NATIONAL UNIVERSITY OF SINGAPORE

SCHOOL OF COMPUTING
Examination for
Semester 2 AY2013/2014

CS2102 – DATABASE SYSTEMS

April 2014 **Time Allowed: 2 Hours**

INSTRUCTIONS TO CANDIDATES

1. This assessment paper contains **THREE (3)** exercises and comprises **NINE (9)** printed pages.
2. Students are required to answer **ALL** questions on the OCR form or within the space provided, as indicated.
3. This is a **Closed Book** examination.
4. Students are allowed to bring one double sided page (A4 size) of hand-written notes.
5. Students are allowed to bring a bilingual dictionary.
6. Students are allowed to bring an electronic calculator.
7. **Please write your Matriculation Number Below.**

MATRICULATION 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.** 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 may be deducted for unnecessary comments and wrong answers.

Exercise I. (20 marks) Multiple choice questions. Answer on the OCR form.

Consider the following database schema for a social network application.

user(id, name)
friend(id1, id2)

The table 'user' records the identifiers, 'id', and names, 'name', of users.
The table 'friend' records that the user with id 'id1' has user with id 'id2' as a friend.

'id' is the primary key of the table 'user'
'{id1, id2}' is the primary key of the table 'friend'
'id1' in the table 'friend' references the table 'user'
'id2' in the table 'friend' references the table 'user'
There are no other constraints.
Note that friendship is not necessarily symmetric, reflexive or transitive.

Question 1. (2 marks) Which of the following queries finds the names of users who have no friend?

a) {<X> | ∃X1 ∀Y1 ∀Y (user(X1, X) ∧ (user(Y1, Y) ⇒ ¬friend(X1, Y1)))}.
b) {<X> | ∃X1 ∀Y ∀Y1 (user(X1, X) ∧ (friend(X1, Y1) ⇒ ¬user(Y1, Y)))}.
c) {<X> | ∃X1 ∀Y1 ∀Y (user(X1, X) ∧ (¬user(Y1, Y) ∨ ¬friend(X1, Y1)))}.
d) All of the above.
e) None of the above.

Question 2. (2 marks) Which of the following queries finds the names of users who have no friend?

a) {<X> | ∃X1 ∀Y1 ∀Y (user(X1, X) ∧ ¬(user(Y1, Y) ∧ friend(X1, Y1)))}.
b) {<X> | ∃X1 ∀Y1 ¬(user(X1, X) ⇒ friend(X1, Y1))}.
c) {<X> | ∃X1 ∀Y1 (user(X1, X) ∧ ¬friend(X1, Y1))}.
d) All of the above.
e) None of the above.

Question 3. (2 marks) Which of the following statements is correct about the following query?

{<X> | ∃X1 ∀Y1 (user(X1, X) ⇒ ¬friend(X1, Y1))}

a) It finds the names of users who have no friend.
b) It finds the identifier of users who have no friend.
c) It is unsafe.
d) It is syntactically incorrect.
e) None of the above.

Question 4. (2 marks) Which of the following statements is correct about the following query?

{<X> | ∃X1 ∀Y1 ∀Y (user(X1, X) ∧ (user(Y1,Y) ⇒ friend(X1,Y1)))}

a) It finds the names of users who have every user as friend.
b) It finds the identifier of users who are friends to everyone.
c) It is unsafe.
d) It is syntactically incorrect.
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 = {{C, D} → {B}, {C} → {D}, {A, D} → {C}, {B, A} → {D, C}, {B, A, C} → {D, 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 dependency is not in F+?

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

Question 10. (2 marks) Which of the following is a 3NF lossless decomposition of R with F?

a) R1={C, B, D}, R2={A, C, D}, R3={A, B, C}, R4={E, A, C}.
b) R1={C, B, D}, R2={A, C, D}, R3={A, B, C}, R4={E, A, D}.
c) R1={C, B, D}, R2={A, C, D}, R3={A, B, C}, R4={E, A, B}.
d) All of the above.
e) None of the above.

Exercise II. (24 marks) Give your answer **in the space provided in the script.** Points may be deducted for unnecessary comments, unnecessary long or complicated answers and wrong answers.

Consider the following self-describing database schema for the management of breakfast at Nang-Si-Da Resort.

customer(name, passport, nationality, age)
menu(type, item, price)
breakfast(passport, date, item)

Primary keys are underlined.
'passport' in the table 'breakfast' references the primary key of the table customer.
'item' in the table 'breakfast' references the primary key of the table 'item'.

