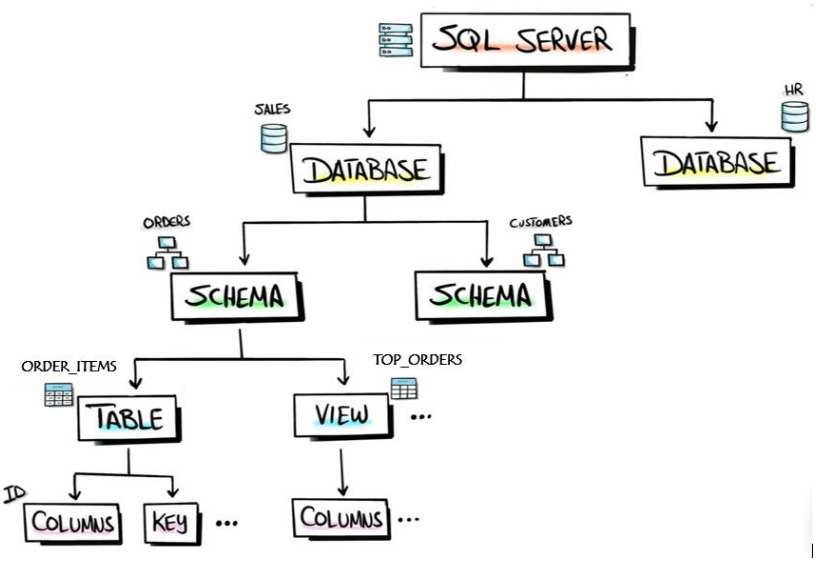
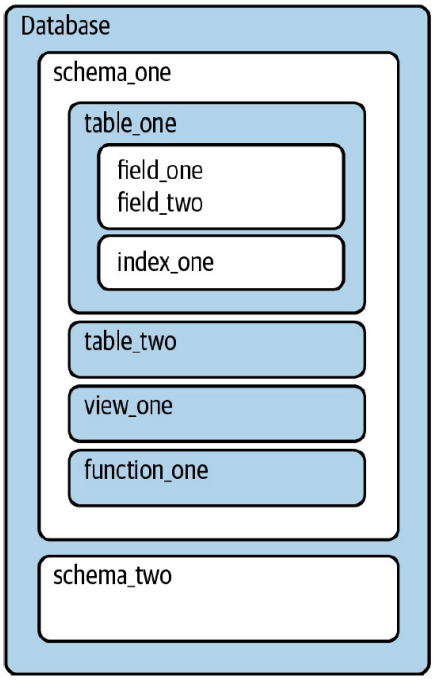
SQL Database Structure

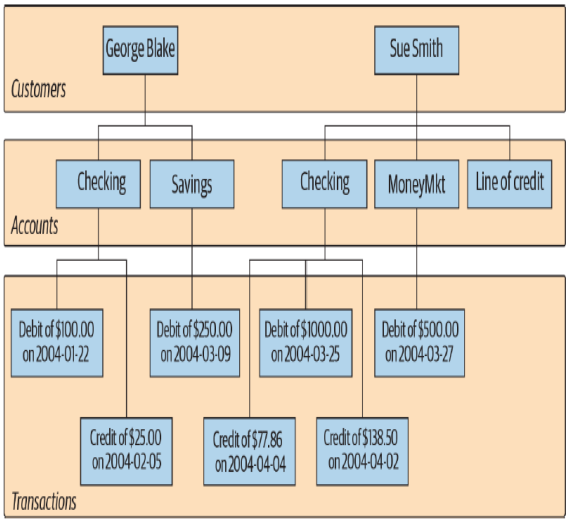
Database systems, are reliable & systematic computerized **data storage** and **access** mechanisms.

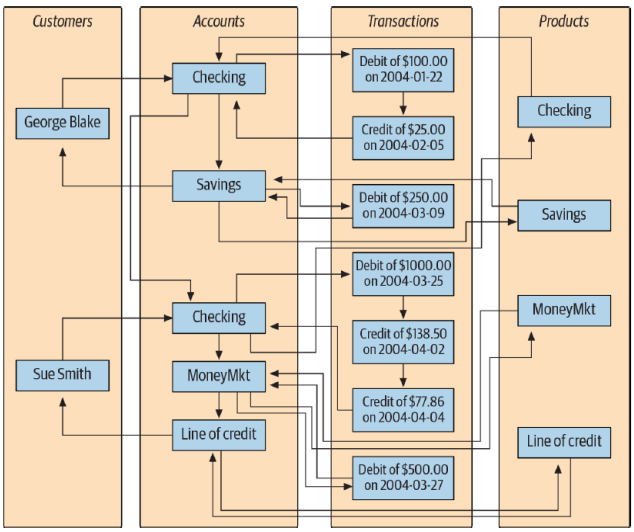




- Database schema can be thought as a working template with data, custom functions, and built-in functions- eg. mathematical & ML operations in BigQuery.

Fundamental data management structures- hierchical & network: file directory & relational model



