NATIONAL UNIVERSITY OF SINGAPORE

SCHOOL OF COMPUTING
Final examination for
Semester 2 AY2012/2013

CS2102 – DATABASE SYSTEMS

May/April 2013   **Time Allowed: 2 Hours**

INSTRUCTIONS TO CANDIDATES

1. This examination paper contains **FOUR (4)** exercises and comprises **ELEVEN (11)** 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	(30)		OCR
E II	(14)		
E III	(10)		
E IV	(6)		
Total	(60)		

This is a series of multiple choice questions (questions **1** to **15**) and short essay questions (questions **16** to **24**).

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. (30 marks) Multiple choice questions. Answer on the OCR form.

Consider the following two self-describing tables. Primary key attributes are underlined.

city		
name	**country**	**population**
Moscow	R	8,717,000
Karachi	PK	9,863,000
Mumbai	IND	9,925,891
Jakarta	RI	8,259,266
Seoul	ROK	10,229,262
Mexico City	MEX	9,815,795
Sao Paulo	BR	9,811,776
Islamabad	PK	204,364
New Delhi	IND	7,206,704
Brasilia	BR	1,817,001

country			
code	**name**	**capital**	**population**
R	Russia	Moscow	148,178,487
PK	Pakistan	Islamabad	129,275,660
IND	India	New Delhi	952,107,694
RI	Indonesia	Jakarta	206,611,600
ROK	South Korea	Seoul	45,482,291
MEX	Mexico	Mexico City	95,772,462
BR	Brazil	Brasilia	162,661,214

Question 1. What is the result of the following query?

$\{<Y1> \mid \exists X1 \, \exists Z1 \, \exists X2 \, \exists Z2 \; (city(X1, Y1, Z1) \land city(X2, Y1, Z2))\}$

a) $\varnothing$.
b) {<'PK'>, <'IND'>, <'BR'>}.
c) {<'R'>, <'PK'>, <'IND'>, <'RI'>, <'ROK'>, <'MEX'>, <'BR'>}.
d) The query is syntactically incorrect.
e) None of the above.

Question 2. What is the result of the following query?

$\{<X1> \mid \exists X1 \, \exists Y1 \, \exists Z1 \, \exists T1 \, \exists X2 \, \exists Y2 \, \exists Z2 \, \exists T2 \; (country(X1, Y1, Z1, T1) \land country(X2, Y2, Z2, T2))\}$

a) $\varnothing$.
b) {<'PK'>, <'IND'>, <'BR'>}.
c) {<'R'>, <'PK'>, <'IND'>, <'RI'>, <'ROK'>, <'MEX'>, <'BR'>}.
d) The query is syntactically incorrect.
e) None of the above.

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

$\{<Y1> \mid \exists X1 \, \exists Z1 \, \exists T1 \, \exists Y2 \, \exists Z2 \, \exists T2 \; (country(X1, Y1, Z1, T1) \land country(X1, Y2, Z2, T2))\}$

a) 0.
b) 7.
c) 49.
d) The query is syntactically incorrect.
e) None of the above.

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

$\{<X1, Y1> \mid \exists Z1 \; \exists T1 \; \exists Z2 \; \exists T2 \; (country(X1, Y1, Z1, T1) \land country(X1, Y1, Z2, T2) \land Z1 <> Z2)\}$

    a) $\emptyset$.
    b) $\{<'R', 'Russia'>\}$.
    c) $\{<'R', 'Russia'>, <'PK', 'Pakistan'>, <'IND', 'India'>, <'RI', 'Indonesia'>, <'ROK', 'South Korea'>, <'MEX', 'Mexico'>, <'BR', 'Brazil'>\}$.
    d) The query is syntactically incorrect.
    e) None of the above.

Question 5. Which of the following queries finds the most populated cities?

    a) $\{<X1> \mid \exists Y1 \; \exists Z1 \; (city(X1, Y1, Z1) \land (\forall X2 \; \forall Y2 \; \forall Z2 \; (city(X2, Y2, Z2) \Rightarrow Z1 > Z2)))\}$.
    b) $\{<X1> \mid \exists Y1 \; \exists Z1 \; (city(X1, Y1, Z1) \land (\forall X2 \; \forall Y2 \; \forall Z2 \; (city(X2, Y2, Z2) \Rightarrow Z1 \geq Z2)))\}$.
    c) $\{<X1> \mid \exists Y1 \; \exists Z1 \; (city(X1, Y1, Z1) \land (\forall X2 \; \forall Y2 \; \forall Z2 \; (city(X2, Y2, Z2) \Rightarrow Z1 < Z2)))\}$.
    d) All of the above.
    e) None of the above.

Question 6. Which of the following queries is unsafe?

    a) $\{<X1> \mid \exists Y1 \; \exists Z1 \; (city(X1, Y1, Z1) \land (\forall X2 \; \forall Y2 \; \forall Z2 \; (city(X2, Y2, Z2) \Rightarrow Z1 > Z2)))\}$.
    b) $\{<X1> \mid \exists Y1 \; \exists Z1 \; (city(X1, Y1, Z1) \land (\forall X2 \; \forall Y2 \; \forall Z2 \; (city(X2, Y2, Z2) \Rightarrow Z1 = Z2)))\}$.
    c) $\{<Z1> \mid \forall X2 \; \forall Y2 \; \forall Z2 \; (city(X2, Y2, Z2) \Rightarrow Z1 = Z2)\}$.
    d) All of the above.
    e) None of the above.

