**BCS THE CHARTERED INSTITUTE FOR IT**

BCS HIGHER EDUCATION QUALIFICATIONS
BCS Level 5 Diploma in IT

# DATABASE SYSTEMS

Friday 10th October 2025 – 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 Section A questions in Answer Book A

**A1.**

a) Define the following concepts commonly used in database design and provide an example for **each**:

i. Entity

**(2 marks)**

ii. 1:1 relationship

**(2 marks)**

iii. Foreign key

**(2 marks)**

iv. Recursive relationship

**(2 marks)**

b) A district council has approached you to design a database that should contain information on the shops in their area and the goods they sell. All the shops are based in (small or large) shopping centres. The specification is given in terms of queries they think customers will use as shown below.

Your task is shown after the queries:

**The queries:**
Searching for goods:

- Find all shops in the county that sell shoes.
- Find all shops in the county that sell shoes of the brand 'RunFast'.
- Find the shop in the city called 'MainTown' that has the highest number of distinct shoe brands.

Combination searches:

- Find a shopping centre that contains both a shoe shop and a sports shop. The words 'shoe' and 'sport' are not part of the names of the shops.
- Find all bed shops owned by 'Sleep Tight'. The word 'bed' and the owner's name might not be part of the shop name.

Inventory searches:

- Find a shop that has four sleeping bags in stock.
- Find a shop that has four sleeping bags in stock, and is in the same shopping centre in which there is a shop that sells tents.

**Your task:**
(NB: You are asked only to show the database design, not the definition of the queries.)

Draw an Entity-Relationship (ER) model for a database that contains sufficient information to answer the searches described above. You can assume that each shop sells only **one** category of product. State any other assumptions that you make. Your answer should show the entities with their attributes and their relations including participation constraints. Only the information needed to answer the queries should be included. You can use any of the typical entity relationship diagram (ERD) notations.

**(11 marks)**

c) Produce a set of tables and columns in the form of:

```
table_name(column_name1, column_name2,...)
```

from your design in part (b), ensuring that you identify primary and foreign keys as appropriate.

**(6 marks)**

**A2.**

a) Consider a database for a zoo that manages information about animals, enclosures and their feeding times. Below are the three tables containing some sample data. Your tasks are shown below.

| **animals** | | | |
|---|---|---|---|
| animal_id | animal_name | species | habitat_id |
| 1 | Leo | Lion | 1 |
| 2 | Stripes | Tiger | 2 |
| 3 | Polly | Parrot | 3 |
| 4 | Slithers | Snake | 4 |

| **habitats** | | |
|---|---|---|
| habitat_id | habitat_name | environment |
| 1 | Savannah | Grassland |
| 2 | Tiger Trail | Forest |
| 3 | Bird Paradise | Tropical |
| 4 | Reptile House | Temperate |

| **Feeding_schedule** | | | |
|---|---|---|---|
| schedule_id | animal_id | food | feeding_time |
| 1 | 1 | Meat | 14:00 |
| 2 | 2 | Chicken | 12:00 |
| 3 | 3 | Seeds | 08:00 |
| 4 | 3 | Fruits | 15:00 |
| 5 | 4 | Mice | 20:00 |

i. Write the SQL Data Definition Language (DDL) statements to create the **Feeding_schedule** and **animals** tables, considering the specified attributes and ensuring that the DDL statements capture the required relationship constraints. You do not need to insert data into the tables.

**(6 marks)**

ii. The zoo needs to also record the name of the current carer for each animal. Provide the SQL DDL statement to alter the animals table to allow for this.

**(2 marks)**

iii. Zoo management have realised that staff are becoming lax and are not entering all information when adding new records. How would you ensure that the environment and species attributes always have values?

**(1 mark)**

**[Question A2 continues over page]**

b) Now that tables have been defined (in part a) for the zoo example, we turn our attention to querying the data.

Answer the following:

i. Write the SQL query that retrieves a list of all animals in the zoo together with their habitats. The result should show the name of the animal and their habitat.