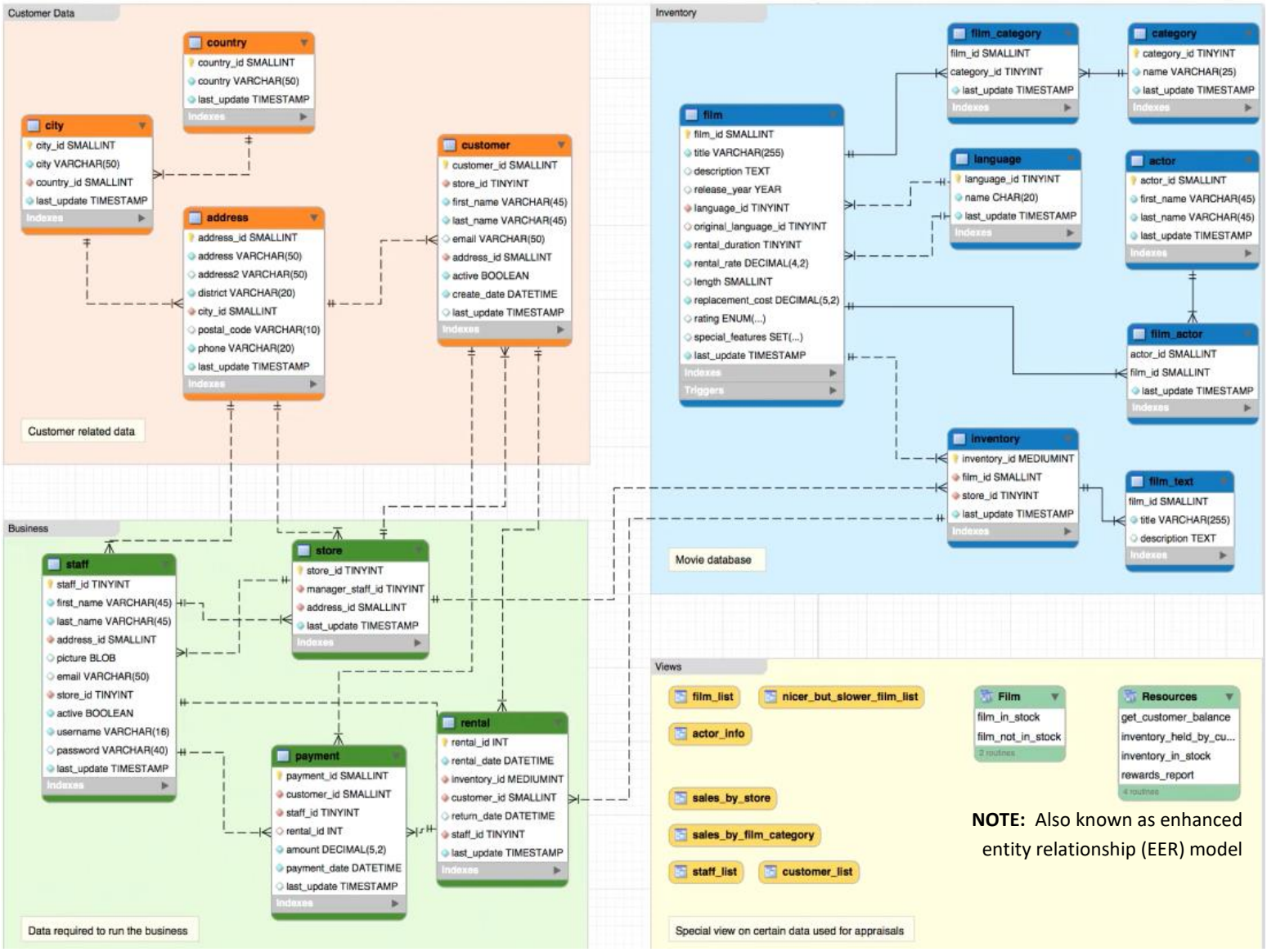


- There are two main storage formats for storing & managing data: **Row- & Column-Store**

  :: Ideal for transactional data with frequent insertions & updates, or analytical workloads involving large-scale data aggregations.

(Row vs. Col: optimized for store & retrieval of long rows—*ie.* samples, but slower for features)

DATABASE DESIGN & MODELLING



NOTE: Also known as enhanced entity relationship (EER) model

As we're designing databases, it can be helpful to create **EER diagrams** to enhance our understanding on how all the data is related by mapping out things like:

- Which tables are in the database
- Which columns exist in each table
- The data types & constraints of the various columns
- Primary & Foreign keys within tables
- Relationship cardinality (one-to-one, one-to-many …) between tables

---

(i) Primary key - unique identifiers for records in the table

(ii) Foreign key - PK defined in other tables, to establish link btw tables

(iii) Logical key - labels that can be used as effective lookup by logical expr,
(eg. `WHERE title= '?'`).

Normalization is the structuring process of breaking data from a single merged table into multiple related tables to **minimize redundancy** and **reduce inconsistencies & anomalies**.

Not normalized:

inventory_id	title	release_year	store_address	store_district
1	ACADEMY DINOSAUR	2006	47 MySakila Drive	Alberta
2	ACADEMY DINOSAUR	2006	47 MySakila Drive	Alberta
3	ACADEMY DINOSAUR	2006	47 MySakila Drive	Alberta
4	ACADEMY DINOSAUR	2006	47 MySakila Drive	Alberta
5	ACADEMY DINOSAUR	2006	28 MySQL Boulevard	QLD
6	ACADEMY DINOSAUR	2006	28 MySQL Boulevard	QLD
7	ACADEMY DINOSAUR	2006	28 MySQL Boulevard	QLD
8	ACADEMY DINOSAUR	2006	28 MySQL Boulevard	QLD
9	ACE GOLDFINGER	2006	28 MySQL Boulevard	QLD
10	ACE GOLDFINGER	2006	28 MySQL Boulevard	QLD
11	ACE GOLDFINGER	2006	28 MySQL Boulevard	QLD
12	ADAPTATION HOLES	2006	28 MySQL Boulevard	QLD
13	ADAPTATION HOLES	2006	28 MySQL Boulevard	QLD
14	ADAPTATION HOLES	2006	28 MySQL Boulevard	QLD
15	ADAPTATION HOLES	2006	28 MySQL Boulevard	QLD
16	AFFAIR PREJUDICE	2006	47 MySakila Drive	Alberta
17	AFFAIR PREJUDICE	2006	47 MySakila Drive	Alberta
18	AFFAIR PREJUDICE	2006	47 MySakila Drive	Alberta
19	AFFAIR PREJUDICE	2006	47 MySakila Drive	Alberta
20	AFFAIR PREJUDICE	2006	28 MySQL Boulevard	QLD

Normalized!

