

**DASC 5333 Database Systems for Data Science**  
**CSCI 4333 Design of Database Systems**  
**Spring 2025**  
**Homework #7 Normalization Theory**

[1] (20%) Conduct normalization analysis on RMS (HW #2 and #3) by listing the FDs and the highest normal form of each relation. You must use [h7q1\\_template.docx](#) (which is based on the suggested solution of HW #3). Complete the task by filling in the rows "Normalization Analysis". Rename the file to h7q1.docx.

[2] (10%) Use Armstrong's axioms and rules to prove that

$$F = \{C \rightarrow AD, AC \rightarrow E, BE \rightarrow F, F \rightarrow A\} \mid\text{-} BC \rightarrow F$$

[3] (20%) List the candidate keys and the highest normal forms for the following relations.

- [a]  $R(A,B,C,D) \{B \rightarrow AD, AD \rightarrow C\}$
- [b]  $R(A,B,C,D) \{AB \rightarrow D, BD \rightarrow C\}$
- [c]  $R(A,B,C,D) \{C \rightarrow ABD, AD \rightarrow BC\}$
- [d]  $R(A,B,C,D) \{A \rightarrow B, B \rightarrow A, AC \rightarrow D, AD \rightarrow C\}$

[4] (20%) Consider  $R(A, B, C, D, E)$  with

$$F = \{A \rightarrow C, BD \rightarrow E, D \rightarrow BC, E \rightarrow B, BE \rightarrow C\}$$

- (a) What are  $A^+$ ,  $B^+$ ,  $C^+$ ,  $D^+$  and  $E^+$ ?
- (b) What are the candidate keys?
- (c) Show all prime attributes and non-prime attributes.
- (d) Provide a canonical cover of  $F$ .
- (e) What is the highest normal form (up to BCNF) of  $R$ ? Why?
- (f) If  $R$  is not in BCNF, provide a lossless FD preserving decompositions of  $R$  into BCNF relations?

[5] (25%) Consider the relation StudentDormMeal with the following attributes. stuId, stulname, dormName, dormRoom, dormFee, mealPlan, planFee, semester. The relation stores information about students being assigned to rooms in dorms.

stuId	stulname	dormName	dormRoom	dormFee	mealPlan	planFee	semester
S1	Lee	Hunter	101	2500	P1	600	Fall 2024
S2	Smith	Hunter	101	2500	P2	750	Fall 2024
S3	Black	Hunter	102	3500	P1	600	Fall 2024
S1	Lee	Hunter	101	2600	P1	600	Spring 2025
S5	Johnson	Forest	101	1800	P2	800	Spring 2025

For example, the first two rows indicate that S1 (lname: Lee) and S2 (lname: Smith) are roommates assigned to room 101 of the Hunter dorm in Fall 2024. Their dorm fees must be the same in that semester as they live in the same room of the same dorm: \$2,500. They have different meal plans, which cost differently. Plan P1 costs \$600 and P2 costs \$750 in Fall 2024. The third row stores the information of S3 assigned to a single occupancy room: Hunter 102. Row 4 shows S1 assigned to Hunter 101 with meal plan P1. The dormFee is different in Spring 2025 (blame inflation). Fortunately, the meal plan P1 costs the same in Spring 2025. Row 5 shows an assignment to a different dorm, Forest. Note that the student Johnson needs to pay \$800 for meal plan P2 in Spring 2025.

- List all applicable functional dependencies. (Make reasonable assumptions if necessary.)
- What are the candidate keys?
- What is the highest normal form? Why?
- If the highest normal form is not BCNF, can the relation Employee be decomposed losslessly into component relations in BCNF while preserving functional dependencies? If yes, how? If not, why?

[6] (5%) It is known that the relation  $R(A,B,C,D,E)$  has exactly two candidate keys. Furthermore, one of the candidate keys is known to be AB. What are the maximum and minimum number of superkeys R may have?

Your solution filename for questions 2 to 6 should be h7.docx. Submit your homework (h7q1.docx and h7.docx) through Canvas.