CS2102 Database Systems

Semester 1 2019/2020

Assignment 04 (Possible Answers Bolded)

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REMINDER: *The choices on Examplify may be randomized.*

1 Questions

Question 1. [0.5 marks]

Consider a relation schema $R(A, B, C, D, E)$ with functional dependencies $F = \{AB \rightarrow CDE,\ AC \rightarrow DE,\ CD \rightarrow AE,\ BE \rightarrow D\}$.

Which of the following are parts of the prime attributes of R with respect to F?

- **A.** $\boldsymbol{A}$
- **B.** $\boldsymbol{B}$
- **C.** $\boldsymbol{C}$
- **D.** $\boldsymbol{D}$
- **E.** $\boldsymbol{E}$

Question 2. [0.5 marks]

Consider a relation schema $R(A, B, C, D, E)$ with functional dependencies $F = \{AB \rightarrow CDE,\ AC \rightarrow DE,\ CD \rightarrow AE,\ BE \rightarrow D\}$.

Write down all the keys of R. You simply need to write the attributes (in uppercase) of each key. For instance, if attributes A and C is one possible key of R, you simply write AC.

You may leave any spot blank if you feel that there are fewer than 3 keys.

The set of keys are $\{\{\boldsymbol{A}, \boldsymbol{B}\},\ \{\boldsymbol{B}, \boldsymbol{C}, \boldsymbol{D}\},\ \{\boldsymbol{B}, \boldsymbol{C}, \boldsymbol{E}\}\}$.

Question 3. [0.5 marks]

Consider a relation schema $R(A, B, C, D, E)$ with functional dependencies $F = \{AB \rightarrow CDE,\ AC \rightarrow DE,\ CD \rightarrow AE,\ BE \rightarrow D\}$.

Which of the following set of functional dependencies is/are possible minimal covers of F? Note that if G is a minimal cover of F, then $G \equiv F$ and G contains no redundancies.

- A. $\{AB \rightarrow C,\ AB \rightarrow D,\ AB \rightarrow E,\ BE \rightarrow D,\ CD \rightarrow A\}$
- **B.** $\{\boldsymbol{AB \rightarrow C},\ \boldsymbol{AC \rightarrow D},\ \boldsymbol{AC \rightarrow E},\ \boldsymbol{BE \rightarrow D},\ \boldsymbol{CD \rightarrow A}\}$
- **C.** $\{\boldsymbol{AB \rightarrow C},\ \boldsymbol{AC \rightarrow D},\ \boldsymbol{BE \rightarrow D},\ \boldsymbol{CD \rightarrow A},\ \boldsymbol{CD \rightarrow E}\}$
- D. $\{AB \rightarrow C,\ AC \rightarrow D,\ AC \rightarrow E,\ BE \rightarrow D\}$
- E. $\{AB \rightarrow C,\ AC \rightarrow D,\ BE \rightarrow D,\ CD \rightarrow A\}$

Question 4. [0.5 marks]

Consider a relation schema $R(A, B, C, D, E)$ with functional dependencies $F = \{AB \rightarrow CDE,\ AC \rightarrow DE,\ CD \rightarrow AE,\ BE \rightarrow D\}$.

Select all functional dependencies in F^+ that violates the BCNF property of R.

- A. $AB \rightarrow E$
- **B.** $\boldsymbol{AC \rightarrow D}$
- **C.** $\boldsymbol{ACD \rightarrow E}$
- **D.** $\boldsymbol{ACE \rightarrow D}$
- **E.** $\boldsymbol{CDE \rightarrow A}$

Question 5. [1 mark]

Consider a relation schema $R(A, B, C, D, E)$ with functional dependencies $F = \{AB \rightarrow CDE,\ AC \rightarrow DE,\ CD \rightarrow AE,\ BE \rightarrow D\}$.

Select a minimal set of fragments below such that:

- Each fragment is in BCNF
- The decomposition formed from all the fragments chosen is a lossless-join decomposition
- The decomposition formed from all the fragments chosen is a dependency-preserving decomposition

The minimal set is a set such that removing any one of the choices will not satisfy the above-mentioned conditions.