**(2 marks)**

ii. Write an SQL query that finds the total number of feedings scheduled for each type of food. The result should include the type of food and the total number of feedings.

**(3 marks)**

iii. Write an SQL query that returns a list of animals that need to be fed more than once per day. The result should show the name of the animal and the number of times it needs to be fed.

**(4 marks)**

c)

i. Write the query that retrieves a list of all animals in the zoo together with their habitats from part (b) in relational algebra notation.

**(3 marks)**

ii. What does the following relational algebra return? As a reminder, in relational algebra, γ is the grouping operator. Your answer should express this at the 'business level' and not talk through the detail of individual technical steps and operations.

$$\pi_{animal\_name,habitat\_name}(\sigma_{feedings\_per\_day>1}(\gamma_{animal\_id;count(schedule\_id)\rightarrow feedings\_per\_day}FeedingSchedule) \bowtie_{animal\_idAnimals} \bowtie_{habitat\_idHabitats})$$

**(4 marks)**

**A3.**

a) Consider the following unnormalised table and answer the questions below:

| student_id (PK) | student_name | enrolment |
|---|---|---|
| 35365 | AA | Computer Science, CS101, 2 credits |
| 78108 | BB | Biology, BIO204, 4 credits<br>Biology, BIO207, 6 credits |
| 63790 | CC | Computer Science, CS101, 2 credits |

i. Explain why this table is not in (at least) first normal form (1NF) and use its data to evidence your point.

**(3 marks)**

ii. Convert the table to a table in 1NF.

**(3 marks)**

iii. State the requirements for second normal form (2NF).

**(2 marks)**

iv. Convert the table to a (set of) tables in 2NF.

**(4 marks)**

b) Consider the relational schema R=(A,B,C,D,E,F) and the functional dependencies F: A->B, A->C, BC->E, BC->D, E->F, BC->F

Answer the following questions:

i. List the minimal candidate key(s) for R, justify your answer and show how you arrive at your answer.

**(4 marks)**

ii. State the requirements that need to hold for a database schema to be in third normal form (3NF).

**(2 marks)**

iii. List the functional dependencies in F that violate 3NF. Show your reasoning and how you arrive at your answer.
(Hint: there is at least one.)

**(4 marks)**

c) Use an example based on the tables to describe the concept of an update anomaly.

**(3 marks)**

**[Turn Over]**

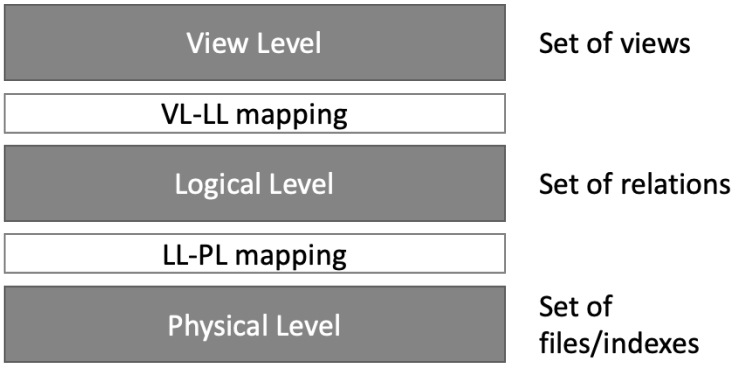
## Section B
## Answer Section B questions in Answer Book B

**B4.**

a) Consider the scenario of modelling and querying a social network where users are connected through friendships, likes, and comments on posts. Provide **three** reasons why a graph database is superior to a relational database management system (RDBMS) in this scenario. Your answer should outline for each of these the strength of the graph database and the weakness and challenge for the RDBMS. Provide an example requirement based on the above scenario to show this.

**(15 marks)**

b) Explain the concepts of **logical data independence** and **physical data independence** in a database management system (DBMS). You might wish to use the following diagram to aid your description:




**(6 marks)**

c) Explain how the concept of views in relational databases helps with maintaining data independence.

