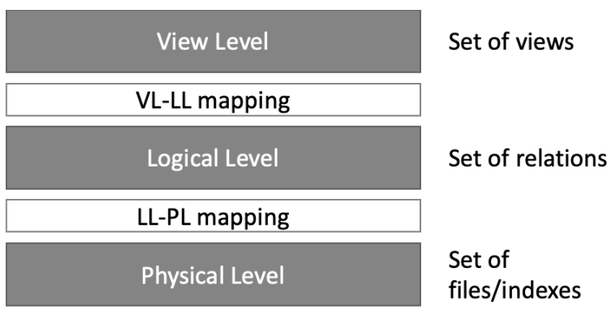
b) Up to now, timetables have been kept in a flat file. Discuss whether this is a reasonable approach and consider any limitations.

(4 marks)

c) Consider whether a Graph Database or a Relational Database is better for the new database implementation. Your answer should include a discussion of the pros and cons for **each**.

(10 marks)

d) Without referring to the scenario above, explain the concepts of logical data independence and physical data independence in a DBMS. You might wish to use the following diagram to aid your description:



(7 marks)

[Turn Over]