

# SQL: My Notes

Databases and SQL for Data Science with Python

Tristan Daret

November 28, 2025

# Table of Contents

- ① SQL Commands Cheatsheet
- ② SQL Key concepts
- ③ Data Query Language (DQL)
- ④ Data Manipulation Language (DML)
- ⑤ Data Definition Language (DDL)
- ⑥ Constraints & Optional Parameters

# SQL Commands Cheatsheet

# SQL Commands Reference - DQL

## DQL ⇒ Data Query Language

Command	Applies to	Description
SELECT	Table	Retrieve data from database tables
WHERE	Rows	Filter rows based on conditions
JOIN	Tables	Combine rows from two or more tables
GROUP BY	Rows	Group rows for aggregation
HAVING	Groups	Filter groups after aggregation
ORDER BY	Result set	Sort results (ASC/DESC)
COUNT	Rows	Count number of rows (aggregate)
SUM	Rows	Sum values (aggregate)
AVG	Rows	Average values (aggregate)
MIN	Rows	Minimum value (aggregate)
MAX	Rows	Maximum value (aggregate)
DISTINCT	Rows	Return unique values only
BETWEEN	Rows	Range selection (inclusive)
IN	Rows	Match any value from a list or subquery
LIKE	Rows	Pattern matching with wildcards
REGEXP	Rows	Regex pattern matching (DB-specific)
LIMIT	Result set	Restrict number of rows returned
OFFSET	Result set	Skip a specified number of rows
AS	Columns/Expressions	Give an alias to a column or expression
ILIKE	Rows	Case-insensitive LIKE (PostgreSQL)

# SQL Commands Reference - DML

**DML** ⇒ Data Manipulation Language

Command	Applies to	Description
INSERT	Rows	Add new rows to a table
UPDATE	Rows	Modify existing rows
DELETE	Rows	Remove rows from a table
SET	Columns	Specify column values in UPDATE

# SQL Commands Reference - DDL

**DDL** ⇒ Data Definition Language

Command	Applies to	Description
CREATE	Table/DB	Create new database objects (tables, etc.)
ALTER	Table	Modify structure of existing objects
ADD	Column	Add new columns to existing table
DROP	Table/DB	Delete database objects permanently
TRUNCATE	Table	Remove all rows from table (keep structure)
RENAME	Table/Column	Rename tables or columns
MODIFY	Column	Change column definition (ALTER variant)
SET CONSTRAINTS	Session	Control timing of constraint checks (IMMEDIATE/DEFERRED)

# SQL Commands Reference - DCL

**DCL** ⇒ Data Control Language

GRANT	Permissions	Give privileges to users or roles
REVOKE	Permissions	Remove privileges from users or roles

# SQL Commands Reference - Constraints & Options

Command	Applies to	Description
NOT NULL	Column	Column must have a value (no NULL)
PRIMARY KEY	Column	Unique identifier for each row
FOREIGN KEY	Column	Link to PRIMARY KEY in another table
UNIQUE	Column	Enforce unique values in a column
CHECK	Column	Custom condition that values must satisfy
DEFAULT	Column	Default value when none provided

# SQL Key concepts

## Primary Key

- **Uniquely identifies** each row in a table
- Analogy: Like a particle's unique quantum state identifier
- Must be NOT NULL and UNIQUE
- Only ONE primary key per table

## Foreign Key

- Column(s) that **reference** a Primary Key in another table
- Analogy: Like conservation laws linking different processes
- Enforces **referential integrity**
- Can have multiple foreign keys in one table
- Prevents orphaned records

# Integrity Constraints

## Entity Integrity

**Purpose:** Guarantees each row is uniquely identifiable

- Enforced via PRIMARY KEY constraint
- No NULL values allowed in primary key
- Prevents duplicate entities in table
- Example: Each particle has unique ID

## Domain Constraints

**Purpose:** Restrict values to valid domain/range

- Data type enforcement (INT, VARCHAR, DATE, etc.)
- NOT NULL: requires a value
- CHECK: custom conditions (e.g., mass > 0)
- UNIQUE: no duplicates allowed
- DEFAULT: provides fallback value

## Referential Integrity

**Purpose:** Maintains consistency between related tables

- FOREIGN KEY references PRIMARY KEY in parent table
- Cannot insert orphaned records (child without parent)
- Cascade actions: ON DELETE/UPDATE CASCADE, SET NULL, RESTRICT
- Example: Experiment must reference existing particle

## Key points

These three constraint types work together to ensure data quality, consistency, and validity throughout the database.