A. $\boldsymbol{R_1(A, C, D)}$
B. $\boldsymbol{R_2(A, B, C)}$
C. $\boldsymbol{R_3(A, C, E)}$
D. $\boldsymbol{R_4(B, D, E)}$
E. $R_5(A, B, E)$

Question 6. [1 mark]

Consider a relation schema $R(A, B, C, D, E)$ with functional dependencies $F = \{AB \rightarrow CDE,\ AC \rightarrow DE,\ CD \rightarrow AE,\ BE \rightarrow D\}$.

Using any minimal cover obtainable from Algorithm #2, find one possible lossless-join and dependency-preserving 3NF decomposition of R using Algorithm #7. You are limited to only up to three relations in this decomposition.

$R_1(\boldsymbol{A, B, C})$, $R_2(\boldsymbol{B, D, E})$, $R_3(\boldsymbol{A, C, D, E})$

Question 7. [2 marks]

Consider a relation schema $R(A, B, C, D, E)$ with functional dependencies $F = \{AB \rightarrow D,\ A \rightarrow BC,\ B \rightarrow C,\ BE \rightarrow D\}$.

We consider BCNF to be better than 3NF. Consider a lossless-join and dependency-preserving decomposition that minimizes redundancies using only either Algorithm #6 for BCNF decomposition or Algorithm #7 (and Algorithm #2 for the minimal cover) for 3NF decomposition. Find the *best lossless-join and dependency-preserving decomposition* achievable by R given F. You are limited to only up to four relations in this decomposition.

The best decomposition is (fill in either BCNF or 3NF) [**BCNF**].

The decompositions are $\{R_1(\boldsymbol{A, E}),\ R_2(\boldsymbol{B, D, E}),\ R_3(\boldsymbol{A, B, D}),\ R_4(\boldsymbol{B, C})\}$.

Steps:

$BDE \rightarrow C$ violates $R(A, B, C, D, E)$ $\Rightarrow \{R_1(B, C, D, E),\ R_2(A, B, D, E)\}$

$B \rightarrow C$ violates $R_1(B, C, D, E)$ $\Rightarrow \{R_2(A, B, D, E),\ R_3(B, C),\ R_4(B, D, E)\}$

$A \rightarrow BD$ violates $R_2(A, B, D, E)$ $\Rightarrow \{R_3(B, C),\ R_4(B, D, E),\ R_5(A, B, D),\ R_6(A, E)\}$

*** The same as answer up to renaming*

Question 8. [1 mark]

Consider a relation schema $R(A, B, C, D, E)$ with functional dependencies $F = \{AB \rightarrow D,\ A \rightarrow BC,\ B \rightarrow C,\ BE \rightarrow D\}$.

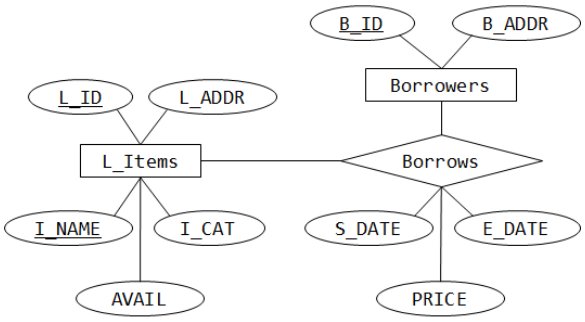
Using Armstrong's axioms, fill in the steps to show that $F \vDash AE \rightarrow ABCDE$. You are limited to only up to five steps in the proof *<u>including</u>* the use of `[Given]` if necessary.

```
A -> BC          [Given]
BE -> D          [Given]
```

```
AE -> ABCE      [Augmentation (1) with AE]
ABCE -> ABCDE   [Augmentation (2) with ABCE]
AE -> ABCDE     [Transitivity (3) and (4)]
```

Question 9. [1 mark]

Consider only the problem description attached. Given the following ER diagram, select all the statements that are true.



