Student Number: _____

HONG KONG UNIVERSITY OF SCIENCE & TECHNOLOGY

COMP3311: Database Management Systems

Spring Semester, 2017

Midterm Examination

March 11, 2017 2:00pm to 4:00pm.

Name: _____ Student Number: _____

Email: _____

Instructions:

1. This is an open-note examination. You are allowed to bring and use the printed course slides from lectures, exercises, tutorials and labs in the examination. No electronic device is allowed throughout the exam.
2. This examination paper consists of **12** pages and **4** questions
3. Please write your name, student ID and Email on this page.
4. For each subsequent page, please write your student ID at the top of the page in the space provided.
5. Please answer **all** the questions within the space provided on the examination paper. You may use the back of the pages for your rough work and afterwards drawn a diagonal line through it to show that it is not part of your answer.
6. Please read each question very carefully and answer the question clearly and to the point. Make sure that your answers are neatly written, readable and legible.
7. Leave all pages stapled together.
8. The examination period will last for **2 hours**.
9. Stop writing immediately when the time is up.

Questions	Marks	Scores
1	30	
2	25	
3	20	
4	25	
Total	100	

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Q1 Multiple-choice Questions (30 marks)
Choose the correct answer for each question and put in the boxes.

1	**A**
2	**A**
3	**D**
4	**D**
5	**C**

6	**B**
7	**A**
8	**D**
9	**C**
10	**C**

11	**D**
12	**C**
13	**C**
14	**A**
15	**B**

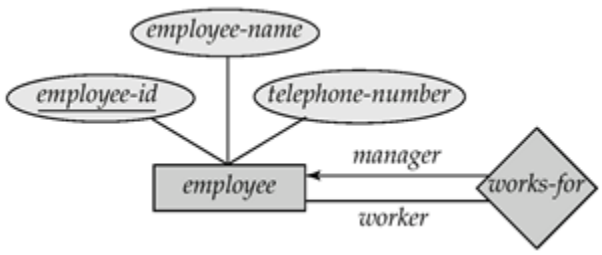
16	**D**
17	**A**
18	**C**
19	**B**
20	**A**

1. In an ERD, an ISA relationship (i.e. specialization and generalization hierarchies) always contains:

   I. Super entity types and sub entity types.
   II. A disjoint constraint.
   III. A covering constraint (total participation).

   A. I only.
   B. I and III only.
   C. II and III only.
   D. I, II and III.

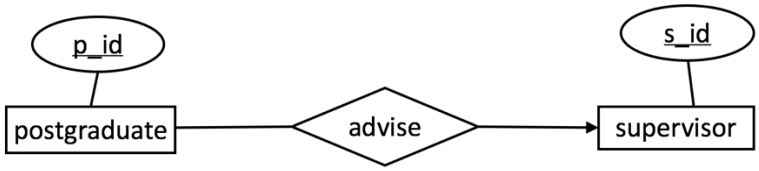
2. Which of the following statements are **true** about converting the following ERD into its corresponding relational schemas?



   I. We need more than three attributes in the employee schema.
   II. We need a foreign key constraint in the employee schema.
   III. We need a relation schema for the works-for relationship.

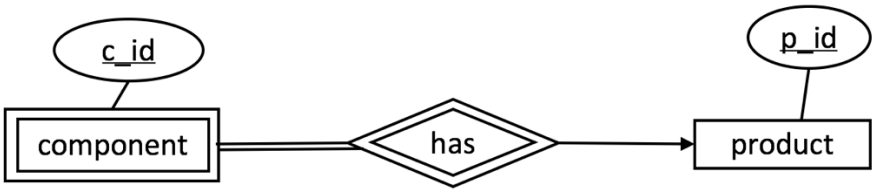
   A. I and II only.
   B. II and III only.
   C. I and III only.
   D. I, II and III.

3. The following relationship is converted into a database schema, which of the following conversion ideas is **correct**?



A. Need a relation schema: Advise(p_id, s_id)
   foreign key p_id references postgraduate on delete cascade
   foreign key s_id references supervisor on delete cascade.
B. Need a relation schema: Advise(p_id, s_id)
   foreign key p_id references postgraduate on delete set null
   foreign key s_id references supervisor on delete cascade.
C. Need a relation schema: Postgraduate(p_id, s_id)
   foreign key s_id references supervisor on delete cascade.
D. Need a relation schema: Postgraduate(p_id, s_id)
   foreign key s_id references supervisor on delete set null.

4. Which of the following statements about the ER-diagram below is **false**?



A. "Component" is a weak entity.
B. A product entity can connect with more than one component entities.
C. A component entity must connect with a product entity.
D. A component entity can connect with more than one product entities.

