Assignment 3: Database Design (Spring 2019)

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Name: _____ Student ID: _____ Grade: _____

Question	1	2(a)	2(b)	2(c)	2(d)	2(e)	3(a)	3(b)	3(c)	3(d)	3(e)	4	Total
Score													

Notes

- **Print the assignment on A4 paper and answer the questions.**

- **Assignment due date: April 3, 2019.**

Questions

1. (2 Points) Given the database schema $R(A, B, C)$, and a relation r on the schema R, write an SQL query to test whether the functional dependency $B \to C$ holds on relation r (the query returns 1 if $B \to C$ holds on r and 0 otherwise). Hint: the following SQL query returns 1 if its result is non-empty; otherwise, it returns 0.

   ```
   SELECT IF(COUNT(*), 1, 0) FROM ... WHERE ... LIMIT 1;
   ```

2. (10 Points) Prove or disprove the following inference rules for functional dependencies. A proof can be made by using Armstrong's axioms. A disproof should be performed by demonstrating a relation instance that satisfies the conditions and functional dependencies in the left-hand side of the inference rule but does not satisfy the dependencies in the right-hand side.

   (a) (2 Points) $\{W \to Y, X \to Z\} \vDash \{WX \to Y\}$

   (b) (2 Points) $\{X \to Y, X \to W, WY \to Z\} \vDash \{X \to Z\}$

   (c) (2 Points) $\{X \to Z, Y \to Z\} \vDash \{X \to Y\}$

   (d) (2 Points) $\{X \to Y, Z \to W\} \vDash \{XZ \to YW\}$

   (e) (2 Points) $\{X \to Y, Y \to Z\} \vDash \{X \to YZ\}$

3. (15 Points) Consider the following set F of functional dependencies on the relation schema $R(A, B, C, D, E)$:

$$A \to B$$
$$A \to C$$
$$BC \to A$$
$$CD \to E$$
$$B \to D$$
$$E \to A$$

   Answer the following questions:

(a) (3 Points) Compute $(BC)_F^+$.

(b) (3 Points) List the candidate keys for R. Prove that they are candidate keys using Armstrong's axioms.

(c) (3 Points) Compute a canonical cover for F; give each step of your derivation with an explanation.

(d) (3 Points) Suppose that R is decomposed into $R_1(A, B, C)$ and $R_2(C, D, E)$. Show that this decomposition is not a lossless decomposition. Hint: Give an example of a relation r on schema R such that
$$\Pi_{A,B,C}(r) \bowtie \Pi_{C,D,E}(r) \neq r.$$

(e) (3 Points) Give a 3NF decomposition of R based on the canonical cover for F.

4. (3 Points) Let $R_1(U_1), R_2(U_2), \ldots, R_n(U_n)$ be a decomposition of schema $R(U)$. Let r be a relation on schema R, and let $r_i = \Pi_{U_i}(r)$. Show that
$$r \subseteq r_1 \bowtie r_2 \bowtie \cdots \bowtie r_n.$$

Answers