Database normalization removes redundancy and ensures that data is logically stored. It removes insertion, deletion, and updation anomalies. Here I'll briefly explain the 5 normalization rules.

1. First Normal Form
2. Second Normal Form
3. Third Normal Form
4. BCNF: Boyce and Codd Normal Form
5. Fourth Normal Form

First Normal Form

A table is supposed to be in first normal form if,

- All the attributes are single-valued (atomic).
- All the columns have unique names.
- The order in which data is stored does not matter.

Example: In Shirt_Info table, Size attribute is not atomic. Hence it can be decomposed into Design_Info and Size_Info as shown in the image.

Shirt_Info		
Shirt_ID	Design	Size
100	Mickey Mouse	XXL,XL,M
101	Flowers	M
102	Good Vibes	M,S
103	Triangles	XL
Primary Key: Shirt_ID		

Design_Info	
Shirt_ID	Design
100	Mickey Mouse
101	Flowers
102	Good Vibes
103	Triangles
Primary Key: Shirt_ID	

Size_Info	
Shirt_ID	Size
100	XXL
100	XL
100	M
101	M
102	M
102	S
103	XL
Primary Key: Shirt_ID, Size	

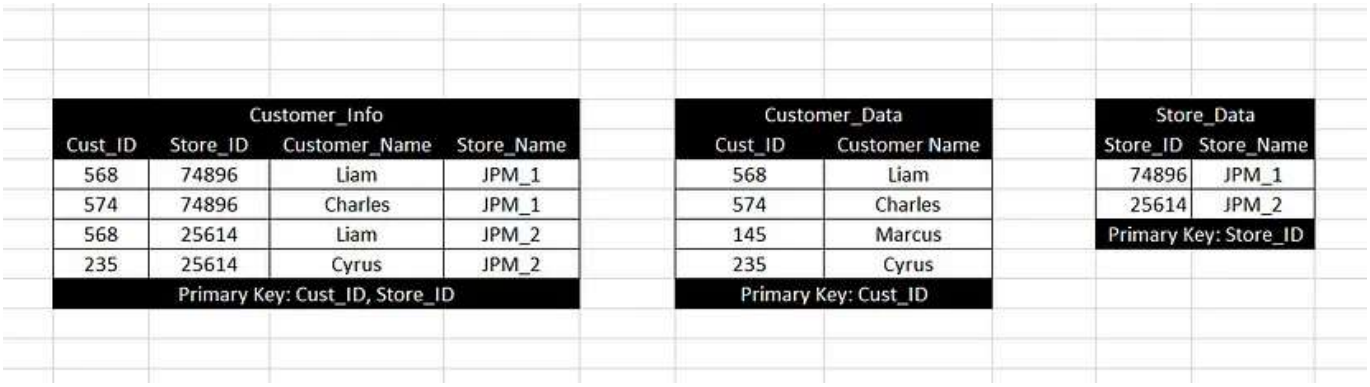
First Normal Form Example

Second Normal Form

A table is supposed to be in second normal form if,

- It is in the 1st normal form.
- It does not have any partial dependency

Example: In Customer_Info table, Store_Name depends on Store_ID and not on Cust_ID. This is a partial dependency. Hence, Customer_Info is not in second normal form (though it satisfies 1NF). It can be decomposed into Customer_Data and Store_Data as shown below.



Customer_Info			
Cust_ID	Store_ID	Customer_Name	Store_Name
568	74896	Liam	JPM_1
574	74896	Charles	JPM_1
568	25614	Liam	JPM_2
235	25614	Cyrus	JPM_2
Primary Key: Cust_ID, Store_ID			

Customer_Data	
Cust_ID	Customer Name
568	Liam
574	Charles
145	Marcus
235	Cyrus
Primary Key: Cust_ID	

