Advanced SQL Techniques

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

Advanced Techniques

- NULL Management
- Windowed Functions
- String Manipulation
- UNION & UNION ALL
- INTERSECT & EXCEPT

NULL Management in SQL

Handling NULLs effectively:

- **IFNULL and COALESCE**: Substitute NULLs with specified values.
- **NULLIF**: Returns NULL if two expressions are equal, else returns the first expression.

IFNULL/ISNULL (flavour dependent) and COALESCE

- `IFNULL` (sqlite) or `ISNULL` (most others) allows us to return a replacement value for NULLs
  - Replacement values can be another column, a calculated value, or static
    - e.g. when col1 is NULL, it is replaced with values from col2
      - values from col2 are only present if col1 is NULL
      - if col2 is NULL, then NULL will be returned
- `COALESCE` does this as well, but behaves slightly differently
  - `COALESCE` allows you to replace NULLs from replacement values themselves
    - e.g. when col1 is NULL, it's replaced with col2; when col2 is NULL, it's replaced with col3, etc
  - `IFNULL` has to be wrapped around another (set of) `IFNULL` function(s) in order to mimic this behaviour
- Both are acceptable, `IFNULL` may be faster in some cases, though this isn't totally clear
  - `IFNULL` is also less flexible for mixed data types

IFNULL/ISNULL (flavour dependent) and COALESCE

(`IFNULL` & `COALESCE` live coding)

NULLIF

- `NULLIF` is a useful, although perhaps uncommon, means of evaluating if two arguments are equal to one another:
  - `NULLIF(5,5) AS [same], NULLIF(5,7) AS [different]`
  - It can be generally viewed as equivalent to:
    - `CASE WHEN parameter_1 = parameter_2 THEN NULL ELSE expr1 END`
- `NULLIF` is particularly useful when embedded within aggregations
  - Consider checking whether employees received a bonus:
    - `SELECT COUNT(NULLIF(Bonus, 0)) FROM Employees`
  - While these may also be possible within CASE statements, the readability is improved
- Because it is NULL producing, it can be useful in combination with `COALESCE`
  - Consider comparing average budgets from year to year:
    - `SELECT AVG(COALESCE(NULLIF(current_year, previous_year), 0.00)) FROM budgets`
- `NULLIF` can also help capture empty strings and turn them into NULLs
  - `NULLIF(col_with_blanks,'')`

NULLIF

(`NULLIF` live coding)

Windowed Functions

- Purpose
- OVER
- PARTITION BY
- ROW_NUMBER()
- Other Windowed Functions

Purpose

- Windowed Functions allow us to create groupings within groupings ("partitions")
- Allow for greater complexity than simple SQL
  - In Module 3, we mentioned briefly a rolling total, e.g. a `SUM` and a `COUNT`; windowed functions allow us to return these types of results
- Often used with a subquery
  - One of the most common techniques is creating a row number `ROW_NUMBER()` per group
    - When combined with `ORDER BY`, the associated row number will be the *highest* or *lowest* per grouping
    - This allows you to select the min or max by setting the row number = 1 in the "outer" query (i.e. not the "inner" subquery)

```
1  SELECT * FROM                                          "outer" query
2  (
3      SELECT                                             "inner" query
4          vi.vendor_id,
5          vi.market_date,
6          vi.product_id,
7          vi.original_price,
8          ROW_NUMBER() OVER (PARTITION BY vendor_id ORDER BY original_price DESC) AS price_rank
9      FROM farmers_market.vendor_inventory vi
10     ORDER BY vi.vendor_id
11 ) x
12 WHERE x.price_rank = 1                                 "outer" query
```

- Image: Teate, Chapter 7 👉

OVER

- Syntax for windowed function always requires the `OVER` clause
  - `{desired_windowed_function} OVER (ORDER BY [a column])`
- The `ORDER BY` clause is required
- Think of the `OVER` clause as applying the function of your choice
  - e.g. create row numbers based on the ordering of this column
  - e.g. rank these values from highest to lowest

PARTITION BY

- Within an `OVER` clause, we can optionally use `PARTITION BY` to create groupings for the function to be applied to
  - `{desired_windowed_function} OVER (PARTITION BY [a column] ORDER BY [a column])`
- Now, the function is being applied to different groups
  - e.g. rank these values from highest to lowest within these groups
    - The ranking will restart for each group
    - Think of this like the Olympics: the top three competitors for each event get gold, silver, and bronze — the `PARTITION BY` is the event, the `ORDER BY` is the time `ASC` or points `DESC` that determine the outcome of the event
- Both the `PARTITION BY` and `ORDER BY` arguments can take more than one column
  - e.g. life expectancy by country by continent