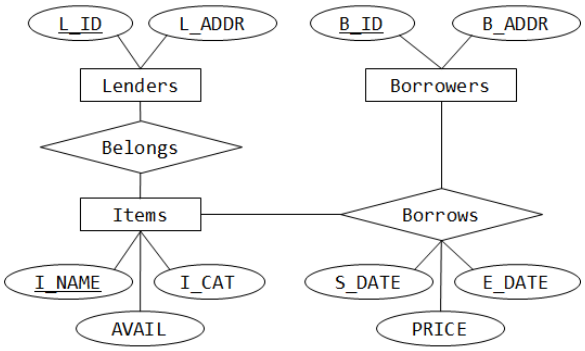
A. **The decomposition of ALL_STUFF into $\{L\_Items,\ Borrowers,\ Borrows\}$ is a lossless-join decomposition**
B. **The decomposition of ALL_STUFF into $\{L\_Items,\ Borrowers,\ Borrows\}$ is a dependency-preserving decomposition**
C. The decomposition of ALL_STUFF into $\{L\_Items,\ Borrowers,\ Borrows\}$ is in BCNF
D. The decomposition of ALL_STUFF into $\{L\_Items,\ Borrowers,\ Borrows\}$ is in 3NF
E. None of the above statement is true

Question 10. [0.5 mark]

Consider only the problem description attached. Select all the ER diagrams (*in which entity-sets and relationship sets is a decomposition*) that are lossless-join decompositions of ALL_STUFF.

In particular, we are only interested in the constraints related to functional dependencies (i.e., we ignore key constraints and total participation constraints).

A.



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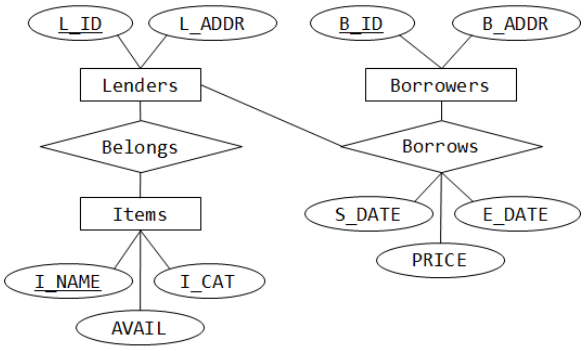

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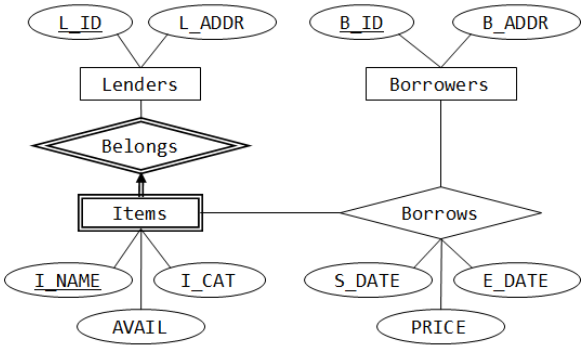
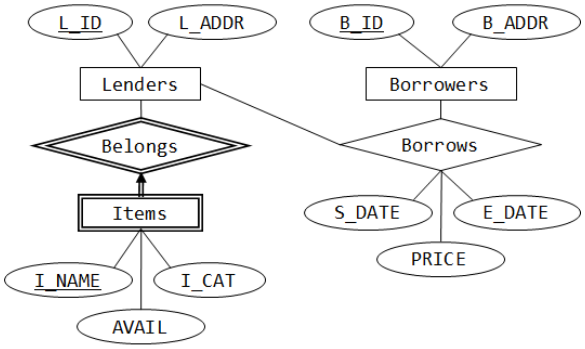
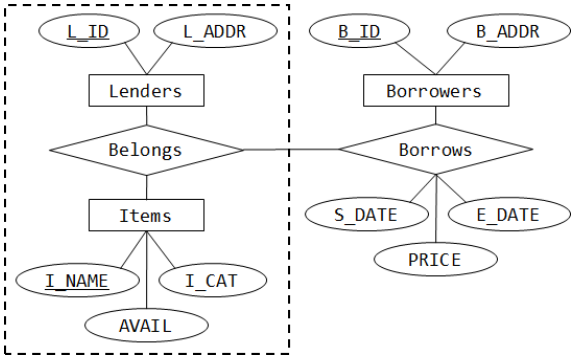


D.



