

What is 4NF

A table is in **Fourth Normal Form (4NF)** if:

1. It is already in **Boyce-Codd Normal Form (BCNF)**.
2. It has **no multi-valued dependencies (MVDs)**.

What is a Multi-Valued Dependency (MVD)?

A multi-valued dependency occurs when:

- For a single value of attribute A, there are **multiple independent values** of attribute B and multiple independent values of attribute C.
- B and C are **not related to each other**, but both depend only on A.

Notation:

If $A \twoheadrightarrow B$ (read as "A multi-determines B"), then $A \twoheadrightarrow C$ also holds, and B and C are independent.

Or

A **multi-valued dependency** happens when **one attribute in a table determines multiple independent values of another attribute**, and those attributes are not dependent on each other.

Example (Before 4NF):

StudentID Hobby Language

101	Painting	English
101	Dancing	English
101	Painting	French
101	Dancing	French

- A student can have **multiple hobbies** and **multiple languages**.
- **Hobbies and languages are independent** but both are related to StudentID.
- This creates **repetition** and **redundancy**.

Converting to 4NF:

Step 1: Decompose into two separate tables:

Student_Hobby

StudentID	Hobby
101	Painting
101	Dancing

Student_Language

StudentID	Language
101	English
101	French

Now, there are **no multi-valued dependencies**, and the design is in **4NF**.

- Use 4NF when there are **multi-valued facts** in the same table.
- It helps eliminate **data redundancy** and **update anomalies**.
- It is mostly required in advanced database designs.