NATIONAL UNIVERSITY OF SINGAPORE

SCHOOL OF COMPUTING
Final examination for
Semester 1 AY2010/2011

CS2102 – DATABASE SYSTEMS

November 2010 Time Allowed: 2 Hours

INSTRUCTIONS TO CANDIDATES

1. This examination paper contains **THREE (3)** 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 (50)		OCR
E II (24)		
E III (26)		
Total (100)		

This is a series of multiple choice questions (questions **1** to **25**) and short essay questions (questions **26** to **39**).

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 are deducted for unnecessary comments and wrong answers.

Exercise I. (50 marks) Multiple choice questions. Answer on the OCR form.

For the next Fourteen (14) (questions **1** to **14**) let us consider the following two instances of relations R(A, B) and S(C, D, E), respectively.

R	
A	B
1	1
1	2
1	3
2	1
3	1

S		
C	D	E
1	2	3
1	3	2
2	1	3
2	3	1
3	2	1
3	1	2

Question 1. Which of the following t-uples are in the result of the following query?

$\{<X> \mid \exists Y \exists Z (R(X, Y) \wedge R(Y, Z))\}$

a) <1>
b) <2>
c) <3>
d) All of the above
e) None of the above

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

SELECT DISTINCT R1.A FROM R R1, R R2 WHERE R1.B = R2.A

a) 0
b) 1
c) 3
d) 11
e) 25

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

SELECT R1.A FROM R R1, R R2 WHERE R1.B = R2.A

a) 0
b) 1
c) 3
d) 11
e) 25

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

SELECT COUNT(DISTINCT R1.A) FROM R R1, R R2 WHERE R1.B = R2.A

a) {<0>}
b) {<1>}
c) {<3>}
d) {<11>}
e) {<25>}

R	
A	B
1	1
1	2
1	3
2	1
3	1

S		
C	D	E
1	2	3
1	3	2
2	1	3
2	3	1
3	2	1
3	1	2

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

SELECT COUNT(R1.A) FROM R R1, R R2 WHERE R1.B = R2.A

a) {<0>}
b) {<1>}
c) {<3>}
d) {<11>}
e) {<25>}

Question 6. Which of the following queries is equivalent to the SQL query?

SELECT DISTINCT R1.A FROM R R1, R R2 WHERE R1.B = R2.A

a) $\{<X> \mid \exists Y \exists Z (R(X, Y) \wedge R(Y, Z))\}$
b) $\{<X> \mid \exists Y \exists Z \exists T (R(X, Y) \wedge R(Z, T) \wedge Y = Z)\}$
c) $\{<U> \mid \exists X \exists Y \exists Z \exists T (R(X, Y) \wedge R(Z, T) \wedge Y = Z \wedge X = U)\}$
d) All of the above
e) None of the above

Question 7. Which of the following sets of t-uples is the result of the following query?

$\{<X> \mid \exists Y \forall Z \forall T (R(X, Y) \wedge (R(Z, T) \Rightarrow R(X, Z)))\}$

a) $\varnothing$
b) {<1>}
c) {<1>, <2>}
d) {<1>, <2>, <3>}
e) The query is unsafe

Question 8. Which of the following sets of t-uples is the result of the following query?

$\{<X> \mid \exists Y \forall Z \forall T \exists U (R(X, Y) \wedge (\neg R(Z, T) \vee S(X, Z, U)))\}$

a) $\varnothing$
b) {<1>}
c) {<1>, <2>}
d) {<1>, <2>, <3>}
e) The query is unsafe

Question 9. Which of the following sets of t-uples is the result of the following query?

$\{<X> \mid \forall T (\neg R(X, T) \vee R(X, X))\}$

a) $\varnothing$
b) {<1>}
c) {<1>, <2>}
d) {<1>, <2>, <3>}
e) The query is unsafe

R	
A	B
1	1
1	2
1	3
2	1
3	1

S		
C	D	E
1	2	3
1	3	2
2	1	3
2	3	1
3	2	1
3	1	2

Question 10. Which of the following sets of t-uples is the result of the following query? (⊗ is the join symbol)

$\pi_B((R / \pi_B(\rho(S, E \rightarrow B))) \otimes_{A=B} (\pi_B(R \times S)))$

a) ∅
b) {<1>}
c) {<1>, <2>}
d) {<1>, <3>}
e) {<1>, <2>, <3>}

Question 11. Which of the following is the result of the following query?