# SQL statement categories

## DDL - Data Definition Language

Defines and modifies database **structure**

- CREATE, ALTER, DROP, TRUNCATE
- Schema operations
- Usually **irreversible**

## DML - Data Manipulation Language

Manipulates the **data** within structures

- INSERT, UPDATE, DELETE
- Data operations
- Can be rolled back

## DQL - Data Query Language

Retrieves data from database

- SELECT (with WHERE, JOIN, etc.)
- Read-only operations
- No data modification

## DCL - Data Control Language

Controls access and permissions

- GRANT, REVOKE
- User permissions
- Security management

# Data Query Language (DQL)

# SELECT - Retrieve Data

## Syntax:

```
SELECT column1, column2, ...
FROM table_name;

-- All columns
SELECT *
FROM table_name;
```

## Example:

```
SELECT particle_name, mass
FROM particles;

-- All data
SELECT *
FROM particles;
```

**Description:** The fundamental query command - retrieves data from one or more tables.

**Note:** SELECT \* can be inefficient for large tables - specify only needed columns.

# WHERE - Filter Rows

## Syntax:

```
SELECT column1, column2  
FROM table_name  
WHERE condition;  
  
-- Multiple conditions  
WHERE condition1  
    AND condition2  
    OR condition3;
```

## Example:

```
SELECT particle_name  
FROM particles  
WHERE mass > 100;  
  
-- Combined  
WHERE charge = 0  
    AND spin = 0.5;
```

**Description:** Filters rows based on specified conditions (like applying selection cuts in analysis).

**Operators:** =, <, >, <=, >=, <>, AND, OR, NOT, IN, LIKE, BETWEEN

# Pattern Matching - LIKE and Wildcards

## Syntax:

```
-- Basic LIKE patterns
WHERE col LIKE 'abc%'          -- starts with 'abc'
      WHERE col LIKE '%xyz'        -- ends with 'xyz'
      WHERE col LIKE '%mid%'       -- contains 'mid'
      WHERE col LIKE 'h_m'          -- h + any single char + m

-- Escape literal % or _
      WHERE col LIKE '50\%%', ESCAPE
            '\'
```

## Wildcards:

- % : any sequence of characters (including empty)
- \_ : exactly one character
- Use ESCAPE to treat wildcard characters literally
- ILIKE (PostgreSQL) : case-insensitive LIKE

## Examples:

```
SELECT name FROM particles
WHERE name LIKE 'mu%';

SELECT name FROM particles
WHERE name ILIKE '%on%'; -- PostgreSQL
```

## Regex Syntax (DB-specific):

```
-- MySQL
WHERE col REGEXP '^A[0-9]{3}$'

-- PostgreSQL
WHERE col ~ '^[A-Z]{2}[0-9]+$'
WHERE col ~* 'pattern'  --
      case-insensitive
```

## Performance Notes:

- Leading % (e.g., ' )
- Prefer 'prefix'
- Regex is more flexible but usually slower than LIKE
- For repeated workloads consider indexed/generated columns

**Use cases:** validation, structured codes, exploratory substring search.

# Range Selection - BETWEEN

## Syntax:

```
-- Inclusive range  
WHERE col BETWEEN low AND high  
  
-- Equivalent  
WHERE col >= low AND col <=  
    high  
  
-- Exclude range  
WHERE col NOT BETWEEN low AND  
    high
```

## Notes:

- 'BETWEEN' is inclusive of both endpoints
- Works for numbers, dates, and strings (DB-specific ordering)
- For exclusive bounds use '>'/'<' explicitly

## Examples:

```
SELECT * FROM experiments  
WHERE mass BETWEEN 10 AND 100;  
  
-- Date range  
SELECT * FROM experiments  
WHERE start_date BETWEEN '2020-01-01' AND '2020-12-31';
```

# Set Selection - IN and Subqueries

## Syntax:

```
-- Match any value in the list
WHERE col IN (val1, val2, ...)

-- Using a subquery
WHERE col IN (SELECT id FROM
    allowed_ids)

-- Negation
WHERE col NOT IN (val1, val2)
```

## Notes:

- 'IN' is shorthand for multiple ORs
- Subquery must return a single column
- Beware 'NULL' with 'NOT IN' (can yield no rows) – prefer 'NOT EXISTS'

