CSCI321 – Fall 2012
Homework Set 5
Solutions

1. LHS of each FD is unique (no need for combining on the RHS); no attribute in the LHS or the RHS of any FD is extraneous. Therefore, $F_c = F$.

2. Not BCNF: $B \to D$ is non-trivial and B is not a superkey. The BCNF decomposition is then

$$\{(B, D), (A, B, C, E)\}$$

   Projecting the FD's onto (A, B, C, E) shows no BCNF violations (all projected nontrivial FD's have keys on the LHS).

3. The given FD's were shown to be a canonical cover in problem 1. Using the canonical cover, we produce the 3NF decomposition

$$\{(A, B, C), (C, D, E), (B, D), (E, A)\}$$

   Note that the original schema was already 3NF. Thus, the decomposition above was not necessary.

4. $\{A, B\}$ is not a candidate key for this relation; it isn't even a superkey: $(AB)^+ = \{A, B, C\}$. $\{A, B, D\}$ is a superkey since $(A, B, D)^+ = \{A, B, C, D, E)\}$. Further, $\{A, B, D\}$ is a candidate key since no subset of $\{A, B, D\}$ is a superkey.

5. $\{A, B\}$ is a candidate key.

6. The only candidate key is $\{Book\_Name, Author, Edition\}$. From the example, it would appear that $\{Book\_Name, Author, Year\}$ would also be a candidate key but we should consider that some books may have a release cycle which causes multiple editions to appear in a given year.

   Here are the FD's and MVD's: $Book\_Name, Edition \to Year$
   $Book\_Name \twoheadrightarrow Author$
   $Book\_Name \twoheadrightarrow Edition$

7. (a) The keys are $\{A, B\}$, $\{B, C\}$ and $\{B, D\}$. Both $C \to D$ and $D \to A$ are BCNF violations. One choice is to decompose using the violation $C \to D$. We get (C, D) and (A, B, C) as decomposed relations. (C, D) is surely in BCNF, since any two-attribute relation is. Projecting FD's onto (A, B, C), we discover that its keys are $\{A, B\}$ and $\{B, C\}$, and that the FD $C \to A$ holds and is a BCNF violation. We must further decompose (A, B, C) into (A, C) and (B, C). Thus, the three relations of the decomposition are (C, D), (A, C) and (B, C).

   Since all attributes are in a key, there can be no 3NF violation.

   (b) The only key is $\{A, B\}$. Thus, $B \to C$ and $B \to D$ are both BCNF violations. The derived FD's $BD \to C$ and $BC \to D$ are also BCNF violations. However, any other nontrivial, derived FD will have A and B on the left, and therefore will contain a key.

One possible BCNF decomposition is (A, B) and (B, C, D). It is obtained starting with any of the four violations mentioned above. $\{A, B\}$ is the only key for (A, B), and $\{B\}$ is the only key for (B, C, D).

Since there is only one key for (A, B, C, D), the 3NF violations are the same, and so is the decomposition.

(c) No answer given.

8. (a) Since there are no functional dependencies, the only key is all four attributes, $\{A, B, C, D\}$. Thus, each of the nontrivial multivalued dependencies $A \twoheadrightarrow B$ and $A \twoheadrightarrow C$ violate 4NF. We must separate out the attributes of these dependencies, first decomposing into (A, B) and (A, C, D), and then decomposing the latter into (A, C) and (A, D) because $A \twoheadrightarrow C$ is still a 4NF violation for (A, C, D). The final set of relations are (A, B), (A, C), and (A, D).

(b) From the FD $B \rightarrow D$, we can deduce that the only key is $\{A, B, C\}$. The MVD $AB \twoheadrightarrow C$ and the easily derived MVD $B \twoheadrightarrow D$ are both 4NF violations.

We must separate out the attributes of these dependencies, first decomposing into (A, B, C) and (A, B, D), and then decomposing the latter into (A, B) and (B, D) because of the 4NF violation of $B \twoheadrightarrow D$. There are no more 4NF violations for the three decomposed relations so we are done. Since the attributes of relation (A, B, C) are a superset of the attributes of relation (A, B), we can discard relation (A, B). The final set of relations is (A, B, C) and (B, D).