

**Name:** \_\_\_\_\_

- COS 480 students should answer non-\* questions; optional \* questions are for extra credit.
- COS 580 students should answer all questions, including \* questions.

1. (1 pt.) Write your name in the space provided above.
2. (9 pts.) List *all* keys of the relation  $R(A, B, C, D, E, F)$  given the functional dependencies:

$$AB \rightarrow C \quad (1)$$

$$C \rightarrow B \quad (2)$$

$$ADE \rightarrow C \quad (3)$$

$$EF \rightarrow AD \quad (4)$$

$$CE \rightarrow F \quad (5)$$

Justify your answer by explaining why the listed attribute-sets are keys and why there are no other keys.

3. (20 pts.) Decompose the relation  $R$  of Question 2 as needed to yield a BCNF schema. Clearly show all intermediate steps, including details such as the dependency used to decompose a relation, the resulting relations, their projected dependencies, and their keys.

[additional space for answering the earlier question]

4. (10 pts.) Use the *chase test* to determine whether the decomposition of the relation  $R$  from the schema of Question 2 into  $R_1(A, B, C)$ ,  $R_2(A, C, E)$ ,  $R_3(B, D, E)$ , and  $R_4(A, B, F)$  is lossless. Clearly indicate the operations on the tableau and the dependency used for each operation.

5. (10 pts.) Use the *chase test* to prove or disprove each of the following for a relation  $S(A, B, C, D, E, F)$ . Clearly indicate the operations on the tableau and the dependency used for each operation.

(a) If  $AB \twoheadrightarrow CD$  then  $AB \twoheadrightarrow EF$ .

(b) If  $AB \twoheadrightarrow C$  and  $AC \twoheadrightarrow B$  then  $BC \twoheadrightarrow A$ .

[additional space for answering the earlier question]

6. (10 pts.) Provide algebra and Datalog equivalents of the following SQL query on a database with relations  $T(A, B, C)$  and  $U(B, D, E, F)$ , or prove that no equivalents exist. (Assume that the types of all attributes used in comparison predicates are compatible.)

```
select T1.A, T2.A, U.E, U.F
from T T1, T T2, U
where T1.B = U.B and T2.B = some (
    select E from U where F < T1.B)
```

7. ★ (20 pts.) Prove or disprove: There exists a relational algebra expression that uses no operators other than  $\sigma$ ,  $\pi$ ,  $\times$ ,  $\cup$ ,  $-$ ,  $\rho$  that is equivalent to the SQL query

```
select A, B
from R
where B = (select min(B) from R where C > 20)
```

To prove, you must provide an algebra expression and prove its equivalence to the SQL query. To disprove, you must clearly articulate why no such expression is possible.



[additional space for answering the earlier question]