SELECT SUM(C) FROM R, S WHERE R.A = S.C AND (D = 1 OR E =1)

a) {<3>}
b) {<6>}
c) {<10>}
d) {<12>}
e) {<16>}

Question 12. Which of the following t-uples belongs to the result of the following query?

$\pi_{R1.A}(\sigma_{R1.B > 1}(\rho(R1, R))) - \pi_{R2.D}(\sigma_{R2.C > R2.E}(\rho(R2, S)))$

a) <1>
b) <2>
c) <3>
d) All of the above.
e) None of the above.

Question 13. Which of the following sets of t-uples is included in the result of the following query?

SELECT R.A, COUNT (DISTINCT S.C) FROM R, S WHERE R.B = S.E GROUP BY R.A

a) {<1, 2>, <2, 2>, <3, 2>}
b) {<1, 2>, <2, 2>, <3, 3>}
c) {<1, 2>, <2, 3>, <3, 3>}
d) {<1, 3>, <2, 2>, <3, 2>}
e) None of the above

Question 14. What is the result of the following query?

SELECT COUNT (DISTINCT S.C) FROM R, S GROUP BY R.A

a) {<1>}
b) {<2>}
c) {<3>}
d) {<3>, <3>, <3>}
e) None of the above.

For the next 11 questions (questions **15 to 25**) consider the relation R = {A, B, C, D} with the set of functional dependencies F= {{A} → {A, B, C}, {A, B} → {A}, {B, C} → {D, A}, {B} → {C}}

Question 15. Which of the following functional dependencies is a trivial functional dependency in F+?

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

Question 16. Which of the following functional dependencies is a functional dependency in F+?

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

Question 17. Which of the following functional dependencies is a non trivial functional dependency in F+?

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

Question 18. Which of the following functional dependencies is a completely non trivial functional dependency in F+?

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

Question 19. Which of the following is a superkey of R with F?

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

Question 20. Which of the following is a candidate key of R with F?

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

Question 21. Which of the following is a possible primary key of R with F?

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

Reminder : R = {A, B, C, D} with F= {{A} → {A, B, C}, {A, B} → {A}, {B, C} → {D, A}, {B} → {C}}

Question 22. Which of the following sets of functional dependencies is a minimal cover of F?

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

Question 23. Which of the following sets of functional dependencies is a minimal cover of F?

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

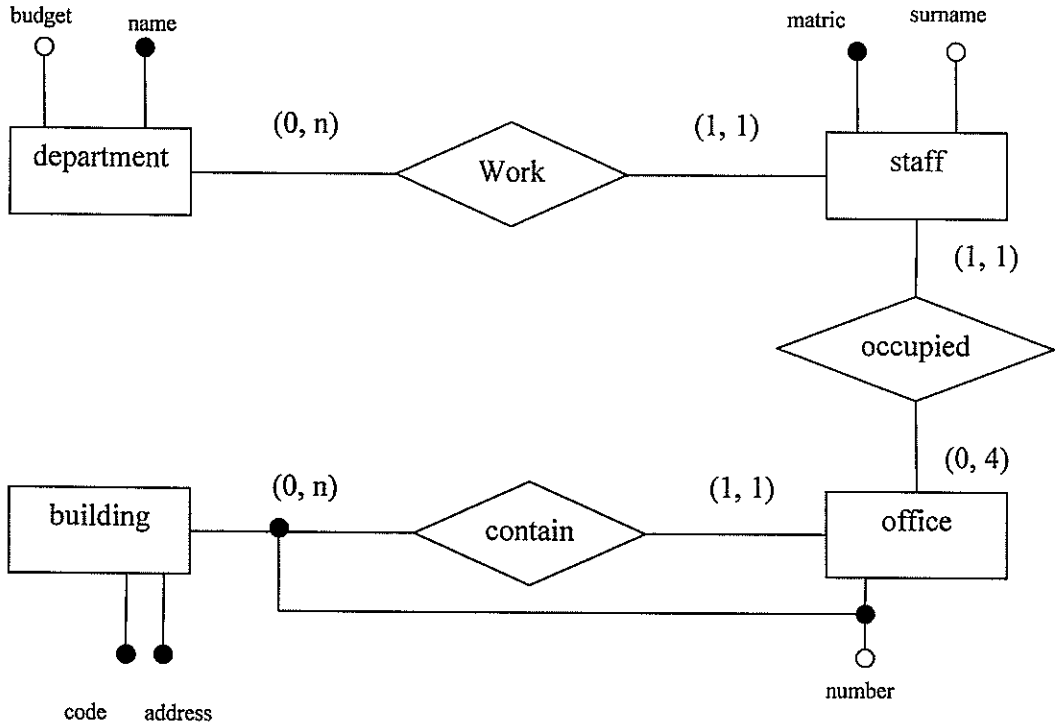
Question 24. The left hand side of the functional dependency {C, D} → {D} in F+ is not a superkey. Which of the following statements is true?

