Essential SQL Techniques

```
$ echo "Data Sciences Institute"
```

Essential Techniques

→ Aggregation Functions

Subqueries

Temporary Tables & CTEs (Common Table Expressions)

Datetime Functions

Aggregation Functions Overview

- **GROUP BY**: Organizes your results based on selected columns.
- **COUNT**: Returns the number of rows that match a specified condition.
- **SUM & AVG**: Calculate total and average values of a specified column.
- **MIN & MAX**: Find the smallest and largest values.
- **Arithmetic Operations**: Perform calculations on column values.
- **HAVING**: Apply filters after aggregations.

GROUP BY: Foundation of Aggregation

- Aggregations generally require a *group*
- `GROUP BY` is mandatory any time a column aside from the one being aggregated is present

GROUP BY: Foundation of Aggregation

For example, a query wanting to know the number of days in each month:

```
    SELECT
    COUNT(days)
    ,months

    FROM calendar
    GROUP by months
```

- `GROUP BY` comes after a `WHERE` clause
- Remember: with all aggregation functions, values will be calculated *per group*

COUNT: Quantifying Rows

- `COUNT` performs counts of any given column or set of columns
- `COUNT(*)` provides a count of rows in a given table
  - no `GROUP BY` is required here
- Multiple counts are treated as separate columns
  - e.g. counting the number of days and months in a year

```
SELECT
COUNT(days)
,COUNT(DISTINCT months)
,years

FROM calendar
GROUP by years
```

COUNT: Quantifying Rows

- When `COUNT` is combined with `DISTINCT`, only unique values are counted
  - `SELECT COUNT(DISTINCT product_id) ...` might produce a different value than `SELECT COUNT(product_id) ...` depending on the context of the table

vendor_id	product_id	market_date
1	1	2025-01-01
1	1	2025-01-02
1	2	2025-01-01
1	2	2025-01-02
1	2	2025-01-03
1	3	2025-01-02
1	4	2025-01-02

vendor_id	count_of_distinct_products
1	4

vendor_id	count_of_products
1	7

COUNT: Quantifying Rows

(`COUNT` live coding)

SUM & AVG: Calculating Totals and Averages

- `SUM` performs the sum total of any numeric column
    - Be wary, SQLite may be more permissive for columns with numbers; it's best practice to coerce (`CAST`) these values into numbers before summing to be certain of their validity
        - e.g. `CAST(SUM(column1) AS INTEGER) AS column1`
- SUM can accommodate multiple columns using the plus `+` operator
    - e.g. `SUM(column1 + column2)`
- Thinking about `SUM` and `COUNT` combined (i.e. a rolling total)? We'll get to that in the next session!

SUM & AVG: Calculating Totals and Averages

- `AVG` performs the average of any numeric column
- Like `SUM`, it can accommodate multiple columns
    - we can also use other mathematical operations for `SUM` and `AVG`, like `-`, `*`, `/`, `%` (i.e. modulo, not percent), etc

SUM & AVG: Calculating Totals and Averages

Watch out! Don't average an average column when using `GROUP BY`

Imagine, `market_avg_temp` stored in the `market_date_info` table:

market_day	market_avg_temp
Saturday	36
Sunday	33
Wednesday	25
Saturday	28
Sunday	31
Wednesday	31
Saturday	29

SUM & AVG: Calculating Totals and Averages

If we `GROUP BY` `market_day`, we can produce an average for each day of the week:

market_day	dow_market_avg_temp
Saturday	31
Sunday	32
Wednesday	28

SUM & AVG: Calculating Totals and Averages

Avoid averaging `dow_market_avg_temp` to get an `overall_market_avg_temp`:

actual_avg	avg_of_avgs
30.42857	30.33333

SUM & AVG: Calculating Totals and Averages

(`SUM` & `AVG` live coding)

MIN & MAX: Finding Extremes

- `MIN` takes the single minimum value of a given column; `MAX` takes the maximum
- Be wary of combining `MIN` & `MAX` with other aggregating functions like `SUM` or `AVG`
- **What do we think happens when `MIN` is performed on a string? Error? Something else? What about `MAX` ?**

MIN & MAX: Finding Extremes

(`MIN` & `MAX` live coding)

Arithmetic in SQL

- SQL can perform many basic (and some complex) calculations
  - addition, subtraction, multiplication, division, power, etc
  - geometric/trigonometric functions sin, cos, tan, degrees, radians, etc
- These calculations can also be combined inside aggregation functions
  - e.g. multiplication inside a SUM `...SUM(quantity * cost)` would create a column like total_spent per group
- SQL is similar to other programming languages in its ability to handle floating point values
- **Because columns are type specific, how would we perform integer division on two numbers?**

Arithmetic

(Arithmetic live coding)