Image: SQLiteTutorial.net

ROW_NUMBER()

- `ROW_NUMBER()` is the simplest windowed function, but also one of the most useful
  - There are no mathematical functions being applied, just an incremental value by group
  - Determining the top (or bottom) per group is often done through `ROW_NUMBER()`
- `ROW_NUMBER()` might feel a bit like ranking `RANK()` ...but it's not quite
  - **What is the difference between `ROW_NUMBER()` and `RANK()`? 💭💬 Think, Pair, Share**

Other Windowed Functions

- SQL supports quite a few other windowed functions
- `NTILE` for example will assign rows to buckets (4: quartile, 5: quintile, 10: decile, etc)
  - As such, the `NTILE` function requires an argument passed to it
    - `NTILE(4) OVER (PARTITON BY...ORDER BY...)`
- `LAG` and `LEAD` allow us to create an offset of another column
  - e.g. show a previous_year_total next to a current_year_total for easy comparison
- Knowing how and why to use these can make querying a lot easier

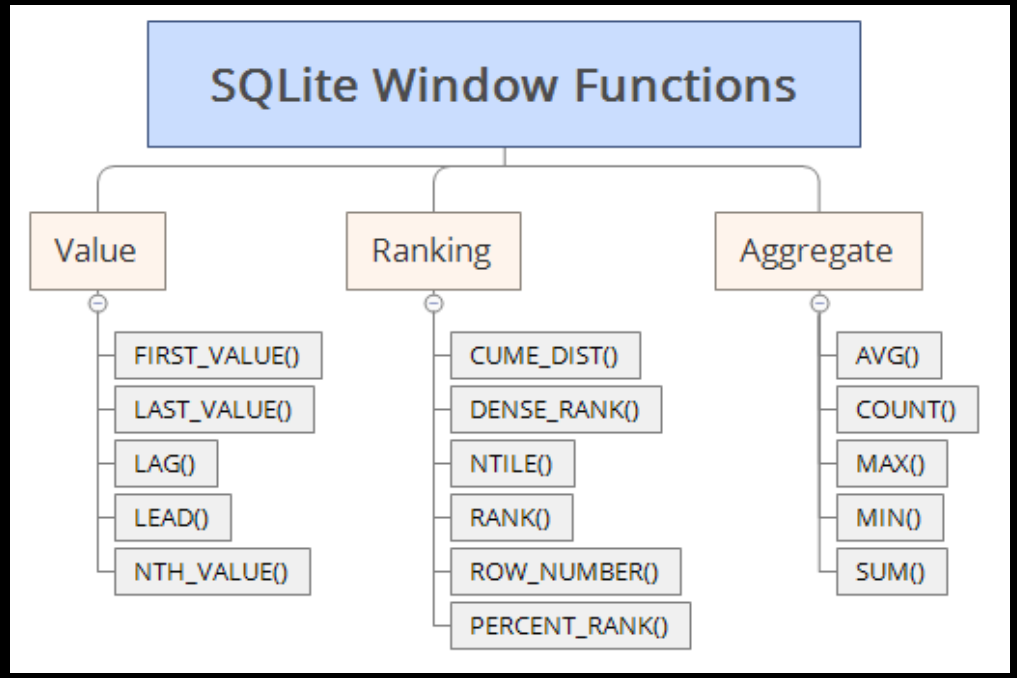


Image: SQLiteTutorial.net 👉

Windowed Functions

(Windowed Functions live coding)

Windowed functions are hard! What questions do you have about them?

String Manipulation

- LTRIM & RTRIM
- REPLACE
- UPPER & LOWER
- Concatenation
- SUBSTR
- INSTR
- LENGTH
- CHAR & UNICODE
- REGEXP

LTRIM & RTRIM

- `LTRIM` and `RTRIM` serve two purposes in SQLite.
  - Their main function is to remove leading or trailing white spaces from strings
    - This is surprisingly common — many SQL databases are populated by human input, and this is a frequently overlooked input error
    - e.g. 'Thomas Rosenthal'
  - Alternatively, they act similarly to `REPLACE` (coming up next), but within their specific context:
    - `LTRIM` removes any specified set of characters from the *left*
    - `RTRIM` removes any specified set of characters from the *right*
      - The usefulness of this is going to be very case specific:
        - e.g. wanting to remove a prefix/suffix of an ID:
          - `LTRIM("A189A", 'A')` would result in '189A'
          - `RTRIM("A189A", 'A')` would result in 'A189'
          - `REPLACE` would remove both A's: '189'