## Examples:

```
SELECT name FROM particles
WHERE charge IN (-1, 0, 1);

SELECT * FROM results
WHERE experiment_id IN (
    SELECT id FROM experiments WHERE status = 'active'
);
```

# COUNT - Count Rows

## Syntax:

```
SELECT COUNT(column_name)
FROM table_name;
```

-- Count all rows

```
SELECT COUNT(*)
FROM table_name;
```

-- With condition

```
SELECT COUNT(*)
FROM table_name
WHERE condition;
```

## Example:

```
SELECT COUNT(particle_id)
FROM particles;
```

-- All particles

```
SELECT COUNT(*)
FROM particles;
```

-- Neutral particles

```
SELECT COUNT(*)
FROM particles
WHERE charge = 0;
```

**Description:** Returns the number of rows (like counting events in a detector).

**Note:** COUNT(\*) includes NULL values; COUNT(column) excludes NULLs.

# DISTINCT - Unique Values

## Syntax:

```
SELECT DISTINCT column1  
FROM table_name;
```

-- Multiple columns

```
SELECT DISTINCT  
    column1, column2  
FROM table_name;
```

## Example:

```
SELECT DISTINCT charge  
FROM particles;
```

-- Unique combinations

```
SELECT DISTINCT  
    charge, spin  
FROM particles;
```

**Description:** Returns only unique values, eliminating duplicates.

**Note:** With multiple columns, DISTINCT applies to the *combination* of values.

# GROUP BY - Aggregate Rows

## Syntax:

```
SELECT column1,  
       aggregate_function(column2)  
    )  
FROM table_name  
GROUP BY column1;  
  
-- Multiple grouping columns  
SELECT col1, col2, SUM(amount)  
FROM sales  
GROUP BY col1, col2;
```

## Description:

- Groups rows that share the same values for the grouped column(s)
- Use with aggregate functions: COUNT, SUM, AVG, MIN, MAX
- Useful to compute summaries per category (e.g., per customer)

# COUNT and Aliases - Label Aggregates

## Syntax / Examples:

```
-- Count rows per category and
-- name the column
SELECT category, COUNT(*) AS
    cnt
FROM items
GROUP BY category;

-- Multiple aggregates
SELECT user_id,
       COUNT(*) AS num_orders,
       SUM(total) AS
           total_spent
FROM orders
GROUP BY user_id;
```

## Notes:

- 'AS' gives a readable name to aggregate output columns
- Aggregates ignore NULLs (except COUNT(\*))
- Use aliases in ORDER BY or in outer queries for clarity

# HAVING - Filter Groups (vs WHERE)

## Syntax:

```
SELECT category, COUNT(*) AS  
      cnt  
FROM items  
GROUP BY category  
HAVING COUNT(*) > 10;  
  
-- Combining WHERE and HAVING  
SELECT user_id, SUM(amount) AS  
      total  
FROM payments  
WHERE status = 'completed'  
      -- filters rows first  
GROUP BY user_id  
      -- then groups the  
      -- filtered rows  
HAVING SUM(amount) > 1000;  
      -- filters groups by  
      -- aggregate
```

## Key Differences:

- WHERE filters raw rows before grouping
- HAVING filters groups after aggregation
- HAVING typically references aggregate functions

# LIMIT - Restrict Result Set

## Syntax:

```
SELECT column1, column2  
FROM table_name  
LIMIT number;
```

```
-- With ORDER BY  
SELECT column1  
FROM table_name  
ORDER BY column1  
LIMIT number;
```

## Example:

```
SELECT particle_name  
FROM particles  
LIMIT 10;
```

```
-- Top 5 heaviest  
SELECT particle_name  
FROM particles  
ORDER BY mass DESC  
LIMIT 5;
```

**Description:** Restricts the number of rows returned (useful for large datasets).

**Note:** Without ORDER BY, which rows are returned is undefined. Different syntax in some databases (TOP in SQL Server).