5. Given a relation schema R(A, B, C, D, E) with a set of functional dependencies F = {A → BD, D → C, B → DE , CB → A }.
   Which of the following is **NOT** a key of R?

A. A
B. CB
C. DE
D. ACD

6. Given a relation schema R(A, B, C ,D, E) with a set of functional dependencies F = {AB → C, B → E, E → A , CD→ E }.

   Which of the following is the *attribute closure* of B (i.e. B^+)?

   A. ABCDE
   B. ABCE
   C. BE
   D. ABDE

7. Consider the following set of functional dependencies F = { B→ C, B → D, A → B , A→ CD }.

   Which of the following is the *canonical cover* of F (i.e. F_C)?

   A. { A→ B, B → CD }
   B. { A→ CD, B → CD }
   C. { B→ C, B → D , A → B }
   D. { A → B , A→ CD }

8. Given a relation schema R(A, B, C, D, E) with a set of functional dependencies F = { A → E, AB → E}.

   Suppose that we decompose R into R1(A, E) and R2(A, B, C, D).
   Which of the following is **true** for the above decomposition?

   A. The decomposition is in 3NF, but not in BCNF.
   B. The decomposition is neither in 3NF nor in BCNF.
   C. The decomposition is in BCNF, but not in 3NF.
   D. The decomposition is both in 3NF and BCNF.

9. Consider the relations r and s having the schemas R(A, B) and S(A, B) respectively.

   Which of the following statement(s) is always **true**?

   I. $r \cap s = r - (r - s)$
   II. $r \cap s = s - (s - r)$
   III. $r \cap s = r \bowtie s$
   IV. $r \cap s = r \times s$

   A. I only.
   B. I and II only.
   C. I, II and III only.
   D. I, II, III and IV.

10. Given a relation r defined over the schema R={<u>A, B</u>, C, D}, where the underlined attributes (A, B) are the primary key of R. Let $|E_{RA}|$ denote the number of tuples returning from the RA expression E_{RA}. For example, |r| is the number of tuples in r and $|\pi_A(r)|$ is the number of tuples in evaluating the expression $\pi_A(r)$.

    Which of the following statement(s) is **false**?

    I. $|\pi_{ABC}(r)| = |r|$.

    II. $|\pi_{BD}(r)| \geq |\pi_{AD}(r)|$.

    III. $|\pi_{ABD}(r)| \geq |\pi_{BCD}(r)|$.

    A. I only.
    B. II only.
    C. III only.
    D. I, II and III.

11. Consider the relations r and s having the schemas R(A, B) and S(B, C). We now execute the natural join $(r \bowtie s)$.

    Which of the following statement(s) is **true**?

    I. The schema of $(r \bowtie s)$ has the attributes A, B and C only.
    II. The result of $(r \bowtie s)$ cannot be empty.
    III. If A = C (i.e. the same attribute), then $(r \bowtie s) = (r \cap s)$.

    A. I only.
    B. I and II only.
    C. II and III only.
    D. I and III only.

12. Given two relational tables **r** and **s** as follows:

r =

Name	ID	Dept
Harry	3415	Finance
Sally	2241	Sales
George	3401	Finance
Harriet	2202	Sales
Tim	1123	Executive

s =

Dept	Manager
Sales	Harriet
Production	Charles

Which operation on **r** and **s** does lead to the following result?

Name	ID	Dept	Manager
Harry	3415	Finance	null
Sally	2241	Sales	Harriet
George	3401	Finance	null
Harriet	2202	Sales	Harriet
Tim	1123	Executive	null
null	null	Production	Charles

A. $(r \rtimes s)$
B. $(r \ltimes s)$
C. $(r \rtimes s) \cup (r \ltimes s)$
D. $(r \bowtie s)$

13. Which of the following SQL statements can be used to remove the entire table called "Staff" in a database?

I. DELETE FROM Staff;
II. DELETE TABLE Staff;
III. DROP TABLE Staff;

A. I only.
B. II only.
C. III only.
D. II and III only.

14. Which one is true about using aggregate functions in an SQL statement?

A. We can apply aggregate functions to tables or views.
B. All aggregate functions do not return null as an answer.
C. We should not use MAX(A) and MIN(A) with attribute A in the same select clause.
D. All aggregate functions operate on a single column.

15. Consider the following relational table having schema R = {A, B}.

A	B
0	*NULL*
0	*NULL*
1	*NULL*
1	1

Now the following SQL is executed. (Assume A and B both have integer domains.)

```
SELECT A, COUNT(*) as C, COUNT(B) as D, MAX(B) as E
FROM R
GROUP BY A
ORDER BY A;
```

We obtain the following table as a result. What are the values of x, y and z?

