SQL OVERVIEW

SQL is a programming language for Relational Databases. It is designed over relational algebra and tuple relational calculus. SQL comes as a package with all major distributions of RDBMS.

SQL comprises both data definition and data manipulation languages. Using the data definition properties of SQL, one can design and modify database schema, whereas data manipulation properties allows SQL to store and retrieve data from database.

Data Definition Language

SQL uses the following set of commands to define database schema −

CREATE

Creates new databases, tables and views from RDBMS.

For example −

```
Create database tutorialspoint;
Create table article;
Create view for_students;
```

DROP

Drops commands, views, tables, and databases from RDBMS.

For example−

```
Drop object_type object_name;
Drop database tutorialspoint;
Drop table article;
Drop view for_students;
```

ALTER

Modifies database schema.

```
Alter object_type object_name parameters;
```

For example−

```
Alter table article add subject varchar;
```

This command adds an attribute in the relation **article** with the name **subject** of string type.

Data Manipulation Language

SQL is equipped with data manipulation language *DML*. DML modifies the database instance by inserting, updating and deleting its data. DML is responsible for all froms data modification in a database. SQL contains the following set of commands in its DML section −

- SELECT/FROM/WHERE
- INSERT INTO/VALUES
- UPDATE/SET/WHERE
- DELETE FROM/WHERE

These basic constructs allow database programmers and users to enter data and information into

the database and retrieve efficiently using a number of filter options.

SELECT/FROM/WHERE

- **SELECT** − This is one of the fundamental query command of SQL. It is similar to the projection operation of relational algebra. It selects the attributes based on the condition described by WHERE clause.
- **FROM** − This clause takes a relation name as an argument from which attributes are to be selected/projected. In case more than one relation names are given, this clause corresponds to Cartesian product.
- **WHERE** − This clause defines predicate or conditions, which must match in order to qualify the attributes to be projected.

For example −

```
Select author_name
From book_author
Where age > 50;
```

This command will yield the names of authors from the relation **book_author** whose age is greater than 50.

INSERT INTO/VALUES

This command is used for inserting values into the rows of a table *relation*.

Syntax−

```
INSERT INTO table (column1 [, column2, column3 ... ]) VALUES (value1 [, value2, value3
... ])
```

Or

```
INSERT INTO table VALUES (value1, [value2, ... ])
```

For example −

```
INSERT INTO tutorialspoint (Author, Subject) VALUES ("anonymous", "computers");
```

UPDATE/SET/WHERE

This command is used for updating or modifying the values of columns in a table *relation*.

Syntax −

```
UPDATE table_name SET column_name = value [, column_name = value ...] [WHERE condition]
```

For example −

```
UPDATE tutorialspoint SET Author="webmaster" WHERE Author="anonymous";
```

DELETE/FROM/WHERE

This command is used for removing one or more rows from a table *relation*.

Syntax −

```
DELETE FROM table_name [WHERE condition];
```

For example −

```
DELETE FROM tutorialspoints
   WHERE Author="unknown";
```

DBMS - JOINS

We understand the benefits of taking a Cartesian product of two relations, which gives us all the possible tuples that are paired together. But it might not be feasible for us in certain cases to take a Cartesian product where we encounter huge relations with thousands of tuples having a considerable large number of attributes.

Join is a combination of a Cartesian product followed by a selection process. A Join operation pairs two tuples from different relations, if and only if a given join condition is satisfied.

We will briefly describe various join types in the following sections.

Theta θ Join

Theta join combines tuples from different relations provided they satisfy the theta condition. The join condition is denoted by the symbol **θ**.

Notation

```
R1 ⋈θ R2
```

R1 and R2 are relations having attributes $A1, A2, . . , An$ and $B1, B2, . . , Bn$ such that the attributes don't have anything in common, that is R1 ∩ R2 = Φ.

Theta join can use all kinds of comparison operators.

Student		
SID	**Name**	**Std**
101	Alex	10
102	Maria	11

Subjects	
Class	**Subject**
10	Math
10	English
11	Music
11	Sports

Student_Detail −

```
STUDENT ⋈Student.Std = Subject.Class SUBJECT
```

Student_detail				
SID	**Name**	**Std**	**Class**	**Subject**
101	Alex	10	10	Math

101	Alex	10	10	English
102	Maria	11	11	Music
102	Maria	11	11	Sports

Equijoin

When Theta join uses only **equality** comparison operator, it is said to be equijoin. The above example corresponds to equijoin.

Natural Join (⋈)

Natural join does not use any comparison operator. It does not concatenate the way a Cartesian product does. We can perform a Natural Join only if there is at least one common attribute that exists between two relations. In addition, the attributes must have the same name and domain.

Natural join acts on those matching attributes where the values of attributes in both the relations are same.

