6.1 Query Languages

1. Assume that no two columns of relations have the same name. Show that a query in the normal form $\exists c (\sigma_F (R_1 \times R_2 \times \ldots \times R_n))$ can be expressed in Domain Relational Calculus (DRC), where $c$ is a vector of columns, $F$ is a boolean formula built from conjunctions of atoms in the form $c_i = c_j$ or $c_i = \text{constant}$ ($c_i$ and $c_j$ are columns).

2. What does “relational completeness” mean? Show that SQL is relational complete by enumerating SQL constructs corresponding to selection, projection, cartesian product, union, and difference.

3. Give two examples of SQL constructs/semantics not expressible in relational algebra (RA).

4. Suppose we have three tables Professor(id), Student(id), and Female(id). Translate the following SQL query into relational calculus and relational algebra.

   ```sql
   select Female.id
   from Professor, Student, Female
   where Professor.id=Female.id or Student.id=Female.id
   ```

5. Figure 1 shows the flow of a query through a DBMS, in which different forms are used to represent a query at different stages. Fill in the three blanks with the corresponding query languages (i.e., SQL, RC, RA).

6.2 Query Formulation

Given are the following relations from a games database:

- **published** with attributes game and publisher, which contains the publishers of each game.
  
  published = \{game, publisher\}

- **designed** with attributes game and designer, which contains the designers of each game.
  
  designed = \{game, designer\}

- **reviewed** with attributes game and reviewer, which contains the reviewers of each game.
  
  reviewed = \{game, reviewer\}
Every relation represents a n:m-relationship, i.e. the key is formed by all attributes of the relation.

Define the following queries as expressions in SQL, RA, and RC (TRC and DRC):

a) Find all designers of the game “Tetris”.
b) Find all publishers of all games designed by “Schmidt”.
c) Find all designers who have designed more than two games.
d) Find all reviewers who have reviewed at least one game that has not yet been published.

6.3 Tableau Transformation

Given the following conjunctive queries in domain calculus.

\[ D_1: \{a_1, a_2 | \exists b_1 \exists b_2 \exists b_3 R(a_1, b_1) \land R(b_1, b_2) \land R(b_2, b_3) \land R(b_3, a_2)\} \]

\[ D_2: \{a_1, a_2 | \exists b_1 \exists b_2 \exists b_3 R(a_1, b_2) \land R(b_1, a_2) \land R(a_1, b_3) \land R(b_2, b_3) \land R(b_3, b_1)\} \]

a) Construct the tableaux \( T_i \) for each query \( D_i \).

b) Prove or disprove: \( T_1 \subseteq T_2 \) and \( T_2 \subseteq T_1 \).