

1-5. Consider the relational schema  $S[ID, A, B, C, D, E, F]$  with the key  $\{ID\}$ . Answer questions 1-5 using the legal instance below:

| ID | A  | B  | C  | D  | E   | F  |
|----|----|----|--|----|-----|----|
| t1 | a1 | b2 | Și abia pleacă bătrânul... Ce mai freamăt, ce mai zbucium! | 0  | 1   | 0  |
| t2 | a1 | b2 | Codrul clocoti de zgomot și de arme și de bucium,          | 1  | 2   | 1  |
| t3 | a1 | b3 | Iar la poala lui cea verde mii de capete pletoase,         | 0  | 3   | 0  |
| t4 | a1 | b3 | Mii de coifuri lucitoare ies din umbra-ntunecoasă;         | 2  | 123 | -1 |
| t5 | a1 | b3 | Călăreții umplu câmpul și roiesc după un semn              | -1 | 4   | -1 |

1. When executed on the above instance S:

a. query `SELECT DISTINCT A, B FROM S` returns 2 tuples.

b. query `SELECT * FROM S WHERE B = 'b2' AND B = 'b3'` returns 0 tuples.

c. query `SELECT * FROM S WHERE B = 'b3' UNION SELECT * FROM S WHERE B = 'b3'` returns 1 tuple.

d. query `SELECT * FROM S WHERE D >= 0 EXCEPT SELECT * FROM S WHERE E <> 4` returns 0 tuples.

e. none of the above answers is correct.

2. Consider projections  $S1[ID, A, B, C, F]$  and  $S2[D, E, F]$ . The result of the natural join  $S1 \bowtie S2$  contains (column order is not important):

a. only the 5 tuples in S

b. 7 tuples, out of which 5 are the original tuples in S

c. no tuples

d. 9 tuples, out of which 5 are the original tuples in S

e. none of the above answers is correct.

3. How many records does the query below return?

```
SELECT B, C, COUNT(*)
FROM S
GROUP BY B, C
HAVING D <= 1
```

a. 5

b. 4

c. 3

d. 2

e. none of the above answers is correct.

match rows for F

original +  $t_1 + t_3$

$t_3 + t_1$

$t_4 + t_5$

$t_5 + t_4$

Last name, first name:  
Group:

1-12. Enter the answers for questions / problems 1-12 in the table below. Each multiple choice question has at least one correct answer.

| 1. D   | 2. B | 3. A | 4. C | 5. E | 6. D/E? | 7. e | 8. A |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |  |  |   |  |
|--|------|------|------|------|---------|------|------|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|--|--|--|---|--|
| 9. <table><tr><th>ID</th><th>M</th><th>N</th><th>P</th><th>Q</th><th>O</th></tr><tr><td>1</td><td>1</td><td>4</td><td>1</td><td>A</td><td>B</td></tr><tr><td>2</td><td>2</td><td>3</td><td>2</td><td>A</td><td>B</td></tr><tr><td>3</td><td>3</td><td>2</td><td>3</td><td>C</td><td>D</td></tr><tr><td>4</td><td>4</td><td>1</td><td>4</td><td>C</td><td>D</td></tr></table> |      | ID   | M    | N    | P       | Q    | O    | 1 | 1 | 4 | 1 | A | B | 2 | 2 | 3 | 2 | A | B | 3 | 3 | 2 | 3 | C | D | 4 | 4 | 1 | 4 | C | D | 10. $\{M, N, P\} \rightarrow \{M\}$ $\{Q, O\} \rightarrow \{Q\}$ $\{10\} \rightarrow \{10\}$ $\{10\} \rightarrow \{M\}$ |  | 11. $\pi_{5,A,50,T,E}(\sigma_{6,A>10}(6 * T))$ |  | 12. $\alpha \rightarrow p \quad p \rightarrow \delta$ $\rightarrow \alpha \rightarrow \delta$ |  |
| ID   | M    | N    | P    | Q    | O       |      |      |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |  |  |   |  |
| 1  | 1    | 4    | 1    | A    | B       |      |      |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |  |  |   |  |
| 2  | 2    | 3    | 2    | A    | B       |      |      |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |  |  |   |  |
| 3  | 3    | 2    | 3    | C    | D       |      |      |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |  |  |   |  |
| 4  | 4    | 1    | 4    | C    | D       |      |      |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |  |  |   |  |

