CS143: Database Systems
Homework #6

1. Suppose that we decompose the schema $R(A, B, C, D, E, F)$ into (A, B, C, F) and (A, D, E). When the following set of functional dependencies hold, is the decomposition lossless?
   $A \to BC, CD \to E, B \to D, E \to A$
   Explain your answer.

   ANSWER:
   (A, B, C, F) `INTERSECT` $(A, D, E) = A$`, and` A `is a key for` (A, D, E)`, so the decomposition is lossless.`

2. List non-trivial functional dependencies satisfied by the following relation. You do not need to find all functional dependencies. It is enough to identify a set of functional dependencies that imply all functional dependencies that is satisfied by the relation.

A	B	C
a_1	b_1	c_2
a_1	b_1	c_2
a_2	b_1	c_1
a_2	b_1	c_3

   ANSWER:
   $A \to B$
   $C \to A$

3. Assume *Student* and *Class* entity sets that we have used in the class. The *Student* and *Class* sets are connected by Take relationship set. We now convert the Take relationship set into a table **Take(sid, dept, cnum)** using our standard translation algorithm, where sid is the key for a student and (dept, cnum) is the key for a class.
   Explain how functional dependencies can be used to indicate the following:

   (a) A one-to-one relationship exists between entity sets *Student* and *Class*.
   ANSWER:
   $sid \to dept, cnum$
   $dept, cnum \to sid$

   (b) A many-to-one relationship exists between entity sets *Student* and *Class*.
   ANSWER:
   $sid \to dept, cnum$

4. Assume the following set of functional dependencies hold for the relation R(A, B, C, D, E):
   $A \rightarrow BC$, $CD \rightarrow E$, $B \rightarrow D$, $E \rightarrow A$

   (a) Is E a key for R? Explain your answer.
   ANSWER:
   Yes, E is a key. $E+ = ABCDE$.

   (b) Is BC a key for R? Explain your answer.
   ANSWER:
   Yes, BC is a key. $BC+ = ABCDE$.

5. Assume the following set of functional dependencies hold for the relation *R(A, B, C, D, E, F)*:
   $A \rightarrow BC$, $C \rightarrow E$, $B \rightarrow D$
   Is it in **BCNF**? Explain your answer. If it is not, normalize it into a set of relations in **BCNF**.
   ANSWER:
   It is not in BCNF.
   The key is AF, so A $\rightarrow$ BC, C $\rightarrow$ E and B $\rightarrow$ D all violate BCNF.
   $R(A, B, C, D, E, F) \Longrightarrow R1(A, B, C, D, F) and R2(C, E) using C \rightarrow E$
   $R1(A, B, C, D, F) \Longrightarrow R3(A, B, C, F) and R4(B, D) using B \rightarrow D$
   $R3(A, B, C, F) \Longrightarrow R5(A, F) and R6(A, B, C) using A \rightarrow BC$

   The final BCNF tables are:
   $R2(C, E)$
   $R4(B, D)$
   $R5(A, F)$
   $R6(A, B, C)$

6. Suppose we have a relation R(A, B, C, D) with a MVD A $\twoheadrightarrow$ BC. If we know that the tuples $(a, b1, c1, d1), (a, b2, c2, d2)$ and $(a, b3, c3, d3)$ are in the current instance of R, what other tuples do we know must also be in R?
   ANSWER:
   The following must also exist: $(a, b1, c1, d2)$
   $(a, b1, c1, d3)$
   $(a, b2, c2, d1)$
   $(a, b2, c2, d3)$
   $(a, b3, c3, d1)$
   $(a, b3, c3, d2)$

7. For relation $R(A, B, C, D, E, F)$, MVDs A $\twoheadrightarrow$ B and AB $\twoheadrightarrow$ C, and FD AB $\rightarrow$ E hold. Is it in 4NF? Explain your answer. If not, normalize it into 4NF.
   ANSWER:
   It is not 4NF, so we need to normalize it.
   Using $AB \rightarrow E$, decompose $R \Rightarrow R1(A, B, E)$ and $R2(A, B, C, D, F)$.
   Using $A \twoheadrightarrow B$, decompose $R1 \Rightarrow R3(A, B)$ and $R4(A, E)$.
   Using $AB \twoheadrightarrow C$, decompose $R2 \Rightarrow R5(A, B, C)$ and $R6(A, B, D, F)$.
   Using $A \twoheadrightarrow B$, decompose $R5 \Rightarrow R3(A, B)$ and $R7(A, C)$.
   Using $A \twoheadrightarrow B$, decompose $R6 \Rightarrow R3(A, B)$ and $R8(A, D, F)$.
   In the end, we have $R3(A, B)$, $R4(A, E)$, $R7(A, C)$, and $R8(A, D, F)$.