Courses		
CID	**Course**	**Dept**
CS01	Database	CS
ME01	Mechanics	ME
EE01	Electronics	EE

HoD	
Dept	**Head**
CS	Alex
ME	Maya
EE	Mira

Courses ⋈ HoD			
Dept	**CID**	**Course**	**Head**
CS	CS01	Database	Alex
ME	ME01	Mechanics	Maya
EE	EE01	Electronics	Mira

Outer Joins

Theta Join, Equijoin, and Natural Join are called inner joins. An inner join includes only those tuples with matching attributes and the rest are discarded in the resulting relation. Therefore, we need to use outer joins to include all the tuples from the participating relations in the resulting relation. There are three kinds of outer joins − left outer join, right outer join, and full outer join.

Left Outer Join(R ⟕ S)

All the tuples from the Left relation, R, are included in the resulting relation. If there are tuples in R

without any matching tuple in the Right relation S, then the S-attributes of the resulting relation are made NULL.

Left	
A	**B**
100	Database
101	Mechanics
102	Electronics

Right	
A	**B**
100	Alex
102	Maya
104	Mira

Courses ⟕ HoD			
A	**B**	**C**	**D**
100	Database	100	Alex
101	Mechanics	---	---
102	Electronics	102	Maya

Right Outer Join: (R ⟖ S)

All the tuples from the Right relation, S, are included in the resulting relation. If there are tuples in S without any matching tuple in R, then the R-attributes of resulting relation are made NULL.

Courses ⟖ HoD			
A	**B**	**C**	**D**
100	Database	100	Alex
102	Electronics	102	Maya
---	---	104	Mira

Full Outer Join: (R ⟗ S)

All the tuples from both participating relations are included in the resulting relation. If there are no matching tuples for both relations, their respective unmatched attributes are made NULL.

Courses ⟗ HoD			
A	**B**	**C**	**D**
100	Database	100	Alex

101	Mechanics	---	---
102	Electronics	102	Maya
---	---	104	Mira

RELATIONAL ALGEBRA

Relational database systems are expected to be equipped with a query language that can assist its users to query the database instances. There are two kinds of query languages − relational algebra and relational calculus.

Relational Algebra

Relational algebra is a procedural query language, which takes instances of relations as input and yields instances of relations as output. It uses operators to perform queries. An operator can be either **unary** or **binary**. They accept relations as their input and yield relations as their output. Relational algebra is performed recursively on a relation and intermediate results are also considered relations.

The fundamental operations of relational algebra are as follows −

- Select
- Project
- Union
- Set different
- Cartesian product
- Rename

We will discuss all these operations in the following sections.

Select Operation σ

It selects tuples that satisfy the given predicate from a relation.

Notation − $\sigma_{p}r$

Where **σ** stands for selection predicate and **r** stands for relation. *p* is prepositional logic formula which may use connectors like **and, or,** and **not**. These terms may use relational operators like − =, ≠, ≥, < , >, ≤.

For example −

$$\sigma_{subject = "database"}(Books)$$

Output − Selects tuples from books where subject is 'database'.

$$\sigma_{subject = "database" \text{ and } price = "450"}(Books)$$

Output − Selects tuples from books where subject is 'database' and 'price' is 450.

$$\sigma_{subject = "database" \text{ and } price = "450" \text{ or } year > "2010"}(Books)$$

Output − Selects tuples from books where subject is 'database' and 'price' is 450 or those books published after 2010.

Project Operation ∏

It projects column*s* that satisfy a given predicate.

Notation − $\prod_{A_1, A_2, A_n} r$

Where A_1, A_2 , A_n are attribute names of relation **r**.

Duplicate rows are automatically eliminated, as relation is a set.

For example −

$$\prod_{subject,\ author} (Books)$$

Selects and projects columns named as subject and author from the relation Books.

Union Operation ∪

It performs binary union between two given relations and is defined as −

$$r \cup s = \{ t \mid t \in r \text{ or } t \in s\}$$

Notion − r U s

Where **r** and **s** are either database relations or relation result set *temporaryrelation*.

For a union operation to be valid, the following conditions must hold −

- **r**, and **s** must have the same number of attributes.
- Attribute domains must be compatible.
- Duplicate tuples are automatically eliminated.

$$\prod_{author} (Books) \cup \prod_{author} (Articles)$$

Output − Projects the names of the authors who have either written a book or an article or both.

Set Difference −

The result of set difference operation is tuples, which are present in one relation but are not in the second relation.

Notation − **r** − **s**

Finds all the tuples that are present in **r** but not in **s**.

$$\prod_{author} (Books) - \prod_{author} (Articles)$$

Output − Provides the name of authors who have written books but not articles.

Cartesian Product X

Combines information of two different relations into one.

