

Question 1: Functional Dependencies I [15 points]

Consider the following legal instance of a relational schema S with attributes XYZ :

| S | X | Y | Z |
|---|-----|----|---|
| | m | 20 | T |
| | m | 10 | F |
| | o | 30 | T |
| | n | 30 | T |
| | o | 20 | T |

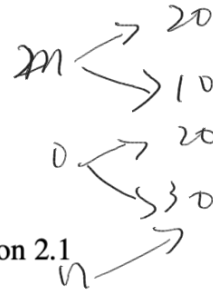
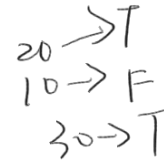


Table 1: Legal instance of schema S for question 2.1

(a) Which of the following dependencies are *violated* by the instances of S in Table 1?

- i. [2 points] ☒ Yes ☐ No : $X \rightarrow Y$ is violated.
- ii. [2 points] ☒ Yes ☐ No : $Z \rightarrow X$ is violated.
- iii. [2 points] ☐ Yes ☒ No : $Y \rightarrow Z$ is violated.
- iv. [2 points] ☐ Yes ☒ No : $XY \rightarrow Z$ is violated.
- v. [2 points] ☒ Yes ☐ No : $YZ \rightarrow X$ is violated.
- vi. [2 points] ☒ Yes ☐ No : $XZ \rightarrow Y$ is violated.



(b) [3 points] By only observing the instance of S in Table 1, can you identify the functional dependencies that hold on schema S ? Why?

☐ Yes ☒ No

不能，因为我们只能看到实例而不能看到属性

Question 2: Functional Dependencies II [32 points]

For the next set of questions consider the relational schema $\mathcal{R} = \{P, Q, R, S, T, U, V, W\}$ and the set of functional dependencies FD:

- $Q \rightarrow U, U \rightarrow V, R \rightarrow W$
 $VT \rightarrow RW \rightarrow RW$
 $SU \rightarrow T \Rightarrow SU \rightarrow VT$
 $\Rightarrow SU \rightarrow RW \Rightarrow SU \rightarrow RTW$
- | | | |
|----------------------|----------------------|-----|
| $Q \rightarrow U$ | $PQ \rightarrow S$ | (1) |
| $U \rightarrow V$ | $PQ \rightarrow SU$ | (2) |
| $PQ \rightarrow WST$ | $PQ \rightarrow TR$ | (3) |
| $SU \rightarrow TR$ | $PQ \rightarrow RW$ | (4) |
| $VT \rightarrow RW$ | $PQ \rightarrow WST$ | (5) |
| | | (6) |

(a) [8 points] Which of the following is a minimum cover of the FD? Mark all that qualify; if none, mark accordingly, and give your own. answer.

- The given FDs (Eq 1-6), is a minimum cover already.
- $\{Q \rightarrow U, U \rightarrow V, PQ \rightarrow S, SU \rightarrow T, SU \rightarrow R, VT \rightarrow R, VT \rightarrow W, R \rightarrow W\}$
- $\{Q \rightarrow U, U \rightarrow V, PQ \rightarrow S, SU \rightarrow T, PQ \rightarrow W, VT \rightarrow R, PQ \rightarrow T, R \rightarrow W\}$
- $\{Q \rightarrow U, U \rightarrow V, PQ \rightarrow S, SU \rightarrow T, VT \rightarrow R, R \rightarrow W\}$
- $\{Q \rightarrow U, U \rightarrow V, PQ \rightarrow S, SU \rightarrow T, SU \rightarrow R, VT \rightarrow R, PQ \rightarrow T, R \rightarrow W\}$
- none of the above - the cover is _____

(b) Yes/No: Which of the following functional dependencies can be deduced, from the above set of functional dependencies (Eq. (1)-(6))?

- [3 points] ☒ Yes ☐ No : $Q \rightarrow V$
- [3 points] ☐ Yes ☒ No : $QU \rightarrow R$
- [3 points] ☒ Yes ☐ No : $SQ \rightarrow T$
- [3 points] ☒ Yes ☐ No : $SQ \rightarrow W$
- [3 points] ☒ Yes ☐ No : $PQ \rightarrow R$
- [3 points] ☐ Yes ☒ No : $VT \rightarrow Q$

$$Q \rightarrow U, Q \rightarrow V$$

(c) [3 points] True or False: The attribute closure $\{Q\}^+$ is $\{Q, U, V\}$.

☒ True ☐ False

(d) [3 points] True or False: The attribute closure $\{PQ\}^+$ is $\{P, Q, W, S, T\}$.

