NATIONAL UNIVERSITY OF SINGAPORE

SCHOOL OF COMPUTING
Final examination for
Semester 2 AY2011/2012

CS2102 – DATABASE SYSTEMS

April 2012 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: | | | | | | | | | | |

This portion is for examiner's use only

EXERCISE	MARKS	REMARK
E I (48)		OCR
E II (32)		
E III (20)		
Total (100)		

This is a series of multiple choice questions (questions **1** to **16**) and short essay questions (questions **17** to **29**).

For each **multiple choice question** choose the best answer and report the corresponding choice onto the **OCR form.** Each multiple choice question is worth 3 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. (48 marks) Multiple choice questions. Answer on the OCR form.

Consider the following database instance. The table SECURITY records the codes of stocks, bonds and other securities together with the name of the issuing company. ***For instance, the company "UOB" issues the stock "U11".*** The table PRICE records historical prices of securities. ***For instance, the stock "C09" was sold at SGD 9.480 on the 20th of January 2012 at 1:22pm ("20-01-2012 1:22 PM").***

SECURITY	
Name	**Code**
JSH	J37
UOB	U11
UOB	GL8
HKLand	H78
CITYDEV	C09
KepLand	K17
DBS	D05

PRICE		
Code	**Timestamp**	**Price**
J37	20-01-2012 1:22 PM	31.120
U11	20-01-2012 1:22 PM	17.060
U11	20-01-2012 1:02 PM	17.055
H78	20-01-2012 1:22 PM	5.170
C09	20-01-2012 1:22 PM	9.480
H78	20-01-2012 1:02 PM	5.185
K17	20-01-2012 1:12 PM	2.715
K17	20-01-2012 1:22 PM	2.720

Question 1. Which key constraint should there be in the corresponding schema?

a) The attribute Price is a primary key for the table PRICE
b) The attribute Code is a primary key for the table PRICE
c) The attributes Code and Timestamp form a primary key for the table PRICE
d) The attributes Code and Price form a primary key for the table PRICE
e) None of the above

Question 2. Consider the natural referential integrity in the corresponding schema. There is no cascading of updates and deletions. Which of the following operations should be rejected?

a) Delete the entry from the PRICE table for J37 on 20-01-2012 1:22 PM
b) Insert an entry for S51 in the PRICE table on 20-01-2012 1:22 PM with price 5.155
c) Insert an entry for Sembcorp Marine, S51 in the SECURITY table
d) Delete the entry for DBS, D05 from the SECURITY table
e) None of the above

Question 3. What is the cardinality of the result of the following query?

SELECT T1.Name FROM SECURITY T1, PRICE T2 WHERE T1.Code = T2.Code

a) 0
b) 6
c) 7
d) 8
e) None of the above

Question 4. What is the result of the following query?

$\{<Y1> \mid \exists X1\ \forall Y2\ \forall Z2\ (SECURITY(X1, Y1) \wedge (PRICE(Y2, \text{'20-01-2012 1:12 PM'}, Z2) \Rightarrow Y1 = Y2))\}$

a) $\varnothing$
b) {<K17>}
c) {<D05>}
d) {<K17>, <D05>}
e) {<J37>, <U11>, <H78>, <C09>,<K17>},

Question 5. What is the result of the following query?

{<Y1> | ∃X1 ∀Y2 ∀Z2 (SECURITY(X1, Y1) ∧ (PRICE(Y2, '20-01-2012 1:22 PM, Z2) ⇒ Y1 = Y2))}

a) ∅
b) {<K17>}
c) {<D05>}
d) {<J37>, <U11>, <H78>, <C09>}
e) {<J37>, <U11>, <H78>, <C09>,<K17>}

Question 6. What is the result of the following query?

{<Y1> | ∃X1 ∀X2 ∀Y2 ∀Z2 (SECURITY(X1, Y1) ∧ ((PRICE(Y2, X2, Z2) ∧ Y1 = Y2) ⇒ Z2 < 5.175))}

a) ∅
b) {<K17>}
c) {<K17>, <D05>, <GL8>}
d) {<H78>, <K17>}
e) {<J37>, <U11>, <C09>}

Question 7. Which of the following queries is unsafe?

a) {<Y1> | ∃X1 ¬ (SECURITY(X1, Y1))}
b) {<X1> | ∃Y1 ∃Z1 (PRICE(X1, Y1, Z1))}
c) {<X1> | ¬ (∀Y1 ∀Z1 (¬(PRICE(X1, Y1, Z1))))}
d) All of the above (they are all unsafe)
e) None of the above (they are all safe)

Consider the following relation schema with the following set of functional dependencies.

