

**Database Systems – George Mason University Mason University**  
**Home Assignment 4**

**Relational Design Theory**

**Problem 1.** Given a relation schema  $R(A,B,C)$  and its relation instance as follows:

A	B	C
1	2	3
4	2	5
6	2	3
6	2	5
7	8	9
7	8	5

Which of the following functional dependencies are satisfied by the above relation instance? Give a “yes” or “no” answer for each.

1.  $AB \rightarrow C$
2.  $A \rightarrow B$
3.  $C \rightarrow A$
4.  $BC \rightarrow A$
5.  $ABC \rightarrow A$
6.  $AB \rightarrow AC$

**Problem 2.** Consider relation schema  $R(A,B,C)$  and the set of functional dependencies:  $F = \{ B \rightarrow A, A \rightarrow C \}$ . Do the following:

1. Find the cover of  $F$ , i.e., the set of all non-trivial FDs implied by  $F$  with a single attribute on the right and a minimal left-hand side.
2. Does there exist an instance that satisfies every FD in  $F$ , but does not satisfy the FD  $AB \rightarrow C$ ? Give a “yes” or “no” answer.

**Problem 3.** Consider the two following sets of functional dependencies:

$F = \{ B \rightarrow CE, E \rightarrow D, E \rightarrow CD, B \rightarrow CE, B \rightarrow A, \}$  and

$G = \{ E \rightarrow CD, B \rightarrow AE \}$ .

Answer: Are they equivalent? Give a “yes” or “no” answer.

**Problem 4.** Consider the following relation schema  $R(A,B,C,D,E,F,G,H,I,J)$  and the set of functional dependencies  $F = \{ A \rightarrow DE, IJ \rightarrow H, I \rightarrow A, J \rightarrow FG, G \rightarrow BC \}$ . Answer the following:

1. Is  $R$  in BCNF? Give a “yes” or “no” answer.

2. Find all candidate keys of R given a set F of functional dependencies.
3. Is R in 3NF? Give a “yes” or “no” answer

**Problem 5.** Consider a relation schema  $R(A,B,C,D,E)$  with the FD's  $F = \{ C \rightarrow E, D \rightarrow BC, E \rightarrow D, B \rightarrow A \text{ and } A \rightarrow D \}$ .

1. Is  $(R,F)$  in BCNF? Give a “yes” or “no” answer.
2. Now, suppose you decompose R into schemas  $S(C,D,E)$  and  $T(A,B,D)$ . Is this a lossless join decomposition? Give a “yes” or “no” answer.
3. Give the cover of F for schema S (i.e., FDs from the cover involving only C,D and E).
4. Give the cover of F for schema T (i.e., FDs from the cover involving only A,B and D).
5. Does this decomposition preserve dependencies? Give a “yes” or “no” answer.

**Problem 6.** Consider the following relational schema  $R(A,B,C,D,E,F)$  with the following functional dependencies cover:  $\text{cover}(F) =$

$\{ B \twoheadrightarrow D, AB \twoheadrightarrow C, AB \twoheadrightarrow E, AB \twoheadrightarrow F, AC \twoheadrightarrow F, ACE \twoheadrightarrow B, ACE \twoheadrightarrow D, AEF \twoheadrightarrow B, AEF \twoheadrightarrow C, AEF \twoheadrightarrow D \}$

Do the following:

1. Give the set of all candidate keys for relation schema  $R(A,B,C,D,E,F)$ .
2. Is  $(R,F)$  in the 3rd Normal Form? Give a “yes” or “no” answer.
3. Give the set of all FDs in  $\text{cover}(F)$  that violate the 3NF condition. Note, that if none exist (i.e., it is in 3<sup>rd</sup> normal form), your answer set should be empty.
4. Is  $(R,F)$  in BCNF? Give a “yes” or “no” answer.
5. Give the set of all FDs in  $\text{cover}(F)$  that violate the BCNF condition, if any. Note that if none exist (i.e., it is in BCNF), your answer set should be the empty set.
6. Decompose the relation schema R into several relational schemas in BCNF using the decomposition algorithm. Show each step of the decomposition algorithm, i.e., an FD from  $\text{cover}(F)$  being used to decompose and the two resulting schemas. For the purpose of grading:
  - always use the LEFTMOST FD in  $\text{cover}(F)$  (in the order it is written) that can be used to decompose a schema at each step of the algorithm.
  - Write each schema as a string sorted in alphabetical order (e.g., “ABDF”, “BDF” or “ACF”)