

NATIONAL UNIVERSITY OF SINGAPORE

CS2102 – DATABASE SYSTEMS

(Semester 1 AY2015/2016)

Time Allowed: 2 Hours**INSTRUCTIONS TO CANDIDATES**

1. Please write your Student Number only. Do not write your name.
2. This assessment paper contains **THREE (3)** exercises and comprises **EIGHT (8)** printed pages.
3. Students are required to answer **ALL** questions
4. Students should write the answers on the OCR form or within the space provided, as indicated.
5. This is a **Closed Book** assessment.
6. One double sided page (A4 size) of hand-written notes is permitted.
7. Electronic calculators are permitted.

STUDENT NO:

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This portion is for examiner's use only

EXERCISE	MARKS	REMARK
E I (20)		OCR
E II (24)		
E III (16)		
Total (60)		

This is a series of multiple choice questions (questions 1 to 10) and short essay questions (questions 11 to 19).

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

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

Exercise 1. (20 marks) Consider the following self-describing schema with the underlined primary key and the corresponding foreign keys. No other constraint can be assumed.

```

person(pid, pname)
workfor(pid, cid)           % This is a composite (compound) key
company(cid, cname)

```

Question 1. (2 marks) Which of the following queries finds the names of persons?

- a) $\{ \langle X \rangle \mid \forall Y (\text{person}(Y, X)) \}$.
- b) $\{ \langle X \rangle \mid \forall Y (\text{person}(X, Y)) \}$.
- c) $\{ \langle X \rangle \mid \exists Y (\text{person}(X, Y)) \}$.
- d) $\{ \langle X \rangle \mid \exists Y (\text{person}(Y, X)) \}$.
- e) None of the above.

Question 2. (2 marks) Which of the following queries finds the names of unemployed persons?

- a) $\{ \langle X \rangle \mid \exists Y \forall Z (\text{person}(Y, X) \wedge \neg \text{workfor}(Y, Z)) \}$.
- b) $\{ \langle X \rangle \mid \exists Y \forall Z \neg (\text{workfor}(Y, Z) \vee \neg \text{person}(Y, X)) \}$.
- c) $\{ \langle X \rangle \mid \exists Y \forall Z \neg (\text{person}(Y, X) \Rightarrow \text{workfor}(Y, Z)) \}$.
- d) All of the above.
- e) None of the above.

Question 3. (2 marks) Which of the following queries finds the names of companies employing all persons?

- a) $\{ \langle Y \rangle \mid \exists X \forall Z \forall T (\text{company}(X, Y) \wedge \text{person}(Z, T) \wedge \text{workfor}(Z, X)) \}$.
- b) $\{ \langle Y \rangle \mid \exists X \forall Z \forall T (\text{company}(X, Y) \wedge (\text{person}(Z, T) \Rightarrow \text{workfor}(Z, X))) \}$.
- c) $\{ \langle Y \rangle \mid \exists X \exists Z \exists T (\text{company}(X, Y) \wedge \text{person}(Z, T) \wedge \text{workfor}(Z, X)) \}$.
- d) All of the above.
- e) None of the above.

Question 4. (2 marks) Which of the following queries is unsafe?

- a) $\{ \langle X \rangle \mid \exists Y \forall Z (\neg \text{workfor}(Y, Z) \wedge \text{person}(Y, X)) \}$.
- b) $\{ \langle X \rangle \mid \exists Y \forall Z \neg (\text{workfor}(Y, Z) \vee \neg \text{person}(Y, X)) \}$.
- c) $\{ \langle X \rangle \mid \exists Y \forall Z \neg (\text{person}(Y, X) \Rightarrow \text{workfor}(Y, Z)) \}$.
- d) All of the above.
- e) None of the above.

Let us consider the relation $R(A, B, C, D, E)$ with the following set F of functional dependencies.

$$F = \{\{A, B\} \rightarrow \{C, D\}, \{C\} \rightarrow \{D\}, \{D\} \rightarrow \{A\}, \{C, D\} \rightarrow \{A, C\}, \{B, C\} \rightarrow \{A, B\}, \{A, B, D\} \rightarrow \{C\}\}$$

It is advised that you study and normalize R with F before answering the questions.

Question 5. (2 marks) Which of the following functional dependencies is **not** in F^+ ?

- a) $\{A, C\} \rightarrow \{D\}$
- b) $\{A, B, E\} \rightarrow \{B, D\}$
- c) $\{A, E\} \rightarrow \{D\}$
- d) All of the above (none of them is in F^+).
- e) None of the above (they are all in F^+).

Question 6. (2 marks) Which of the following is a completely non trivial functional dependency in F^+ ?

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

Question 7. (2 marks) Which of the following is a candidate key of R with F ?

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

Question 8. (2 marks) Which of the following is a super-key of R with F ?

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

Question 9. (2 marks) Which of the following is an extended minimal cover of F ?

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

Question 10. (2 marks) Which of the following is a dependency preserving BCNF lossless decomposition of R with F ?

- a) $R_1=\{A, B, C\}, R_2=\{C, D\}, R_3=\{A, B, E\}$.
- b) $R_1=\{A, B, C\}, R_2=\{C, D\}, R_3=\{A, D\}$.
- c) $R_1=\{A, B, C\}, R_2=\{C, D\}, R_3=\{A, D\}, R_4=\{B, D, E\}$.
- d) All of the above.
- e) None of the above.

Exercise II. (24 marks) Consider the following self-describing schema with underlined primary keys and the corresponding foreign keys.

```
person(pid, pname, pcity)
workfor(pid, cid)
company(cid, cname, ccity)
```

A person lives in `pcity`. A company is located in `ccity`. A person can work for several companies. A person working for a company is an employee. `(pid, cid)` is a composite (compound) key of `workfor`.

Consider primary and foreign key constraints to simplify your answers.

Question 11. (4 marks) (SQL) Find the identifiers of the persons living in Singapore.

Question 12. (4 marks) (SQL) Find, for each small and medium enterprise (SME) in Singapore, its identifier and the total number of its employees who are living in Singapore. A SME is a company with less than 250 employees worldwide.

For the next two questions (13 and 14), the English query is the same.

Question 13. (4 marks) (Algebra) Find the names of the persons working for a company located in Singapore.

Question 14. (4 marks) (TRC) Find the names of the persons working for a company located in Singapore.

Question 15. (8 marks) (TRC) Find the identifiers of the companies located in a city in which all their employees live.

Exercise III. (16 marks) Let us consider the relation R with five attributes: $\{A, B, C, D, E\}$ with the set of functional dependencies $F = \{\{A, B\} \rightarrow \{D, E\}, \{A, B\} \rightarrow \{B\}, \{D, E\} \rightarrow \{B\}, \{A, B, C\} \rightarrow \{C, D\}, \{C, D, E\} \rightarrow \{B\}\}$.

Question 16. (4 marks) Use the Armstrong's Axiom to prove that $\{A, C, D, E\}$ is a super-key of R with F . State the axioms used in each step.

Question 17 (2 marks) Find the candidate key(s) of R with F . Give the answers only.

Question 18 (4 marks) Is R with F in BCNF? Justify your answer.

Question 19 (6 marks) Find the minimal cover with F . Give the answer only.

Synthesize a 3NF decomposition of R with F . Indicate the functional dependencies on each fragment. Give the answer only. Justify that every fragment is in 3NF.

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