A	**C**	**D**	**E**
0	x	y	z
1	2	1	1

A. x = 2, y = *NULL*, z = *NULL*
B. x = 2, y = 0, z = *NULL*
C. x = *NULL*, y = *NULL*, z = *NULL*
D. None of the above

16. Which SQL statement is used to insert new data in a database?

A. ADD TO ...
B. ADD RECORD ...
C. INSERT TO ...
D. INSERT INTO ...

17. Consider the following **Students** table.

STU_ID	**DEP_ID**	**CGA**
S1	COMP	8
S2	ELEC	9
S3	COMP	10
S4	COMP	
S5	ELEC	8

What is the result of executing the following SQL statement?

```
SELECT DEP_ID, AVG(CGA)
FROM STUDENTS
WHERE STU_ID <> 'S1'
GROUP BY DEP_ID
HAVING COUNT(CGA)>=2;
```

A. One record is displayed, and it is (ELEC, 8.5).
B. One record is displayed, and it is (COMP, 5).
C. Two records are displayed, and they are (COMP, 5) and (ELEC, 8.5).
D. Two records are displayed, and they are (COMP, 10) and (ELEC, 8.5).

18. Referring to the **Students** table in the previous question, what is the result of the following SQL statement?

```
SELECT STU_ID FROM STUDENTS
WHERE DEP_ID IN
(SELECT DEP_ID FROM (SELECT DEP_ID, COUNT(*) AS SCOUNT FROM
STUDENTS GROUP BY DEP_ID) TEMP
WHERE TEMP.SCOUNT = (SELECT MAX(SCOUNT) FROM (SELECT DEP_ID,
COUNT(*) AS SCOUNT FROM STUDENTS GROUP BY DEP_ID)));
```

A. Two records are displayed, and they are (S2; S5).
B. Two records are displayed, and they are (S1; S3).
C. Three records are displayed, and they are (S1; S3; S4).
D. Five records are displayed, and they are (S1; S2; S3; S4; S5).

19. What is the result of the following SQL statement (in Oracle database):

```
SELECT NEXT_DAY('11-MAR-17',’MONDAY’) FROM dual;
```

A. '12-MAR-17'.
B. '13-MAR-17'.
C. '12-MARCH-2017'
D. Syntax error, cannot execute.

20. What is the result of the following SQL statement (in Oracle database):

```
SELECT RPAD('a',2,'b') FROM dual;
```

A. 'ab'.
B. 'abb'.
C. 'aab'
D. Syntax error, cannot execute.

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Q2 ER Diagram Design (25 marks)

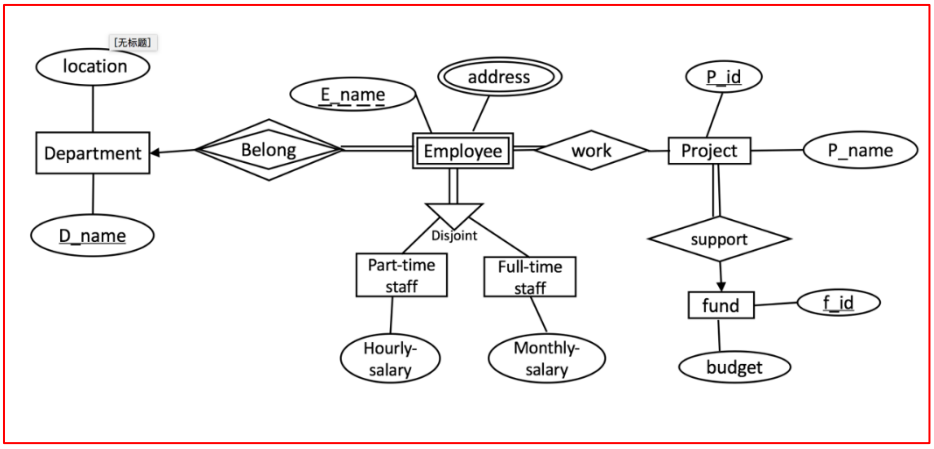
You are required to draw an ER-diagram for a company according to the following requirements.

- There are several departments; each **department** has a name which is unique and identifiable, and a location.
- Each department hires a number (may be zero) of employees, each **employee** has a name, and one or many addresses. Each employee belongs to exactly one department. Employees in the same department are identified by their names. However, two employees from different departments may have the same name.
- Each employee is either a **full-time employee** or a **part-time employee,** but cannot be both. For full-time employees we have to record their monthly salary. For part-time employees we have to record their hourly salary.
- There is a number of **projects** and each project has a unique id and a name.
- Each employee works on at least one project. Each project normally has some employees to work on, but it is also possible that a project has no employees to work on.
- There is a number of **funds**, each fund has a unique id, and a budget.
- A fund can support zero or many projects. However, each project has exactly one fund to support it.

