

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

IFNULL/ISNULL (flavour dependent) and COALESCE

- **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

NULLIF

- 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=
- Image: Teate, Chapter 7 🖱️

```
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
```

Purpose

- 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)

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])`

PARTITION BY

- 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

PARTITION BY

- Both the `PARTITION BY` and `ORDER BY` arguments can take more than one column
 - e.g. life expectancy by country by continent

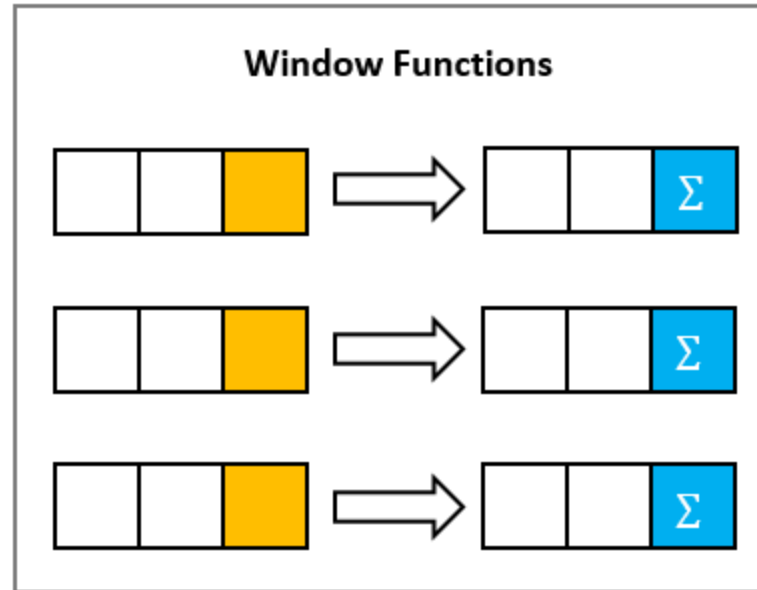
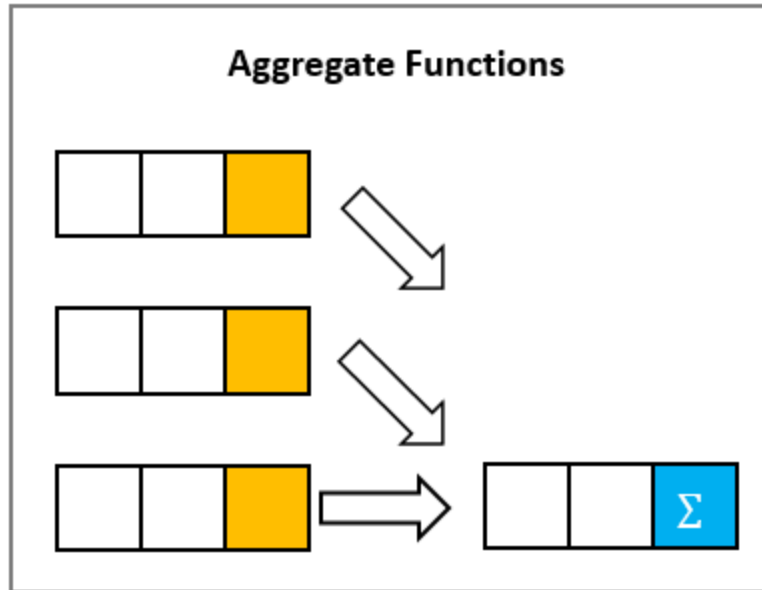


Image: SQLiteTutorial.net

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()` ?** `r`
`structure("\U1F4AD", class = "emoji")` `r structure("\U1F4AC", class = "emoji")` **Think, Pair, Share**