LTRIM & RTRIM

(`LTRIM` & `RTRIM` live coding)

REPLACE

- `REPLACE` is likely going to be one of your most commonly used string manipulations
- It substitutes a character or set of characters with another
  - We specify which string (or set of strings within a column), what we want to replace, and the replacement value
    - e.g. `REPLACE('A is an excellent instructor','instructor','TA')` results in 'A is an excellent TA'
  - You can also replace a character with nothing, using an empty string: `''`
    - e.g. `REPLACE('colour','u','')` results in 'color'
- `REPLACE` statements can be strung together — the innermost function will be executed first
  - e.g. `REPLACE(REPLACE(REPLACE(REPLACE('A?lot-of,punctuation.','.',' '),',',' '),'-',' '),'?',' ')` results in 'A lot of punctuation'

REPLACE

(`REPLACE` live coding)

UPPER & LOWER

- `UPPER` forces all string characters to be uppercase
- `LOWER` forces all string characters to be lowercase
- Both `UPPER` and `LOWER` are essential for filtering tables based on strings
  - It's always best to assume that there is some string variety
  - Sometimes a `LIKE` statement will not be an option

annoying_string_column
WORD
Word
word
wOrD
DifferentWord

- We can always use `UPPER` or `LOWER` in a `WHERE` clause, even without using the commands in the `SELECT` statement

```
 SELECT annoying_string_column
FROM table
WHERE LOWER(annoying_string_column) = 'word'
```

UPPER & LOWER

(`UPPER` & `LOWER` live coding)

Concatenation (sometimes CONCAT, flavour dependent)

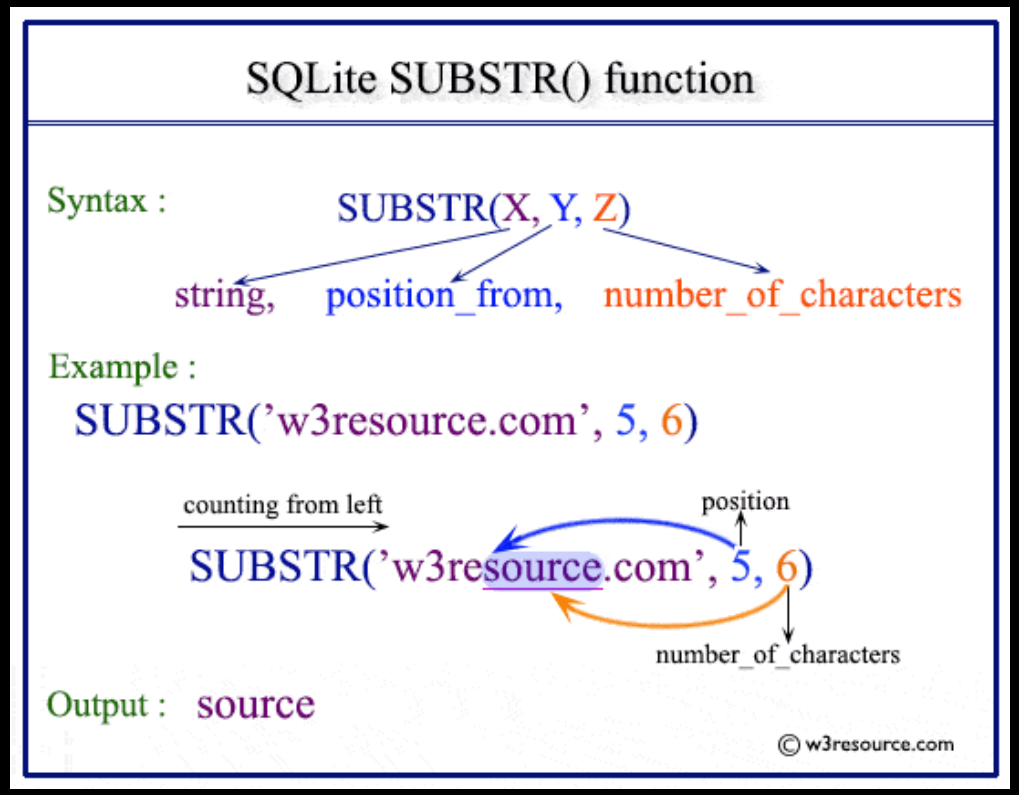
- String concatenation combines two or more columns into a single column
- Concatenation can handle non-column values too
  - e.g. `first_name || ' ' || last_name as full_name`
  - Or `last_name || ', ' || first_name AS full_name`
- In SQLite, `CONCAT` is replaced by two vertical bar characters: `||`
  - Most other flavours use `CONCAT`
- By default, spaces are not included between columns
  - i.e. you need to add a blank space between quotes

