Exercise 8
Date of issue: 25th April 2017  Deadline: 2nd May 2017

1 Normal Forms
(a) Consider relation schema $R_1(A, B, C, D)$, where all attributes are atomic, and the following set of functional dependencies:

$$F_1 = \{ A \rightarrow B, A \rightarrow C, C \rightarrow D \},$$

(b) Consider relation schema $R_2(A, B, C, D)$, where all attributes are atomic, and the following set of functional dependencies:

$$F_2 = \{ CB \rightarrow AD, AB \rightarrow CD, D \rightarrow A \}.$$

For each relation schema and its set of functional dependencies ($R_1$ and $F_1$; $R_2$ and $F_2$) perform the following tasks:

1. Determine the set $S$ of all candidate keys for the relation schema.
2. Determine the highest normal form (no NF, 1NF, 2NF, 3NF, BCNF) that the relation schema is in. Explain your answer.
3. Decompose the relation schema into new relation schemas that satisfy the next higher normal form.
4. Show the minimal set of functional dependencies for the decomposed relation schemas.
5. List the candidate keys of the decomposed relation schemas.
6. Determine if the decomposition is a lossless join decomposition or/and dependency preserving. Explain your answer.

2 Functional Dependencies
1. Consider relation schema $R_3(A, B, C, D, F, E)$ and the set of functional dependencies:

$$F = \{ A \rightarrow BC, B \rightarrow C, AD \rightarrow B, DF \rightarrow E, F \rightarrow D \}.$$  

Determine the minimal cover of $F$.

2. Consider relation schema $R_4(A, B, C, D)$ and the two sets of functional dependencies:

$$H = \{ A \rightarrow B, A \rightarrow BC, AB \rightarrow C, AC \rightarrow D, B \rightarrow C \},$$

$$G = \{ CA \rightarrow B, BA \rightarrow D, B \rightarrow D, DB \rightarrow C \}.$$  

Determine if $H \models G$, $G \models H$, or $H$ equivalent to $G$ ($H \Leftrightarrow G$). Explain your answer.
3 Multivalued Dependencies

Relation catWinner with schema CatWinner(CatName, Color, Award) stores information about cats: their names, their colors, and their awards. All cats have different names. All attributes in CatWinner are atomic. The set of functional dependencies \( F \) for the relation schema CatWinner is empty.

Consider the following assumptions:

(a) Assumption: a cat might have one color only.

(b) Assumption: a cat might have several colors.

Answer the following questions for each of assumptions:

1. How does the assumption change \( F \)?

2. What is the set of candidate keys of relation schema CatWinner under the stated assumption?

3. What is the set of all multivalued dependencies from the attribute CatName in relation schema CatWinner under the stated assumption?

Explain your answers.