E.



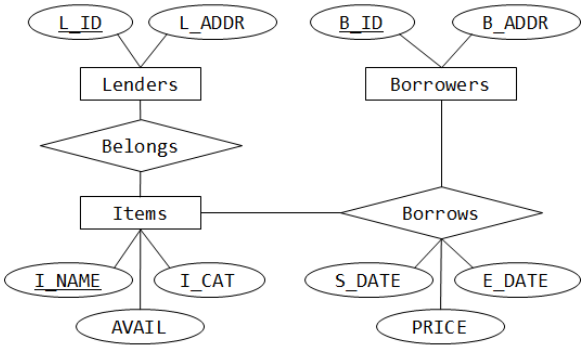
ANS: C

Question 11. [0.5 mark]

Consider only the problem description attached. Select all the ER diagrams (*in which entity-sets and relationship sets is a decomposition*) that are dependency-preserving decompositions of ALL_STUFF.

In particular, we are only interested in the constraints related to functional dependencies (i.e., we ignore key constraints and total participation constraints).

A.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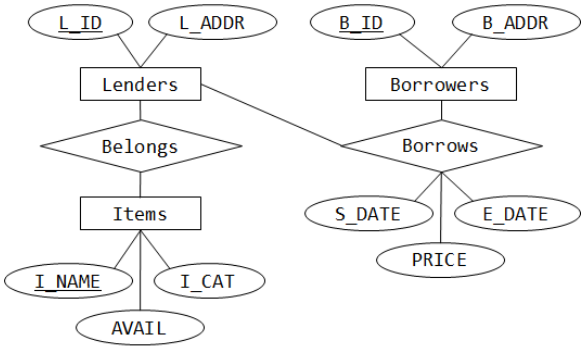
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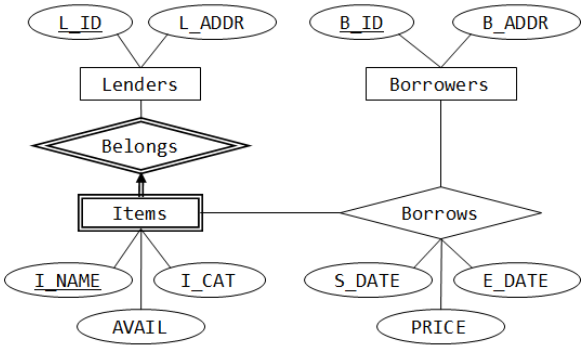
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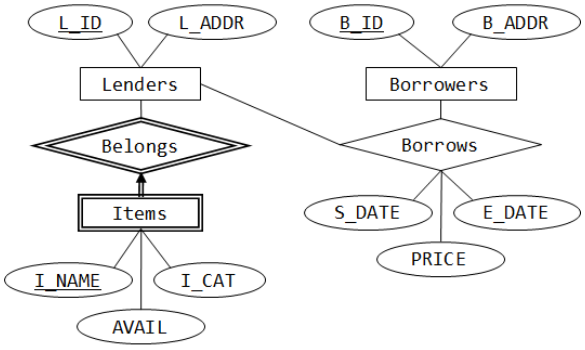
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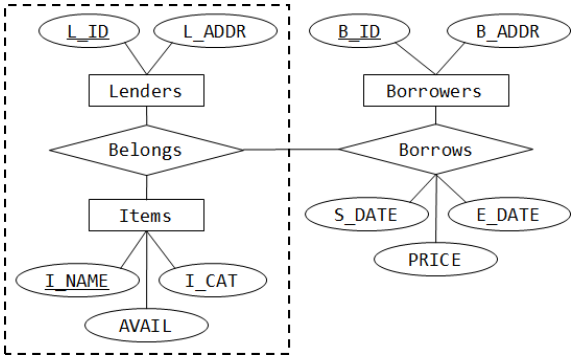
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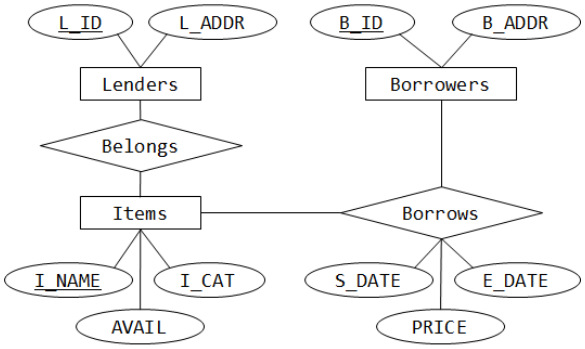
ANS: C

