Common SQL Data Types

INT, SMALLINT, BIGINT
Definition: Integer types with varying ranges. Example: `INT`

VARCHAR(n)
Definition: Variable-length character string up to `n` chars. Example: `VARCHAR(50)`

CHAR(n)
Definition: Fixed-length character string of length `n`. Example: `CHAR(10)`

TEXT
Definition: Large variable-length text. Example: —

DATE, TIME, DATETIME, TIMESTAMP
Definition: Date and/or time values. Example: `DATE`

DECIMAL(p,s), NUMERIC(p,s)
Definition: Exact numeric with `p` total digits, `s` after decimal. Example: `DECIMAL(10,2)`

FLOAT, REAL, DOUBLE PRECISION
Definition: Approximate numeric types. Example: —

BOOLEAN
Definition: Logical TRUE/FALSE. Example: —

BLOB
Definition: Binary large object. Example: —

Aggregation & Grouping

COUNT(*), SUM(col), MIN(col), MAX(col), AVG(col)
Definition: Aggregate functions; ignore NULLs.

GROUP BY
Definition: Groups rows for aggregates. Example: `GROUP BY col;`

HAVING
Definition: Filters groups after aggregation. Example: `HAVING AVG(x)>10;`

ORDER BY
Definition: Sorts result set (ASC/DESC). Example: `ORDER BY cnt DESC;`

Eval Order
`FROM` → `WHERE` → `GROUP BY` → `HAVING` → `SELECT` → `ORDER BY`

Creating Tables

Customers / Products / Junction
Definition: Example of CREATE TABLE with PKs and FKs. Example:

```
CREATE TABLE Customers (
  CustomerID INT NOT NULL,
  FirstName  VARCHAR(50),
  LastName   VARCHAR(50),
  Email      VARCHAR(100) UNIQUE,
  PRIMARY KEY (CustomerID)
);
CREATE TABLE Products (
  ProductID   INT NOT NULL,
  ProductName VARCHAR(100),
  Price       DECIMAL(10,2) DEFAULT 0.00,
  PRIMARY KEY (ProductID)
);
CREATE TABLE CustomerOrders (
  CustomerID INT NOT NULL,
  OrderID    INT NOT NULL,
  OrderDate  DATE NOT NULL,
  PRIMARY KEY (CustomerID, OrderID),
  FOREIGN KEY (CustomerID) REFERENCES
      Customers(CustomerID),
  FOREIGN KEY (OrderID)     REFERENCES
      Orders(OrderID)
);
```

Joins in SQL

Inner Join
Definition: Returns rows with matches in both tables. Example:

```
SELECT *
FROM A
JOIN B ON A.x = B.x;
```

Left Outer Join
Definition: All rows from left, matched or NULLs from right. Example: `A LEFT JOIN B ON A.x=B.x;`

Right Outer Join
Definition: All rows from right, matched or NULLs from left. Example: `A RIGHT JOIN B ON A.x=B.x;`

Full Outer Join
Definition: Rows matching in either, NULLs elsewhere. Example: `A FULL JOIN B ON A.x=B.x;`

Self Join
Definition: A table joined to itself via aliases. Example:

```
SELECT e1.Name AS Emp, e2.Name AS Mgr
FROM Employees e1
JOIN Employees e2
  ON e1.ManagerID = e2.ID;
```

Data Modification

```
-- update specific data with the WHERE clause
  UPDATE table1 SET col1 = 1 WHERE col2 = 2
-- insert values manually
  INSERT INTO table1 (ID, FIRST_NAME, LAST_NAME)
    VALUES (1, 'Rebel', 'Labs');
-- or by using the results of a query
  INSERT INTO table1 (ID, FIRST_NAME, LAST_NAME)
    SELECT id, last_name, first_name FROM table2
```

Nested Queries

Correlated Subquery
Definition: Subquery evaluated per outer row. Example:

```
SELECT a.actorname,
 (SELECT m.genre
  FROM Movie m
  WHERE m.name = a.moviename)
  AS genre
FROM ActedIN a;
```

Subquery in FROM
Definition: Treat subquery as table. Example:

```
SELECT x.name, x.rating
FROM (SELECT * FROM Movie WHERE
     rating>8) AS x
WHERE x.rating<9;
```

EXISTS / IN
Definition: Existential tests in WHERE. Example:

```
WHERE EXISTS (
  SELECT 1 FROM Movie m
  WHERE m.name=a.moviename
    AND m.genre='Sci-Fi');
-- OR --
WHERE a.moviename IN (
  SELECT m.name FROM Movie m
  WHERE m.genre='Sci-Fi');
```

ALL / NOT EXISTS
Definition: Universal tests. Example:

```
WHERE 100000<ALL(
  SELECT a.salary FROM ActedIN a
  WHERE a.moviename=m.name);
-- OR --
WHERE NOT EXISTS (
  SELECT 1 FROM ActedIN a
  WHERE a.moviename=m.name
    AND a.salary<=100000);
```

Set Operations

UNION
Definition: Combines two queries, removes duplicates. Example: `SELECT ... UNION SELECT ...;`

UNION ALL
Definition: Combines two queries, keeps duplicates.

