

Homework 5: Database Theory

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. List all *nontrivial* functional dependencies (FDs) satisfied by the following relation instance. (5pts)

<i>Name</i>	<i>Age</i>	<i>City</i>
<i>Bob</i>	25	<i>Akron</i>
<i>Bob</i>	25	<i>Cleveland</i>
<i>Barb</i>	25	<i>Akron</i>
<i>Barb</i>	25	<i>Columbus</i>

2. Recall that it is possible to derive new *inference rules* for generating FDs in $FD(R)^+$. 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. You are required to use only Armstrong's Axioms for derivation. I'll do the first one for you. (10pts each)

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

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

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

(c) $\alpha \cup \gamma \rightarrow \beta \stackrel{?}{\implies} \alpha \rightarrow \beta, \gamma \rightarrow \beta$

3. Consider a relation $R(A, B, C, D, E)$. You are given the following functional dependencies. Find all the keys for the relation. In what normal form is relation R ? $AD \twoheadrightarrow E$, $BE \twoheadrightarrow C$, $C \twoheadrightarrow D$

4. Consider the unnormalized *ShmeepleSoft* relation you were given in a previous assignment.
- (a) Verify that you obtain these relations (and their primary keys) after applying the BCNF algorithm. Specifically, identify the set of FDs for the unnormalized relation, as well as its canonical cover FD_c . Then use FD_c for BCNF decomposition. (30pts = 10 for FDs + 10 for cover + 10 for decomposition)

- (b) Even though it is in BCNF, you should find that one of your relations (the one that stores data on course enrollment) still suffers from *anomalies*. Show that this is true by giving examples of the three anomalies. (15pts = 5 per example)

- (c) Speculate over why anomalies still exist in the previous problem even though it is in BCNF, and propose a decomposition that would remove those anomalies. (5pts)