First Normal Form (1NF)

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

1. It contains only atomic (indivisible) values.
2. Each column contains values of a single type.
3. Each column has a unique name.
4. The order in which data is stored does not matter.

Example:

Table: Orders (Unnormalized)

OrderID	Customer	Products
1	Alice	Widget, Gadget
2	Bob	Thingamajig, Gadget
3	Alice	Widget

Table: Orders (1NF)

OrderID	Customer	Product
1	Alice	Widget
1	Alice	Gadget
2	Bob	Thingamajig
2	Bob	Gadget
3	Alice	Widget

Second Normal Form (2NF)

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

1. It is in First Normal Form (1NF).
2. It has no partial dependencies (i.e., non-key attributes are fully dependent on the entire primary key).

Example:

Table: Orders (1NF)

OrderID	CustomerID	ProductID	Quantity	OrderDate
1	1001	P001	4	2023-01-10
2	1002	P002	2	2023-01-11
3	1001	P003	1	2023-01-12

Table: Orders (2NF)

OrderID	CustomerID	OrderDate
1	1001	2023-01-10
2	1002	2023-01-11
3	1001	2023-01-12

Table: OrderDetails (2NF)

OrderID	ProductID	Quantity
1	P001	4
2	P002	2
3	P003	1

Third Normal Form (3NF)

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

1. It is in Second Normal Form (2NF).
2. It has no transitive dependencies (i.e., non-key attributes are not dependent on other non-key attributes).

Example:

Table: Orders (2NF)

OrderID	CustomerID	OrderDate
1	1001	2023-01-10
2	1002	2023-01-11
3	1001	2023-01-12

Table: Customers (2NF)

CustomerID	CustomerName	CustomerAddress
1001	Alice	123 Elm St
1002	Bob	456 Oak St

Transition to 3NF (Separate transitive dependencies)

Table: Orders (3NF)

OrderID	CustomerID	OrderDate
1	1001	2023-01-10
2	1002	2023-01-11
3	1001	2023-01-12

Table: Customers (3NF)

CustomerID	CustomerName	CustomerAddressID
1001	Alice	ADDR001
1002	Bob	ADDR002

Table: CustomerAddresses (3NF)

CustomerAddressID	CustomerAddress
ADDR001	123 Elm St
ADDR002	456 Oak St

Fourth Normal Form (4NF)

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

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

Example:

Table: StudentSubjectsHobbies

StudentID	Subject	Hobby
1	Math	Basketball
1	Science	Painting
2	Math	Basketball
2	Science	Swimming

Transition to 4NF (Separate multi-valued dependencies)

Table: StudentSubjects (4NF)

StudentID	Subject
1	Math
1	Science
2	Math
2	Science

Table: StudentHobbies (4NF)

StudentID	Hobby
1	Basketball
1	Painting
2	Basketball
2	Swimming

Fifth Normal Form (5NF)

A table is in Fifth Normal Form (5NF) if:

1. It is in Fourth Normal Form (4NF).
2. It has no join dependencies (i.e., the table cannot be decomposed further without losing information).

Example:

Table: Project Assignments

EmployeeID	ProjectID	RoleID
1	101	R1
1	102	R2
2	101	R2
2	103	R1

Transition to 5NF (Separate join dependencies)

Table: EmployeeProjects (5NF)

EmployeeID	ProjectID
1	101
1	102
2	101
2	103

Table: ProjectRoles (5NF)

ProjectID	RoleID
101	R1
101	R2
102	R2
103	R1

Table: EmployeeRoles (5NF)

EmployeeID	RoleID
1	R1
1	R2
2	R2
2	R1

By decomposing the tables into smaller, related tables, we achieve Fifth Normal Form (5NF) and eliminate join dependencies