1-6. Consider the relational schema  $T(\underline{ID}, A, B, C, D, E)$  in SQL Server, with primary key  $\{ID\}$ , and the CHECK constraint  $CHECK(A+B=100)$ . T doesn't have any other constraints apart from domain ones. Answer questions 1-6 using the legal instance below.

| ID | A  | B  | C                           | D  | E  |
|----|----|----|-----------------------------|----|----|
| 1  | 1  | 99 | A-nceput de ieri să cadă    | d1 | e1 |
| 2  | 50 | 50 | Câte-un fulg, acum a stat,  | d1 | e2 |
| 3  | 50 | 50 | Norii s-au mai răzbunat     | d1 | e2 |
| 4  | 40 | 60 | Spre apus, dar stau grămadă | d2 | e1 |
| 5  | 20 | 80 | Peste sat.                  | d2 | e1 |

1. When executed on the above instance T:

☒ query `SELECT * FROM T WHERE C IS NULL` returns 5 tuples.

☒ query `SELECT * FROM T WHERE B < 50` returns 2 tuples.

☒ query `SELECT * FROM T t1 LEFT OUTER JOIN T t2 ON t1.D = t2.E WHERE t1.ID IS NULL OR t2.ID IS NULL` returns 1 tuple.

☒ query `SELECT * FROM T t1 WHERE (t1.D NOT IN (SELECT t2.E FROM T t2))` returns 5 tuples.

e. none of the above answers is correct.

2. What's the effect of executing the statement:

`ALTER TABLE T  
ADD UNIQUE(C)`

☒ an error is generated: a UNIQUE constraint cannot be added on C because T already has a primary key.

☒ the UNIQUE constraint is successfully added to the table.

☒ an error is generated: a UNIQUE constraint cannot be added on C because C doesn't have a DEFAULT constraint.

☒ an error is generated: a UNIQUE constraint cannot be added on C because T has a CHECK constraint using columns A and B.  
e. none of the above answers is correct.

3. How many tuples does the following query return:  
`SELECT t1.*  
FROM T t1 LEFT JOIN T t2 ON t1.D = t2.E  
WHERE (t1.ID BETWEEN 1 AND 10 AND t1.A = 50  
AND (t1.C = 'Norii s-au mai răzbunat' OR  
t1.C = 'Câte-un fulg, acum a stat,')`

- ☒ a. 2  
b. 3  
c. 4  
d. 5

e. none of the above answers is correct.

4. How many rows will have a value of 50 in column B after the execution of the statement below?

`UPDATE T  
SET B = 50`

- a. 5  
b. 3

☒ c. 2 → since there will be a constraint failure

- d. 0

e. none of the above answers is correct.

5. How many records does the query below return?

`SELECT t1.A, t1.B, MAX(t1.B) MaxB  
FROM T t1  
GROUP BY t1.A, t1.B  
HAVING COUNT(*) > (SELECT MIN(t2.ID)  
FROM T t2  
WHERE t2.A < 50)`

- a. 1  
b. 2  
c. 3  
d. 4

☒ e. none of the above answers is correct.



6. How many records does the query below return?

SELECT r2.ID, SUM(r1.B) SumB

FROM

(SELECT t1.\*

FROM T t1 INNER JOIN T t2 ON t1.C = t2.C) r1

RIGHT JOIN

(SELECT t2.\*

FROM T t1 RIGHT JOIN T t2 ON t1.ID = t2.ID) r2

ON r1.ID < r2.ID

WHERE r1.ID NOT BETWEEN 2 AND 4

GROUP BY r2.ID

a. 1

b. 2

c. 3

d. 4

e. none of the above answers is correct.

7. A SELECT query:

~~a.~~ can contain a HAVING clause only if it contains a WHERE clause.

~~b.~~ can contain a WHERE clause only if it contains a HAVING clause.

~~c.~~ can contain a HAVING clause only if it contains an ORDER BY clause.

d. can contain a GROUP BY clause only if it contains a HAVING clause.

e. none of the above answers is correct.