Question 7. Which of the following functional dependencies hold in the above schema according to the indicated integrity constraints?

    a) $\{\{city.name\} \rightarrow \{city.country\}\}$
    b) $\{\{city.name, city.population\} \rightarrow \{city.country\}\}$
    c) $\{\{city.name, city.country\} \rightarrow \{city.population\}\}$
    d) All of the above.
    e) None of the above.

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

R= {A, B, C, D, E, G, H}
F= {{A, B} → {C, D}, {C} → {E, G}, {H} → {A}, {H} → {G}, {C, E} → {G}}

Question 8. Which of the following is a functional dependency in F+?
a) {B, H} → {C, D, G}
b) {B, G, H} → {A, H, E}
c) {A, B, H} → {C, D, G}
d) All of the above
e) None of the above

Question 9. Which of the following is a non trivial but not completely non trivial functional dependency in F+?
a) {B, H} → {C, D}
b) {B, G, H} → {A, H, E}
· c) {A, B, H} → {B, H}
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) {B, H} → {C, D, G}
b) {B, G, H} → {A, H, E}
c) {A, B, H} → {G, B, H}
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) {B, H} → {C}
b) {B, G, H} → {D}
c) {A, G} → {E}
d) All of the above
e) None of the above

Question 12. Which of the following is a super key of R with F?
a) {A, B, E, H}
b) {A, D, E, H}
c) {C, E, G, H}
d) All of the above
e) None of the above

Question 13. Which of the following is a candidate key of R with F?
a) {A, B}
b) {A, G}
c) {B, H}
d) All of the above
e) None of the above

Question 14. In which of the following normal form is R with F?
a) 2NF
b) 3NF
c) BCNF
d) All of the above
e) None of the above

Question 15. Which of the following is a 3NF lossless dependency preserving decomposition of R with F?
a) R1= {A, B, C, D}, R2={B, C, G}, R3={G, A}, R4={H, B}.
b) R1= {A, B, C, D}, R2={C, E, G}, R3={H, A, G}, R4={H, B}.
c) R1= {A, B, C}, R2={C, E, G}, R3={H, A, G}, R4={H, B}.
d) All of the above
e) None of the above

Exercise II. (14 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, unnecessary long or complicated answers and wrong answers.

Consider the following self-describing database schema.

City(<u>name, country</u>, population)
Country(<u>code</u>, name, capital, population)

Question 16. (6 marks) Draw the corresponding Entity-relationship diagram. Indicate keys and cardinality constraints. Make sure the entities and relationships are genuine and the attributes intrinsic and do not merely mimic the relational schema.

Question 17. (2 marks) (TRC) Print the name, country name and population of capital cities.

Question 18. (2 marks) (TRC) There exist cities in different countries that have the same name. For instance, Paris is in Texas, USA, and Paris is the capital city of France. We assume, however, that every city in one country has a unique name in that country. Find the names of cities that have a unique name.

Question 19. (2 marks) (SQL) Find different codes of countries in which no city has strictly more than 2,000,000 inhabitants.

Question 20. (2 marks) (Algebra) Find the names and countries of cities that are not capital cities.

Exercise III. (10 marks) The following 3 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.

Question 21. (6 marks) We consider a relation scheme R={A, B, C, D} with a set of functional dependencies F. A lossless dependency-preserving decomposition of R with F into 3NF, obtained using the algorithm for 3NF synthesis given in the lecture, is as follows.

R1={A, B, C} R2={C, D}

F is not given. Our task is to discover what F could have been.

R with F **must not be in 3NF**.

Find **three** possible sets of functional dependencies F such that the above decomposition was obtained using the algorithm for **3NF synthesis** given in the lecture.

The two sets F **must be different and minimal**, and **must neither be equivalent nor equivalent under renaming** of the attributes.

Question 22. (4 marks) We consider a relation scheme R={A, B, C, D} with a set of functional dependencies F. A lossless dependency-preserving decomposition of R with F into BCNF, obtained using the algorithm for BCNF decomposition given in the lecture, is as follows.

R1={A, B, C} R2={C, D}

F is not given. Our task is to discover what F could have been.

Find **two** possible sets of functional dependencies F such that the above decomposition was obtained using the algorithm for **BCNF decomposition** given in the lecture.

R with F **must not be in BCNF**.

The two sets F they **must contain exactly three functional dependencies**.

The two sets F **must be different and minimal**, and **must neither be equivalent nor equivalent under renaming** of the attributes.

Exercise IV. (6 marks) The following questions are structured essay questions. Give your answer **in the space provided in the script.**

We consider a query on a database. The database consists of a finite set of tables each of which has a finite set of rows.

Question 23. (3 marks) If the query is written in relational Calculus, the result of the query can be **infinite**. Explain when and why this is the case.

Question 24. (3 marks) If the query is written in relational Algebra, the result is always finite. Explain why this is the case.

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