inventory_id	film_id	address_id
1	1	1
2	1	1
3	1	1
4	1	1
5	1	2
6	1	2
7	1	2
8	1	2
9	2	2
10	2	2
11	2	2
12	3	2
13	3	2
14	3	2
15	3	2
16	4	1
17	4	1
18	4	1
19	4	1
20	4	2

film_id	title	release_year
1	ACADEMY DINOSAUR	2006
2	ACE GOLDFINGER	2006
3	ADAPTATION HOLES	2006
4	AFFAIR PREJUDICE	2006

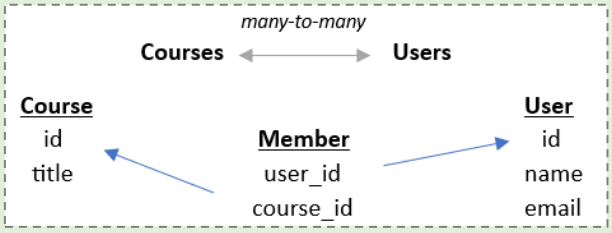
address_id	address	district
1	47 MySakila Drive	Alberta
2	28 MySQL Boulevard	QLD

*We now have **single records** containing all of the information about our films and addresses – no more redundancy!*

[Reduces the width of tables, but called for many joins during preprocessing of a complete dataset]

When building an entity relationship model for an application,

#1 Start w/ first table –the main description of application (*eg.* Music API = a map that manages tracks)
#2 Brainstorm to see what kind of information is helpful to include.
#3 Do not put the same string twice, separate main feature to its attrs using relationships.
#4 Create a connection table w/ foreign keys for many-to-many relation / ≥3 JOIN tables.
(as multiple values are generally not encouraged within a single cell in table – separating PK)



- Some databases may take compound type (*ie.* multiple field values) as primary key, which is the combination of natural & surrogate key that enforces uniqueness
  — *Careful consideration is required, as it is not allowed to change once assigned.*

- Often, INT value is used as primary key with lesser overhead for quick sorting & scanning of rows.

Creating & Populating a Database

1.
```
CREATE TABLE User (
    id INTEGER NOT NULL PRIMARY KEY AUTOINCREMENT,
    name TEXT
    email TEXT
);

CREATE TABLE Course (
    id INTEGER NOT NULL PRIMARY KEY AUTOINCREMENT,
    title TEXT
);

CREATE TABLE Member (
    user_id INTEGER,
    course_id INTEGER,
    role INTEGER,
    PRIMARY KEY (user_id, course_id)  unique compound key table constraint
);
```

2. **INSERT INTO User (name, email) VALUES ('JANE','jane@tsugi.org'),('Ed', 'ed@tsugi.org'),**

   INSERT INTO Course (title) VALUES ('Python'), ('SQL')

   INSERT INTO Member (user_id, course_id, role) VALUES (1,1,1), (2,1,0), …

   # connecting the rows btw tables by integer id representation in foreign keys.

3. **SELECT User.name, Member.role, Course.title FROM User JOIN Member JOIN Course**

   ON Member.user_id = User.id AND Member.course_id = Course.id

   ORDER BY Course.title, Member.role DESC, User.name

Pro Tip:

- A DCL script can be edited & imported into database to ease the creation of tables esp. for large relational data. (Refer. CreateStatements.sql)
- Likewise, an external data may be loaded from an SQL Script or CSV file using `Table Data Import Wizard`.
- MySQL also allows us to store & call frequently used queries on server as Stored Procedure, which offers the ability to share complex procedures more easily with other users.

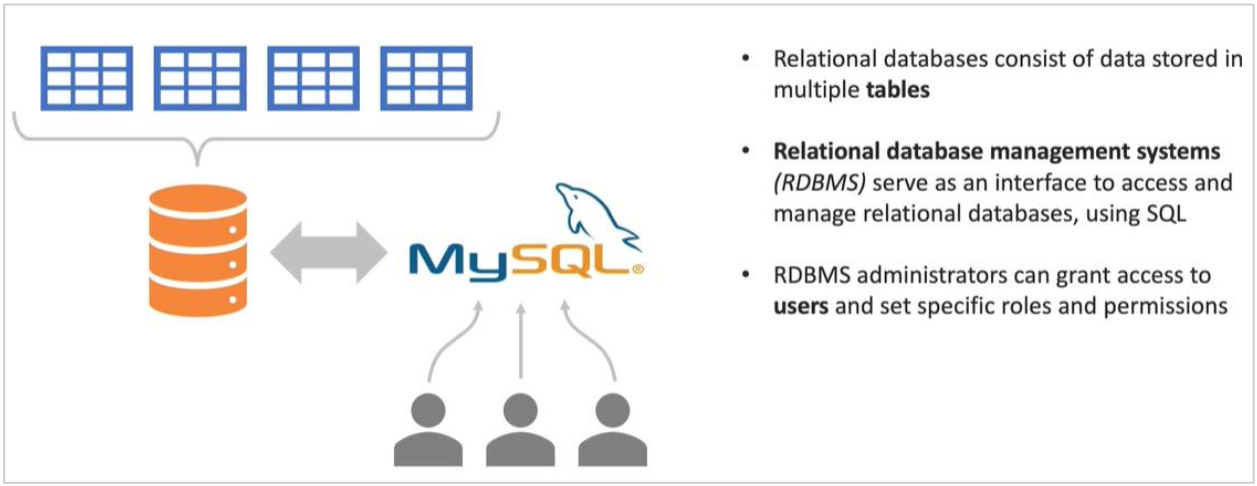
" The no. of columns for a relational table is usually large enough, the constraint is often due to disk memory size &/ maintainability on a server w.r.t the no. of rows for an application rather than the software capability to process the information. "

When creating a relation table, it is required to specify the homogenous datatype to a field (sometimes, with expected memory size – *eg*. int64) for efficient data storage & management.