Concatenation

(Concatenation live coding)

SUBSTR ("substring")

- `SUBSTR` specifies any section of a string to return, based on:
  - Which string (i.e. column)
  - Where to begin the section (i.e. the string position to start, as an integer)
  - The (optional) number of characters to return (i.e. how far to go, as an integer)
- `SUBSTR` replaces flavour specific functions like `LEFT` or `RIGHT`
  - By default `SUBSTR` counts from the left
    - e.g. `substr('a long string', 3, 4)` will return "long"
  - To count from the right, specify a negative number to start
    - e.g. `substr('a long string', -6, 6)` will return "string"



- Image: www.w3resource.com/sqlite/core-functions-substr.php 👉

SUBSTR

(`SUBSTR` live coding)

INSTR (CHARINDEX flavour dependent)

- `INSTR` provides the starting position or location of a specified string
- `INSTR('The instructor is named Thomas','Thomas')` will result in 25, because "Thomas" is the 25th through 30th character in our string
  - `INSTR('The Instructor is named Thomas','Th')` will result in 1 because "Th" arises in "The" before "Thomas"
- `INSTR` can help with splitting a text string on delimiters
  - By finding the distance between delimiters and extracting the appropriate characters with `SUBSTR` we can move through delimiters in text columns
  - The code get's a wild quite quickly:

```
 SELECT
  SUBSTR('FirstWord, SecondWord, ThirdWord',0, INSTR('FirstWord, SecondWord, ThirdWord',',')) as FirstDelim
 ,SUBSTR('FirstWord, SecondWord, ThirdWord',
   INSTR('FirstWord, SecondWord, ThirdWord',',')+1,
   INSTR('FirstWord, SecondWord, ThirdWord',',')+1) as SecondDelim
 ,SUBSTR('FirstWord, SecondWord, ThirdWord',
   INSTR(
     (SUBSTR('FirstWord, SecondWord, ThirdWord',
     INSTR('FirstWord, SecondWord, ThirdWord',',')+1))
   ,',') +
   INSTR('FirstWord, SecondWord, ThirdWord',',')+1) AS ThirdDelim
```

INSTR

(`INSTR` live coding)

LENGTH

- `LENGTH` returns the number of characters in a given string (or set of strings in a column)
  - `LENGTH` also works on integers
- `LENGTH` is perhaps less of a string manipulation in and of itself, but is useful in debugging
  - Combined with `MAX`, `LENGTH` can be useful, especially when adding string length constraints to a column
  - Combined with `SUBSTR`, `LENGTH` can cut strings within a column by a dynamic value
- What happens when we apply `SELECT SUBSTR(CanadianMusicians, 0, LENGTH(CanadianMusicians)-6)` to table 1?

CanadianMusicians - Table 1	CanadianMusicians - Table 2
Neil Young	Neil
Leonard Cohen	Neil
Shania Twain	Leonard
Michael Bublé	Michael

LENGTH

(`LENGTH` live coding)

CHAR

- When provided an ASCII value, `CHAR` will return the appropriate character from the ASCII table
  - e.g. `CHAR(98)` will result in 'b'
- Pronunciation is split on "char":
  - "char" as in "*char*-broiled"
  - "char" as in "*car*"
  - "char" as in "*char*acter"
  - "char" as in "*care*"
- `CHAR` is hugely useful with `REPLACE`
  - Occasionally, line breaks affect SQL column validity, so `REPLACE(lf_column,CHAR(10),'')` and/or `REPLACE(cr_column,CHAR(13),'')` will be hugely useful
    - Where `CHAR(10)` is a linefeed "lf" and `CHAR(13)` is a carriage return "cr"
- `CHAR` can help with structure and control of strings as they flow into columns

UNICODE (ASCII in some flavours)