Store_Data	
Store_ID	Store_Name
74896	JPM_1
25614	JPM_2
Primary Key: Store_ID	

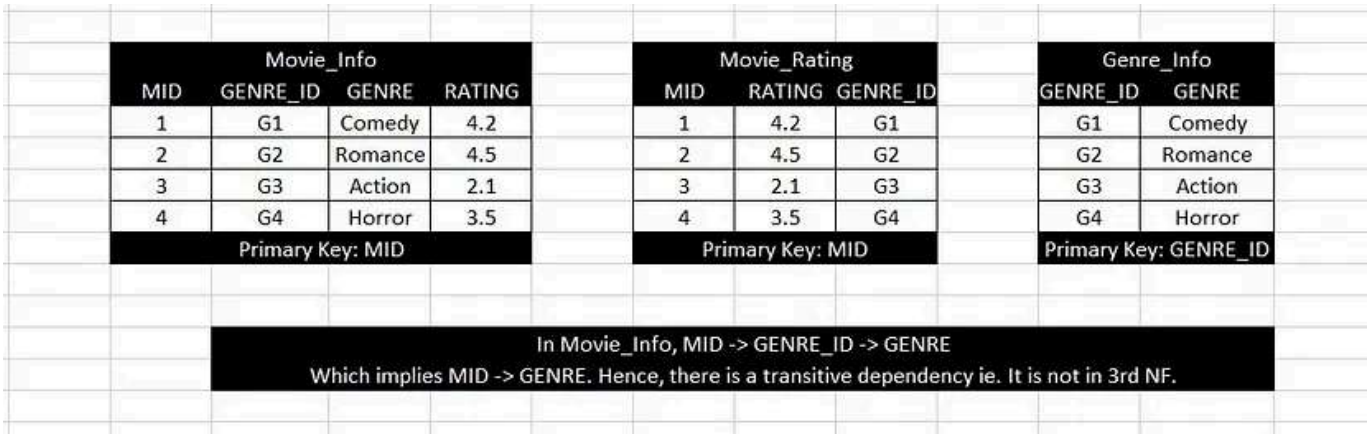
Second Normal Form Example

Third Normal Form

A table is supposed to be in third normal form if,

- It satisfies 2nd normal form.
- It does not have any transitive dependency.

Example: Movie_Info is in second normal form but it has a transitive dependency. Therefore, it is not in third normal form. It can be decomposed into Movie_Rating and Genre_Info as shown below.



Movie_Info

MID	GENRE_ID	GENRE	RATING
1	G1	Comedy	4.2
2	G2	Romance	4.5
3	G3	Action	2.1
4	G4	Horror	3.5

Primary Key: MID

Movie_Rating

MID	RATING	GENRE_ID
1	4.2	G1
2	4.5	G2
3	2.1	G3
4	3.5	G4

Primary Key: MID

Genre_Info

GENRE_ID	GENRE
G1	Comedy
G2	Romance
G3	Action
G4	Horror

Primary Key: GENRE_ID

In Movie_Info, MID -> GENRE_ID -> GENRE
Which implies MID -> GENRE. Hence, there is a transitive dependency ie. It is not in 3rd NF.

