CSCI3170 Introduction to Database Systems

Midterm Examination (Spring 2015)

Date : March 12, 2015

Time : 10:35 am - 12:05 pm

Time allowed : 1 hour and 30 minutes

Question	Marks
1	15
2	12
3	11
4	17
5	18
6	8
7	12
8	7
Total	

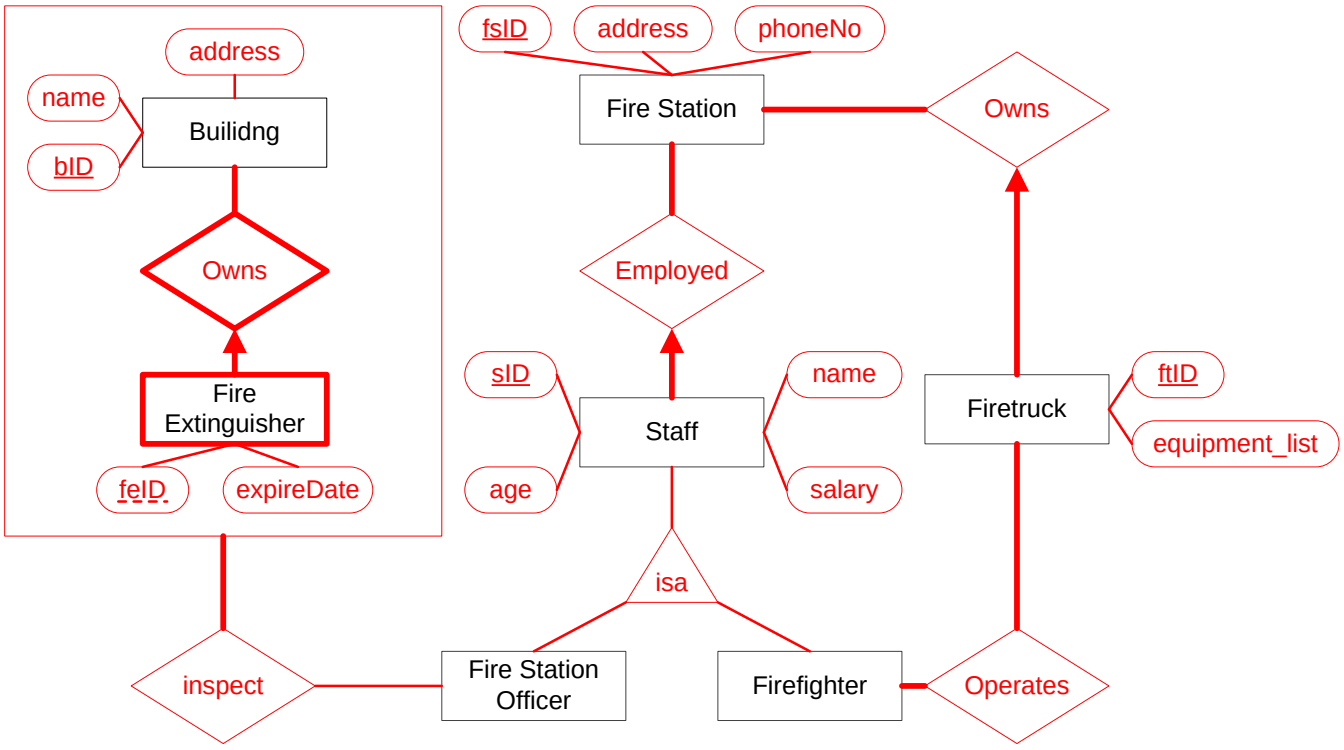
Student ID : _____

Student Name : _____

(Please do not turn over this page until you are told to do so)