HAVING: Filtering Aggregated Results

- `WHERE` clauses filter rows *before* an aggregation occurs

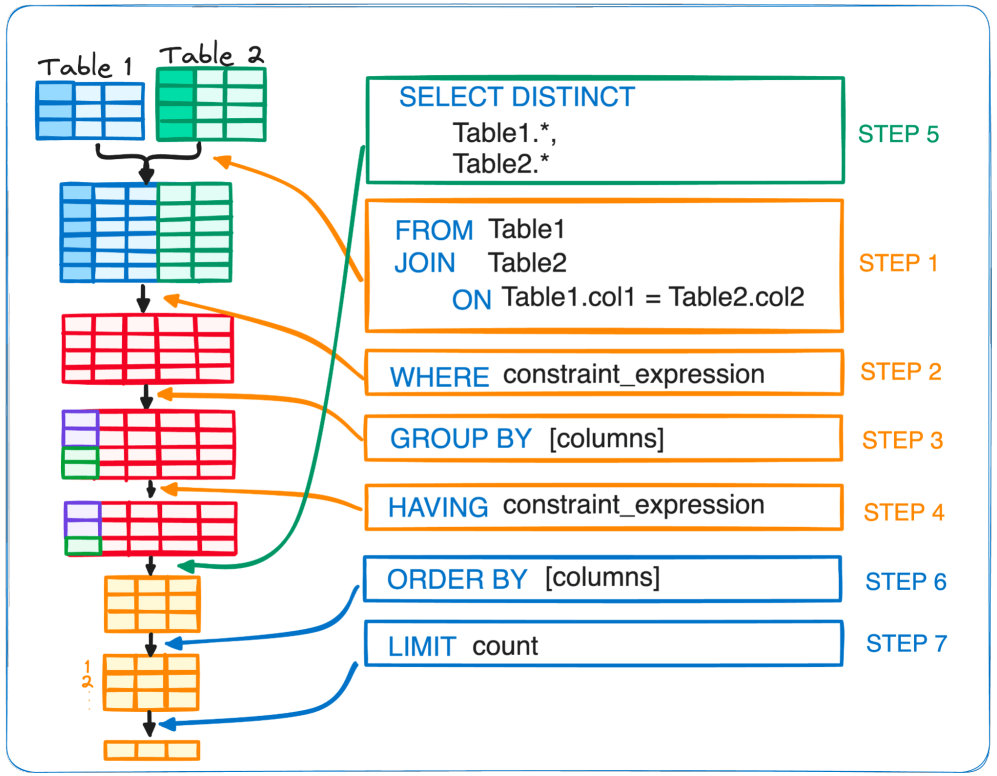
  ...so `HAVING` clauses allow us to filter rows *after* an aggregation is calculated

- `HAVING` clauses come after `GROUP BY`, but before `ORDER BY`
- `HAVING` clauses only filter aggregated calculations
  - you can have both `WHERE` and `HAVING`
  - they are not interchangeable

HAVING: Filtering Aggregated Results

(`HAVING` live coding)

Image: Joseph Ferrer, KDnuggets



What questions do you have about Aggregations?

Subqueries: Queries Within Queries

- SQL allows us to query the results of another query
  - We call this a subquery
- In a subquery, all columns need to be uniquely named
- Subqueries can usually be run for testing purposes by highlighting them, IDE dependent

Subqueries: Queries Within Queries

- Subqueries can be used in both `JOIN` and `WHERE` clauses
  - In the case of `JOIN` (or `FROM`):
    - you want the subquery to add columns to your output
    - you are using a subquery because you are joining/selecting complex criteria that require manipulation
      - it is often the case that you are joining two or more tables within a subquery to another table

```
SELECT *                                              outer query:
FROM                                                  everything from the subquery
    (
    SELECT
    vendor_id                                         subquery:
    ,market_date                                      ordering each vendor's
    ,product_id                                       items by price
    ,original_price
    ,ROW_NUMBER() OVER (PARTITION BY vendor_id
                        ORDER BY original_price DESC) AS price_rank
    FROM vendor_inventory
    ) x
WHERE x.price_rank = 1                                outer query:
                                                      filtered by price_rank
```

Subqueries: Queries Within Queries

- In the case of `WHERE`:
  - you want to filter results
  - you are using a subquery because it is simpler than joining and filtering the columns otherwise
  - it's important to note: *you can only return a single column* in your subquery
    - **Why do we think this is?**

```
SELECT
market_date                                        outer query:
                                                   each sale that's occurred
,customer_id
,vendor_id
,quantity * cost_to_customer_per_qty price
FROM customer_purchases
WHERE market_date IN
    (
     SELECT market_date
     FROM market_date_info                         subquery:
                                                   all days it has rained
     WHERE market_rain_flag = 1
    )
```

Subqueries

(Subqueries live coding)

SELECT Questions? FROM (Questions?)