Third Normal Form Example

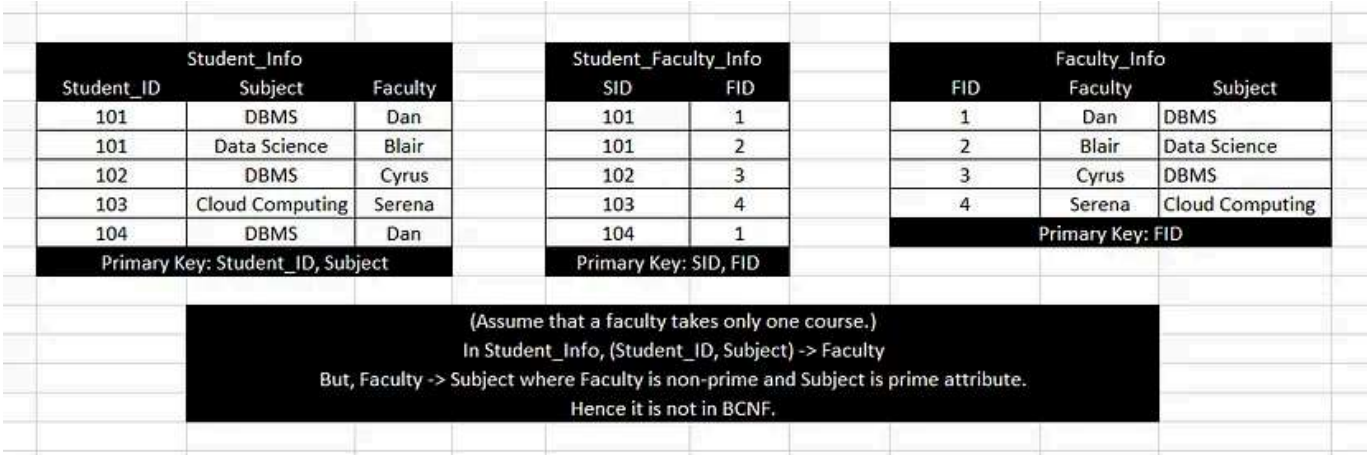
Boyce and Codd Normal Form (BCNF)

A table is supposed to be in BCNF if,

- It is in 3rd Normal Form.
- For every dependency X->Y, X cannot be a non-prime attribute if Y is prime attribute (i.e. X should be a super key)

Example: Student_Info is not in BCNF because in the dependency Faculty -> Subject, Subject is prime attribute and Faculty is non-prime attribute. It can

Algorithm.



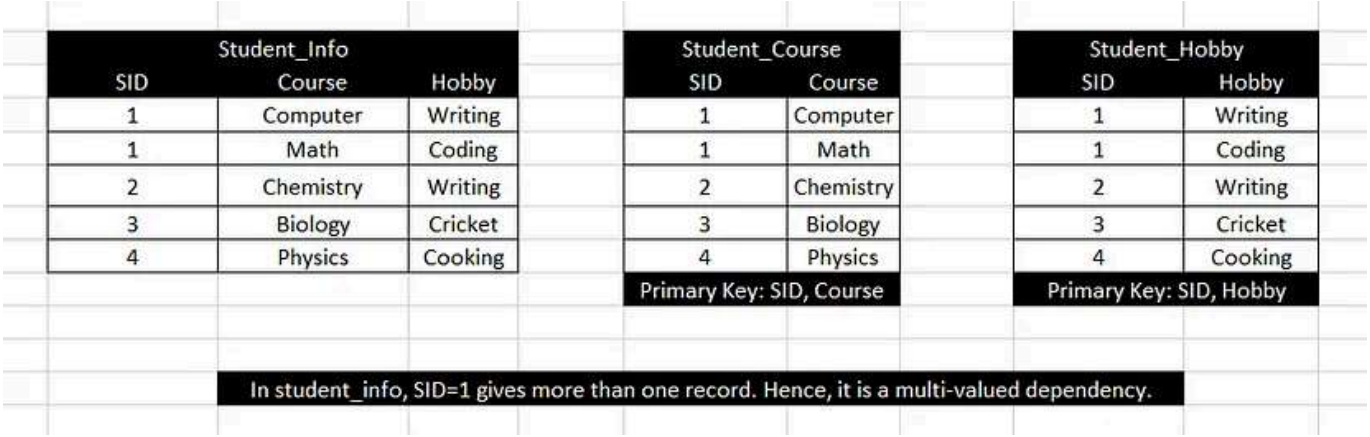
BCNF Example

Fourth Normal Form

A table is supposed to be in fourth normal form if,

- It is in BCNF.
- It has no multi-valued dependency.

Multi-valued Dependency: *For a dependency A → B, if for a single value of A, multiple values of B exists, then the relation will be a multi-valued dependency.*



Fourth Normal Form Example