Question 1 [12 points] - Functional Dependencies

Consider a relation R(A, B, C, D, E) which satisfies the following functional dependencies:

- \( \{A\} \rightarrow C \)
- \( \{D\} \rightarrow E \)
- \( \{B, E\} \rightarrow A \)

Question 1.1 [8 points] - Closures

Calculate the closures of the following sets of attributes:

a) \( \{D\} \)
b) \( \{A, D\} \)
c) \( \{A, E\} \)
d) \( \{B, D\} \)
e) \( \{C, E\} \)
f) \( \{A, B, E\} \)
g) \( \{B, C, D\} \)
h) \( \{A, B, C, D\} \)

Question 1.2 [4 points] - Keys/Superkeys

Identify all the keys and superkeys of the relation.
Question 2 [10 points] - More FDs

Question 2.1 [2 points] - Keys

Consider a relation R(A, B, C, D, E, F, G, H, I, J) which satisfies the following functional dependencies:

- \{A, B\} → C
- \{B, D\} → E, F
- \{A, D\} → G, H
- \{A\} → I
- \{H\} → J

What are the key(s) in R?

Question 2.2 [4 points]

Consider the relation R(A, B, C) below with the following values.

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>b</td>
<td>c</td>
</tr>
<tr>
<td>a</td>
<td>b</td>
<td>c</td>
</tr>
<tr>
<td>a</td>
<td>b</td>
<td>c</td>
</tr>
<tr>
<td>a</td>
<td>b</td>
<td>c</td>
</tr>
</tbody>
</table>

List all the non-trivial functional dependencies that the above relation satisfies.

Question 2.3 [4 points]

Consider the same relation as in part 2.2. Assume that the value of attribute C of the second record \((a_1, b_1, c_2)\) is changed from \(c_2\) to \(c_1\). What are the non-trivial functional dependencies satisfied by the relation now?
Question 3 [5 points] - Anomalies

Consider a table with schema defined as Player(player name, team name, stadium, league, goals, assists).

<table>
<thead>
<tr>
<th>player name</th>
<th>team name</th>
<th>stadium</th>
<th>league</th>
<th>goals</th>
<th>assists</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lionel Messi</td>
<td>Barcelona</td>
<td>Camp Nou</td>
<td>La Liga</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>Luis Suarez</td>
<td>Barcelona</td>
<td>Camp Nou</td>
<td>La Liga</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Cristiano Ronaldo</td>
<td>Juventus</td>
<td>Allianz</td>
<td>Serie A</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

Question 3.1 [2 points]

Say Barcelona builds a brand new stadium and we want to update the table to reflect this change. Let’s say there are 30 players in our table that have their team name as Barcelona. Describe what could be a potential problem or why this might be inefficient.

Question 3.2 [3 points]

Describe how you might go about fixing the problem you described above.