1. Complete the following ER-diagram according to the following conditions: (15 marks)
   1. A fire station has an fsID, an address and a phoneNo.
   2. A fire station can be uniquely identified by its fsID.
   3. A staff member has an sID, a name, an age and a salary attribute.
   4. A staff member can be uniquely identified by its sID.
   5. Staff members can be classified into 2 subclasses, namely fire station officer and firefighter.
   6. A fire truck has an ftID and an equipment list (a string attribute).
   7. A fire truck can be uniquely identified by its ftID.
   8. A fire truck must be owned by exactly 1 fire station, and a fire station must own at least 1 fire truck.
   9. A staff member must be employed by exactly 1 fire station and a fire station must employ at least 1 staff member.
   10. A firefighter must be able to operate at least 1 fire truck and a fire truck must be operated by at least 1 firefighter as well.
   11. A building has an address, a name and a bID.
   12. A building can be uniquely identified by its bID.
   13. A fire extinguisher has an expireDate and an feID.
   14. A fire extinguisher can only be uniquely identified by using a pair of bid of a building and its feID.
   15. Each Installation of a fire extinguisher in its building must be inspected by a fire station officer but a fire station officer may not need to inspect any installations of any fire extinguishers.

Answer



2. Consider the relation instances and the SQL statements for creating the relations. (12 marks)

Insurance_Plan

cid	account_no	plan_type	monthly_pay
1	196-8612806-539	Life	5000
1	196-4184622-310	Life	4800
2	196-1487410-443	MPF	6000
4	196-1974547-590	Life	1500
4	196-5895553-731	MPF	2400

Customer

id	name	salary
1	Rose Lee	40000
2	Fannie Chan	35000
3	Larry Wong	22000
4	Robert Leung	35000
5	Jessica Lau	22000

```
CREATE TABLE Insurance_Plan (
        cid INTEGER,
        account_no CHAR(15),
        plan_type CHAR(10),
        monthly_pay INTEGER,
        PRIMARY KEY (account_no, plan_type),
        FOREGIN KEY (cid) REFERENCES Customer (id)
                                ON DELETE CASCADE
                                ON UPDATE NO ACTION);
```

```
CREATE TABLE Customer (
        id INTEGER,
        name CHAR(12),
        salary INTEGER,
        PRIMARY KEY (id));
```

Determine if the following SQL statements can be executed successfully. If not, write down the reasons. You may assume that there is **no syntax error**.

a. INSERT INTO **Insurance_Plan** VALUES (5, '196-97263573-381818', 'health', 76400); (3 marks)
Answer
No, because the input value of “account_no” is too long.

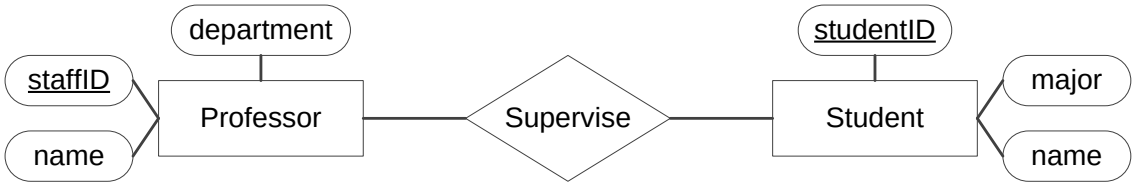
b. INSERT INTO **Insurance_Plan** VALUES (1, '196-8612806-539', 'Life', 7500); (3 marks)
Answer
No, because a tuple with the same primary key already exists.

c. INSERT INTO **Insurance_Plan** VALUES (7, '196-588950-266', 'MPF', 12900); (3 marks)
Answer
No, because the input value of “cid” does not exist in the relation “Customer”.

d. DELETE FROM **Customer** WHERE **salary** = 40000; (3 marks)
Answer
Yes, the SQL statement can be executed successfully.

