

All questions are to be answered. You are encouraged to use the tools at <https://www.comp.nus.edu.sg/~adi-yoga/CS2102/FD/> to simplify your work. Note that the questions on final exams will be easier due to the absence of the tool.

Please submit your answer on LumiNUS quiz. You are only allowed one submission but without any time limit.

1. [0.5 Mark] Prime Attributes

To start your assignment 2, let's begin with something simple. Given a schema $R(A, B, C, D, E)$ find the prime attributes given the set of functional dependencies below:

$$\{\{A,D\} \rightarrow \{C,D\}, \{B,C\} \rightarrow \{A,C\}, \{C,E\} \rightarrow \{A,B\}, \{C,D\} \rightarrow \{D,E\}\}$$

Select all the prime attributes of R with respect to the set of functional dependencies above.

2. [1 Mark] Inference

You started a work at an IT company COM2. They have a database DB with a table $R(A, B, C, D, E)$. Unfortunately, the way the database created was lost. What you know is only that the **key** of R are: $\{A,B\}$, $\{B,C\}$, $\{C,D\}$, $\{D,E\}$, and $\{A,E\}$.

There are a few set of functional dependencies that satisfies this conditions. You know that the following functional dependencies are valid in the database:

- | | | |
|--------------------------------|---------------------------------|---------------------------------|
| 1. $\{A,B\} \rightarrow \{C\}$ | 6. $\{B,C\} \rightarrow \{A\}$ | 11. $\{D,E\} \rightarrow \{B\}$ |
| 2. $\{A,B\} \rightarrow \{D\}$ | 7. $\{C,D\} \rightarrow \{E\}$ | 12. $\{D,E\} \rightarrow \{C\}$ |
| 3. $\{A,B\} \rightarrow \{E\}$ | 8. $\{C,D\} \rightarrow \{A\}$ | 13. $\{A,E\} \rightarrow \{B\}$ |
| 4. $\{B,C\} \rightarrow \{D\}$ | 9. $\{C,D\} \rightarrow \{B\}$ | 14. $\{A,E\} \rightarrow \{C\}$ |
| 5. $\{B,C\} \rightarrow \{E\}$ | 10. $\{D,E\} \rightarrow \{A\}$ | 15. $\{A,E\} \rightarrow \{D\}$ |

Select **exactly five (5)** functional dependencies that will form a set of functional dependencies such that the schema R has exactly the **key** above. Note that there can be more than one possible answers. Obviously, if you choose all, it will definitely be correct by definition of **key**, but you can only choose exactly five.

3. [1 Mark] Finding Functional Dependencies

This question relates the concept of functional dependencies with ER diagram and database schema. In this question, you may ignore the NULL value from your analysis.

(a) Consider the following ER diagram:

We know that the attribute **b1** uniquely identifies the attribute **b2**. As such, we can write the following functional dependency: $\{b1\} \rightarrow \{b2\}$.