R={A, B, C, D, E, G} F ={{A, C} -> {D, E}, {A, D, G} -> {B, C}}.

Question 8. Which of the following is a functional dependency in F+?

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

Question 9. Which of the following is a trivial functional dependency in F+?

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

Question 10. Which of the following is a completely non trivial functional dependency in F+?

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

Question 11. Which of the following is a functional dependency in a minimal cover of F?

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

Reminder: R={A, B, C, D, E, G} F ={{A, C} -> {D, E}, {A, D, G} -> {B, C}}.

Question 12. Which of the following is a functional dependency in a minimal cover of F?

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

Question 13. Which of the following is a super key of R with F?

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

Question 14. Which of the following is a candidate key of R with F?

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

Question 15. Which of the following is a candidate key of R with F?

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

Question 16. How many candidate keys are there for R with F?

a) 0
b) 1
c) 2
d) 3
e) 4

Exercise II. (32 marks) The following 8 questions are structured essay questions. 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.

Your company, Apasaja Pte Ltd, has been commissioned by a group of airlines to design and implement their joined reservations system. Consider the following self-describing schema.

Two airlines **compete** if they serve the same route. A **route** is a direct flight between two airports.

```
CREATE TABLE airline (
name VARCHAR(64) UNIQUE,
designator VARCHAR(3) PRIMARY KEY,
telephone VARCHAR(16)
)

CREATE TABLE airport (
name VARCHAR(64),
country VARCHAR(64),
designator CHAR(3) PRIMARY KEY
)

CREATE TABLE flight (
airline VARCHAR(3) REFERENCE airline(designator),
number VARCHAR(6),
departure TIME,
arrival TIME,
origin CHAR(3) REFERENCE airport(designator),
destination CHAR(3) REFERENCE airport(designator),
PRIMARY KEY (airline, number)
)
```

Answer the following queries in the language indicated. Take primary keys and foreign keys into account to simplify queries.

Question 17. (4 marks) (TRC) Print the name and designator of all airports in Thailand.

Question 18. (4 marks) (SQL) Print the number of airports in Thailand.

Question 19. (4 marks) (Algebra) Print the designators of pairs of competing airlines. Remove the symmetry from the result. An airline does not compete with itself.

Question 20. (4 marks) (TRC) Print the designators of pairs of competing airlines. Remove the symmetry from the result. An airline does not compete with itself.

Question 21. (4 marks) (TRC) Print the names of the airlines that have flights to all listed airports in Thailand.

Question 22. (4 marks) (SQL) Print the designator of distinct airlines serving exactly the same set of routes. Remove the symmetry of the result.

Question 23. (4 marks) Why is the above query possibly returning pairs of airlines that do not compete although they deserve the same set of routes?

Question 24. (4 marks) (SQL) Print the designator of distinct airlines that do not compete on any route. A route is a one flight connection between two airports. Remove the symmetry of the result. Use the algebraic operator in SQL corresponding to intersection.

Exercise III. (20 marks) The following 5 questions are structured essay questions. Give your answer **in the space provided in the script.** Points may be deducted for unnecessary comments and wrong answers. If there is no possible answer, then indicate "IMPOSSIBLE".

Question 25. (4 marks) Find a smallest relation schema in BCNF and the smallest corresponding set of functional dependencies with exactly two candidate keys {A, B} and {C}.

Question 26. (4 marks) Find a smallest relation schema in 3NF and the smallest corresponding set of functional dependencies with exactly two candidate keys {A, B} and {C}.

Question 27. (4 marks) Find a smallest relation schema in 3NF but not in BCNF and the smallest corresponding set of functional dependencies with exactly two candidate keys {A, B} and {C}.

Question 28. (4 marks) Find a smallest relation schema in 3NF but not in BCNF and the smallest corresponding set of functional dependencies with at least two candidate keys {A, B} and {C}.

Question 29. (4 marks) Find a smallest relation schema in 2NF but not in 3NF and the smallest corresponding set of functional dependencies with at least two candidate keys {A, B} and {C}.

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