The following constraints are enforced. Customers are identified by their passport number. Note that two different customers may have the same name. Menu items are identified by their name (attribute 'item'). The combination of attributes: 'date', 'item' and 'passport', is unique in the breakfast table and none of their values is null. The natural referential integrity applies.

For example, Ms. Sinsamut, a 35 years old Thai national, with passport L123X, ordered fried rice and coffee on 31/12/2013. The next day, she ordered coffee. Fried rice is a food item, which costs 120 Baht. Coffee is a drink item, which costs 50 Baht. There is another customer called Sinsamut. This other customer is a 60 years old American national, with passport U0001.

The following is the corresponding excerpt of the database instance:

customer('Sinsamut', 'L123X', 'Thai', 35)
customer('Sinsamut', 'U0001', 'American', 60)
menu('food', 'Fried Rice', 120)
menu('drink' 'Coffee', 50)
breakfast('L123X', '31/12/2013', 'Fried Rice')
breakfast('L123X', '31/12/2013', 'Coffee')
breakfast('L123X', '01/01/2014', 'Coffee')

Consider primary and foreign key constraints to simplify your answers.

Question 11. (4 marks) (SQL) Find the different nationalities of customers called Sinsamut.

Question 12. (4 marks) (TRC) Find the different passport numbers of customers who ordered fried rice for breakfast.

Reminder:

customer(name, passport, nationality, age)
menu(type, item, price)
breakfast(passport, date, item)

Question 13. (4 marks) Explain, in English, why the following SQL query may not correctly find the average age of the customers who ordered fried rice for breakfast.

```
SELECT AVG(c.age)
FROM customer c, breakfast b
WHERE c.passport=b.passport AND b.item='Fried Rice';
```

Question 14. (4 marks) (SQL) Find the average age of the customers who ordered fried rice for breakfast.

Reminder:

customer(name, passport, nationality, age)
menu(type, item, price)
breakfast(passport, date, item)

Question 15. (4 marks) (SQL) Find the names of different customers who only ordered coffee or toasts (**or both or none**) for breakfast but nothing else.

Question 16. (4 marks) (TRC) Find the cheapest food item on the menu (the type of the item is food).

Exercise III. (16 marks) Give your answer **in the space provided in the script.** Points may be deducted for unnecessary comments and wrong answers.

Let us consider the relation R with three attributes A, B and C: R = {A, B, C} with the set of functional dependencies F = {{A} -> {C}}.

Question 17. (6 marks) Decompose R with F into BCNF (using the algorithm given in the lecture, if needed). Is the decomposition dependency preserving? Explain and justify the steps and the conclusion.

Question 18. (10 marks) Let us consider the relation R with three attributes A, B and C: **R = {A, B, C}**.

Find **two different sets F1 and F2** (different from the example set, F, below) of functional dependencies such that, in R with F1 and in R with F2, respectively, **A and B are prime attributes and C is not a prime attribute**.

The sets F1 and F2 (and F) should be minimal, not equivalent, and not equivalent under renaming of attributes (e.g. renaming of A as B and of B as A).

Find a set F1, give the candidate keys of R with F1 and indicate whether R with F1 is in 2NF, 3NF and BCNF.
Find a set F2, give the candidate keys of R with F2 and indicate whether R with F2 is in 2NF, 3NF and BCNF.

For example, for R with F,

F = *{{A} -> {C}}*

(notice that F = {{B} -> {C}} is equivalent under the renaming of A as B)

The candidate keys of R with F are:

{A, B} (There is only one candidate key)

Therefore A and B are prime attributes and C is not.

R with F is in 2NF?	**YES**		**NO**	✓
R with F is in 3NF?	**YES**		**NO**	✓
R with F is in BCNF?	**YES**		**NO**	✓

Find a set **F1** such that **A and B are prime attributes and C is not a prime attribute of R**.

F1 =

The candidate keys of R with F1 are:

R with F1 is in 2NF? **YES** ☐ **NO** ☐

R with F1 is in 3NF? **YES** ☐ **NO** ☐

R with F1 is in BCNF? **YES** ☐ **NO** ☐

Find a set **F2** such that **A and B are prime attributes and C is not a prime attribute of R**.

F2 =

The candidate keys of R with F2 are:

R with F2 is in 2NF? **YES** ☐ **NO** ☐

R with F2 is in 3NF? **YES** ☐ **NO** ☐

R with F2 is in BCNF? **YES** ☐ **NO** ☐

-- END OF PAPER ---