Database Normalization

Normalization is a **systematic process** in database systems used to **organize data** to reduce **redundancy** and improve **data integrity (سلامة وتكامل البيانات)**. It involves dividing a database into tables and defining relationships between them to:

- Minimize duplicate data
- Eliminate update anomalies
- Ensure meaningful data dependencies

Purpose of Normalization

1. **Reduce Data Redundancy**
   Prevent duplicate data across tables to save storage and avoid inconsistencies.
2. **Enhance Data Integrity**
   Ensure accuracy and consistency using well-defined relationships and constraints.
3. **Simplify Data Maintenance**
   Make updates, inserts, deletions, and retrievals easier and safer.

1. First Normal Form (1NF)

- **Rule:** Eliminate repeating groups and ensure atomic (indivisible) values in each field.
- **Goal:** No multivalued attributes; each row is unique.

Example (before 1NF):

من الطلاب الي مسجلين في مادة الرياضيات؟!

StudentID	StudentName	Courses
1	Ali Salim	Math, Science
2	Ahmed Nasser	English, History, Math

After 1NF:

StudentID	StudentName	Course
1	Ali Salim	Math

1	Ali Salim	Science
2	Ahmed Nasser	English

2. Second Normal Form (2NF)

- **Rule:** Achieve 1NF and remove partial dependencies.
- **Goal:** All non-key attributes must depend on the **whole** primary key (not part of it).

Example (before 2NF):

Suppose this table uses a **composite key** (StudentID, CourseID):

StudentID	CourseID	StudentName	CourseName
1	101	Ali Salim	Math
1	102	Ali Salim	Science
2	101	Ahmed Nasser	Math

- StudentName depends only on StudentID
- CourseName depends only on CourseID

After 2NF (split into 3 tables):

Students Table

StudentID	StudentName
1	Ali Salim
2	Ahmed Nasser

Courses Table

CourseID	CourseName
101	Math
102	Science

Enrollments Table

StudentID	CourseID
1	101
1	102
2	101

4. Third Normal Form (3NF)

Rule: Achieve 2NF and remove transitive dependencies (non-key attributes should depend only on the key, not other non-key attributes).

Before 3NF:

OrderID	CustomerID	CustomerName	CustomerAddress
1	C001	Salim Al Harithi	Gulf Street 12, Muscat
2	C002	Maryam Al Balushi	Nahdha Street 45, Sohar

CustomerName and CustomerAddress depend on CustomerID, not on OrderID.

After 3NF:

Orders Table

OrderID	CustomerID
1	C001
2	C002

Customers Table

CustomerID	CustomerName	CustomerAddress
C001	Salim Al Harithi	Gulf Street 12, Muscat
C002	Maryam Al Balushi	Nahdha Street 45, Sohar