CS 455 Principles of Database Systems

Homework 8: Normalization

Name:

Instructions: Print this assignment using single-side pages. Fill in your name above, and write in the solutions in the space provided below each question. You are allowed to use the back of each page. If you used any scratch paper to show your work, append those to the end. **Note:** It is important you use this format for gradescope.

Submission: After you've filled in the answers, scan all pages into a PDF, and submit to canvas.

Problems

1. **[Functional Dependencies]** List all *nontrivial* FDs satisfied by the following relation instance.

Name	**Age**	**City**
Bob	25	$Akron$
Bob	25	$Cleveland$
$Barb$	25	$Akron$
$Barb$	25	$Columbus$

2. **[Closure of Attribute Sets]** Consider a relation $R(A, B, C)$ and the following set of functional dependencies:

$$F = \{A \to B, C \to B\}$$

Consider the following attribute combinations, and find their *attribute closures*. Recall that the closure of a set of attributes γ (written as γ^+) is the set of attributes that can be determined using γ with respect to F. Further indicate if the set of attributes is a superkey by **circling** it. **Double-circle** the candidate key(s). I've done the first one for you.

(a) $\{A\}^+ = \{A, B\}$ (Not a superkey)

(b) $\{B\}^+ =$

(c) $\{C\}^+ =$

(d) $\{A, B\}^+ =$

(e) $\{A, C\}^+ =$

(f) $\{B, C\}^+ =$

(g) $\{A, B, C\}^+ =$

3. **[Inference Rules]** Recall that it is possible to derive new *inference rules* for generating FDs in F^+. For each of the following, show it is either sound through derivation, or unsound by giving a relation instance that satisfies the left-hand side, but contradicts the right-hand side of the implication. You are **required** to use only Armstrong's Axioms for derivation. I'll do the first one for you.

   (a) $\alpha \rightarrow \beta \stackrel{?}{\Longrightarrow} \alpha\gamma \rightarrow \beta$

   $$\begin{array}{rl} \alpha \rightarrow \beta & \text{1. given} \\ \alpha\gamma \rightarrow \beta\gamma & \text{2. augmentation rule: (1) with } \gamma \\ \beta\gamma \rightarrow \beta & \text{3. trivial rule} \\ \alpha\gamma \rightarrow \beta & \text{4. transitivity rule: (2) and (3)} \\ \therefore\ \ \alpha \rightarrow \beta \implies \alpha\gamma \rightarrow \beta & \text{is sound.} \ \blacksquare \end{array}$$

   (b) $\alpha\gamma \rightarrow \beta\delta \stackrel{?}{\Longrightarrow} \alpha \rightarrow \beta, \gamma \rightarrow \delta$

   (c) $\alpha \rightarrow \beta, \gamma \rightarrow \delta \stackrel{?}{\Longrightarrow} \alpha\gamma \rightarrow \beta\delta$

4. **[Normal Forms]** Consider the relation $R(A, B, C, D, E)$. You are given the following functional dependencies. Find all the keys for the relation. What's the highest normal form that R satisfies (choose from 1NF, 2NF, 3NF, or BCNF)? State why.

$$\begin{aligned} F = \{&AD \rightarrow E, \\ &BE \rightarrow C, \\ &C \rightarrow D\} \end{aligned}$$

5. **[Canonical Cover and 3NF]** The relation $R(A, B, C, W, X, Z)$ has the set of functional dependencies,

$$\begin{aligned} F = \{ & A \to B, \\ & C \to WX, \\ & AC \to ZX \} \end{aligned}$$

Split R into a set of relations satisfying 3NF. Clearly show your work to produce the *canonical cover* F_c of F.