

NATIONAL UNIVERSITY OF SINGAPORE

SCHOOL OF COMPUTING

**Final examination for
Semester 2 AY2010/2011**

CS2102 – DATABASE SYSTEMS

April 2011

Time Allowed: 2 Hours

INSTRUCTIONS TO CANDIDATES

1. This examination paper contains **THREE (3)** exercises and comprises **NINE (9)** printed pages.
2. Answer **ALL** questions.
3. Answer **ALL** questions on the OCR form or within the space provided **ONLY**, as indicated.
4. **Unnecessary** comments will be penalised.
5. This is a **Closed Book** examination.
6. Please write your **Matriculation Number Below**.

MATRICULATION NO:

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This portion is for examiner's use only

EXERCISE	MARKS	REMARK
E I (44)		OCR
E II (28)		
E III (18)		
Total (90)		

This is a series of multiple choice questions (questions 1 to 22) and short essay questions (questions 23 to 40).

For each **multiple choice question** choose the best answer and report the corresponding choice onto the **OCR form**. Each multiple choice question is worth 2 marks. No mark is deducted for wrong answers.

For each **short essay question** give your answer in the reserved space in the script. Points are deducted for unnecessary comments and wrong answers.

Exercise 1. (44 marks) Multiple choice questions. Answer on the OCR form.

Question 1. Which of the following constraints can be violated by the insertion of a t-uple into a table? The constraint and the insertion are not necessarily on the same table.

- a) Primary key constraint
- b) Foreign key constraint
- c) Unique constraint
- d) Not null constraint
- e) All of the above constraints can be violated by insertion

Question 2. Which of the following constraints can be violated by the deletion of a t-uple from a table? The constraint and the deletion are not necessarily on the same table. (Assume that there is no ON DELETE statement)

- a) Primary key constraint
- b) Foreign key constraint
- c) Unique constraint
- d) Not null constraint
- e) None of the above constraints can be violated by deletion

Question 3. Which of the following constraints declared with a relation A can be violated by the insertion of a t-uple into A? Namely, the constraint and the insertion are on the same table.

- a) Primary key constraint
- b) Foreign key constraint
- c) Unique constraint
- d) Not null constraint
- e) All of the above constraints can be violated by insertion

Question 4 Which of the following constraints declared with a relation A can be violated by the deletion of a t-uple from A? Namely, the constraint and the deletion are on the same table. (Assume that there is no ON DELETE statement)

- a) Primary key constraint
- b) Foreign key constraint
- c) Unique constraint
- d) Not null constraint
- e) None of the above constraints can be violated by deletion

For the next 7 questions (questions 5 to 11) let us consider the following relation R(a, b) and its instance as follows:

a	b
1	2
2	3
1	3
3	1
1	1

Question 5. Consider the following query. Which of the following t-uples belongs to the result?

$\{ \langle X \rangle \mid R(X, X) \}$

- a) $\langle 1 \rangle$
- b) $\langle 2 \rangle$
- c) $\langle 3 \rangle$
- d) All of the above t-uples belong to the result
- e) None of the above t-uples belongs to the result

Question 6. Consider the following query. Which of the following t-uples belongs to the result?

$$\{ \langle X \rangle \mid \exists Y (R(X, Y)) \}$$

- a) $\langle 1 \rangle$
- b) $\langle 2 \rangle$
- c) $\langle 3 \rangle$
- d) All of the above t-uples belong to the result
- e) None of the above t-uples belongs to the result

Question 7. Consider the following query. Which of the following t-uples belongs to the result?

$$\{ \langle X, Y \rangle \mid (R(X, Y) \wedge R(Y, X)) \}$$

- a) $\langle 3, 3 \rangle$
- b) $\langle 1, 3 \rangle$
- c) $\langle 2, 2 \rangle$
- d) $\langle 2, 3 \rangle$
- e) $\langle 2, 1 \rangle$

Question 8. Consider the following query. Which of the following t-uples belongs to the result?

$$\{ \langle X, Y \rangle \mid (R(X, Y) \wedge \neg(R(Y, X))) \}$$

- a) $\langle 2, 3 \rangle$
- b) $\langle 1, 3 \rangle$
- c) $\langle 1, 1 \rangle$
- d) All of the above t-uples belong to the result
- e) None of the above t-uples belongs to the result

Question 9. Consider the following query. Which of the following t-uples does not belongs to the result?