# OFFSET - Skip Rows

## Syntax:

```
SELECT column1, column2  
FROM table_name  
LIMIT number  
OFFSET skip_count;
```

-- Alternative syntax

```
SELECT column1  
FROM table_name  
LIMIT skip_count, number;
```

## Example:

```
SELECT particle_name  
FROM particles  
LIMIT 10  
OFFSET 20;
```

-- Skip first 20,  
-- return next 10  
-- (rows 21-30)

**Description:** Skips specified number of rows before returning results (pagination).

**Note:** Often used with LIMIT for pagination. OFFSET 0 returns from the first row.

# Data Manipulation Language (DML)

# INSERT - Add New Rows

## Syntax:

```
INSERT INTO table_name
  (col1, col2, ...)
VALUES
  (val1, val2, ...);

-- Multiple rows
INSERT INTO table_name
VALUES
  (val1, val2),
  (val3, val4);
```

## Example:

```
INSERT INTO particles
  (name, mass, charge)
VALUES
  ('electron', 0.511, -1);

-- Multiple
INSERT INTO particles
VALUES
  ('muon', 105.7, -1),
  ('tau', 1776.9, -1);
```

**Description:** Adds new rows of data to a table.

**Warning:** Must satisfy all constraints (PRIMARY KEY, NOT NULL, etc.).

# UPDATE - Modify Existing Rows

## Syntax:

```
UPDATE table_name  
SET column1 = value1,  
    column2 = value2  
WHERE condition;
```

## Example:

```
UPDATE particles  
SET mass = 0.511  
WHERE name = 'electron';  
  
-- Multiple columns  
UPDATE particles  
SET mass = 105.658,  
    spin = 0.5  
WHERE name = 'muon';
```

**Description:** Modifies existing data in a table.

**WARNING:** Without WHERE clause, **ALL rows will be updated!** Always test with SELECT first.

# SET - Assign Values (UPDATE)

## Syntax:

```
UPDATE table_name  
SET column1 = value1,  
    column2 = value2,  
    column3 = expression  
WHERE condition;
```

## Example:

```
UPDATE experiments  
SET status = 'complete',  
    end_date = CURDATE(),  
    duration = 365  
WHERE exp_id = 42;
```

**Description:** SET is not standalone - it's the clause in UPDATE that specifies which columns to modify and their new values.

**Note:** Can use expressions, functions, or values from other columns.

# DELETE - Remove Rows

## Syntax:

```
DELETE FROM table_name  
WHERE condition;  
  
-- Delete all rows  
DELETE FROM table_name;
```

## Example:

```
DELETE FROM particles  
WHERE mass < 0.001;  
  
-- Remove all data  
-- (structure remains)  
DELETE FROM temp_data;
```

**Description:** Removes rows from a table permanently.

**WARNING:** Without WHERE, **ALL rows deleted!** Cannot delete if foreign key constraints are violated. Use TRUNCATE for faster full-table deletion.

# Data Definition Language (DDL)

# CREATE - Build New Objects

## Syntax:

```
CREATE TABLE table_name (
    column1 datatype,
    column2 datatype,
    column3 datatype,
    PRIMARY KEY (column1)
);
```

## Example:

```
CREATE TABLE particles (
    particle_id INT,
    name VARCHAR(50),
    mass DECIMAL(10,3),
    charge INT,
    PRIMARY KEY (particle_id)
);
```

**Description:** Creates new database objects (tables, databases, indexes, etc.).

**Note:** Define structure carefully - changing it later requires ALTER. Common datatypes: INT, VARCHAR, DECIMAL, DATE, BOOLEAN.

# ADD - Add Columns to Table

## Syntax:

```
ALTER TABLE table_name  
ADD column_name datatype;  
  
-- With constraints  
ALTER TABLE table_name  
ADD column_name datatype  
constraint;  
  
-- Multiple columns  
ALTER TABLE table_name  
ADD column1 datatype1,  
ADD column2 datatype2;
```

## Example:

```
ALTER TABLE particles  
ADD spin DECIMAL(3,1);  
  
-- With NOT NULL  
ALTER TABLE particles  
ADD mass DECIMAL(10,3)  
NOT NULL;  
  
-- Multiple columns  
ALTER TABLE particles  
ADD color VARCHAR(20),  
ADD discovered DATE;
```

**Description:** Adds new columns to an existing table without affecting existing data.

**Note:** New column is added with NULL values for existing rows (unless DEFAULT specified). Cannot add NOT NULL without DEFAULT on non-empty tables.