3. For each of the following ER-diagram, write a relational schema with the smallest number of tables which are in BCNF (proof is not required). If necessary, state your assumptions to avoid ambiguity. (11 marks)

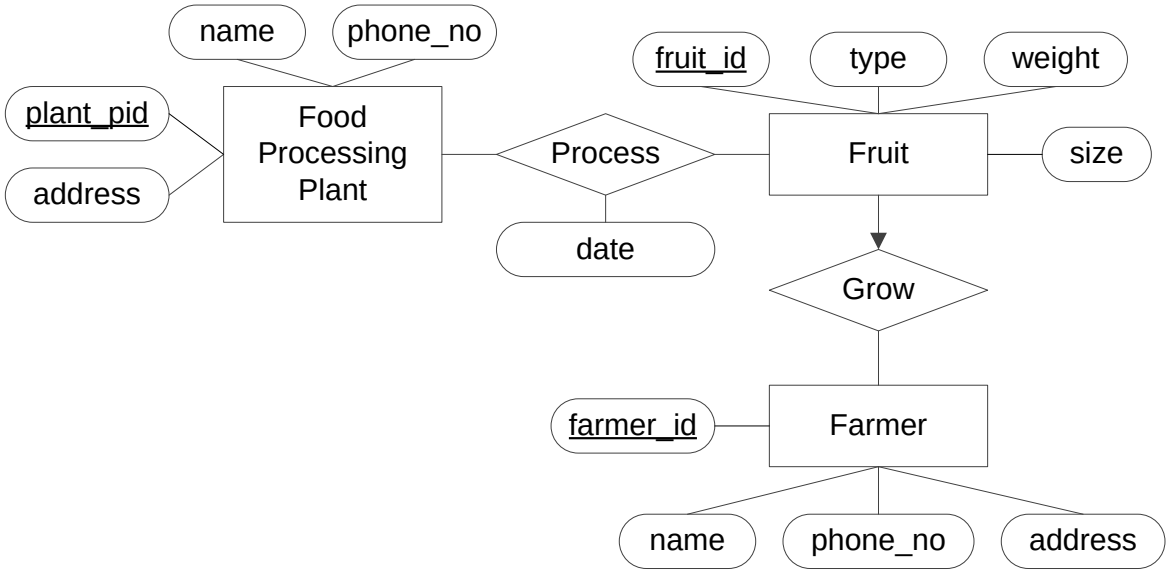
   a. Diagram 1 (3 marks)



Answer

Professor (staffID, name, department)
Student (studentID, name, major)
Supervise (staffID, studentID)

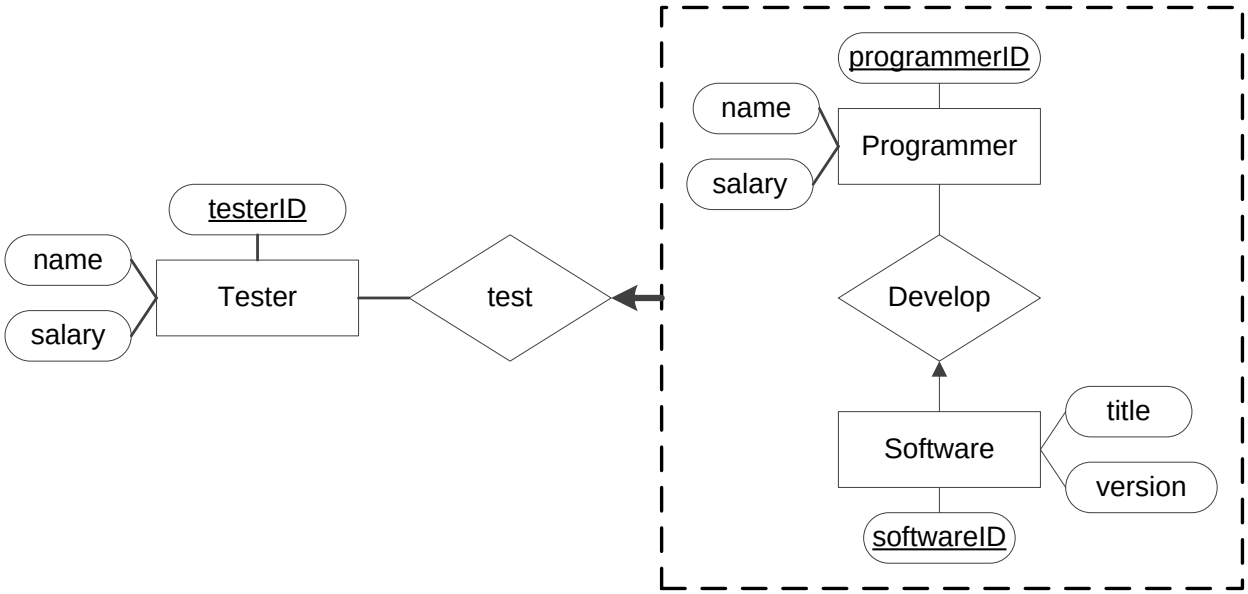
   b. Diagram 2 (4 marks)



