6 Databases (TGG)

(a) We are given a relational schema \( R(A, B, C, D, E) \) and told that the following table represents a legal instance of \( R \).

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>tuple number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td></td>
<td>(#1)</td>
</tr>
<tr>
<td>1</td>
<td>4</td>
<td>5</td>
<td>4</td>
<td>4</td>
<td></td>
<td>(#2)</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>5</td>
<td>4</td>
<td>5</td>
<td></td>
<td>(#3)</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td></td>
<td>(#4)</td>
</tr>
</tbody>
</table>

Which of the following sets of functional dependencies may hold in \( R \)? If a set of dependencies cannot hold, then explain why. You can refer to tuple numbers in your explanation.

(i) \( F_1 \) is the set \( \{ A \rightarrow D \} \). [2 marks]

(ii) \( F_2 \) is the set

\[
\begin{align*}
A, B & \rightarrow C \\
E & \rightarrow B \\
D, E & \rightarrow A
\end{align*}
\]

[2 marks]

(iii) \( F_3 \) is the set

\[
\begin{align*}
A, B & \rightarrow C \\
D, E & \rightarrow C \\
A & \rightarrow D
\end{align*}
\]

[4 marks]

(b) We are given a relational schema \( R(Z, W, Y) \). Suppose that in some (correct) instance of \( R \) the query

\[
(\pi_{Z,W}(R) \bowtie \pi_{Z,Y}(R)) - R
\]

is not empty. What can we conclude about the functional dependency \( Z \rightarrow W \)? Explain your answer. [4 marks]

(c) In the process of using functional dependencies to normalise a schema, what is meant by a *lossless join decomposition* and how is such a decomposition guaranteed? [4 marks]

(d) In schema normalisation, is Boyce-Codd Normal Form (BCNF) always to be preferred over 3rd Normal Form (3NF)? Explain your answer. [4 marks]