# ALTER - Modify Table Structure

## Syntax:

```
-- Add column  
ALTER TABLE table_name  
ADD column_name datatype;  
  
-- Drop column  
ALTER TABLE table_name  
DROP COLUMN column_name;  
  
-- Modify column  
ALTER TABLE table_name  
MODIFY column_name datatype;
```

## Example:

```
-- Add spin column  
ALTER TABLE particles  
ADD spin DECIMAL(3,1);  
  
-- Remove old column  
ALTER TABLE particles  
DROP COLUMN old_field;  
  
-- Change type  
ALTER TABLE particles  
MODIFY mass FLOAT;
```

**Description:** Modifies the structure of an existing table.

**Warning:** Can cause data loss if not careful (e.g., reducing column size).

# DROP - Delete Objects Permanently

## Syntax:

```
DROP TABLE table_name;  
  
DROP DATABASE database_name;  
  
-- With safety check  
DROP TABLE IF EXISTS  
    table_name;
```

## Example:

```
DROP TABLE temp_results;  
  
DROP DATABASE test_db;  
  
-- Safe version  
DROP TABLE IF EXISTS  
    old_particles;
```

**Description:** Permanently deletes database objects (table, database, index, etc.). Can be used before a fresh CREATE.

**WARNING: IRREVERSIBLE!** All data AND structure are destroyed. Cannot drop if foreign keys reference it. Use IF EXISTS to avoid errors.

# TRUNCATE - Empty Table Fast

## Syntax:

```
TRUNCATE TABLE table_name;
```

## Example:

```
TRUNCATE TABLE temp_events;
```

-- Faster than:

```
-- DELETE FROM temp_events;
```

**Description:** Removes ALL rows from a table, but keeps the structure intact.  
Much faster than DELETE for large tables.

**Warning:** Cannot be rolled back in most databases. Resets AUTO\_INCREMENT counters. May fail if foreign key constraints exist.

# RENAME - Rename Database Objects

## Syntax:

```
-- Rename table  
ALTER TABLE old_name  
RENAME TO new_name;  
  
-- Or (MySQL/MariaDB)  
RENAME TABLE old_name  
    TO new_name;  
  
-- Rename column (MySQL)  
ALTER TABLE table_name  
RENAME COLUMN old_col  
    TO new_col;
```

## Example:

```
-- Rename table  
ALTER TABLE temp_particles  
RENAME TO particles_backup;  
  
-- MySQL shorthand  
RENAME TABLE old_data  
    TO archive_data;  
  
-- Rename column  
ALTER TABLE particles  
RENAME COLUMN mass  
    TO particle_mass;
```

**Description:** Changes the name of database objects (tables, columns) without affecting data or structure.

**Note:** Syntax varies by database system. Update all references (views, stored procedures, application code) after renaming. Foreign keys typically remain valid.

# MODIFY - Change Column Definition

## Syntax:

```
-- MySQL/Oracle
ALTER TABLE table_name
MODIFY column_name
    new_datatype;

-- PostgreSQL/SQL Server
ALTER TABLE table_name
ALTER COLUMN column_name
    TYPE new_datatype;
```

## Example:

```
-- MySQL
ALTER TABLE particles
MODIFY mass
    DECIMAL(15,5);

-- PostgreSQL
ALTER TABLE particles
ALTER COLUMN mass
    TYPE DOUBLE PRECISION;
```

**Description:** Part of ALTER TABLE - changes a column's datatype or constraints.

**Note:** Syntax varies by database system. May fail if existing data incompatible with new type.

# IMMEDIATE - Constraint Checking Mode

## Syntax:

```
-- DB2/Some systems
SET CONSTRAINTS ALL
    IMMEDIATE;

-- vs DEFERRED
SET CONSTRAINTS ALL
    DEFERRED;
```

## Example:

```
SET CONSTRAINTS ALL
    IMMEDIATE;

INSERT INTO particles
VALUES (1, 'test', 0, 0);
-- Constraints checked
-- immediately
```

**Description:** Controls when constraint checking occurs. IMMEDIATE = check after each statement; DEFERRED = check at transaction end.

**Note:** Not supported in all database systems (mainly DB2, Oracle). Useful for complex multi-table operations.

# Constraints & Optional Parameters

# NOT NULL - Require Values

## Syntax:

```
CREATE TABLE table_name (
    column1 datatype NOT NULL,
    column2 datatype,
    column3 datatype NOT NULL
);

-- Add to existing
ALTER TABLE table_name
MODIFY column_name
datatype NOT NULL;
```

## Example:

```
CREATE TABLE particles (
    id INT NOT NULL,
    name VARCHAR(50) NOT NULL,
    mass DECIMAL(10,3),
    charge INT NOT NULL
);

-- Make mandatory
ALTER TABLE particles
MODIFY name
VARCHAR(50) NOT NULL;
```

**Description:** Constraint that prevents NULL values in a column - the column must have a value.

**Note:** Primary keys are automatically NOT NULL. Essential for critical fields like identifiers.