First Name: 
Last Name: 
Student Number: 

Instructions:

1. This is a closed book examination.
2. No electronic devices may be used.
3. Please write down your answers using a pen.
4. Answer each question in the space provided. You should not need more space.
5. Exam duration is 90 minutes (12:00 – 1:30pm)
6. This exam includes 10 questions. Answer all the questions.
7. The exam is 10 (ten) pages. Make sure you have all of the pages.

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Q1 (20 points). Consider the following SQL query:

```
SELECT reporterFName, reporterLName, caseId
FROM Cases
WHERE reporterId IN (SELECT SIN
    FROM Person
    WHERE city = 'Vancouver')
```

(a) Depict the representative parse tree for this query. (10 points)
(b) Convert your parse tree to the Relational Algebraic (RA) tree representation and write down the equivalent RA expression. (10 points)
Q2 (10 points). Suppose we maintain student information using a relation defined by the following schema:

Student (sid, name, gpa)

attributes abbreviated as (s, n, g) and using the following transactions:

T1: R(s); R(n); R(g); W(g);
T2: R(s); W(g); R(g);
T3: R(s); W(n); R(g); W(n);

for each of the schedules shown below, indicate categories (Serial, Serializable, Conflict-serializable, Not Serializable) that the given schedule satisfies. (5 points each)
Please show your detailed work for each schedule.

R1(s); R2(s); R1(n); R1(g); R3(s); W1(g); W2(g); W3(n); R3(g); R2(g); W3(n);

R2(s); R1(s); R3(s); W3(n); W2(g); R1(n); R1(g); R3(g); W1(g); W3(n); R2(g);
Q3 (15 points). Suppose City of Vancouver’s database has the following relations to track Greater Vancouver’s construction contract projects:

Employee(eno, ename, title, city)
Pay(title, salary)
Project(pno, pname, budget, city)
Works(eno, pno, title, reportsTo, responsibility, duration)

The primary keys are underlined. Attribute title from table Employee, references title from table Pay. Attribute eno from table Works references eno from table Employee. Attribute pno from table Works references pno from table Project. For each of the items (a), (b), and (c) please write a single SQL statement that accomplishes the given task:

(a) For each city, how many projects are located in that city and what is the total budget over all projects in the city? (5 points)

(b) For each project, what percentage of the total budget is spent on salaries for the people working on that project? Sort the answers ascending by budget. (5 points)

(c) Remove the work assignment of all persons to any projects for which more than any 2 persons share the same responsibility. (5 points)
Q4 (10 points). There is an educational system maintaining the following relation for student information:

Student (SSN, name, cgpa, faculty, ugradAdvisor, courseTaken, courseGrade)

Given the following functional dependencies

- courseTaken \( \rightarrow \) courseGrade
- SSN \( \rightarrow \) name, cgpa, faculty, courseTaken
- faculty \( \rightarrow \) ugradAdvisor

(a) List one key of the Student relation.

(b) Is the Student relation in BCNF? If yes, show why. If no, decompose it into BCNF and underline all keys and foreign keys in the final relations.
Q5 (15 points). Design an E/R diagram describing the following domain:

- A house is identified by number, street, and city.
- An apartment is identified by suite number, number, street, and city.
- A person is identified by a SIN number, name, age, and gender.
- Persons who are at least 18 years old may own zero or more houses or apartments, and every house or apartment is owned by at least one person.
- Any person lives in at most one house or apartment, as principal residence, and a house or apartment can have zero or more persons living.
Q6 (10 points). We are maintaining a banking database that among other relations, has relation Accounts to maintain client accounts, as defined below:

Accounts(account, type, balance, branch)

What is the following piece of code doing on this relation? Please describe in detail, identifying the important elements.

```
CREATE TRIGGER AccountBalance
AFTER UPDATE OF balance ON Accounts
REFERENCING
    OLD ROW AS OldTuple,
    NEW ROW AS NewTuple
FOR EACH ROW
WHEN (OldTuple.balance < 0)
    UPDATE Accounts
    SET balance = OldTuple.balance
    WHERE account = NewTuple.account;
```

Q7 (5 points). What are the two main transaction management functionalities implemented in DBMSs to preserve ACID properties (2 points), and which ACID properties each of them maintains? (3 points)
Q8 (5 points). Name and define the Armstrong’s axioms? (3 points)
What are these axioms used for? (2 points)

Q9 (5 points). What is an index? (1 point) What is a view? (1 point) What are the similarities and differences between indexes, views, and stored relations? (3 points)
Q10 (5 points). Is any two-attribute relation in BCNF? Prove your answer.