Notation − r X s

Where **r** and **s** are relations and their output will be defined as −

r X s = { q t | q ∈ r and t ∈ s}

$$\sigma_{author = 'tutorialspoint'}(Books\ X\ Articles)$$

Output − Yields a relation, which shows all the books and articles written by tutorialspoint.

Rename Operation ρ

The results of relational algebra are also relations but without any name. The rename operation allows us to rename the output relation. 'rename' operation is denoted with small Greek letter **rho**

ρ.

Notation − $\rho_x E$

Where the result of expression **E** is saved with name of **x**.

Additional operations are −

- Set intersection
- Assignment
- Natural join

Relational Calculus

In contrast to Relational Algebra, Relational Calculus is a non-procedural query language, that is, it tells what to do but never explains how to do it.

Relational calculus exists in two forms −

Tuple Relational Calculus *TRC*

Filtering variable ranges over tuples

Notation − {T | Condition}

Returns all tuples T that satisfies a condition.

For example −

```
{ T.name |  Author(T) AND T.article = 'database' }
```

Output − Returns tuples with 'name' from Author who has written article on 'database'.

TRC can be quantified. We can use Existential ∃ and Universal Quantifiers ∀.

For example −

```
{ R| ∃T   ∈ Authors(T.article='database' AND R.name=T.name)}
```

Output − The above query will yield the same result as the previous one.

Domain Relational Calculus *DRC*

In DRC, the filtering variable uses the domain of attributes instead of entire tuple values *asdoneinTRC, mentionedabove*.

Notation −

{ a_1, a_2, a_3, ..., a_n | P (a_1, a_2, a_3, ... ,a_n)}

Where a1, a2 are attributes and **P** stands for formulae built by inner attributes.

For example −

```
{< article, page, subject > |  ∈ TutorialsPoint ∧ subject = 'database'}
```

Output − Yields Article, Page, and Subject from the relation TutorialsPoint, where subject is database.

Just like TRC, DRC can also be written using existential and universal quantifiers. DRC also involves relational operators.

The expression power of Tuple Relation Calculus and Domain Relation Calculus is equivalent to Relational Algebra.

DBMS - NORMALIZATION

Functional Dependency

Functional dependency *FD* is a set of constraints between two attributes in a relation. Functional dependency says that if two tuples have same values for attributes A1, A2,..., An, then those two tuples must have to have same values for attributes B1, B2, ..., Bn.

Functional dependency is represented by an arrow sign → that is, X→Y, where X functionally determines Y. The left-hand side attributes determine the values of attributes on the right-hand side.

Armstrong's Axioms

If F is a set of functional dependencies then the closure of F, denoted as F^+, is the set of all functional dependencies logically implied by F. Armstrong's Axioms are a set of rules, that when applied repeatedly, generates a closure of functional dependencies.

- **Reflexive rule** − If alpha is a set of attributes and beta is_subset_of alpha, then alpha holds beta.
- **Augmentation rule** − If a → b holds and y is attribute set, then ay → by also holds. That is adding attributes in dependencies, does not change the basic dependencies.
- **Transitivity rule** − Same as transitive rule in algebra, if a → b holds and b → c holds, then a → c also holds. a → b is called as a functionally that determines b.

Trivial Functional Dependency

- **Trivial** − If a functional dependency *FD* X → Y holds, where Y is a subset of X, then it is called a trivial FD. Trivial FDs always hold.
- **Non-trivial** − If an FD X → Y holds, where Y is not a subset of X, then it is called a non-trivial FD.
- **Completely non-trivial** − If an FD X → Y holds, where x intersect Y = Φ, it is said to be a completely non-trivial FD.

Normalization

If a database design is not perfect, it may contain anomalies, which are like a bad dream for any database administrator. Managing a database with anomalies is next to impossible.

- **Update anomalies** − If data items are scattered and are not linked to each other properly, then it could lead to strange situations. For example, when we try to update one data item having its copies scattered over several places, a few instances get updated properly while a few others are left with old values. Such instances leave the database in an inconsistent state.
- **Deletion anomalies** − We tried to delete a record, but parts of it was left undeleted because of unawareness, the data is also saved somewhere else.
- **Insert anomalies** − We tried to insert data in a record that does not exist at all.

Normalization is a method to remove all these anomalies and bring the database to a consistent state.

First Normal Form

First Normal Form is defined in the definition of relations *tables* itself. This rule defines that all the attributes in a relation must have atomic domains. The values in an atomic domain are indivisible units.

Course	Content
Programming	Java, c++
Web	HTML, PHP, ASP

We re-arrange the relation *table* as below, to convert it to First Normal Form.

