NATIONAL UNIVERSITY OF SINGAPORE

CS2102 – DATABASE SYSTEMS

(Semester 2 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 **TEN (10)** 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: | | | | | | | | | | |

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 **18**).

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 I. (20 marks) Consider the following self-describing schema with the underlined **primary keys** and the **corresponding foreign keys** for the following questions (questions **1** to **4**).

```
warehouse(wid, address, city)
stock(wid, pid, qty)                    % This is a composite key
product(pid, name, category )

The following column constraint holds.

CHECK(qty>0);

An empty warehouse is a warehouse with no corresponding stock record.
```

Question 1. (2 marks) Which of the following queries finds the addresses of warehouses in London?

a) {<X> | ∀Y (warehouse(Y, X, 'London'))}.
b) {<X> | ∀Y ∀Z (warehouse(Y, X, Z) ∧ Z = 'London')}.
c) {<X> | ∃X ∃Y (warehouse(Y, X, 'London'))}.
d) {<X> | ∃Y (warehouse(Y, X, 'London'))}.
e) None of the above.

Question 2. (2 marks) Which of the following queries finds the identifiers of the empty warehouses?

a) {<X> | ∃Y ∃Z ∀U ∀V ∀W ∃T (warehouse(X, Y, Z) ∧ (product(U, V, W) ⇒ ¬ stock(X, U, T)))}.
b) {<X> | ∃Y ∃Z ∀U ∀T (warehouse(X, Y, Z) ∧ ¬ stock(X, U, T))}.
c) {<X> | ∃Y ∃Z ∀U ∀T ¬ (¬ warehouse(X, Y, Z) ∨ stock(X, U, T))}.
d) All of the above.
e) None of the above.

Question 3. (2 marks) Which of the following queries finds the identifiers of the empty warehouses?

a) {<X> | ∃Y ∃Z ∀U ∀V ∀W ∃T (warehouse(X, Y, Z) ∧ product(U, V, W) ∧ ¬ stock(X, U, T))}.
b) {<X> | ∃Y ∃Z ∀U ∀T (warehouse(X, Y, Z) ∨ ¬ stock(X, U, T))}.
c) {<X> | ∃Y ∃Z ∀U ∀T ¬ (warehouse(X, Y, Z) ⇒ stock(X, U, T))}.
d) All of the above.
e) None of the above.

Question 4. (2 marks) Which of the following queries always returns an empty result?

a) {<X1, X2> | ∃Y1 ∃Z1 ∃Y2 ∃Z2 (warehouse(X1, Y1, Z1) ∧ warehouse(X1, Y2, Z2) ∧ Y1<>Y2)}.
b) {<X1, X2> | ∃Y1 ∃Z1 ∃Y2 ∃Z2 (warehouse(X1, Y1, Z1) ∧ warehouse(X1, Y2, Z2) ∧ Z1=Z2)}.
c) {<X1, X2> | ∃Y1 ∃Z1 ∃Y2 ∃Z2 (warehouse(X1, Y1, Z1) ∧ warehouse(X1, Y2, Z2) ∧ (Y1=Y2 ∨ Z1=Z2))}.
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.

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

It is advised that you study and normalize R with F before answering the following questions (questions **5** to **10**).

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) $\{E\} \rightarrow \{D\}$.
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 functional dependencies is trivial?

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

Question 7. (2 marks) Which of the following functional dependencies is completely non-trivial and in F+?

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

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

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

Question 9. (2 marks) Which of the following is a candidate key of R with F?

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

Question 10. (2 marks) Which of the following sets of functional dependencies is a minimal cover of F?

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

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

```
warehouse(wid, address, city)
stock(wid, pid, qty)                % This is a composite key
product(pid, name, category )

The following column constraint holds.

CHECK(qty>0);

An empty warehouse is a warehouse with no corresponding stock record.
```

Translate the following queries. Use your knowledge of integrity constraints to simplify the queries.
Do not use SQL JOIN and its variants, if possible and unless otherwise indicated.
Do not use nested queries in the SELECT and FROM clause, if possible and unless otherwise indicated.
Prefer simpler queries to aggregates, to nested queries, to algebraic queries and other complicated answers, if possible and unless otherwise indicated.

Question 11. (4 marks) (SQL) Find the different cities in which there are **two or more** different warehouses. Use aggregates.

Question 12. (4 marks) (Algebra) Find the cities in which there are **two or more** different warehouses. Do not use join. Feel encouraged drawing the query as a tree.

```
warehouse(wid, address, city)
stock(wid, pid, qty)                    % This is a composite key
product(pid, name, category )
```

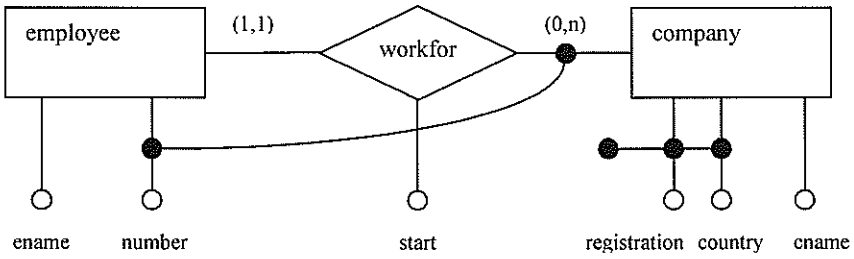
Question 13. (4 marks) (SQL) Find the identifier of the warehouses having in stock the largest individual quantity of the product with identifier 'X213'. 'individual quantity' here refers to the quantity of the product in one warehouse(attribute `qty`). Do not use aggregates. The product must be in stock.

Question 14. (6 marks) (TRC) Find the names of the products (products listed in the table `product`) that are currently **not** in stock in any warehouse in London.

```
warehouse(wid, address, city)
stock(wid, pid, qty)                % This is a composite key
product(pid, name, category )
```

Question 15. (6 marks) (SQL) Find the cities in which there are warehouses and all products of the category 'monitor' are in stock in individual quantity of 100 or more in some of the warehouses in the city. 'individual quantity' here refers to the quantity of one product in one warehouse (attribute `qty`). Different products can be in the same or in different warehouses. The same product can be in more than one warehouse.
Do not use <>. Do not use aggregate functions and GROUP BY.

Exercise III. (16 marks) Consider the following entity-relationship diagram.



Question 16. (6 marks) Write the corresponding SQL DDL code (use the original entity and attribute names). Choose appropriate domains.

For convenience, let us rename the following attributes: ename, number, start, registration, country and cname into A, B, C, D, E and F, respectively.

Instead of the translation discussed in question 15, we decide to represent the entity-relationship diagram above in one single table:

R(A, B, C, D, E, F). % i.e. *R(ename, number, start, registration, country, cname)*

Question 17. (4 marks) Find a **minimal cover** Σ of the set of functional dependencies that hold on this table according to the entity-relationship diagram above. Use A, B, C, D, E and F.

Question 18. (6 marks)

What are the candidate keys of R with Σ? Use A, B, C, D, E and F.

Is R with Σ in Boyce-Codd Normal Form?
Tick the appropriate answer: ☐ R is in BCNF. ☐ R is not in BCNF.
Explain. Use A, B, C, D, E and F.

-- END OF PAPER ---