13. A research team of linguists is conducting a study on a group of subjects to determine the impact spoken language has on cognition. The team is using a relational database. A **subject** has a name, date of birth, educational level, occupation, and native language. A **language** has a name and type; the **type** has 2 values, *right-branching* and *left-branching*, each accompanied by a description. As subjects are assessed on a battery of memory tasks, their **answers** are stored in the database. A **memory task** has a description and includes multiple stimuli. A stimulus is a picture of an animal or object (e.g., a cat, a lamp) and can be part of several memory tasks. For a stimulus, the database retains the file path to the actual picture file and one keyword describing the animal / object in the picture (e.g., cat, lamp); the keyword is unique across all stimuli (e.g., there is at most one picture of a cat). A stimulus has a precise position in a memory task, e.g., memory task T1 includes stimuli S7, S2, and S4 on positions 1, 2, and 3, respectively; when evaluated on task T1, a subject will first be shown S7, then S2, and finally S4. A subject can be assessed on several memory tasks, but only once on a given memory task. Of course, multiple subjects can be evaluated on a given memory task. A subject is evaluated on a memory task on a specific date; the subject is shown all the stimuli in the task on a screen in the order specified by their positions; every stimulus is visible for 3 seconds. Upon seeing all the stimuli, the subject is asked to provide the following answer: he/she must recall all the stimuli in the order in which they were presented, by specifying the keyword corresponding to every stimulus. E.g., the subject is shown the following stimuli in a memory task: position 1 – picture of a cat, position 2 – picture of a lamp, position 3 – picture of a dog; the subject provides the following (incorrect) answer: position 1 – lamp, position 2 – cat, position 3 – dog.

Draw a database diagram (tables with primary key, foreign key and unique constraints) for the above data. The schema must be BCNF.

14. Let A, B, C, D be 4 relations with schemas A[ID, A1, A2, A3], B[B1, B2], C[C1, C2], D[ID, D1], and E an expression in the relational algebra:

$E = (\sigma_{ID=B1 \text{ AND } A2='exam'} \text{ AND } B2='DB' (A \times B)) * (\sigma_{C1=3} (C \times D))$

Optimize E and draw the evaluation tree for the optimized version of the expression.

8. Let R[ID1, ID2, ID3, A, B, C, D, E, F, G] be a relational schema with no repeating attributes. {ID1, ID2, ID3} and {A, B} are the only candidate keys. The following dependencies hold: {ID1, ID2} → {C} and {A} → {G}. R is:

a. 1NF → no repeating attributes

b. 2NF not fully func. dep

c. 3NF

d. BCNF

e. none of the above answers is correct.

9-10. Consider the relational schema T[ID, M, N, P, Q, O], with primary key {ID}.

9. Give an example of a T instance that has at least 4 tuples and satisfies the functional dependency {M, N, P} → {Q, O}.

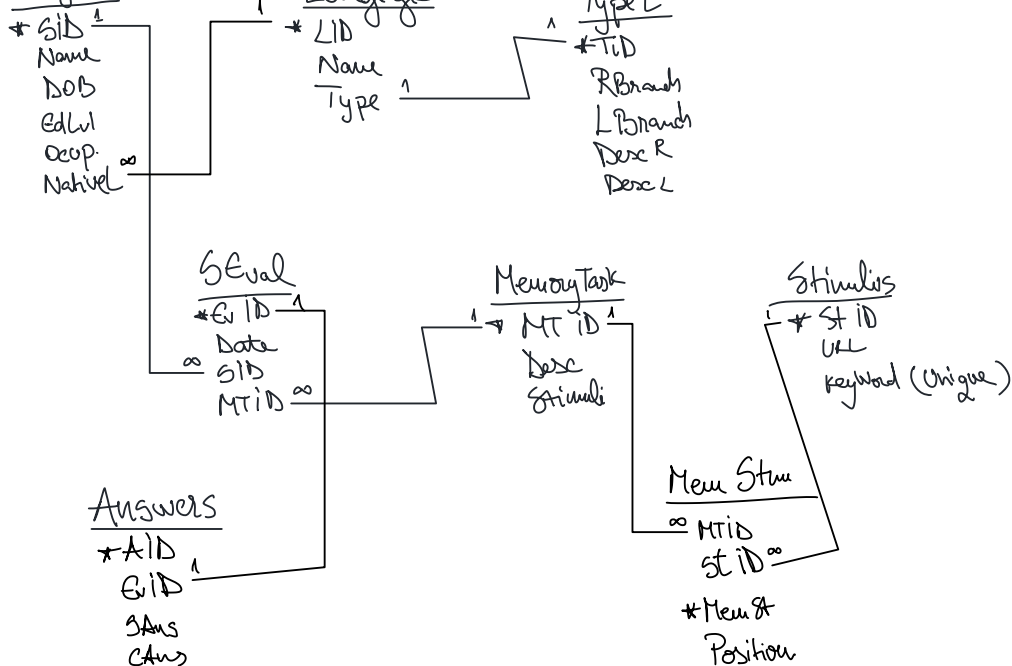
10. Write 3 trivial functional dependencies on T.