Common SQL Datatypes:

Type	Name	Description
String	`CHAR(n)/ VARCHAR`	Holds fixed (n) / flexible length up to maximum (0-255 / n) which differs in the way they are stored & retrieved w±wo trailing spaces. : 'ab' - CHAR(4) ~ 'ab ' {4 bytes} ; VARCHAR(4) ~ 'ab' {2 bytes}.
	`TEXT /VARBINARY(byte)`	Holds long context / binary byte string – (0-65535). (*eg*. Byte image content or free text entered by survey respondents)
	`ENUM(val1, val2, ...) /SET(val1, val2, ...)`	- Holds one str from the specified list, or a blank is inserted. - Holds 0 or more than one str from the list.
Numeric	`TINY/SMALL/MEDIUM INT/BIGINT(size) UNSIGNED`	Holds signed / unsigned integers of {1, 2, 3, 4, 8, } bytes : *(-128 : 127), (-32,768 : 32,767), (-8,388,608 : 8,388,607), (-2,147,483,648 : 2,147,483,647), … ($-2^{63} : 2^{63}-1$).*
	`FLOAT/DOUBLE(n,d) /DECIMAL(n,d)`	Holds unsigned values of : *Decimal (precise to 23 digits), (23 to 53 digits), (to 65 digits)* *Ie.* total no. decimal (n) default: 10-65 ± points (d) 0-30 specified.
Logical	`BOOLEAN`	Holds only TRUE {non-zero} / False {0} values.
Datetime	`DATETIME /TIMESTAMP`	Holds YYYY-MM-DD HH:MM:SS / YYYYMMDDHHMMSS format (w±wo the support of time zones depending on database)
	`DATE/TIME /INTERVAL`	Holds separate date / time / a span of time values only : YYYY-MM-DD; HH:MM:SS; '1 hour 30 minutes'.

Note: ① ZEROFILL constraint- INT(4) :: 0005 with a fixed maximum display width (size) of 4.
② Float stores approximate values, but is able to do faster calculations while decimal stores exact values.

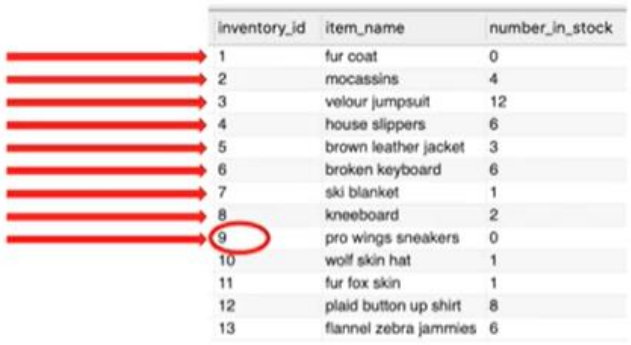


! **As a general rule of thumb, when we're setting up a database and partitioning out permission, we want to restrict access to just the types of activities that a given person would need.**

—eg. An analyst who's never going to manipulate tables, should be granted read only access to database.

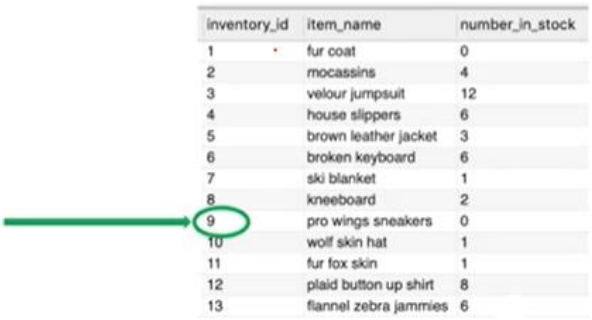
Creating Indexes

Searching Without an Index:



inventory_id	item_name	number_in_stock
1	fur coat	0
2	mocassins	4
3	velour jumpsuit	12
4	house slippers	6
5	brown leather jacket	3
6	broken keyboard	6
7	ski blanket	1
8	kneeboard	2
9	pro wings sneakers	0
10	wolf skin hat	1
11	fur fox skin	1
12	plaid button up shirt	8
13	flannel zebra jammies	6

Using an Index:



inventory_id	item_name	number_in_stock
1	fur coat	0
2	mocassins	4
3	velour jumpsuit	12
4	house slippers	6
5	brown leather jacket	3
6	broken keyboard	6
7	ski blanket	1
8	kneeboard	2
9	pro wings sneakers	0
10	wolf skin hat	1
11	fur fox skin	1
12	plaid button up shirt	8
13	flannel zebra jammies	6

Note: In MySQL, the **PK** & any **FK** created on a table is always an index automatically.

Creating Stored Procedure & Triggers

- **Triggers** are a common way to make sure related tables remain in sync as they are updated over time.
- We may prescribe the trigger action occurs either `BEFORE/AFTER` an `INSERT`, `UPDATE`, or a `DELETE`.

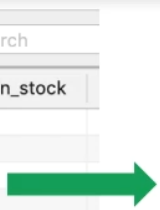
```
DELIMITTER //

CREATE PROCEDURE ProcedureName()  -- Store Procedure
BEGIN
...   -- Complex SQL Statements
END //

DELIMITTER ;

CALL ProcedureName;  -- Execute stored procedure
```

Note: Delimitter change is added at the beginning of a stored procedure, to prevent SQL from ending midway when reading the SQL statement ending with the conventional delimitter.

```
CREATE TRIGGER purchaseUpdateInventory
AFTER INSERT ON customer_purchases
FOR EACH ROW
    UPDATE inventory
        -- subtracting an item for each purchase
        SET number_in_stock = number_in_stock - 1
    WHERE inventory_id = NEW.inventory_id;  -- When inventory_id =
                                            new record inventory_id
INSERT INTO customer_purchases VALUES
(13,NULL,3,NULL), -- inventory_id = 3, velour jumpsuit
(14,NULL,4,NULL) -- inventory_id = 4, house slippers
;

SELECT * FROM inventory;
```

Result Grid | Filter Rows: Search

inventory_id	item_name	number_in_stock
1	fur coat	0
2	mocassins	4
3	velour jumpsuit	12
4	house slippers	6
5	brown leather jacket	3
6	broken keyboard	6
8	kneeboard	2
9	pro wings sneakers	0
10	wolf skin hat	1
11	fur fox skin	1
12	plaid button up shirt	8
13	flannel zebra jammies	6