Question 12. [1 mark]

Consider only the problem description attached. Select all the ER diagrams (*in which entity-sets and relationship sets is a decomposition*) that are in BCNF of ALL_STUFF. We are only interested in whether or not the decompositions (i.e., ER diagrams) are in BCNF, they may or may not be lossless-join and/or dependency-preserving decompositions.

In particular, we are only interested in the constraints related to functional dependencies (i.e., we ignore key constraints and total participation constraints).

A.



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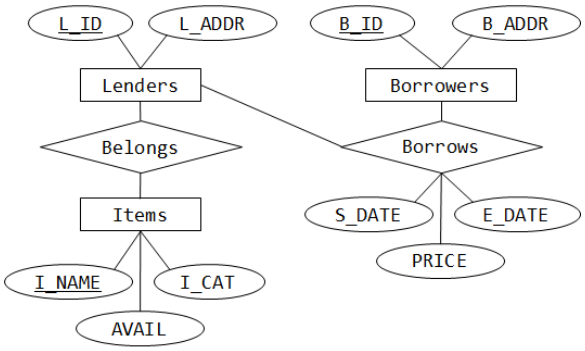
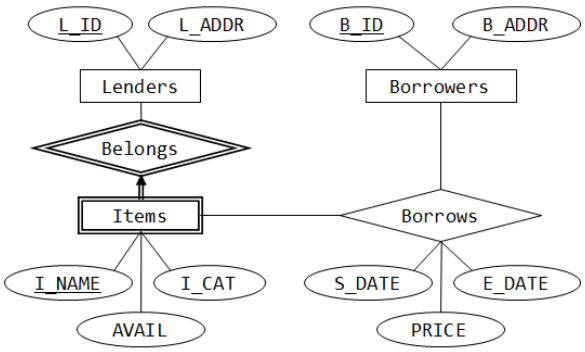
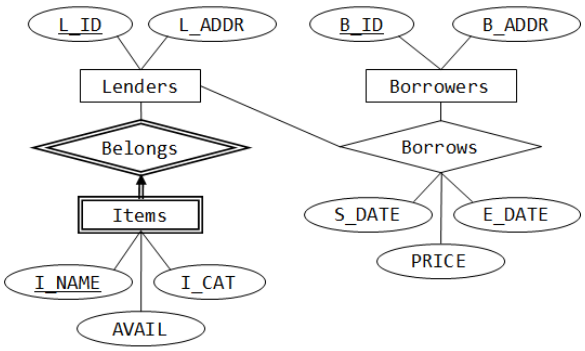


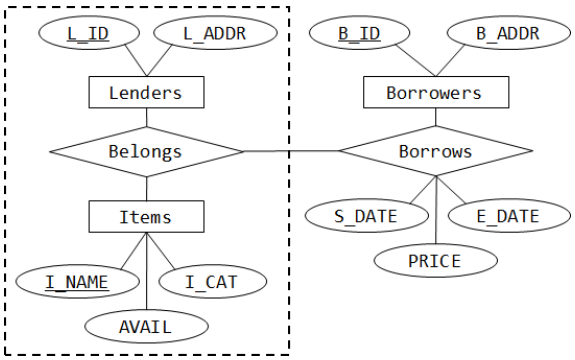
C.



D.



E.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