$$\{ \langle X, Y \rangle \mid \exists Z (R(X, Z) \wedge R(Z, Y)) \}$$

- a) $\langle 2, 3 \rangle$
- b) $\langle 1, 3 \rangle$
- c) $\langle 3, 3 \rangle$
- d) $\langle 1, 1 \rangle$
- e) $\langle 2, 1 \rangle$

Question 10. Consider the following query. Which of the following t-uples belongs to the result?

$$\{ \langle X \rangle \mid \exists Y \forall Z \forall T (R(X, Y) \wedge (R(T, Z) \Rightarrow R(X, Z))) \}$$

- a) $\langle 1 \rangle$
- b) $\langle 2 \rangle$
- c) $\langle 3 \rangle$
- d) All of the above t-uples belong to the result
- e) None of the above t-uples belongs to the result

Question 11. Consider the following query. Which of the following t-uples belongs to the result?

$$\{ \langle X \rangle \mid \exists Y \forall Z \forall T (R(X, Y) \wedge (R(T, Z) \Rightarrow (R(X, Z) \vee R(Z, X)))) \}$$

- a) $\langle 1 \rangle$
- b) $\langle 2 \rangle$
- c) $\langle 3 \rangle$
- d) All of the above t-uples belong to the result
- e) None of the above t-uples belongs to the result

For the next 11 questions (questions 12 to 22) consider the relation $R = \{A, B, C, D, E\}$ with the set of functional dependencies $F = \{\{A\} \rightarrow \{B\}, \{B\} \rightarrow \{C\}, \{C\} \rightarrow \{D\}, \{D\} \rightarrow \{A\}\}$

Question 12. Which of the following functional dependencies is a trivial functional dependency in F^+ ?

- a) $\{B\} \rightarrow \{A\}$
- b) $\{B\} \rightarrow \{B, C\}$
- c) $\{A, E\} \rightarrow \{E\}$
- d) All of the above
- e) None of the above

Question 13. Which of the following functional dependencies is a functional dependency in F^+ ?

- a) $\{B\} \rightarrow \{A\}$
- b) $\{B\} \rightarrow \{B, C\}$
- c) $\{A, E\} \rightarrow \{E\}$
- d) All of the above
- e) None of the above

Question 14. Which of the following functional dependencies is a non trivial functional dependency in F^+ ?

- a) $\{E\} \rightarrow \{A\}$
- b) $\{B\} \rightarrow \{B, C\}$
- c) $\{A, E\} \rightarrow \{E\}$
- d) All of the above
- e) None of the above

Question 15. Which of the following functional dependencies is a completely non trivial functional dependency in F^+ ?

- a) $\{E\} \rightarrow \{A\}$
- b) $\{B\} \rightarrow \{B, C\}$
- c) $\{A, E\} \rightarrow \{E\}$
- d) All of the above
- e) None of the above

Question 16. Which of the following is a superkey of R with F ?

- a) $\{A, E\}$
- b) $\{A, B, E\}$
- c) $\{B, C, D, E\}$
- d) All of the above
- e) None of the above

Question 17. Which of the following is a candidate key of R with F ?

- a) $\{A, E\}$
- b) $\{A\}$
- c) $\{B, C\}$
- d) All of the above
- e) None of the above

Question 18. Which of the following is a possible primary key of R with F ?

- a) $\{A, E\}$
- b) $\{A\}$
- c) $\{B, C\}$
- d) All of the above
- e) None of the above

Question 19. Which of the following sets of functional dependencies is a minimal cover of F?

- a) $\{\{A\} \rightarrow \{B\}, \{B\} \rightarrow \{C\}, \{C\} \rightarrow \{D\}, \{D\} \rightarrow \{A\}\}$
- b) $\{\{B\} \rightarrow \{A\}, \{A\} \rightarrow \{D\}, \{D\} \rightarrow \{C\}, \{C\} \rightarrow \{B\}\}$
- c) $\{\{A\} \rightarrow \{C\}, \{C\} \rightarrow \{D\}, \{B\} \rightarrow \{A\}, \{D\} \rightarrow \{B\}\}$
- d) All of the above
- e) None of the above

Question 20. Which of the following sets of functional dependencies is an extended minimal cover of F?

- a) $\{\{A, B, C, D\} \rightarrow \{A, B, C, D\}\}$
- b) $\{\{A\} \rightarrow \{B, C, D\}, \{B\} \rightarrow \{A, C, D\}, \{C\} \rightarrow \{A, B, D\}, \{D\} \rightarrow \{A, B, C\}\}$
- c) $\{\{A\} \rightarrow \{B, C, D, E\}, \{B\} \rightarrow \{A, C, D, E\}, \{C\} \rightarrow \{A, B, D, E\}, \{D\} \rightarrow \{A, C, D, E\}\}$
- d) All of the above
- e) None of the above

Question 21. Which of the following statements is true?

