DATABASE NORMALIZATION (1NF to 5NF)

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1. What is Normalisation?

Normalisation is the process of **organising data in a database** to:

- Reduce data redundancy
- Avoid update anomalies
- Improve data integrity
- Make the database efficient and consistent

Normalisation is achieved by applying a series of **Normal Forms**.

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2. Running Example (Unnormalized Table)

Student_Course_Teacher

StudentID	StudentName	Courses	Teachers
1	Alex	Math, Science	John, Mary

Problems:

- Multiple values in one column
- Data repetition
- Difficult to update and maintain

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3. First Normal Form (1NF)

Rule

1NF → No multiple values in a column

How to Fulfil:

- Remove repeating groups
- Ensure atomic (single) values

Table in 1NF

StudentID	StudentName	Course	Teacher
1	Alex	Math	John
1	Alex	Science	Mary

✔ Each column has a single value

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4. Second Normal Form (2NF)

Rule

2NF → No partial dependency on primary key

Explanation:

- Applies when the primary key is **composite**
- Non-key attributes must depend on the **entire primary key**

Problem:

Primary Key = (StudentID, Course)
`StudentName` depends only on `StudentID`

Decomposition

Students

StudentID	StudentName
1	Alex

Enrollments

| StudentID | Course | Teacher |

✔ Partial dependency removed

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5. Third Normal Form (3NF)

Rule

3NF → No dependency between non-key columns

Explanation:

- No transitive dependency
- Non-key attributes must depend **only on the primary key**

Problem:

`The teacher` depends on `the course`, not on `StudentID`

Decomposition

Courses

Course	Teacher

Enrollments

| StudentID | Course |

✔ Transitive dependency removed

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6. Fourth Normal Form (4NF)

Rule

4NF → No multi-valued dependency

Explanation:

- A table should not store **two or more independent multi-valued facts**

Problem:

- Students can take many courses
- A course can have many teachers
- These are independent facts

Decomposition

Student_Course

| StudentID | Course |

Course_Teacher

| Course | Teacher |

✔ Independent multi-valued dependencies separated

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7. Fifth Normal Form (5NF)

Rule

5NF → No join dependency

Explanation:

- The table should be decomposed until it cannot be further split
- Data should be reconstructable using joins without loss

Final Tables (5NF)

- **Students**(StudentID, StudentName)
- **Student_Course**(StudentID, Course)
- **Course_Teacher**(Course, Teacher)

✔ No redundancy
✔ No anomalies
✔ Fully normalized

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8. Summary Table

Normal Form	Key Rule
1NF	Atomic values
2NF	Full key dependency
3NF	Key-only dependency
4NF	One multi-valued fact
5NF	No join dependency