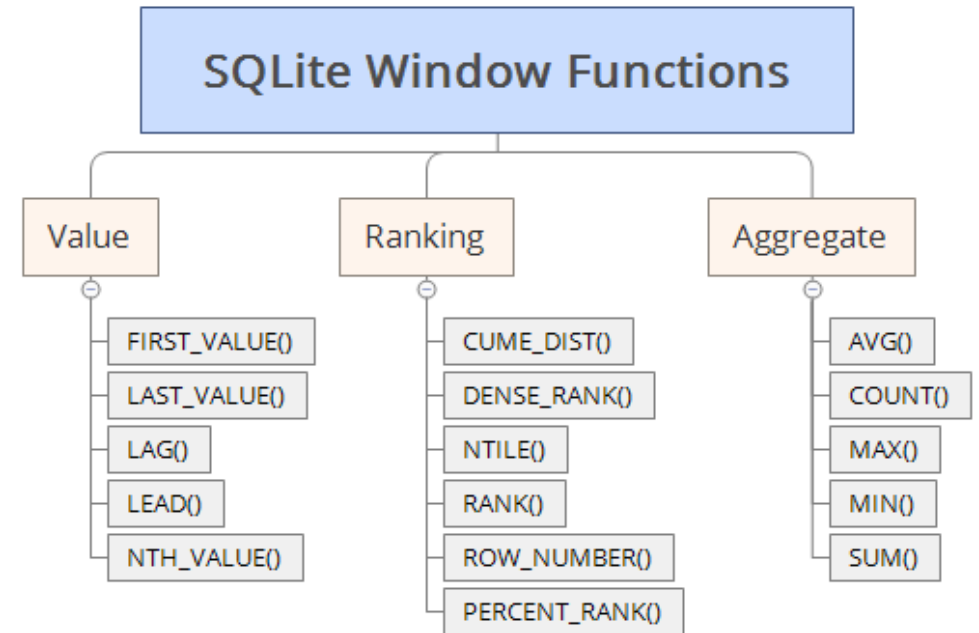
Other Windowed Functions

- 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 (PARTITION 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

Other Windowed Functions

- 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.

1. 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 '

LTRIM & RTRIM

2. 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

- 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

UPPER & LOWER

annoying_string_column
WORD
Word
word
wOrD
DifferentWord

UPPER & LOWER

- 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'
```

- *(This is also true for all of these string manipulations!)*

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")

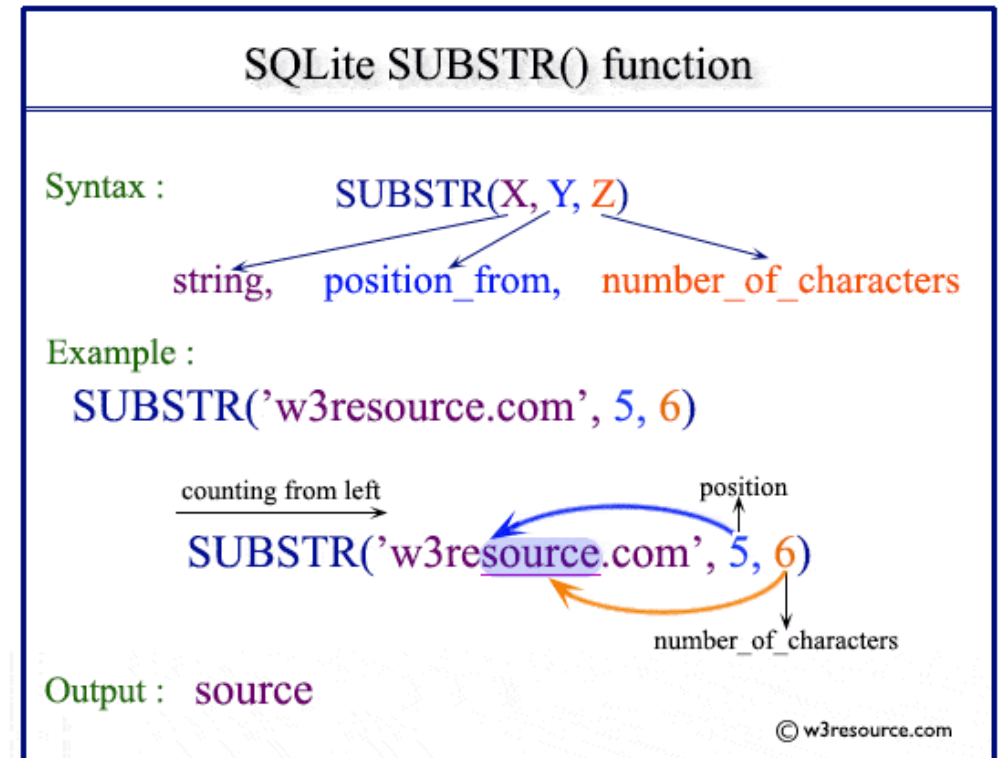
- SUBSTR specifies any section of a string to return, based on:
 - Which string (i.e. column)
 - Where to begin the section (i.e. the string position to start, as an integer)
 - The (optional) number of characters to return (i.e. how far to go, as an integer)

SUBSTR ("substring")

- 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"

SUBSTR ("substring")

- 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:

INSTR (CHARINDEX flavour dependent)

```
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?

LENGTH

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

class: top, left, inverse

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 "*character*"
 - "char" as in "*care*"

CHAR

- 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$'`

REGEXP (flavour dependent)

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 to 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	2

order_id	product_id
1	1
2	1
2	1

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?