11. Write the SQL query below as a relational algebra expression.

SELECT S.A, S.B, T.C  
FROM S NATURAL JOIN T  
WHERE S.A > 10

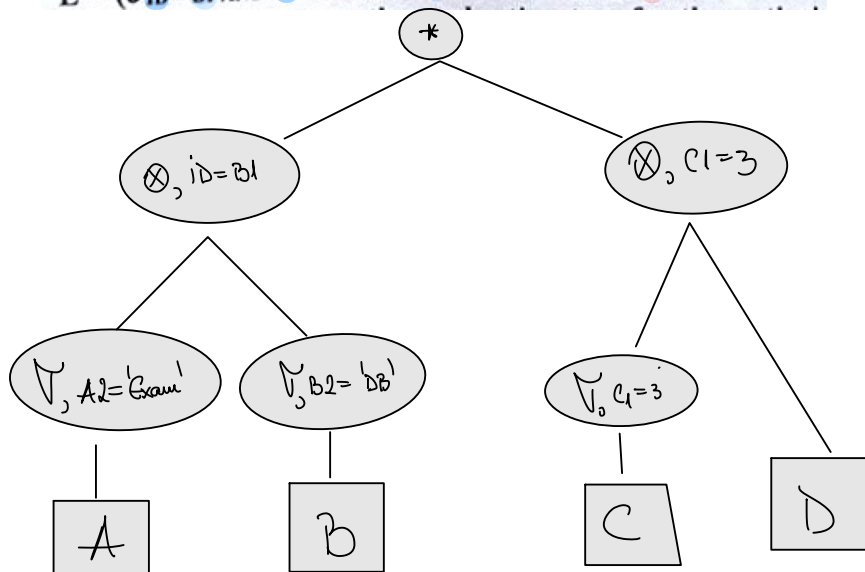
12. State the pseudotransitivity rule for functional dependencies in terms of sets of attributes  $\alpha, \beta, \gamma, \delta$ .

Subject



14.

$$E = (\sigma_{ID=B1} \text{ AND } A2='exam' \text{ AND } B2='DB' (A \times B))^* (\sigma_{CI=3} (C \times D))$$



1-12. Enter the answers for questions / problems 1-12 in the table below. Each multiple choice question has at least one correct answer.

| 1. C  | 2. BD | 3. B  | 4. A | 5. C | 6. B | 7. ABD | 8. E |    |    |   |    |    |   |    |    |   |    |    |   |    |    |  |     |     |     |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |     |
|---|-------|---|------|------|------|--------|------|----|----|---|----|----|---|----|----|---|----|----|---|----|----|--|-----|-----|-----|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|-----|
| 9. <del>TE</del> TE, MaxB<br>d1 e2 99<br>d2 e1 99 | 10.   | <table border="1"><thead><tr><th>ID</th><th>A</th><th>B</th></tr></thead><tbody><tr><td>1</td><td>99</td><td>99</td></tr><tr><td>2</td><td>50</td><td>50</td></tr><tr><td>3</td><td>50</td><td>50</td></tr><tr><td>4</td><td>60</td><td>60</td></tr><tr><td>5</td><td>80</td><td>80</td></tr></tbody></table> |      | ID   | A    | B      | 1    | 99 | 99 | 2 | 50 | 50 | 3 | 50 | 50 | 4 | 60 | 60 | 5 | 80 | 80 | 11. <table border="1"><thead><tr><th>ID1</th><th>ID2</th><th>ID3</th><th>A</th><th>B</th><th>C</th><th>D</th></tr></thead><tbody><tr><td>1</td><td>2</td><td>3</td><td>1</td><td>1</td><td>2</td><td>2</td></tr><tr><td>2</td><td>3</td><td>4</td><td>1</td><td>1</td><td>2</td><td>3</td></tr><tr><td>3</td><td>4</td><td>5</td><td>1</td><td>1</td><td>3</td><td>3</td></tr></tbody></table> | ID1 | ID2 | ID3 | A | B | C | D | 1 | 2 | 3 | 1 | 1 | 2 | 2 | 2 | 3 | 4 | 1 | 1 | 2 | 3 | 3 | 4 | 5 | 1 | 1 | 3 | 3 | 12. |
| ID  | A     | B   |      |      |      |        |      |    |    |   |    |    |   |    |    |   |    |    |   |    |    |  |     |     |     |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |     |
| 1   | 99    | 99  |      |      |      |        |      |    |    |   |    |    |   |    |    |   |    |    |   |    |    |  |     |     |     |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |     |
| 2   | 50    | 50  |      |      |      |        |      |    |    |   |    |    |   |    |    |   |    |    |   |    |    |  |     |     |     |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |     |
| 3   | 50    | 50  |      |      |      |        |      |    |    |   |    |    |   |    |    |   |    |    |   |    |    |  |     |     |     |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |     |
| 4   | 60    | 60  |      |      |      |        |      |    |    |   |    |    |   |    |    |   |    |    |   |    |    |  |     |     |     |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |     |
| 5   | 80    | 80  |      |      |      |        |      |    |    |   |    |    |   |    |    |   |    |    |   |    |    |  |     |     |     |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |     |
| ID1   | ID2   | ID3   | A    | B    | C    | D      |      |    |    |   |    |    |   |    |    |   |    |    |   |    |    |  |     |     |     |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |     |
| 1   | 2     | 3   | 1    | 1    | 2    | 2      |      |    |    |   |    |    |   |    |    |   |    |    |   |    |    |  |     |     |     |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |     |
| 2   | 3     | 4   | 1    | 1    | 2    | 3      |      |    |    |   |    |    |   |    |    |   |    |    |   |    |    |  |     |     |     |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |     |
| 3   | 4     | 5   | 1    | 1    | 3    | 3      |      |    |    |   |    |    |   |    |    |   |    |    |   |    |    |  |     |     |     |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |     |