**(4 marks)**

**B5.**

a) Consider a database with the following tables:

- `Employees (EmpID, EmpName, Department, Salary)`
- `Departments (DeptID, DeptName, ManagerID)`

i. You are the database administrator for a company and need to manage access to these tables.

Write the appropriate SQL GRANT statements to perform the following tasks:

1. Grant INSERT and UPDATE privileges on the `Departments` table to a user named `admin_user`, but only on the `DeptName` column.
2. Grant SELECT privileges on the `Employees` table to a role named `manager_role` for all users assigned to that role.
3. Revoke all privileges on the `Employees` table from `hr_user`.

**(6 marks)**

ii. In your role as a database administrator, you realise you need to limit further access to sensitive data. The `Employees` table contains sensitive salary information, and you need to ensure that users can access the employee data without seeing the salary details.

1. Create a view named `EmployeeInfo` that allows users to see all columns from the `Employees` table except the `Salary` column.
2. Write **two** SQL statements to ensure that a user named `hr_user` can access employee data using only the view and not the underlying `Employees` base table.
3. Describe how using the `EmployeeInfo` view can improve security and access control for the `Employees` table.

**(7 marks)**

b) You are the database administrator for a financial institution that handles sensitive customer information, including account details, transaction history and personal identification data. Due to regulatory requirements and the need to maintain the integrity of the system, it is crucial to implement a robust auditing mechanism for the database system. The institution uses a relational database management system (RDBMS) to store the following tables:

```
Customers (CustomerID, Name, Address, DateOfBirth, Email)
Accounts (AccountID, CustomerID, Balance, AccountType)
Transactions (TransactionID, AccountID, Date, Amount,
              TransactionType)
```

The organisation wants to track the following:

1. Changes to customer data (e.g., updates to the `Customers` table).
2. Changes to account balances (e.g., deposits, withdrawals in the `Accounts` table).
3. All transactions (including deposits, withdrawals, transfers) that occur in the system.
4. User access to sensitive data and any modifications made by privileged users.

Please answer the following questions:

i. Describe the types of events that should be captured in the audit logs for the system based on the scenario.

**(8 marks)**

ii. Identify a security consideration in setting up an auditing mechanism for the scenario.

**(2 marks)**

iii. Identify and discuss **one** potential challenge in implementing an effective auditing system for the given scenario.

**(2 marks)**

**[Turn Over]**

**B6.**

a) An online ticket service is used by several customers simultaneously to purchase tickets for events. A customer adds a ticket to their basket and continues to browse; a few minutes later they return to the basket and try to checkout. Checkout then fails with the reason that the ticket is no longer available.

Appropriate database locking mechanisms can help prevent such behaviour.

i. Explain the concepts of row and table level locking highlighting **two** disadvantages of each method.

**(6 marks)**

ii. Which mechanism is most appropriate in the above scenario and why?

**(3 marks)**

b) Briefly explain the following three types of database failure and explain a suitable recovery option for each:

i. Transaction failure
ii. System crash
iii. Permanent media failure **(9 marks)**

c) Consider the following transaction schedule and answer the questions below:

| **T1** | **T2** |
|---|---|
| BEGIN | |
| READ(A) | |
| A= A + 50 | |
| | BEGIN |
| | READ(A) |
| | A= A + 200 |
| | WRITE(A) |
| | READ(B) |
| | B = 3 ∗B |
| | WRITE(B) |
| | COMMIT |
| WRITE(A) | |
| READ(B) | |
| B = 10 ∗B | |
| WRITE(B) | |
| COMMIT | |

i. Briefly explain the fundamental aim of two phase locking (2PL).

**(3 marks)**

ii. Considering the schedule above with the assumption that the initial value of A = 50 and B = 2 determine the final values of A and B for the following two cases:

1. No locking protocol is used
2. 2PL is used

Briefly justify your answer. **(4 marks)**

**END OF EXAMINATION**