

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

因为只知道关系的一个实例不能推断出关系模式的函数依赖

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:

$$Q \rightarrow U \quad (1)$$

$$U \rightarrow V \quad (2)$$

$$PQ \rightarrow WST \quad (3)$$

$$SU \rightarrow TR \quad (4)$$

$$VT \rightarrow RW \quad (5)$$

$$R \rightarrow W \quad (6)$$

(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.

i. The given FDs (Eq 1-6), is a minimum cover already.

ii. $\{Q \rightarrow U, U \rightarrow V, PQ \rightarrow S, SU \rightarrow T, SU \rightarrow R, VT \rightarrow R, VT \rightarrow W, R \rightarrow W\}$

iii. $\{Q \rightarrow U, U \rightarrow V, PQ \rightarrow S, SU \rightarrow T, PQ \rightarrow W, VT \rightarrow R, PQ \rightarrow T, R \rightarrow W\}$

✓ iv. $\{Q \rightarrow U, U \rightarrow V, PQ \rightarrow S, SU \rightarrow T, VT \rightarrow R, R \rightarrow W\}$

v. $\{Q \rightarrow U, U \rightarrow V, PQ \rightarrow S, SU \rightarrow T, SU \rightarrow R, VT \rightarrow R, PQ \rightarrow T, R \rightarrow W\}$

vi. 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))?

i. [3 points] ☒ Yes ☐ No : $Q \rightarrow V$

ii. [3 points] ☐ Yes ☒ No : $QU \rightarrow R$

iii. [3 points] ☒ Yes ☐ No : $SQ \rightarrow T$

iv. [3 points] ☒ Yes ☐ No : $SQ \rightarrow W$

v. [3 points] ☒ Yes ☐ No : $PQ \rightarrow R$

vi. [3 points] ☐ Yes ☒ No : $VT \rightarrow Q$

(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

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} :

$$A \rightarrow B$$

$$B \rightarrow CD$$

$$E \rightarrow F$$

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

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} . $\{P, Q\} \quad \{R, S\} \quad \{R, Q\} \quad \{P, S\}$

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

(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

(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.

$\{P, Q, R, S\}$

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

$\{R, P\} \quad \{S, Q\} \quad \{S, R\}$