☐ True ☒ False

$$\begin{aligned}
 PQ &\rightarrow R & PQ &\rightarrow V \\
 PQ &\rightarrow Q & PQ &\rightarrow W \\
 PQ &\rightarrow Q \\
 PQ &\rightarrow W \\
 PQ &\rightarrow S \\
 PQ &\rightarrow T
 \end{aligned}$$

Question 3: Decompositions.....[20 points]

For this set of questions, consider the relation with attributes, $\mathcal{X} = \{A, B, C, D, E, F\}$, Let the following functional dependencies FD be defined over the relation \mathcal{X} :

$$A \rightarrow B$$

$$B \rightarrow CD$$

$$E \rightarrow F$$

$$\{AB\}^+ = \{A, B, C, D\}$$

- (a) [2 points] Provide the attribute closure of $\{AB\}$.
- (b) Consider the decomposition AB, BCD, EF . Mark 'True' or 'False':
- [3 points] ☐ True ☒ False : It is lossless
 - [3 points] ☒ True ☐ False : It is dependency-preserving
- (c) Consider the decomposition $AB, BCDF, EF$. Mark 'True' or 'False':
- [3 points] ☐ True ☒ False : It is lossless
 - [3 points] ☒ True ☐ False : It is dependency-preserving
- (d) Consider the decomposition $ABCEF, EBD$. Mark 'True' or 'False':
- [3 points] ☒ True ☐ False : It is lossless
 - [3 points] ☒ True ☐ False : It is dependency-preserving

$$(b) U_1 = AB : A \rightarrow B, \quad U_2 = BCD : B \rightarrow CD$$

$$U_3 = EF, \quad E \rightarrow F$$

| | A | B | C | D | E | F |
|--------------------|----------|----------|----------|----------|----------|----------|
| $A \rightarrow B$ | a_1 | a_2 | a_3 | a_4 | b_{15} | b_{16} |
| $B \rightarrow CD$ | b_{21} | a_2 | a_3 | a_4 | b_{25} | b_{26} |
| $E \rightarrow F$ | b_{31} | b_{32} | b_{33} | b_{34} | a_5 | a_6 |

✗ 不是无损

(c)

$$A \rightarrow B$$

$$B \rightarrow CD$$

$$E \rightarrow F$$

Question 4: Normal Forms.....[33 points]

Consider the relation with attributes, $\mathcal{E} = \{P, Q, R, S\}$. Suppose that the following functional dependencies hold:

$$PQ \rightarrow R \quad (7)$$

$$PQ \rightarrow S \quad (8)$$

$$R \rightarrow P \quad (9)$$

$$S \rightarrow Q \quad (10)$$

(a) [6 points] List *all* the candidate key(s) for \mathcal{E} .

$\{PQ\}$ 、 $\{RS\}$ 、 $\{PS\}$ 、 $\{QR\}$

(b) [2 points] Is the relation \mathcal{E} in BCNF? ☐ Yes ☒ No

(8) (10)

(c) From the list below, select all applicable choices to justify whether \mathcal{E} is (or is not) in BCNF.

Note: when we refer to the *main requirement* for BCNF, we mean: *every determinant is a super key*.

i. [1 point] ☐ True ☒ False : All FD's satisfy the main requirement.

ii. [1 point] ☐ True ☒ False : FD (7) violates the main requirement.

iii. [1 point] ☐ True ☒ False : FD (8) violates the main requirement.

iv. [1 point] ☒ True ☐ False : FD (9) violates the main requirement.

v. [1 point] ☒ True ☐ False : FD (10) violates the main requirement.

(d) [2 points] Is the relation \mathcal{E} in 3NF? ☒ Yes ☐ No

都是主属性

(e) From the list below, select all applicable choices to justify whether \mathcal{E} is (or is not) in 3NF.

Note: when we refer to the *secondary requirement* for 3NF, we mean: *for every FD $X \rightarrow A$, A is part of a candidate key*.

i. [1 point] ☒ True ☐ False : All FD's satisfy the secondary requirement.

ii. [1 point] ☐ True ☒ False : FD (7) violates the secondary requirement.

iii. [1 point] ☐ True ☒ False : FD (8) violates the secondary requirement.

iv. [1 point] ☐ True ☒ False : FD (9) violates the secondary requirement.

v. [1 point] ☐ True ☒ False : FD (10) violates the secondary requirement.

(f) [5 points] Give a 3NF decomposition of \mathcal{E} that is lossless, dependency preserving, and has as few tables as possible.

(g) [8 points] Give a BCNF decomposition of \mathcal{E} that is lossless, and has as few tables as possible.

$$(f) \quad F = \{ PQ \rightarrow R, PQ \rightarrow S, R \rightarrow P, S \rightarrow Q \}$$

$$\text{最小依赖集} \quad \{ P \rightarrow S, Q \rightarrow R, R \rightarrow P, S \rightarrow Q \}$$

$$\{ PS \}, \{ QR \}, \{ RP \}, \{ SQ \}$$

$$\Rightarrow \mathcal{E} = (P, S, R, Q) \quad \text{全是主属性}$$

$$(g) \quad R_1(R, P) \quad \text{in BCNF} \quad \mathcal{D}$$

$$R_2(R, Q, S)$$

$\Rightarrow R_3(S, Q)$ in BCNF ②

$R_4(R, S)$ in BCNF ③.

$\Rightarrow \{RP, SQ, RS\}$