A114 Midterm

1. (20 points) Briefly answer the following questions.

(a) What is a foreign key? Specify why knowing the foreign keys in a database supports database integrity. (You can use an example to illustrate your answer.)

- A foreign key \( F \) in a relation \( R \) is an attribute of \( R \) that references a primary key attribute \( K \) of another relation \( S \). This means that whenever we have a row \( r \) in \( R \), then its \( F \)-value, \( r.F \) value must occur as the \( B \)-value of a tuple \( s \) in \( S \), i.e., \( r.F = s.K \).

- Database integrity between \( R \) and \( S \) is maintained upon updates of the relations \( R \) and \( S \). For example, if we insert a new tuple \( r \) in \( R \), then there must already exist a tuple \( s \) in \( S \) such that \( r.F = s.K \); otherwise \( r \) will not be inserted in \( R \). Similarly, if we delete a tuple \( s \) from \( S \), then each tuple \( r \) in \( R \) such that \( r.F = s.K \) must be deleted from \( R \).

(b) Consider the following two transactions named \( T_1 \) and \( T_2 \), respectively.

\[
T_1 \quad T_2
\]

\[
\begin{align*}
\text{read}(A) & \quad \text{read}(A) \\
A & := A+1 \quad A := A-1 \\
\text{write}(A) & \quad \text{write}(A)
\end{align*}
\]

Assume that the initial value of the data object \( A \) on disk is 0.

i. Specify an interleaving of the operations of \( T_1 \) and \( T_2 \) such that the update of \( A \) by \( T_1 \) is lost. What is the final value of \( A \)?

\[
T_1 \quad T_2
\]

\[
\begin{align*}
\text{read}(A) & \quad \text{read}(A) \\
A & := A+1 \quad A := A-1 \\
\text{write}(A) & \quad \text{write}(A)
\end{align*}
\]

1
The final value of $A$ is $-1$.

ii. Specify an interleaving of the operations of $T_1$ and $T_2$ such that neither the update of $A$ by $T_1$ nor the update of $A$ by $T_2$ are lost. What is the final value of $A$?

\[
\begin{array}{c|c}
T_1 & T_2 \\
\hline
\text{read}(A) & \text{read}(A) \\
A := A+1 & A := A-1 \\
\text{write}(A) & \text{write}(A)
\end{array}
\]

The final value of $A$ is $0$.

2. (30 points) Assume that we wish to maintain a database that contains the flight information of an airline. This database maintains information about flights, pilots, and assignments of pilots to flights. Each flight has a unique flight number, a departure city, a destination city, a departure time, and an arrival time. Each pilot has a unique company ID, a name, and an experience level. Pilots are assigned to fly certain flights on particular days of the year.

(a) Using this description of the database, identify the data objects and a relationship that need to be maintained in the database.
Data objects: flights and pilots
Relationship: assigned-to, i.e., pilots are assigned to flights.

(b) For each data object specify its relevant attributes and identify its primary key.
Flight: flight number, departure city, destination city, departure time, and arrival time. The primary key is the flight number attribute.
Pilot: company ID, name, and experience level. The primary key is the company attribute attribute.

(c) For the relationship, determine its attribute(s) and identify its foreign keys.
Assigned-to: flight number, company ID, and date.
Assigned-to as two foreign keys. The Assigned-to.(flight number) attribute is a foreign key referencing the Flight.(flight number) key attribute. And, the Assigned-to.(company ID) attribute is a foreign key referencing the Pilot.(company ID) key attribute.

(d) Draw an entity-relationship diagram that conceptually represents this situation. Identify the type of the relationship in your diagram.

(e) Use relational tables to represent the data objects and relationships with their attributes and constraints.

<table>
<thead>
<tr>
<th>Flight</th>
<th>Pilot</th>
<th>Assigned-to</th>
</tr>
</thead>
<tbody>
<tr>
<td>flight number</td>
<td>company ID</td>
<td>company ID</td>
</tr>
<tr>
<td>dept. city</td>
<td>name</td>
<td>flight number</td>
</tr>
<tr>
<td>dest. city</td>
<td>experience level</td>
<td>date</td>
</tr>
<tr>
<td>dept. time</td>
<td></td>
<td></td>
</tr>
<tr>
<td>arrival time</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Primary keys are underlined ones. Foreign keys are underlined twice.

3. (30 points) Consider the following table. Each row in such a table specifies a client (ClientSS#) and a food item (FoodItemName), the price of the food item, and the date (Date) when the client bought the food item.

<table>
<thead>
<tr>
<th>Buys</th>
</tr>
</thead>
<tbody>
<tr>
<td>ClientSS#</td>
</tr>
</tbody>
</table>

Consider the following queries. For each of the queries (1) identify whether its is a filtering query (selection, projection, or both) or an aggregate query; (2) specify the query using the Query Construction Method.
(a) List the social security numbers of all clients.
   - Projection query (vertical filtering).
     
     **Data:** ClientSS#
     **Location** Buys
     **Condition**
     **Format**

(b) Specify the name and price of all food items bought by client 999-99-9999 on December 1, 1998.
   - Selection and projection query. Horizontal and vertical filtering.
     
     **Data:** FoodItemName, Price
     **Location** Buys
     **Condition** ClientSS# = 999-99-9999 AND Date = December 1, 1998
     **Format**

(c) Find the amount paid for food item milk by all clients.
   - Aggregate query.
     
     **Data:** SUM(Price)
     **Location** Buys
     **Condition** FoodItemName = milk
     **Format**

(d) For each client, find the total amount of money spent by clients between January 1, 1999 and January 31, 1999.
   - Aggregate query.
     
     **Data:** ClientSS#, SUM(Price)
     **Location** Buys
     **Condition** Date between(January 1, 1999, January 31, 1999)
     **Format** GROUP BY(ClientSS#)