**1. First Normal Form (1NF)**

**Definition:**

A table is in **First Normal Form (1NF)** if:

1. It has a primary key.
2. All columns contain atomic (indivisible) values.
3. There are no repeating groups or arrays.

**Example Table (Unnormalized):**

Orders

+------------+-----------+--------------+-------------+

| OrderID | Customer | Products | Quantities |

+------------+-----------+--------------+-------------+

| 101 | Alice | Apple, Orange | 2, 3 |

| 102 | Bob | Banana | 1 |

| 103 | Charlie | Apple, Mango | 2, 4 |

+------------+-----------+--------------+-------------+

**Issues:**

* The **Products** and **Quantities** columns contain multiple values (not atomic).
* We must split these into separate rows.

**1NF Table:**

CREATE TABLE Orders\_1NF (

OrderID INT,

Customer VARCHAR(50),

Product VARCHAR(50),

Quantity INT,

PRIMARY KEY (OrderID, Product)

);

+------------+-----------+---------+----------+

| OrderID | Customer | Product | Quantity |

+------------+-----------+---------+----------+

| 101 | Alice | Apple | 2 |

| 101 | Alice | Orange | 3 |

| 102 | Bob | Banana | 1 |

| 103 | Charlie | Apple | 2 |

| 103 | Charlie | Mango | 4 |

+------------+-----------+---------+----------+

**2. Second Normal Form (2NF)**

**Definition:**

A table is in **Second Normal Form (2NF)** if:

It is in **1NF**.

1. All **non-key columns** are fully dependent on the **whole primary key** (No partial dependencies).

**Issues in 1NF Table:**

* **Customer** depends only on **OrderID**, not on **Product**.
* This creates a **partial dependency**.

**Solution:**

* Separate **Orders** and **OrderDetails** into different tables.

**2NF Tables:**

CREATE TABLE Orders\_2NF (

OrderID INT PRIMARY KEY,

Customer VARCHAR(50)

);

CREATE TABLE OrderDetails\_2NF (

OrderID INT,

Product VARCHAR(50),

Quantity INT,

PRIMARY KEY (OrderID, Product),

FOREIGN KEY (OrderID) REFERENCES Orders\_2NF(OrderID)

);

Orders\_2NF:

+------------+-----------+

| OrderID | Customer |

+------------+-----------+

| 101 | Alice |

| 102 | Bob |

| 103 | Charlie |

+------------+-----------+

OrderDetails\_2NF:

+------------+---------+----------+

| OrderID | Product | Quantity |

+------------+---------+----------+

| 101 | Apple | 2 |

| 101 | Orange | 3 |

| 102 | Banana | 1 |

| 103 | Apple | 2 |

| 103 | Mango | 4 |

+------------+---------+----------+

**3. Third Normal Form (3NF)**

**Definition:**

A table is in **Third Normal Form (3NF)** if:

1. It is in **2NF**.
2. There are no **transitive dependencies** (i.e., non-key columns should not depend on other non-key columns).

**Issues in 2NF Table:**

* If we add a **ProductPrice** column to **OrderDetails\_2NF**, it would depend on **Product**, not on **OrderID**.

**Solution:**

* Create a separate **Products** table.

**3NF Tables:**

CREATE TABLE Products\_3NF (

Product VARCHAR(50) PRIMARY KEY,

Price DECIMAL(10,2)

);

CREATE TABLE OrderDetails\_3NF (

OrderID INT,

Product VARCHAR(50),

Quantity INT,

PRIMARY KEY (OrderID, Product),

FOREIGN KEY (OrderID) REFERENCES Orders\_2NF(OrderID),

FOREIGN KEY (Product) REFERENCES Products\_3NF(Product)

);

Products\_3NF:

+---------+-------+

| Product | Price |

+---------+-------+

| Apple | 1.00 |

| Orange | 1.50 |

| Banana | 0.75 |

| Mango | 2.00 |

+---------+-------+

OrderDetails\_3NF:

+------------+---------+----------+

| OrderID | Product | Quantity |

+------------+---------+----------+

| 101 | Apple | 2 |

| 101 | Orange | 3 |

| 102 | Banana | 1 |

| 103 | Apple | 2 |

| 103 | Mango | 4 |

+------------+---------+----------+

**Summary of Transformations:**

|  |  |
| --- | --- |
| **Normal Form** | **Key Changes** |
| **1NF** | Remove repeating groups, ensure atomicity. |
| **2NF** | Remove partial dependencies by creating separate tables. |
| **3NF** | Remove transitive dependencies by further normalization. |

Following these steps, we ensure our database is well-structured, reduces redundancy, and improves data integrity.