Information and Database Management Systems I (CIS 4301)
(Fall 2016)

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Homework 4

Name: ____________________________
UFID: ____________________________
Email Address: ____________________

Pledge (Must be signed according to UF Honor Code)

On my honor, I have neither given nor received unauthorized aid in doing this assignment.

_______________________________________________
Signature

For scoring use only:

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Exercise 1 (Knowledge Questions) [21 points]


2. Please give the definition to the following concepts:

   First Normal Form (1NF)
   Second Normal Form (2NF)
   Third Normal Form (3NF)
   Boyce-Codd Normal Form (BCNF) [4 points]

3. Give a set of FDs for the relation schema R(A,B,C,D) with primary key AB under which
   R is in 1NF but not in 2NF. [4 points]

4. Give a set of FDs for the relation schema R(A,B,C,D) with primary key AB under which
   R is in 2NF but not in 3NF. [4 points]

5. Multiple Choice Questions: [3 points each]
   i. Consider relation R(A,B,C,D) with FD's A → D, B → D, and D → BC. Which of the
      following is true about the decomposition of R into relations with schemas AB and BCD?
      Explain your answer.
      A. The decomposition is neither lossless nor dependency-preserving.
      B. The decomposition is lossless, but not dependency-preserving.
      C. The decomposition is dependency-preserving, but not lossless.
      D. The decomposition is both lossless and dependency-preserving.

   ii. Suppose we have a relation R(A, B, C, D, E) and the FD's A → DE, D → B, and E → C.
       If we project R (and therefore its FD's) onto schema ABC, what is true about the key(s)
       for ABC? Explain why.
       A. Only ABC is a key.
       B. Only A is a key.
       C. Only DE is a key.
       D. A, B, and C are each keys.
**Exercise 2 (Functional Dependencies) [25 points]**

1. Prove the following deductions using Armstrong’s Axioms or give a counter example to it. [6 points]

   (1) \{X → Y, XY → Z\} ⇒ \{X → Z\}
   (2) \{XY → Z, Y → W\} ⇒ \{XZ → W\}
   (3) \{X → Z, Y → W\} ⇒ \{XY → ZW\}

2. Consider the relation
   FacebookPost (postId, time, title, userId, userName, @userId)
   with the following FD’s:
   - postId → time;
   - userId → userName;
   - postId → title.

   Let A = (postId, userId), determine the closure of A, i.e. A+. [4 points]

3. Consider the relation R (CLASS, TEACHER, MEET_DAY, STUDENT, GRADE, BUILDING, MANAGER) with the meaning:
   • A CLASS has one TEACHER, but can meet on several days in each week.
   • A STUDENT can take multiple classes and gets a GRADE in each CLASS.
   • Each CLASS meeting happens at one BUILDING, different meetings can happen at different BUILDINGs.
   • Each BUILDING has only one MANAGER, but each manager can manage one or more BUILDINGs.

   Find all the non-trivial FDs (Functional Dependencies) that hold in R. [5 points]


   (1) Determine the closure F+ (don’t need to show trivial dependencies). [5 points]
   (2) Given a functional dependency X → Y (where X, Y ⊆ R), how to check whether X → Y ∈ F+ without computing F+. Write down the algorithm. [5 points]
Exercise 3 (Decomposition) [24 points]

Let R(A, B, C, D, E) be decomposed into relations with the following three sets of attributes: {A, B, C}, {B, C, D}, and {A, C, E}. Consider the following sets of functional dependencies:

(a) B → E and CE → A.
(b) AC → E and BC → D.
(c) A → D, D → E, and B → D.
(d) A → D, CD → E, and E → D.

1. For each set of FDs, use the chase test to tell whether the decomposition of R is lossless. For those that are not lossless, give an example of an instance of R that returns more than R when projected onto the decomposed relations and rejoined. [3 points each]

2. For each set of the FDs, are dependencies preserved by the decomposition? Explain why. [3 points each]
Exercise 4 (Functional Dependencies and Normal Forms) [30 points]

Consider the relation schema R(ABCDEF) with functional dependencies AC → B, BD → F, and F → CE.

1. Using Armstrong’s axioms (reflexivity, augmentation, transitivity), show that the given FD’s (functional dependencies) imply that ADF → BCE. For each step, indicate which axiom and other FD’s you’re using. [6 points]

2. List all candidate keys of R. [4 points]

3. Is R in 3NF? If yes, justify. If no, specify at least one FD that violates the definition. [4 points]

4. Suppose we project R onto S(ACDE). Give a minimal cover of FD’s that hold in S. [4 points]

5. Consider the decomposition of R into R₁(AB), R₂(BC), R₃(CD), R₄(DE), R₅(EF).
   i. Show that all these relations are in BCNF by proving a general assertion that any two-attribute relation is in BCNF. [6 points]
   ii. Show that this decomposition is not lossless by constructing an instance of R whose projection onto R₁ to R₅ and subsequent rejoining does not yield the original relation R. [6 points]