Result Grid | Filter Rows: Search

inventory_id	item_name	number_in_stock
1	fur coat	0
2	mocassins	4
3	velour jumpsuit	11
4	house slippers	5
5	brown leather jacket	3
6	broken keyboard	6
8	kneeboard	2
9	pro wings sneakers	0
10	wolf skin hat	1
11	fur fox skin	1
12	plaid button up shirt	8
13	flannel zebra jammies	6

WORKING WITH MULTIPLE TABLES

Step-by-step approach when joining multiple tables:

- Start with table with complete keys desired as leftmost table
- Then join one table on some condition
- Check if the output is correct
- Join another table on another condition
- Check the output again & specify the column desired as final output

(You can join any tables as long as you specify the columns that link the tables together)

```
SELECT  hs.year, hs.country, hs.happiness_score,
        cs.continent, ir.inflation_rate
FROM    happiness_scores hs
        LEFT JOIN country_stats cs
            ON hs.country = cs.country
        LEFT JOIN inflation_rates ir
            ON hs.year = ir.year AND hs.country = ir.country_name;
```

ANY, ALL, EXISTS: **To provide more specific filtering logic**

EXAMPLE *Only return happiness scores for countries that EXIST in the inflation rates table*

```
SELECT *
FROM happiness_scores h
WHERE EXISTS (
    SELECT i.country_name
    FROM inflation_rates i
    WHERE i.country_name = h.country);
```

```
SELECT *
FROM happiness_scores h
     INNER JOIN inflation_rates i
     ON h.country = i.country_name
     AND h.year = i.year;
```

year	country	region	happiness_score	year	country_name	inflation_rate
2015	Bangladesh	South Asia	4.694	2015	Bangladesh	6.1
2015	Brazil	Latin America and Caribbean	6.983	2015	Brazil	9.0
2015	China	East Asia	5.140	2015	China	1.4
2015	Ethiopia	Sub-Saharan Africa	4.512	2015	Ethiopia	6.1
2015	France	Western Europe	6.575	2015	France	0.1
2015	Germany	Western Europe	6.750	2015	Germany	0.3

** Correlated subqueries can be slow in some RDBMSs;*
In best practice test it out out, and replace it (as shown) with a JOIN if it's an issue.

A **SELF-JOIN** is used when you want to compare rows within the same table side-by-side.
(*eg.* comparing country's happiness score to every other countries in the same region)

Through:
i. Combine table with itself based on a matching column
ii. Filter on the resulting rows based on some criteria

```
SELECT * FROM employees;
```

employee_id	name	salary
1	Ava	85000
2	Bob	72000
3	Cat	59000
4	Dan	85000

```
-- Employees with the same salary
SELECT    e1.name, e1.salary,
          e2.name, e2.salary
FROM      employees e1 INNER JOIN employees e2
          ON e1.salary = e2.salary
WHERE     e1.name <> e2.name
ORDER BY  e1.name;
```

name	salary	name	salary
Ava	85000	Dan	85000
Dan	85000	Ava	85000

EXAMPLE (1) | Finding Related / Sequential Events

-- Here, to find *log entries by the same user that occurred within a short time of each other*.

```
SELECT l1.UserID, l1.activity AS activity1, l1.Timestamp AS timestamp1,
       l2.activity AS activity2, l2.Timestamp AS timestamp2,
FROM LogEntries l1 INNER JOIN LogEntries l2
     ON l1.UserID AND TIMESTAMPDIFF(MINUTE, l2.Timestamp, l1.Timestamp)< 10
WHERE l1.EntryID <> l2.EntryID AND l1.Timestamp < l2.Timestamp;
```

```
SELECT * FROM employees;
```

employee_id	name	salary
1	Ava	85000
2	Bob	72000
3	Cat	59000
4	Dan	85000

```
-- Employees that have a greater salary
SELECT    e1.name, e1.salary,
          e2.name, e2.salary
FROM      employees e1 INNER JOIN employees e2
          ON e1.salary > e2.salary
ORDER BY  e1.name;
```

name	salary	name	salary
Ava	85000	Bob	72000
Ava	85000	Cat	59000
Bob	72000	Cat	59000
Dan	85000	Bob	72000
Dan	85000	Cat	59000

EXAMPLE (2) | Comparing values within rows in a table

```
SELECT * FROM managers;
```

employee_id	employee_name	manager_id
1	Ava	NULL
2	Bob	1
3	Cat	1
4	Dan	2

```
-- Employees and their managers
SELECT  m1.employee_id, m1.employee_name,
        m1.manager_id,
        m2.employee_name AS manager_name
FROM    managers m1 LEFT JOIN managers m2
        ON m1.manager_id = m2.employee_id;
```

employee_id	employee_name	manager_id	manager_name
1	Ava	NULL	NULL
2	Bob	1	Ava
3	Cat	1	Ava
4	Dan	2	Bob

EXAMPLE (3) | Hierarchical Data

Subqueries & CTEs

- to allow aggregation & logical comparison in WHERE & HAVING clauses.

```
:: SELECT * FROM Employees     ⇒   SELECT * FROM Employees
   WHERE salary > AVG(salary)     WHERE salary >
                                  (SELECT AVG(salary) FROM Employees)
```

- to create an aggregated column that is aligned with each row value for comparison.

```
:: SELECT id, salary, AVG(salary)  ⇒  SELECT id, salary,
   FROM Employees                       ( SELECT AVG(salary) FROM Employees
                                          WHERE id = outer_table.id )
                                        FROM Employees AS outer_table
```

- to allow creation of a virtual table to facilitate sub-selection in FROM clause.

```
:: SELECT COUNT(*) FROM        OR    WITH cte_name AS (
     (SELECT c1, c2, … FROM t1) t       SELECT … FROM t1), … cte_name2(…)
```

```
--Return each country's happiness score for the year alongside its average
SELECT  hs.year, hs.country, hs.happiness_score,
        country_hs.avg_hs_by_country
FROM    happiness_scores hs LEFT JOIN
            (SELECT country, AVG(happiness_score) AS avg_hs_by_country
            FROM    happiness_scores
            GROUP BY country) AS country_hs
            ON hs.country = country_hs.country;
```

