

### **Experiment – 1.4**

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**Semester:** 5<sup>th</sup>

**Subject Name:** ADBMS

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**Section/Group:** KRG-1-B

**Date:** 09-09-25

**Subject Code:** 23CSP-333

**Aim:** To analyze given relations with functional dependencies, determine candidate keys, classify prime and non-prime attributes, remove redundant dependencies, and identify the highest normal form of the relation schemas.

**Objective:** The objective of this work is to analyze functional dependencies in given relations to determine candidate keys and classify attributes as prime or non-prime. It also focuses on minimizing functional dependencies by removing redundancy and evaluating the highest normal form achieved by each relation.

**Q1:**

For relation  $R(A,B,C,D)$  with FDs  $\{AB \rightarrow C, C \rightarrow D, D \rightarrow A\}$ , find candidate keys, prime and non-prime attributes. Also state the highest normal form.

**Dependencies:**  $AB \rightarrow C, C \rightarrow D, D \rightarrow A$

**Solution:**

- Candidate Keys: **AB, BC, BD**
- Prime Attributes: **A, B, C, D**
- Non-Prime Attributes:  **$\emptyset$**

**Explanation:**

$AB^+ = \{A,B,C,D\}$ ,  $BC^+ = \{B,C,D,A\}$ ,  $BD^+ = \{B,D,A,C\}$ . All attributes are prime.

Highest Normal Form = **3NF** ( $C \rightarrow D$  violates BCNF but is allowed in 3NF since D is prime).

## Q2:

For relation  $R(A,B,C,D,E)$  with FDs  $\{A \rightarrow D, B \rightarrow A, BC \rightarrow D, AC \rightarrow BE\}$ , find candidate keys, prime and non-prime attributes. Also state the highest normal form.

**Dependencies:**  $A \rightarrow D, B \rightarrow A, BC \rightarrow D, AC \rightarrow BE$

## Solution:

- Candidate Keys: **AC, BC**
- Prime Attributes: **A, B, C**
- Non-Prime Attributes: **D, E**

## Explanation:

$AC^+ = \{A,B,C,D,E\}$ ,  $BC^+ = \{B,C,A,D,E\}$ . Both are keys. Non-primes  $\{D,E\}$  depend only on part of key (A), so violates 2NF.

Highest Normal Form = **1NF**.

## Q3:

For relation  $R(A,B,C,D,E)$  with FDs  $\{B \rightarrow A, A \rightarrow C, BC \rightarrow D, AC \rightarrow BE\}$ , find candidate keys, prime and non-prime attributes. Also state the highest normal form.

**Dependencies:**  $B \rightarrow A, A \rightarrow C, BC \rightarrow D, AC \rightarrow BE$

## Solution:

- Candidate Keys: **A, B**
- Prime Attributes: **A, B**
- Non-Prime Attributes: **C, D, E**

## Explanation:

$A^+ = \{A,C,B,E,D\}$ ,  $B^+ = \{B,A,C,D,E\}$ . Both generate full set. Since all LHS are keys, no violations.

Highest Normal Form = **BCNF**.

#### Q4:

For relation  $R(A,B,C,D,E,F)$  with FDs  $\{A \rightarrow BCD, BC \rightarrow DE, B \rightarrow D, D \rightarrow A\}$ , find candidate keys, prime and non-prime attributes. Also state the highest normal form.

**Dependencies:**  $A \rightarrow BCD, BC \rightarrow DE, B \rightarrow D, D \rightarrow A$

#### Solution:

- Candidate Keys: **AF, BF, DF**
- Prime Attributes: **A, B, D, F**
- Non-Prime Attributes: **C, E**

#### Explanation:

$A^+ = \{A,B,C,D,E\}$ , missing  $F \rightarrow AF$  is key. Similarly  $BF$  and  $DF$ . Partial dependencies ( $A \rightarrow C, E$ ) mean it fails 2NF.

Highest Normal Form = **1NF**.

#### Q5:

For relation  $R(W,X,Y,Z)$  with FDs  $\{X \rightarrow Y, WZ \rightarrow X, WZ \rightarrow Y, Y \rightarrow W, Y \rightarrow X, Y \rightarrow Z\}$ , find candidate keys, prime and non-prime attributes, minimal cover, and highest normal form.

**Dependencies:**  $X \rightarrow Y, WZ \rightarrow X, WZ \rightarrow Y, Y \rightarrow W, Y \rightarrow X, Y \rightarrow Z$

#### Solution:

- Minimal Cover:  **$\{X \rightarrow Y, WZ \rightarrow X, Y \rightarrow W, Y \rightarrow Z\}$**
- Candidate Keys: **X, Y, WZ**
- Prime Attributes: **W, X, Y, Z**
- Non-Prime Attributes:  **$\emptyset$**
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#### Explanation:

$Y^+ = \{Y,W,X,Z\}$ ,  $X^+ = \{X,Y,W,Z\}$ ,  $WZ^+ = \{W,Z,X,Y\}$ . All attributes are prime.

Highest Normal Form = **BCNF** (all FDs have LHS as key).

#### Q6:

For relation  $R_1(A,B,C,D,E,F)$  with FDs  $\{A \rightarrow BC, A \rightarrow D, BC \rightarrow D, D \rightarrow E\}$ , find candidate keys, prime and non-prime attributes. Also state the highest normal form.

**Dependencies:**  $A \rightarrow BC$ ,  $A \rightarrow D$ ,  $BC \rightarrow D$ ,  $D \rightarrow E$

**Solution:**

- Candidate Key: **AF**
- Prime Attributes: **A, F**
- Non-Prime Attributes: **B, C, D, E**

**Explanation:**

$A^+ = \{A, B, C, D, E\}$ , missing  $F \rightarrow AF$  is key. Non-primes depend only on part of key, violating 2NF.

Highest Normal Form = **1NF**.

**Learning Outcomes**

After completing these questions, students will be able to:

1. Apply closure method to find candidate keys.
2. Differentiate prime and non-prime attributes in a relation.
3. Detect and eliminate redundant functional dependencies.
4. Identify the highest normal form of a given relation schema.
5. Improve conceptual clarity of normalization for efficient database design.