INTERSECT
Definition: Rows common to both, removes duplicates.

EXCEPT
Definition: Rows in first not in second.

Relational Algebra

$\sigma_C(R)$
Definition: Selection — picks rows satisfying C. Example: $\sigma_{year>2010}(\text{Movie})$

$\pi_{A_1,\ldots,A_n}(R)$
Definition: Projection — picks columns A_i. Example: $\pi_{name,genre}(\text{Movie})$

$R_1 \cup R_2$
Definition: Union of two relations.
$R_1 \cap R_2$
Definition: Intersection of two relations.
$R_1 - R_2$
Definition: Set difference.
$R_1 \times R_2$
Definition: Cartesian product.
$\rho_{B_1,\ldots,B_n}(R)$
Definition: Renaming relation/attributes. Example: $\rho_{M(name)}(Movie)$

$\gamma_{G;f}(R)$
Definition: Grouping + aggregate. Example: $\gamma_{genre;count(*)}(Movie)$

$\bowtie_C$
Definition: Theta-join $= \sigma_C(R_1 \times R_2)$. Example: see Joins box.

$\tau_{A_1,\ldots}(R)$
Definition: Sorting by A_i. Example: $\tau_{year,name}(Movie)$

TEXT OPERATORS
Fetch names of cities that start with a 'P' or end with an 's':

```
SELECT name
FROM city
WHERE name LIKE 'P%'
  OR name LIKE '%s';
```

```
DROP TABLE IF EXISTS WorksOn;
DROP TABLE IF EXISTS Project;
DROP TABLE IF EXISTS Developer;

CREATE TABLE Project(
  pid INT PRIMARY KEY,
  name TEXT,
  startYear INT
);

CREATE TABLE Developer(
  did INT PRIMARY KEY,
  name TEXT,
  hireYear INT
);

CREATE TABLE WorksOn(
  pid INT REFERENCES Project(pid),
  did INT REFERENCES Developer(did),
  year INT
);
```

1. **Dev count per project-year** Returns for each project and for each year the total number of developers who worked on that project in that year. Your query should return the project's ID, name, year, and number of developers, sorted by year in increasing order, and, within each year, sorted in decreasing order of the number of developers.

```
SELECT P.pid, P.name, W.year, COUNT(*)
    AS cnt
FROM Project AS P
JOIN WorksOn AS W ON P.pid = W.pid
GROUP BY P.pid, P.name, W.year
ORDER BY W.year ASC, cnt DESC;
```

2. **Inactive projects** A project is called inactive if no developer worked on it since 2010 (including and after 2010). Write a SQL query to find all inactive projects. You should return their IDs and names.

```
-- Solution 1
SELECT P.pid, P.name
FROM Project AS P
WHERE NOT EXISTS (
SELECT 1
FROM WorksOn AS W
WHERE W.pid = P.pid AND W.year >= 2010
);

-- Solution 2
SELECT P.pid, P.name
FROM Project AS P
LEFT OUTER JOIN WorksOn AS W
ON P.pid = W.pid AND W.year >= 2010
GROUP BY P.pid, P.name
HAVING COUNT(W.pid) = 0;
```

3. **Top projects since 1990** For each year since 1990 (including and after 1990), return the project(s) that the most developers worked on during that year. Return the year and project ID. In case of a tie (if multiple projects had the maximum number of developers) return all of them.

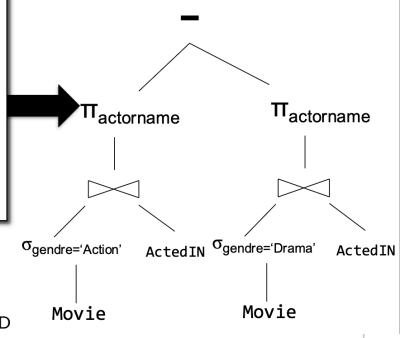
```
-- Universal Quantifier Approach
SELECT W.year, W.pid
FROM WorksOn AS W
WHERE W.year >= 1990
GROUP BY W.year, W.pid
HAVING COUNT() >= ALL (
SELECT COUNT()
FROM WorksOn AS W2
WHERE W2.year = W.year
GROUP BY W2.pid
);

-- Witness Approach
WITH A AS (
SELECT year, pid, COUNT(*) AS cnt
FROM WorksOn
WHERE year >= 1990
GROUP BY year, pid
),
B AS (
SELECT year, MAX(cnt) AS maxcnt
FROM A
GROUP BY year
)
SELECT A.year, A.pid
FROM A JOIN B ON A.year = B.year AND
     A.cnt = B.maxcnt;
```