a) It violates the 2NF conditions
b) It violates the 3NF conditions
c) It violates the BCNF conditions.
d) All of the above
e) None of the above

Question 25. Which of the following statements is true about R with F?

a) It is not in 1NF
b) It is not in 2NF
c) It is in 2NF but not in 3NF
d) It is in 3NF but not in BCNF
e) It is BCNF

Exercise II. (24 marks) Given the following self-explanatory entity relationship diagram.



Consider the following corresponding database schema.

CREATE TABLE department(
name STRING PRIMARY KEY,
budget NUMERIC NOT NULL)

CREATE TABLE building(
code STRING PRIMARY KEY,
address STRING NOT NULL UNIQUE)

CREATE TABLE office(
number NUMERIC
code STRING,
PRIMARY KEY (number, code)
FOREIGN KEY code REFERENCES building(code),

CREATE TABLE staff(
matric STRING PRIMARY KEY,
surname STRING NOT NULL,
name STRING NOT NULL,
number NUMERIC NOT NULL,
code STRING NOT NULL,
FOREIGN KEY name REFERENCES department(name),
FOREIGN KEY (number, code) REFERENCES office(number, code))

Answer the following queries in the language indicated. Use constraints to simplify the queries. Only eliminate duplicates when required and necessary. Use t-uple variables in SQL statements. (Do not use outer and inner joins, nested queries in the select and from clause or other features not mentioned in the lecture and tutorials). Unnecessarily complex queries will be penalized.

Answer the following queries in the language indicated.

Question 26. (3 marks) (SQL) Create an assertion that checks that the maximum capacity of every office is four staffs, as required by the entity relationship diagram.

Question 27. (3 marks) (SQL) Find the surname and office (print the primary key) of employees in the 'information systems' department.

Question 28. (3 marks) (TRC) Find the surname and office (print the primary key) of employees in the 'information systems' department

Question 29. (3 marks) (TRC) Some different staffs may have the same surname. Find the surnames of such staffs.

Question 30. (3 marks) (TRC) Find the empty offices (print the primary keys).

Question 31. (3 marks) (Algebra) Find the empty offices (print the primary keys).

Question 32. (3 marks) (SQL) Find the empty offices (use EXCEPT) (print the primary keys).

Question 33. (3 marks) (SQL) Find the empty offices (do not use EXCEPT; do not use aggregate functions) (print the primary keys).

Exercise III. (26 marks) Consider the relational scheme R with the set of functional dependencies F.

R = {A, B, C, D}
F = { {A} → {C}, {B,C} → {D}, {A,B} →{C} }

Question 34. (2 marks) Find the candidate keys of R with F. Do not give the steps. Give the result only.

Question 35. (4 marks) Compute a minimum cover of F. Do not give the steps. Give the result only.

Question 36. (4 marks) Give a 3NF synthesis of R with F. Do not give the steps. Give the result only.

Question 37. (4 marks) Explain (precisely and briefly) why R with F is not in BCNF.

Using the algorithm of the lecture, there are two decompositions in BCNF. The first is not dependency preserving, the second is dependency preserving. Find the two decompositions. Give the steps (clearly and concisely). Give the resulting fragments and their projected sets of functional dependencies and indicate whether they are in BCNF or not.

Question 38. (6 marks) The first decomposition is not dependency preserving. Indicate the lost functional dependency.

Question 39. (6 marks) The second decomposition is dependency preserving.

-- END OF PAPER ---