## **CS 455 Principles of Database Systems**

## 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)

| Name | Age | City       |
|------|-----|------------|
| Bob  | 25  | Akron      |
| Bob  | 25  | Clevel and |
| Barb | 25  | Akron      |
| Barb | 25  | Columbus   |

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 <u>sound</u> through derivation, or <u>unsound</u> 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)

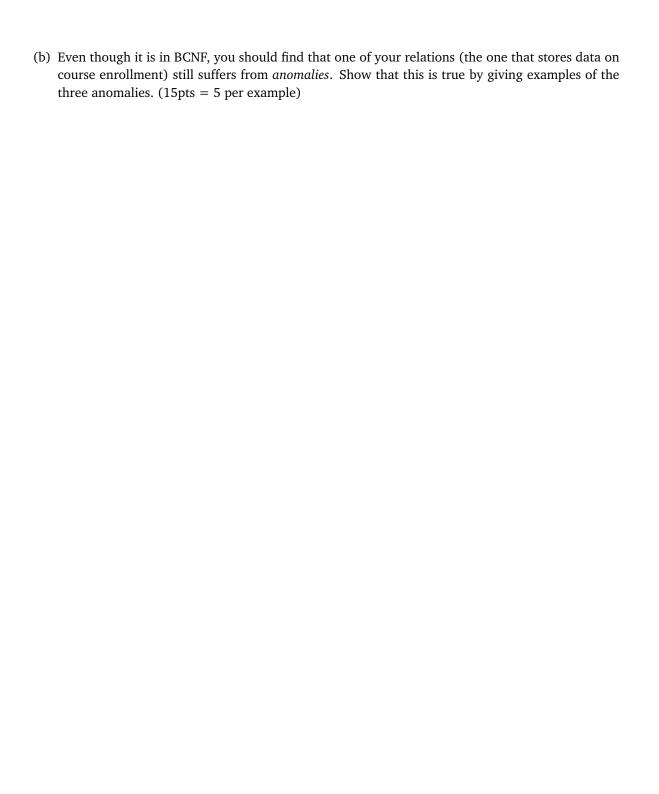
(a) 
$$\alpha \to \beta \stackrel{?}{\Longrightarrow} \alpha \cup \gamma \to \beta$$

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

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

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

- 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)



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(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)