4. **SystemX devs** `SystemX` is the oldest project of the company. Write a SQL query that returns all developers who worked every year on `SystemX`, from when it started until 2015. Your query should return the developers' ID and name.

```
-- Solution 1
SELECT D.did, D.name
FROM Project AS P
JOIN WorksOn AS W ON P.pid = W.pid
JOIN Developer AS D ON W.did = D.did
WHERE P.name = 'SystemX'
AND W.year BETWEEN P.startYear AND 2015
GROUP BY D.did, D.name, P.startYear
HAVING COUNT(*) = (2015 - P.startYear +
     1);
```

```
SELECT a1.actorname
FROM   Movie m1, ActedIN a1
WHERE  m1.name= a1.moviename
AND m1.genre ='Action'
EXCEPT
SELECT a2.actorname
FROM   Movie m2, ActedIN a2
WHERE  m2.name= a2.moviename
AND m2.genre ='Drama'
```



A self-join is typically used to: Compare rows within the same table.
"In SQL, NONE values represent missing or unknown data." False
What does the SQL command LIMIT 10 do? Limits the result set to the first 10 rows.
Which of the following data integrity constraints ensures values in one table correspond to values in another table? Foreign key constraint.
Which of the following SQL clauses is best suited for filtering out duplicates based on specific columns, and not all columns? GROUP BY.
Which type of subquery is executed once for every row processed by the outer query? Correlated subquery.
What distinguishes a primary key from a foreign key? A primary key identifies a unique row in a table, while a foreign key links data between tables.
Is the following statement true or false? "SQL keywords are case-sensitive." False.
Which of the following allows you to uniquely identify a tuple? Super key.
What does a Common Table Expression (CTE) allow you to do? Define a temporary result set that can be referred to within a SELECT, INSERT, UPDATE, or DELETE statement.

```
SELECT FirstName, LastName, CustomerID
FROM Customers
JOIN Orders
ON Customers.CustomerID=Orders.CustomerID
```

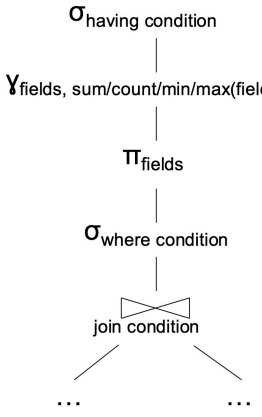
πFirstName, LastName, CustomerID (Customers) ⋈ πCustomerID (Orders)

```
SELECT X.did
FROM Developer X
WHERE NOT EXISTS
      (SELECT *
       FROM Project Z
       WHERE NOT EXISTS
             (SELECT *
              FROM WorksOn Y
              WHERE X.did = Y.did AND Y.pid = Z.pid
                AND Y.year = 2015));
```

The First Normal Form – 1NF
- A single cell must not hold more than one value (atomicity)
- There must be a primary key for identification
- No duplicated rows or columns
- Each column must have only one value for each row in the table

The Second Normal Form – 2NF
It's already in 1NF, Has no partial dependency: all non-key attributes are fully dependent on the primary key

The Third Normal Form – 3NF
- It's in 2NF
- Has no transitive dependency: no non-prime attribute depends on another non-prime attribute




```
SELECT fields
FROM R, S, …
WHERE condition
GROUP BY fields
HAVING condition
```

How can you use a nested query to find the second highest salary in a company?

SELECT MAX(salary) FROM employees WHERE salary < (SELECT MAX(salary) FROM employees)

```
SELECT X.did, X.name, count(*)
FROM Developer X, WorksOn y, Project Z
WHERE X.did = y.did and y.pid = Z.pid
  AND y.year < Z.startYear + 2
GROUP BY X.did, X.name, X.hireYear
HAVING X.hireYear + 10 < max(startYear);
```

Solution:

$$\pi_{(X3.did)}(\rho_{X3}(Developer)) - \pi_{(X.did)}(A - B)$$

Where A is

$$\pi_{(Y2.pid,Y2.did)}($$
$$(\rho_{Y2}(WorksOn))$$

Where B is

$$\pi_{(Z.pid,X.did)}($$
$$\sigma_{(Y.year=2015)}($$
$$\rho_X(Developer) \bowtie_{(X.did=Y.did)} \rho_Y(WorksOn) \bowtie_{(Y.pid=z.pid)} \rho_Z(Project)))$$

Solution:

$$\pi_{(X.did,X.name,C)}($$
$$\sigma_{(X.hireYear+10<M)}($$
$$\gamma_{(X.did,X.name,X.hireYear,count(*)->C,max(Z.startYear)->M)}($$
$$\sigma_{(Y.year<Z.startYear+2)}($$
$$\rho_X(Developer) \bowtie_{(X.did=Y.did)} \rho_Y(WorkOn) \bowtie_{(Y.pid=Z.pid)} \rho_Z(Project)))))$$

SELECT FirstName, LastName, SUM(Quantity) FROM Customers JOIN Orders ON Customers.CustomerID=Orders.CustomerID JOIN OrderDetails ON Orders.OrderID=OrderDetails.OrderID GROUP BY FirstName, LastName

(πFirstName, LastName, SUM(Quantity) (γ FirstName, LastName, SUM(Quantity) (πFirstName, LastName, Quantity (πFirstName, LastName, CustomerID(Customers) ⋈ πCustomerID, OrderID (Orders)) ⋈ πQuantity, OrderID (OrderDetails))))