Complete the following ER-diagram where a sketch of ***some*** entities without their full details is given. **Use** arrow notation to denote relationship cardinality and double line to denote total participation. (i.e. ***Do not*** use the cardinality limits such as 1..* on the edges for a relationship.) Marks will be deducted if any icon, line or arrow clarity is not sufficient.

Department

Project



Fund

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Q3 Functional Dependencies and Normalization (20 marks)

Consider a relation schema R(A, B, C, D, E). Given the functional dependencies in the first column of the following table, you are required to complete all empty cells in the table accordingly. An example row is already given.

- In the second column, write down all candidate keys for R.
- In the third column, write down a maximal decomposition of R in 3NF (i.e. we only decompose when there is violation of 3NF) – if R is already in 3NF just write R(A, B, C, D, E) as the example row instead of doing a decomposition.
- In the fourth column, do the same for BCNF decomposition. However, if there are many options, choose a *dependency preserving* decomposition (if there is one).
- No comments or explanations are required for all the decompositions.

Functional Dependencies	**Candidate keys for R**	**Decompose R in 3NF**	**Decompose R in BCNF**
{ A → BCDE }	*A*	*R(A, B , C, D, E)*	*R(A, B, C, D, E)*
{ B → CD }	*ABE*	R1(A, B, E) R2(B, C, D)	R1(A, B, E) R2(B, C, D)
{ BE→ A, D → E }	BCD	R1(A, B, E) R2(D, E) R3(B, C, D)	R1(B, C, D) R2(D, E) R3(A, B, E) or R1(A, B, C, D) R2(D, E)
{ AD → C, C → AB }	ADE, CDE	R1(A, B, C) R2(A, C, D) R3(A, D, E) or R1(A, B, C) R2(A, C, D) R3 (C, D, E)	R1(A, B, D, E) R2(A, D, C) or R1(C, D, E) R2(A, B, C)
{ A→ B, B → CE }	AD	R1(A, B) R2(B, C, E) R3(A, D)	R1(A, C, D, E) R2 (A, B) or R1(A, D) R2(A, B) R3(B, C, E)

Q4 Structured Query Language (25 marks)

Consider the following database having four relational schemas:

employee(employee-name, street, city)
works(employee-name, company-name, salary)
company(company-name, city)
manages(employee-name, manager-name)

Write the following queries in SQL. State your assumptions if any.

a. Find the names, street address, and cities of residence for all employees who work for the company ‘SpaceX' and earn more than $50,000.

```
SELECT EMPLOYEE.EMPLOYEE-NAME, EMPLOYEE.STREET, EMPLOYEE.CITY
FROM EMPLOYEE, WORKS
WHERE EMPLOYEE.EMPLOYEE-NAME=WORKS.EMPLOYEE-NAME
AND COMPANY-NAME = 'SPACEX'
AND SALARY > 50000
```

Or any other feasible queries.

b. Find the names of all employees in the database who live in the same cities and on the same streets as do their managers.

```
SELECT P.EMPLOYEE-NAME
FROM EMPLOYEE P, EMPLOYEE R, MANAGES M
WHERE P.EMPLOYEE-NAME = M.EMPLOYEE-NAME
AND M.MANAGER-NAME = R.EMPLOYEE-NAME
AND P.STREET = R.STREET
AND P.CITY = R.CITY
```

Or any other feasible queries.

c. Find the names of all employees in the database who earn more than every employee of the company 'HKUST'. Assume that all people work for at most one company.

```
SELECT EMPLOYEE-NAME
FROM WORKS
WHERE SALARY > ALL (SELECT SALARY
FROM WORKS
WHERE COMPANY-NAME = 'HKUST')
```

Or any other feasible queries.

d. Find the names of all employees who earn more than the average salary of all employees of their company. Assume that all people work for at most one company.

```
SELECT EMPLOYEE-NAME
FROM WORKS T
WHERE SALARY >(SELECT AVG(SALARY) FROM WORKS S
WHERE T.COMPANY-NAME = S.COMPANY-NAME)
```

Or any other feasible queries.

e. Find the name of the company that has the smallest payroll (i.e. the total amount of money that a company pays to its employees).

```
SELECT COMPANY-NAME
FROM WORKS
GROUP BY COMPANY-NAME
HAVING SUM(SALARY) <= ALL (SELECT SUM(SALARY)
FROM WORKS
GROUP BY COMPANY-NAME)
```

Or any other feasible queries.

- End of the Exam Paper-