This subquery calculates the average happiness score by country, and is then joined with the main query

*Subqueries in the FROM clause need to have an **alias***

year	country	happiness_score	avg_hs_by_country
2015	Afghanistan	3.575	2.9907778
2015	Albania	4.959	4.8932222
2015	Algeria	5.605	5.4090000
2016	Afghanistan	3.360	2.9907778
2016	Albania	4.655	4.8932222
2016	Algeria	6.355	5.4090000
2017	Afghanistan	3.794	2.9907778
2017	Albania	4.644	4.8932222
2017	Algeria	5.872	5.4090000

PRO TIP: Using subqueries within the JOIN clause is great for speeding up queries, since it allows you to join smaller tables

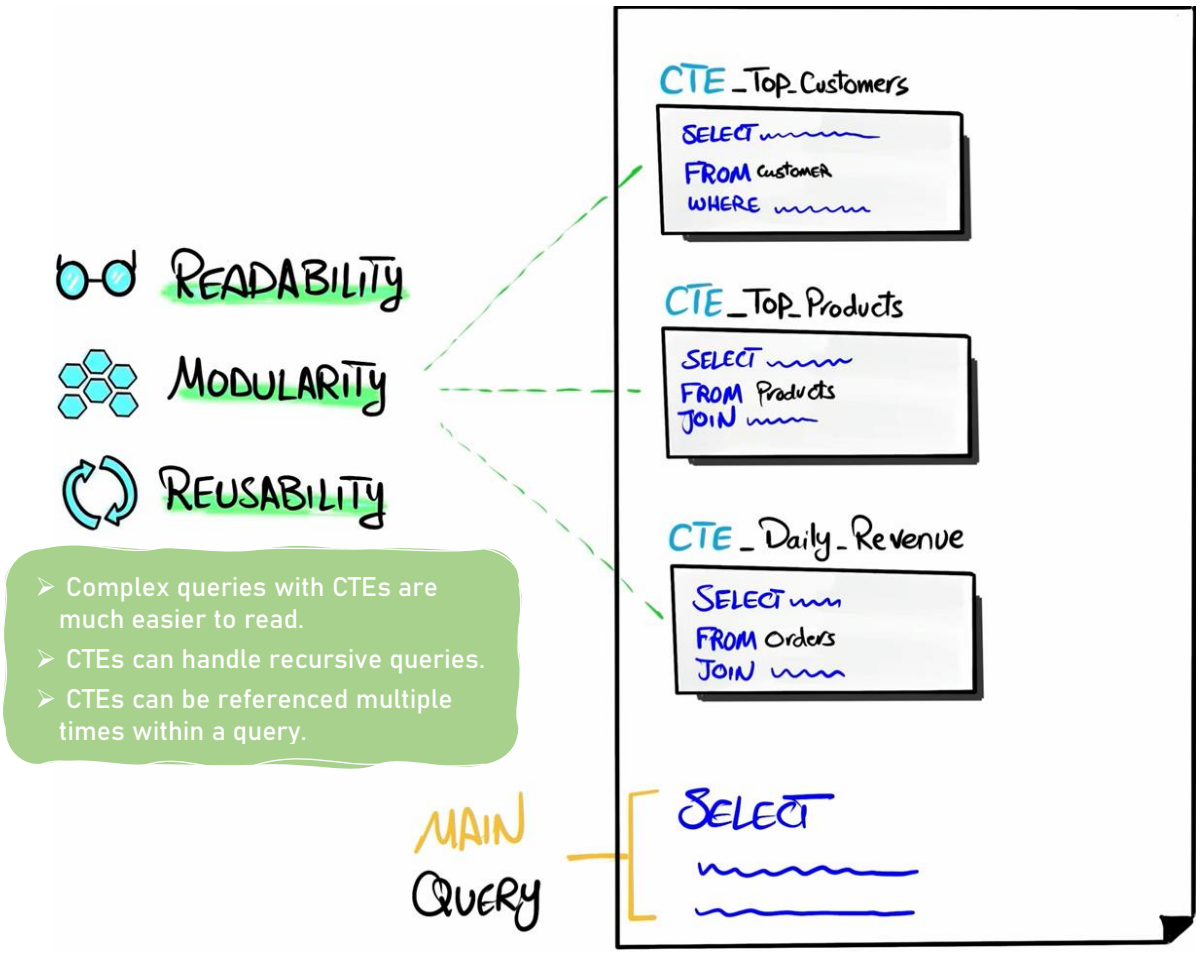
Queries can contain **multiple subqueries** as long as each one has a different alias

```
SELECT * FROM
(SELECT hs.year, hs.country, hs.happiness_score,
        country_hs.avg_hs_by_country
 FROM   (SELECT year, country, happiness_score FROM happiness_scores
         UNION ALL
         SELECT 2024, country, ladder_score FROM happiness_scores_current) AS hs
        LEFT JOIN
        (SELECT country, AVG(happiness_score) AS avg_hs_by_country
         FROM   happiness_scores
         GROUP BY country) AS country_hs
        ON hs.country = country_hs.country) AS hs_country_hs

WHERE   happiness_score > avg_hs_by_country + 1;
```

*This is a **nested subquery** now, used to return years where the happiness is a whole point greater that the country's average score*

year	country	happiness_score	avg_hs_by_country
2015	Lesotho	4.898	3.8561429
2015	Venezuela	6.810	5.3042222

For simple queries, sometimes a subquery is readable enough and works just fine.



① **Multiple CTEs** can be used in a query, or even **combine them with subqueries**.

② **Temporary tables** & **views** are other options for reference in multiple main queries.