1. Let Q be a query of the form: SELECT A FROM T.

To ensure the result of Q doesn't have any duplicates:

- a. CROSS JOIN must be added to Q's FROM clause.
- ☒ b. TOP must be added to Q's SELECT clause.
- ☒ c. DISTINCT must be added to Q's SELECT clause.
- ☒ d. the ORDER BY clause must be added to Q.
- e. none of the above answers is correct.

2. Let R be a relation. Which of the following sentences is / are true for R?

- a. If R is in 2NF, then it's also in 3NF.
- ☒ b. If R is in 3NF, then it's also in 2NF.
- ☒ c. If R is in 1NF, then it's also in 2NF.
- ☒ d. If R is in 2NF, then it's also in 1NF.
- e. none of the above answers is correct.

3. A primary index: *include the PK*

- ☒ a. can be clustered.
- ☒ b. can be unclustered.
- ☒ c. can have a composite search key.
- ☒ d. can contain duplicates.
- e. none of the above answers is correct.

4. The DBMS component that propagates in-memory changes to disk is:

- a. Transaction Manager.
- b. Recovery Manager.
- c. Storage Manager.
- d. Query Optimizer.
- e. none of the above answers is correct.

5-10. Consider the relational schema T[ID, A, B, C, D, E] in SQL Server, with primary key {ID}, the CHECK constraint CHECK(A+B=100), and a DEFAULT constraint on column C with default value 'TBW'. T doesn't have any other constraints apart from domain ones. Answer questions 5-10 using the legal instance below.

| ID | A  | B  | C                           | D  | E  |
|----|----|----|-----------------------------|----|----|
| 1  | 1  | 99 | A-nceput de ieri să cadă    | d1 | e1 |
| 2  | 50 | 50 | Câte-un fulg, acum a stat,  | d1 | e2 |
| 3  | 50 | 50 | Norii s-au mai răzbunat     | d1 | e2 |
| 4  | 40 | 60 | Spre apus, dar stau grămadă | d2 | e1 |
| 5  | 20 | 80 | Peste sat,                  | d2 | e1 |

5. What's the effect of executing the statement:

ALTER TABLE T  
ADD F VARCHAR(100)

- ☒ a. an error is generated: column F cannot be added to the table because T has a CHECK constraint using columns A and B.
- ☒ b. column F is added to the table, and in all existing rows F takes on the default value of column C.
- ☒ c. column F is added to the table, and in all existing rows F takes on the NULL value.
- ☒ d. an error is generated: column F cannot be added to the table because T has a DEFAULT constraint on C.
- e. none of the above answers is correct.