Temporary Tables & CTEs

Temporary ("temp") Tables

- Table objects created on the fly
- Automatically saved to a reserved `temp` schema
- Accessible across SQL queries in the same session
- Cleared from memory when SQL is closed (or the server connection is terminated)
- Temporary tables can be chained in the same query
    - You can place one temporary table into another
- Must be dropped (deleted from memory) to recreate them with the same name

Temporary ("temp") Tables

- Some older versions of SQL don't allow temporary tables
- They are *fantastic placeholders*
    - **What scenarios can we think of where a temporary table would be particularly useful? 💭💬 Think, Pair, Share**

Temporary Tables

(Temporary Table live coding)

Common Table Expressions (CTEs)

- Similar to temporary tables
  - CTEs were developed *before* temp tables
    - Some SQL versions/flavours (especially much older ones) might not support temp tables, so CTEs are an important skill
- Instantiated query results created on the fly
  - Utilize the `WITH` command
    - Many RDBMs require a semicolon terminating the `WITH` clause
    - Multiple CTEs don't use more than one `WITH` clause, but rather follow one another with a comma
  - Need to be written *before* the final `SELECT` statement

Common Table Expressions (CTEs)

- Sometimes easier than a subquery
  - If subqueries become overly complex, they can be harder to read
- Stored in memory
- Limited to your current query window only

Common Table Expressions (CTEs)

(CTEs live coding)

What questions do you have?

Datetime Functions: Managing Dates and Times

- **Formats**: Understand and convert between different date formats.
- **'NOW'**: Get the current date and time.
- **STRFTIME**: Format dates and times based on specific patterns.
- **Adding and Subtracting Dates**: Calculate date intervals and future/past dates.
- **Difference between Dates**: Find the interval between two dates.

Formats

- Date formats vary widely in SQL databases
  - A general rule of thumb when working with multiple date fields is to force them all into a similar format
    - This may seem obvious, but different source systems may write dates different in SQL DBs
- It is not uncommon to store date values as integers YYYYMMDD to increase optimization and decrease storage size
- Manipulating dates varies by flavour
- SQLite is *less* flexible with dates, requiring all dates to either be:
  - "YYYY-MM-DD" *strings*
  - Julian Day *fractions*
  - Seconds from Unix Time *integers*

'NOW' (or GETDATE() or DATE, flavour dependent)

- These functions (there are actually more of them) get the current date and time
  - Some will return UTC time if requested (this can be useful) e.g. `GETUTCDATE()`
- When combined with other Datetime functions, this can serve as a dynamic value
  - e.g. "yesterday", "last year", and so on
- SQLite uses `DATE()`, `DATETIME()`, `TIME()` (without any arguments) *or* `DATE('now')`

'NOW'

(`'NOW'` live coding)

STRFTIME

- `STRFTIME` converts DATE and DATETIME values into different formats
- `STRFTIME` also allows you to extract specific "dateparts"
  - e.g. `SELECT STRFTIME('%Y','NOW')`
- The first argument of `STRFTIME` is flexible — you can specify more than one datepart at a time *and* any formatting
  - e.g. `SELECT STRFTIME('%Y-%m','NOW')` would return 2025-08

STRFTIME

- `STRFTIME` also allows modification to date dynamically
  - e.g. `SELECT STRFTIME('%Y-%m-%d', '2025-08-07', 'start of month')`
  - **How do we go about subtracting dates rather than adding them?**
- Modifiers include:
  - +/- N years/months/days/hours/minutes/seconds
  - start of year/month/day
  - weekday
- Be mindful: because outcome is a *string*, modification should be done within the `STRFTIME` argument to ensure it is correct
- Some flavours have built in convenience dateparts, like `YEAR`, `MONTH`, etc that make extracting values a bit easier

STRFTIME

(`STRFTIME` live coding)

Adding Dates (sometimes DATEADD or DATE_ADD, flavour dependent)

- SQLite supports two means of adding increments of time to a date:
  - `STRFTIME` as mentioned previously
  - Using `DATE`
    - e.g. `SELECT DATE('2025-08-07', 'start of month')`
- Both of these methods allow you to chain modifiers
  - e.g. `SELECT DATE('2025-08-07', 'start of month', '-1 day')`

What do we see as the difference between these?

- This syntax is fairly unique to SQLite, but is conceptually the same, so briefly I will touch on `DATEADD`
  - Generally, we specify a datepart, add/subtract a value, and the date

Difference between Dates (an extension of STRFTIME or DATEDIFF, flavour dependent)

- The difference between dates can vary in complexity
- We can use `STRFTIME`, subtracting the two dates from one another, using '%s' as our unit
  - e.g. `SELECT (STRFTIME("%s", Date1) - Date2) / {increment, e.g. 3600.0 for hours, 60.0 for minutes, etc}`
    - Be sure to include *.0* for float precision: `ROUND` or `CAST` to integer if desired
  - `STRFTIME` works well for calculating months and years
    - e.g., months until next total solar eclipse 🌑☀️ `SELECT STRFTIME('%m','2026-08-12') - STRFTIME('%m','NOW')`

Difference between Dates (an extension of STRFTIME or DATEDIFF, flavour dependent)

- We can use also use `JULIANDAY`:
    - Julian Days are *fractional* by nature and result in a difference of days
        - e.g., difference in hours `SELECT CAST((JULIANDAY(Date1) – JULIANDAY(Date2) * 24) AS INT)`
- This syntax is also fairly unique to SQLite, but is conceptually the same, so briefly I will touch on `DATEDIFF`
    - Generally, we specify a datepart, startdate, and enddate

Datetime Functions

(Adding Dates and Difference between Dates live coding)

What questions do you have about anything from today?