

Indian Statistical Institute
End-Semester Examination: PGDBA 2025
Fundamentals of Database Systems

Part I

Duration: 1 Hour 30 Minutes Maximum Marks: 50

Date: 15 December 2025

1. Consider two vectors $\mathbf{u}$ and $\mathbf{v}$ of the same dimension n , stored as tables $U(\text{index}, \text{value})$ and $V(\text{index}, \text{value})$ with the same schema. A row (i, u_i) of U specifies that the i -th row of $\mathbf{u}$ has value u_i (similarly for V and $\mathbf{v}$, respectively). Only the non-zero entries of the vectors are stored in the corresponding tables.

- (a) Write a relational algebra expression or an SQL query to output the sum of the two vectors, given by $\mathbf{u} + \mathbf{v}$.
- (b) Write a relational algebra expression or an SQL query to output the dot product of the two vectors, given by $\mathbf{u}^T \mathbf{v}$.

(5 + 5 = 10 marks)

2. Suppose an asymmetric social network similar to Twitter (that is, users follow other users, but mutual following is not essential) stores its data in the following simplified database tables. Assume some attributes to be non-null whenever you find that to be a reasonable assumption.

- Table `users` to store the user profiles: `users(id VARCHAR(32), name VARCHAR(64), gender CHAR(1), date_of_birth DATE)`, `id` being the primary key.
- Table `interests` storing the topics users are interested in: `interests(id VARCHAR(32), topic VARCHAR(16))`, the two attributes together forming the primary key.
- Table `following` storing the following network: `following(src_id VARCHAR(32), dest_id VARCHAR(32))`, where every row $(src_id, dest_id)$ means the user with ID src_id follows the user with ID $dest_id$. The two attributes together form the primary key.

Write relational algebra expressions or SQL queries for each of the following.

- (a) Output the number of users who are following the user with id `iamsachin`.
- (b) Output the *name* of the user who has the most number of followers in the whole network. Assume there is no tie at the first place.
- (c) Output all the user ids and names of the users who are either followers or followers of followers of the user with id `iamsachin`.

(5 + 5 + 5 = 15 marks)

4. Explain the use of the `EXPLAIN` statement when using `SELECT` statements.

Answer in 100 words or less.

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(2 × 2.5 = 5 marks)

5. Evaluate the truth value (TRUE, FALSE, or UNKNOWN) of each of the following SQL expressions:

(a) `NOT (NULL <> 5)`

(b) `5 > ALL (3, NULL, 1)`

(c) `5 NOT IN (3, NULL, 9)`

(d) `NULL <> SOME (NULL, 4)`

(e) `(NULL = 5) AND (10 > NULL)`

(1 × 5 = 5 marks)

5. Consider two entities **Department**(**DeptID**) and **Employee**(**EID**) with the following constraints:

- Every department must have at least one employee.
- Every employee must belong to exactly one department.
- A department may have many employees.
- No additional attributes may be introduced during ER-to-relational schema (table) conversion, except foreign keys.

Answer the following:

- (a) State the cardinality of the relationship (one/many to one/many) between the entities.
- (b) How many relations are produced in the relational schema, and where does the foreign key appear? Justify why.

(2 + 3 = 5 marks)

6. Let $R(A, B, C)$ and $S(B, C, D)$ be two relations. Assume R has 100 tuples and S has 40 tuples. Attributes may contain duplicates (no distinctness is assumed), and no tuple contains NULL.

Answer the following:

- (a) What is the *maximum* number of tuples in $\pi_{A,D}(R \times S)$?
- (b) What is the *maximum* and *minimum* number of tuples in the result of the natural join $R \bowtie_{R.B=S.B} S$?
- (c) Under what condition(s) will $\pi_A(R) \bowtie \pi_A(S)$ be *identical* to $\pi_A(R \bowtie S)$?

(2 + (2 + 2) + 4 = 10 marks)