Course	Content
Programming	Java
Programming	c++
Web	HTML
Web	PHP
Web	ASP

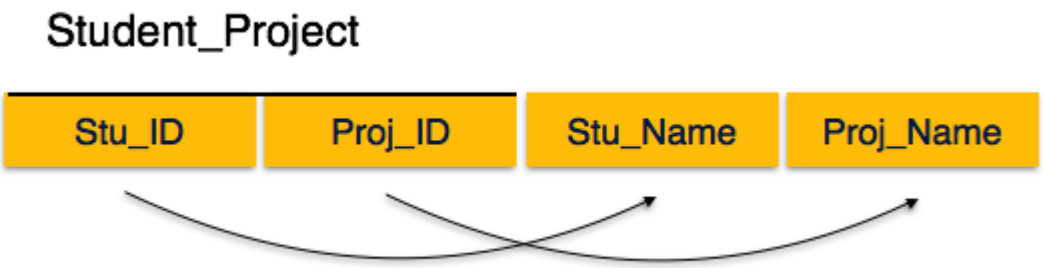
Each attribute must contain only a single value from its pre-defined domain.

Second Normal Form

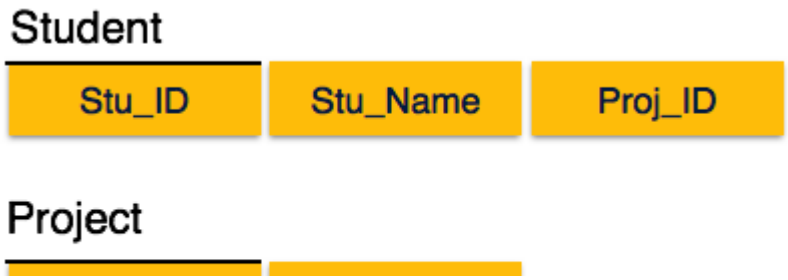
Before we learn about the second normal form, we need to understand the following −

- **Prime attribute** − An attribute, which is a part of the prime-key, is known as a prime attribute.
- **Non-prime attribute** − An attribute, which is not a part of the prime-key, is said to be a non-prime attribute.

If we follow second normal form, then every non-prime attribute should be fully functionally dependent on prime key attribute. That is, if X → A holds, then there should not be any proper subset Y of X, for which Y → A also holds true.



We see here in Student_Project relation that the prime key attributes are Stu_ID and Proj_ID. According to the rule, non-key attributes, i.e. Stu_Name and Proj_Name must be dependent upon both and not on any of the prime key attribute individually. But we find that Stu_Name can be identified by Stu_ID and Proj_Name can be identified by Proj_ID independently. This is called **partial dependency**, which is not allowed in Second Normal Form.



We broke the relation in two as depicted in the above picture. So there exists no partial dependency.

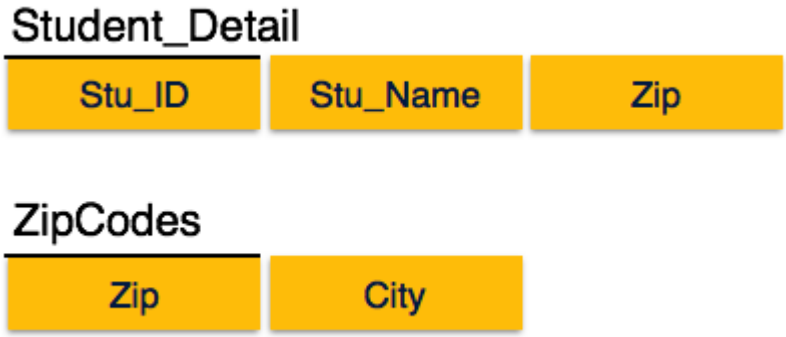
Third Normal Form

For a relation to be in Third Normal Form, it must be in Second Normal form and the following must satisfy −

- No non-prime attribute is transitively dependent on prime key attribute.
- For any non-trivial functional dependency, X → A, then either −
  - X is a superkey or,
  - A is prime attribute.

We find that in the above Student_detail relation, Stu_ID is the key and only prime key attribute. We find that City can be identified by Stu_ID as well as Zip itself. Neither Zip is a superkey nor is City a prime attribute. Additionally, Stu_ID → Zip → City, so there exists **transitive dependency**.

To bring this relation into third normal form, we break the relation into two relations as follows −



Boyce-Codd Normal Form

Boyce-Codd Normal Form $BCNF$ is an extension of Third Normal Form on strict terms. BCNF states that −

- For any non-trivial functional dependency, X → A, X must be a super-key.

In the above image, Stu_ID is the super-key in the relation Student_Detail and Zip is the super-key in the relation ZipCodes. So,

Stu_ID → Stu_Name, Zip

and

Zip → City

Which confirms that both the relations are in BCNF.