- a) $\{A\} \rightarrow \{D\}$ is in F+ and violates the 2NF conditions
- b) $\{A\} \rightarrow \{D\}$ is in F+ and violates the 3NF conditions
- c) $\{A\} \rightarrow \{D\}$ is in F+ and violates the BCNF conditions.
- d) All of the above
- e) None of the above

Question 22. Which of the following statements is true about R with F?

- a) It is not in 1NF
- b) It is not in 2NF
- c) It is in 2NF but not in 3NF
- d) It is in 3NF but not in BCNF
- e) It is BCNF

Exercise II. (28 marks) The following 9 questions are structured essay questions. Give your answer in the space provided in the script. Points are deducted for unnecessary comments and wrong answers.

Consider the following self-explanatory database schema. Attributes of primary keys are underlined. The natural foreign keys (same or similar attribute names) should be assumed. NULL values are forbidden everywhere. Use the knowledge of primary keys and foreign keys to simplify SQL queries. Only eliminate duplicates when necessary. Always use t-uple variables. Prefer simple queries to aggregate and nested queries unless impossible or otherwise indicated.

message(IMO, utc, longitude, latitude)
ship(IMO, name, class, owner, country)

For instance The name of the ship identified by the International Maritime Organization seven digit number '9321483' is 'Emma Mærsk'. It is an E-class ship ('E') owned by 'A. P. Moller-Maersk Group' flying Danish flag. On 2011-01-24 at 04:36, it was located at longitude 100.0969 (North, indicated by a positive number) and latitude 5.235232 (East, indicated by a positive number).

message('9321483', '2011-01-24 04:36', 100.0969, 5.235232)
ship('9321483', 'Emma Mærsk', 'E', 'A. P. Moller-Maersk Group', 'Denmark')

Answer the following queries in the language indicated.

Question 23. (3 marks) (SQL) Find the different ships that reported on 31st January 2011 at 1am. Print the IMO number of the ships.

Question 24. (3 marks) (Algebra) Find the different ships that reported on 31st January 2011 at 1am. Print the IMO number of the ships.

Question 25. (3 marks) (TRC) Find the different ships that reported a position between latitude 12.71, longitude 53.20 and latitude 13.26, longitude 53.90 on 31st January 2011 between 1am and 2am. Print the IMO number and the name of the ships.

Question 26. (3 marks) (Algebra) Find the different pairs of different ships that reported the same position at the same time. Print the pairs of IMO number and the name of the ships.

Question 27. (3 marks) (SQL) Find the ships that have never reported a position below latitude -50 (50 degree South). Print the ship's IMO. Do not use aggregate functions. Do not use aggregates or nested queries.

Question 28. (3 marks) (SQL) Find the different ships that have reported the south-most position. Print the ship's IMO. Use aggregate functions.

Question 29. (3 marks) (TRC) Find the different ships that have reported the south-most position. Print the ship's IMO.

Question 30. (3 marks) (Algebra) Find the different ships that have reported the south-most position. Print the ship's IMO.

Question 31. (4 marks) Explain why the following query does not always find the ships that have never reported a position below latitude -50 (50 degree South). Your answer should be as precise and concise as possible

```
SELECT s.IMO, s.name
FROM ship s, message m
WHERE s.IMO = m.IMO
GROUP BY s.IMO, s.name
HAVING MIN(m.latitude) >= -50
```


Exercise III. (18 marks) The following 9 questions are structured essay questions. Give your answer in the space provided in the script. Points are deducted for unnecessary comments and wrong answers.

Consider the relational scheme $R = \{A, B, C\}$.

Question 32. (2 marks) Find a set of functional dependencies F_1 with which R is in BCNF.

Question 33. (2 marks) Give a minimal cover F_1' of F_1 .

Question 34. (2 marks) Give the candidate keys of R with F_1 .

Question 35. (2 marks) Find a set of functional dependencies F_2 with which R is not in BCNF but is in 3NF.

Question 36. (2 marks) Give a minimal cover F_2' of F_2 .

Question 37. (2 marks) Give the candidate keys of R with F_2 .

Question 38. (2 marks) Find a set of functional dependencies F_3 with which R is in neither in BCNF nor in 3NF.

Question 39. (2 marks) Give a minimal cover F_3' of F_3 .

Question 40. (2 marks) Give the candidate keys of R with F_3 .

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