Answer

Farmer(farmer_id, name, address, phone_no)
Fruit(fruit_id, type, weight, size, farmer_id)
FoodProcessingPlant(plant_id, name, address, phone_no)
Process(plant_id, fruit_id, date)

c. Diagram 3 (4 marks)



Answer

Tester (testerID, name, salary)
Programmer (programmerID, name, salary)
Software (softwareID, title, version)
Test (softwareID, programmerID, testerID)

4. Suppose we have the following schema: (17 marks)

   Teacher = {tid, tname, title, dept}
   Student = {sid, sname, dept, year, gpa}
   Course = {cid, cname, tid}
   Enroll = {sid, cid, marks}

   The primary key in each relation is underlined. Please use **relational algebra** to:

   a. Find the name of courses which are taught by "MH Wong". (3 marks)
   Answer
   $\Pi_{cname}\left(Course \bowtie \sigma_{tname='MHWong'}(Teacher)\right)$

   b. Find the Student ID of year 3 students who have never enrolled the course named "Final Project". (4 marks)
   Answer
   $\Pi_{sid}\left(\sigma_{year=3}(Student)\right) - \Pi_{sid}\left(Enroll \bowtie \sigma_{cname='Final\ Project'}(Course)\right)$

   c. Find the Student ID of the student(s) with the highest GPA from those who are in CSE department and enrolled in the course "Advanced Topics in AI". (5 marks)
   Answer
   $\rho\left(S1, \sigma_{dept='CSE'}(Student) \bowtie Enroll \bowtie \sigma_{cname='Advanced\ Topics\ in\ AI'}(Course)\right)$
   $\rho(S2, S1)$
   $\Pi_{S1.sid}(S1) - \Pi_{S1.sid}\left(S1 \bowtie_{S1.gpa>S2.gpa} S2\right)$

   d. Find the Student ID of the student(s) who have taken all courses taught by the teachers from EE department. (5 marks)
   Answer
   $\Pi_{sid,cid}(Enroll) / \Pi_{cid}\left(Course \bowtie \sigma_{dept='EE'}(Teacher)\right)$

5. Consider the following schemas for a CD-shop: (18 marks)

   Customer = {cid, name, age, sex}
   CD = {cdid, title, language, singer, category, price}
   Purchase = {cid, cdid, date}

   The Purchase relation stores the purchase records of CDs. The primary key in each schema is underlined. Write down the **SQL statements** to:

   a. Find the name(s) of customer(s) whose have bought CD(s) with a title called "Thriller". (4 marks)
   Answer
   ```
   SELECT C.name
   FROM Customer C, Purchase P, CD D
   WHERE C.cid = P.cid AND D.cdid = P.cdid AND D.title = ' Thriller';
   ```

   b. Find cid(s), name(s) and the total price of CD(s) purchased by each customer. (4 marks)
   Answer
   ```
   SELECT C.cid, C.name, SUM(D.price)
   FROM Customer C, CD D, Purchase P
   WHERE C.cid = P.cid AND D.cdid = P.cdid
   GROUP BY C.cid, C.name;
   ```