- Both require additional permissions, they exist for a session or store in schema until modified.

```
SELECT * FROM

(WITH hs23 AS (SELECT *
               FROM happiness_scores
               WHERE year = 2023),
     hs24 AS (SELECT *
               FROM happiness_scores_current)

SELECT  hs23.country,
        hs23.happiness_score AS hs_2023,
        hs24.ladder_score AS hs_2024
FROM    hs23 INNER JOIN hs24
        ON hs23.country = hs24.country) AS hs_23_24

WHERE hs_2023 < hs_2024;
```

country	hs_2023	hs_2024
Albania	5.277	5.304
Algeria	5.329	5.364
Argentina	6.024	6.188
Armenia	5.342	5.455

Recursive CTE: A query that references itself, which is useful for generating sequences and working with hierarchical data.

```sql
SELECT *
FROM stock_prices;
```

date	price
2024-11-01	678.27
2024-11-03	688.83
2024-11-04	645.40
2024-11-06	591.01

Notice the missing dates

Step 1: Generate by recursive CTE

```sql
WITH RECURSIVE my_dates(dt) AS
    (SELECT '2024-11-01'
     UNION ALL
     SELECT dt + INTERVAL 1 DAY
     FROM my_dates
     WHERE dt < '2024-11-06')
```

Step 2: Join with stock price table

```sql
SELECT  md.dt, sp.price
FROM    my_dates md
        LEFT JOIN stock_prices sp
        ON md.dt = sp.date;
```

dt	price
2024-11-01	678.27
2024-11-02	NULL
2024-11-03	688.83
2024-11-04	645.40
2024-11-05	NULL
2024-11-06	591.01

EXAMPLE

Return the reporting chain for each employee

```sql
SELECT  *
FROM    employees;
```

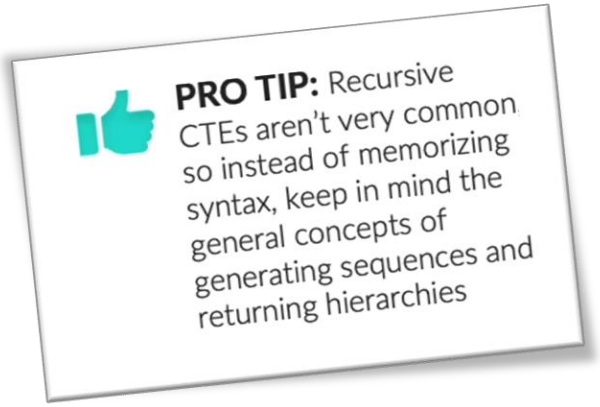
employee_id	employee_name	manager_id
1	Ava	NULL
2	Bob	1
3	Cat	1
4	Dan	2

```sql
WITH RECURSIVE employee_hierarchy AS (
    SELECT  employee_id, employee_name, manager_id,
            employee_name AS hierarchy
    FROM    employees
    WHERE   manager_id IS NULL

    UNION ALL

    SELECT  e.employee_id, e.employee_name, e.manager_id,
            CONCAT(eh.hierarchy, ' > ', e.employee_name) AS hierarchy
    FROM    employees e INNER JOIN employee_hierarchy eh
            ON e.manager_id = eh.employee_id)

SELECT  employee_id, employee_name, manager_id, hierarchy
FROM    employee_hierarchy
ORDER BY employee_id;
```

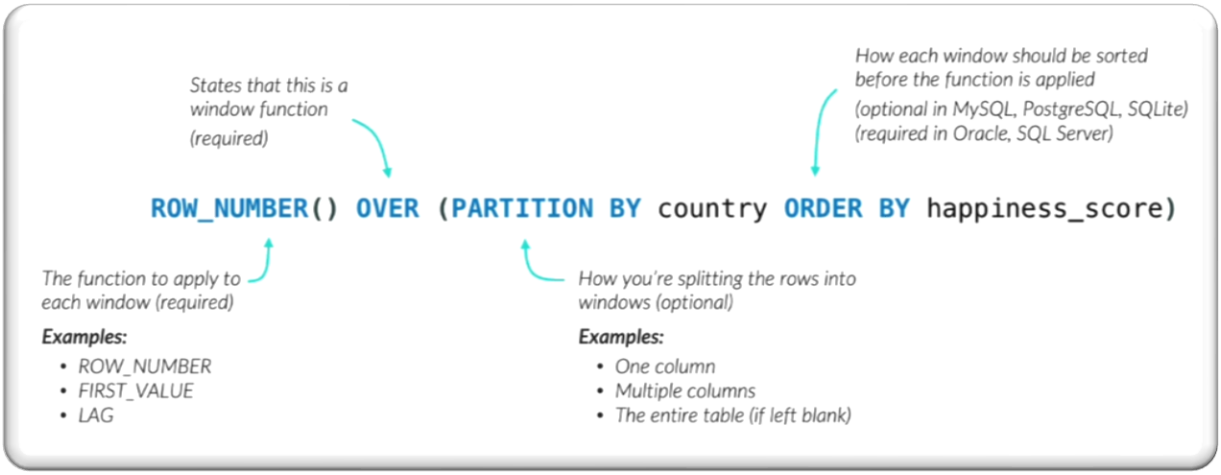
This sets the highest-ranking employee as the anchor

This stops the recursion when there is nothing left to join

employee_id	employee_name	manager_id	hierarchy
1	Ava	NULL	Ava
2	Bob	1	Ava > Bob
3	Cat	1	Ava > Cat
4	Dan	2	Ava > Bob > Dan



WINDOW FUNCTIONS



Note: It operates by assessing the rows sequentially within each window. (See. example below)

— Without an ORDER BY clause, rows are processed in an arbitrary order, leading to inconsistent / unpredictable results.