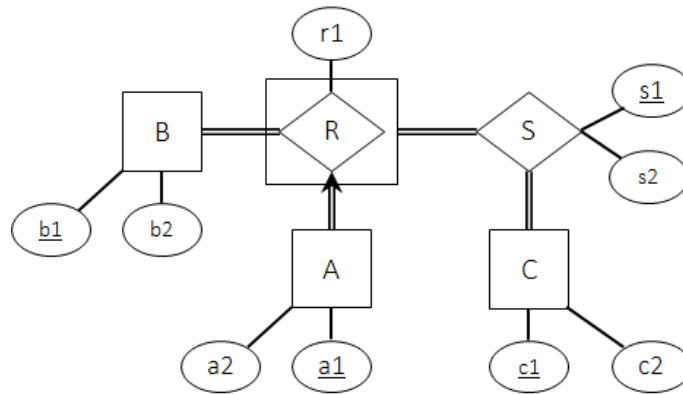


Figure 1: ER Diagram

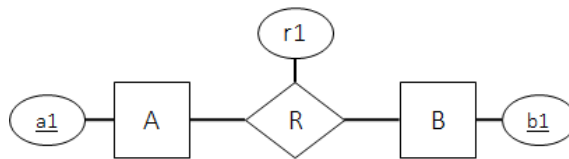


Figure 2: Relationship Set

Remember that by definition of functional dependency $A \rightarrow B$, we only care when the value of the attributes A are the same and when the values actually exists in the table. As such, given the following ER diagram: the following functional dependency is valid: $\{a1, b1\} \rightarrow \{r1\}$.

First, find all the functional dependencies that are valid based on the ER diagram. Your task is to find a **key** of the entire ER diagram. In other words, find a set of attributes A such that:

$$A \rightarrow \{a1, a2, b1, b2, c1, c2, r1, s1, s2\}$$

Remember that for the set of attributes A to be a key, there must not be another set of attributes B where $B \subset A$ and B is a superkey.

Select **ALL** the attributes that makes up A .

- (b) Consider the following relational schema which has no connection with the previous question:

```

1 CREATE TABLE A (
2   a1  INTEGER PRIMARY KEY,
3   a2  INTEGER NOT NULL
4 );
5 CREATE TABLE B (
6   b1  INTEGER PRIMARY KEY,
7   b2  INTEGER NOT NULL,
8   a1  INTEGER NOT NULL REFERENCES A
9 );
10 CREATE TABLE C (
11   c1  INTEGER PRIMARY KEY,
12   c2  INTEGER UNIQUE NOT NULL,
13   b1  INTEGER NOT NULL REFERENCES B,

```

```

14 );
15 CREATE TABLE D (
16     c1 INTEGER PRIMARY KEY REFERENCES C,
17     d2 INTEGER NOT NULL,
18 );

```

Your task is to find a **key** of the entire database schema. In other words, find a set of attributes A such that:

$$A \rightarrow \{a1, a2, b1, b2, c1, c2, d1, d2\}$$

Remember that for the set of attributes A to be a key, there must not be another set of attributes B where $B \subset A$ and B is a superkey.

Select **ALL** the attributes that makes up A .

4. [2.5 Marks] Normal Forms

We have learnt two normal forms in Lecture¹. We will try to use the concepts learnt.

For this question, we will use the following schema $R(A, B, C, D, E)$ with the following set of functional dependencies:

$$\{\{A, B, D\} \rightarrow \{E\}, \{A, C, E\} \rightarrow \{A, D\}, \{B, D\} \rightarrow \{E\}, \{C, D\} \rightarrow \{B, E\}, \{C, E\} \rightarrow \{B, D\}\}$$

- (a) Find all the keys of R . You do not have to show your step. Write the answer in the following format:

$$\{A, B, C, D\}, \{B, C, D, E\}, \{C, D, E, A\}$$

- (b) Find a lossless-join BCNF decomposition of R . You do not have to show your step. Write the answer in the following format:

$$\{R1(A, B, C, D), R2(B, C, D, E), R3(C, D, E, A)\}$$

- (c) Find a minimal basis of the set of functional dependencies. You do not have to show your step. Write the answer in the following format:

$$\{A, B, C\} \rightarrow \{C, D, E\}, \{B, C, D\} \rightarrow \{D, E, A\}, \{C, D, E\} \rightarrow \{E, A, B\}$$

- (d) Using the minimal basis you computed in part (c), find a lossless-join and dependency-preserving 3NF decomposition of R . Note that you have to first ensure that your answer to part (c) is a minimal basis first. Write the answer in the same format as part (b).
- (e) Is there a lossless-join and dependency-preserving BCNF decomposition of R ? If **yes**, write the lossless-join and dependency-preserving BCNF decomposition of R in the same format as (d). Otherwise, briefly explain the reason why you think that there is no such decomposition.

¹Well, one of them is still not completed as of the release of this assignment