   c. Find the title and price of the CD(s) that are bought by the oldest female customer(s). (5 marks)
   Answer
   ```
   SELECT T.title, T.price
   FROM CD T, Purchase P, Customer C1
   WHERE T.cdid = P.cdid AND P.cid = C1.cid  AND C1.sex = 'F' AND C1.age = (
           SELECT MAX(C2.age)
           FROM Customer C2
           WHERE C2.sex = 'F');
   ```

   d. Find the name(s) of customer(s) who have never bought CD(s) with price ranging from 100 to 200 inclusively. (5 marks)
   Answer
   ```
   SELECT C.name
   FROM Customer C
   WHERE C.cid NOT IN (
           SELECT P.cid
           FROM Purchase P, CD D
           WHERE P.cdid = D.cdid AND D.price <= 200 AND D.price >= 100);
   ```

6. Prove the following properties by using **Armstrong's Axiom ONLY**. In your answers, you have to **clearly state the rules applied**. No mark will be given if the properties are proved by finding out the closure of any attribute. (8 marks)

   a. If $M \rightarrow NO$ and $M \rightarrow P$, then $M \rightarrow NP$. (4 marks)

   Answer

   M → NO ⋯ (1) (Given)
   M → P ⋯ (2) (Given)
   NO → N ⋯ (3) (Reflexivity)
   M → N ⋯ (4) (Transitivity on (1) and (3))
   MP → NP ⋯ (5) (Augmentation on (4))
   MM → MP ⋯ (6) (Augmentation on (2))
   M → MP ⋯ (7) (Simplify (6))
   M → NP ⋯ (8) (Transitivity on (5) and (7))

   b. If $X \rightarrow YZ$ and $Y \rightarrow P$, then $X \rightarrow P$. (4 marks)

   Answer

   X → YZ ⋯ (1) (Given)
   Y → P ⋯ (2) (Given)
   YZ →PZ ⋯ (3) (Augmentation on (2))
   X → PZ ⋯ (4) (Transitivity on (1) and (3))
   PZ → Z ⋯ (5) (Reflexivity)
   X → P ⋯ (6) (Transitivity on (4) and (5))

7. Consider a relation R with five attributes MNOPQ. You are given the following dependencies: F={P → O, O → Q, MN → O, PQ → N}. (12 marks)

   a. Please find $(MN)^+$ (2 marks)
   Answer
   MNOQ

   b. Please find $(MNP)^+$ (2 marks)
   Answer
   MNOPQ

   c. Please find $(MNPQ)^+$ (2 marks)
   Answer
   MNOPQ

   d. Is MNPQ a superkey for R? Please explain your answer. (3 marks)
   Answer
   Yes. It is because MNPQ → R.

   e. Is MNPQ a candidate key for R? Please explain your answer. (3 marks)
   Answer
   No. It is because MNP → R, where MNP is a subset of MNPQ. Hence, MNPQ does not satisfy the minimal requirement.

8. Consider the following relation schema of the database that stores the information of the teaching staff in a university (7 marks):

   TeachingStaff (name, gender, courseList, educationLevel, experience, ranking)

   Assumption:
   i. name → gender
   ii. {experience, ranking} → salary
   iii. salary → ranking

   The 2 candidate keys of this schema are:
   i. {name, courseList, educationLevel, experience, ranking}
   ii. {name, courseList, educationLevel, experience, salary}

   a. Is the schema in BCNF? Please formally proof your answer. (3 marks)
      Answer
      No.
      name → gender is not trivial
      name is not a superkey **OR**

      {experience, ranking} → salary is not trivial
      {experience, ranking} is not a superkey **OR**

      salary → ranking is not trivial
      salary is not a superkey

   b. Is the schema in 3rd normal form? Please formally proof your answer. (4 marks)
      Answer
      No. Consider name → gender
      name → gender is not trivial
      $name$ is not a superkey
      $gender$ is not part of some key

- End -