6. What's the effect of executing the statement:

UPDATE T  
SET B = 100 WHERE ID = 1

- ☒ a. the statement is successfully executed: B becomes 100 and there are no other changes in the modified row.
- ☒ b. an error is generated, the row is not changed.
- ☒ c. the statement is successfully executed: B becomes 100 and A becomes 0 in the modified row.
- ☒ d. the statement is successfully executed: B becomes 100 and A remains 1 in the modified row, and the CHECK constraint is eliminated from the schema of T.
- e. none of the above answers is correct.

7. When executed on the above instance T:

- ☒ a. query SELECT \* FROM T WHERE C IS NOT NULL returns 5 tuples.
- ☒ b. query SELECT \* FROM T WHERE B = 50



returns 2 tuples.

✓ query  $\text{SELECT COUNT(*)} \rightarrow \text{over?}$

FROM T1 FULL OUTER JOIN T2

ON T1.D = T2.E

WHERE (T1.ID IS NULL OR T2.ID IS NULL

returns 1 tuple.

① query  $\text{SELECT * FROM T1 WHERE (T1.D IN (SELECT T2.E FROM T2))}$

returns 0 tuples.

e. none of the above answers is correct.

8. How many tuples does the following query return:

$\text{SELECT t1.*}$

FROM T1 INNER JOIN T2 ON T1.A = T2.B

WHERE (T1.ID BETWEEN 1 AND 10 AND T1.A <= 50)  $\rightarrow \text{all}$

AND (T1.C = 'A-nceput de ieri să cadă' AND

T1.C = 'Câte-un fulg, acum a stat,')

a. 2

b. 3

c. 4

d. 5

$\Rightarrow 0$  returned

None?

① none of the above answers is correct.

9. What's the result set returned by the following query?  
Write the tuples' values and the names of the columns.

| D              | E              | MaxB |
|----------------|----------------|------|
| d <sub>1</sub> | e <sub>2</sub> | 50   |
| d <sub>2</sub> | e <sub>1</sub> | 80   |

The MemeTracker website is powered by a relational database. A meme is uploaded on the site by a user logged an account and it has a name, description, path to the file on the server that contains an image, animation, etc. associated with the meme, origin, and status. The status has 4 possible values: sent, currently under research, /med, or rejected, each accompanied by a status description. The origin of a meme could be a movie, a TV show, an me post, etc.; regardless of its nature, the database retains its name and description (examples: <Reddit, Discussion website where ...>, <D'ale lu' Mitica, TV Show that ...>, etc.). A user account has a name, affiliation date, and location. For each meme, the database retains its associated hashtags, each hashtag having a name and a description. Instances of meme usage on the Internet are also recorded: the date when the meme was used, the communication channel where the meme was posted (e.g., Snapchat, Instagram – can be a character string), the author (e.g., anonymous, a particular Instagram account, etc. – can be a character string), and the number of positive reactions (e.g.: likes, up-votes, etc. – if applicable, otherwise, the column has the NULL value).

13. Draw a database diagram (tables with primary key, foreign key and unique constraints) for the above data. The schema must be BCNF.

14. Write one SQL query for the following task: For each account having uploaded more confirmed memes than rejected ones, find the total number of uploaded memes. The result must have the schema (AccountName, TotalNoMemes). Don't use views.

$\text{SELECT t1.D, t1.E, MAX(t1.B) MaxB}$   
FROM T1  
GROUP BY (t1.D, t1.E  
HAVING COUNT(\*) > (SELECT MIN(t2.ID)  
FROM T2  
WHERE (t2.A + t2.B = 100))

10. What's the result set returned by the following query? Write the tuples' values and the names of the columns.

$\text{SELECT r1.ID, SUM(r1.B) SumB}$   
FROM

(SELECT t1.\*

FROM T1 INNER JOIN T2 ON t1.ID = t2.ID) r1

RIGHT JOIN

(SELECT t2.\*

FROM T1 LEFT JOIN T2 ON t1.ID = t2.ID) r2

ON r1.ID = r2.ID  $\rightarrow R$

WHERE r1.ID BETWEEN 2 AND 4

GROUP BY r1.ID

11-12. Consider the relational schema R(ID1, ID2, ID3, A, B, C, D), with primary key {ID1, ID2, ID3}.

11. Give an example of an R instance that has at least 3 tuples and doesn't satisfy the functional dependency {A, B}  $\rightarrow$  {C, D}.

12. Write an SQL statement that checks whether an instance of R satisfies the primary key constraint.

1-12: 0.5p/question

13: 1.5p

14: 1.5p

1p of