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>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</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>(#1)</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>4</td>
<td>5</td>
<td>4</td>
<td>4</td>
<td>(#2)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>5</td>
<td>4</td>
<td>5</td>
<td>(#3)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>(#4)</td>
<td></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 → 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

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

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