- `UNICODE` provides the ASCII value of any given character
  - i.e. the opposite of `CHAR`
- The usage? I'm a bit unsure! Maybe faster than looking it up online?
  - e.g. `UNICODE('b')` will result in '98'

CHAR & UNICODE

(`CHAR` & `UNICODE` live coding)

REGEXP (flavour dependent)

- `REGEXP` allows for string filtering based on regular expressions (regex)
- Situated within a `WHERE` clause, very similar to `LIKE`
- Can use either SQL's or regex's Boolean operators
  - e.g. `WHERE austen_books REGEXP '(sion|ice)$'`
  - Or `WHERE austen_books REGEXP 'sion$' OR book_title REGEXP 'ice$'`

Austen Books - Table a	**Austen Books - Table b**
Sense & Sensibility	Pride & Prejudice
Pride & Prejudice	Persuasion
Mansfield Park	
Emma	
Persuasion	
Northanger Abbey	

REGEXP (flavour dependent)

(Quick `REGEXP` live coding)

> "Some people, when confronted with a problem think: 'I know, I'll use regular expressions.' Now they have two problems."
>
> - Jamie Zawinski (probably)

LOWER(wHaT qUeStIoNs dO yOu hAvE?)

UNION & UNION ALL

- `UNION` and `UNION ALL` combine the results of two or more queries vertically (i.e. row-wise)
- `UNION ALL` keeps duplicate values, whereas `UNION` removes them
  - The difference between the two is one of the most common interview questions!

UNION & UNION ALL

- `UNION` and `UNION ALL` require both/all queries to have the same number of columns
  - You could `UNION` unrelated columns if you had a specific use-case for it
    - Column names will come from the first query
  - In situations where you don't have exactly the same columns, but still need to `UNION`, you can pass a `NULL` (or zero, or blank) column
    - Similarly, you can pass a string character to keep track of which data is associated to which query

UNION & UNION ALL

```
 SELECT number_of_chips, number_of_tacos, 0 AS number_of_burritos, 'lunch' AS meal
FROM lunch

UNION

SELECT NULL as number_of_chips, number_of_tacos, number_of_burritos, 'dinner' AS meal
FROM dinner
```

UNION & UNION ALL

- If we recall SQLite's lack of support for `FULL OUTER JOINS`, `UNION ALL` will allow us to emulate one:

```
 SELECT s1.quantity, s1.costume, s2.quantity
FROM store1 s1
LEFT JOIN store2 s2 ON s1.costume = s2.costume

UNION ALL

SELECT s1.quantity, s2.costume, s2.quantity
FROM store2 s2
LEFT JOIN store1 s1 ON s2.costume = s1.costume

WHERE s1.quantity IS NULL
```

UNION & UNION ALL

(`UNION` & `UNION ALL` live coding)

What Questions do you have?

INTERSECT & EXCEPT

- Both `INTERSECT` and `EXCEPT` require both/all queries to have the same number of columns

INTERSECT

- `INTERSECT` returns data in common with both/all `SELECT` statements
- Values returned will be distinct
- What's the difference between `INTERSECT` and `INNER JOIN`?

EXCEPT

- `EXCEPT` returns the opposite of an `INTERSECT`
  - for whatever rows are returned by the first `SELECT` statement, `EXCEPT` will return rows that were *not* returned by the second `SELECT` statement
- The "direction" of `EXCEPT` matters a lot
  - `EXCEPT` is relative the the first `SELECT` statement, so changing which comes first will always change the results of the query

INTERSECT & EXCEPT

Let's consider an example:

product	product_id
blue bike	1
tiger onesie	2
house plant	3
headphones	4

order_id	product_id
1	1
2	1
3	1
4	4

INTERSECT & EXCEPT

`INTERSECT` will find all products with work orders

```
SELECT product_id FROM product
INTERSECT
SELECT product_id FROM orders
```

Resulting in product_id's 1 & 4

INTERSECT & EXCEPT

`EXCEPT` will find all products *without* work orders

```
SELECT product_id FROM product
EXCEPT
SELECT product_id FROM orders
```

Resulting in product_id's 2 & 3

OR all work orders *without* products

```
SELECT product_id FROM orders
EXCEPT
SELECT product_id FROM product
```

Resulting in nothing (because no orders have a product_id that is not found in the product table)

INTERSECT & EXCEPT

(`INTERSECT` & `EXCEPT` live coding)

What questions do you have about anything from today?