Row Numbering	• **ROW_NUMBER()** gives every row a unique number • **RANK()** accounts for ties • **DENSE_RANK()** accounts for ties and leaves no missing numbers in between
Value Within a Window	• **FIRST_VALUE()** extracts the first value in a window, in sequential row order • **LAST_VALUE()** extracts the last value • **NTH_VALUE()** extracts the value at a specified position
Value Relative to a Row	• LEAD • LAG
Aggregate Functions	• SUM, AVG, COUNT • MIN, MAX
Statistical Functions	• NTILE • CUME_DIST • PERCENT_RANK

** LEAD / LAG(c1, offset -> int, default-> NULL) can specify a default if there's no lead/lagging record.

```
SELECT country, year, happiness_score,
       AVG(happiness_score) OVER(PARTITION BY country ORDER BY year) row_num
FROM   happiness_scores
ORDER BY country, year;
```

country	year	happiness_score	row_num
Afghanistan	2015	3.575	3.5750000
Afghanistan	2016	3.360	3.4675000
Afghanistan	2017	3.794	3.5763333
Afghanistan	2018	3.632	3.5902500
Afghanistan	2019	3.203	3.5128000
Afghanistan	2020	2.567	3.3551667
Afghanistan	2021	2.523	3.2362857
Afghanistan	2022	2.404	3.1322500

NTILE: divides the rows in a window into *n* groups containing equal (or nearly) no.

EXAMPLE *View the top 25% of happiness scores for each region*

```
WITH hs_pct AS (SELECT  region, country, happiness_score,
                        NTILE(4) OVER(PARTITION BY region ORDER BY happiness_score DESC) AS hs_percentile
                FROM    happiness_scores
                WHERE   year = 2023)

SELECT  *
FROM    hs_pct
WHERE   hs_percentile = 1
ORDER BY region, happiness_score DESC;
```

*Return the percentiles in a **CTE***

Then simply filter for the top percentile (25%)

region	country	happiness_score	hs_percentile
North America and ANZ	New Zealand	7.123	1
South Asia	Nepal	5.360	1
South Asia	Pakistan	4.555	1
Southeast Asia	Singapore	6.587	1
Southeast Asia	Malaysia	6.012	1
Southeast Asia	Thailand	5.843	1

The number of results will differ by region because some regions have more countries, so the top 25% calculation can contain more or fewer rows

There are many **practical applications** of window functions, incl.: calculating moving averages, running totals, and more.

```
-- Calculate the three year moving average of happiness scores
SELECT  country, year, happiness_score,
        AVG(happiness_score) OVER (PARTITION BY country
        ORDER BY year ROWS BETWEEN 2 PRECEDING AND CURRENT ROW)
        AS three_year_ma
FROM    happiness_scores;
```

Note that this uses an AVG() aggregate function as part of a window function

We've added some additional keywords at the end that specify rows within the window

country	year	happiness_score	three_year_ma
Afghanistan	2015	3.575	3.5750000
Afghanistan	2016	3.360	3.4675000
Afghanistan	2017	3.794	3.5763333
Afghanistan	2018	3.632	3.5953333
Afghanistan	2019	3.203	3.5430000
Afghanistan	2020	2.567	3.1340000
Afghanistan	2021	2.523	2.7643333
Afghanistan	2022	2.404	2.4980000
Afghanistan	2023	1.859	2.2620000

STRING FUNCTIONS

Category	Function	Description
Length	LENGTH	Returns the number of characters in a string
Update	TRIM	Removes leading or trailing spaces (or other characters)
	REPLACE	Replaces a substring with another
Case	UPPER / LOWER	Converts all characters to uppercase or lowercase
Combine	CONCAT	Combines multiple strings into one
Find Location	INSTR	Returns the position of a substring within a string
	SUBSTR	Extracts part of a string of a specified length, starting from a given position
Find Pattern	LIKE*	Performs a pattern match within a string, typically using wildcards
	REGEXP	Matches a string against a regular expression pattern

```
SELECT  event_name,
        CASE WHEN INSTR(event_name, ' ') = 0 THEN event_name
             ELSE SUBSTR(event_name, 1, INSTR(event_name, ' ') - 1)
             END AS first_word
FROM    events;
```

event_name	first_word
New Year's Day	New
Lunar New Year	Lunar
Persian New Year	Persian
Birthday	Birthday
Last Day of School	Last
Vacation	Vacation

```
-- Return words with hyphens in them
SELECT  event_desc,
        REGEXP_SUBSTR(event_desc, '[A-Z][a-z]+(-[A-Za-z]+)+') AS hyphen_phrase
FROM    events;
```

event_desc	hyphen_phrase
A much-anticipated break from daily routines, this vacation period allows individuals and fam…	much-anticipated
An exciting and sometimes nerve-wracking day for students, marking the beginning of a new…	nerve-wracking
A festive occasion celebrated with costumes, trick-or-treating, and various spooky activities.…	trick-or-treating
A holiday rooted in gratitude and family, Thanksgiving is celebrated with a large feast that ty…	NULL
A major holiday celebrated around the world, Christmas commemorates the birth of Jesus C…	gift-giving

- **When dealing with RegExp, instead of memorizing the syntax, think about what you want to do and use AI tools (ChatGPT, Gemini, etc.) to help generate the syntax.**
  —*eg.* create a regex that returns sentences that start with a 3 letter word.

NULL FUNCTIONS

To do a simple IF-ELSE NULL check:

- Use the **IFNULL** function (*NVL in Oracle, not supported in PostgreSQL*)

To do more complex IF-ELSE NULL checks:

- Use the **COALESCE** function (*supported in most modern RDBMS's*)

PRO TIP: COALESCE is a more flexible version of the two, and will allow you to do multiple NULL checks, and returns the first non-NULL value

```sql
-- Return an alternative field after multiple checks
SELECT  name, email, alt_email,
        IFNULL(email, 'no email') AS contact_email_value,
        IFNULL(email, alt_email) AS contact_email_column,
        COALESCE(email, alt_email, 'no email') AS contact_email_coalesce
FROM    contacts;
```

name	email	alt_email	contact_email_value	contact_email_column	contact_email_coalesce
Anna	anna@example.com	NULL	anna@example.com	anna@example.com	anna@example.com
Bob	NULL	bob.alt@example.com	no email	bob.alt@example.com	bob.alt@example.com
Charlie	NULL	NULL	no email	NULL	no email
David	david@example.com	david.alt@example....	david@example.com	david@example.com	david@example.com

DATETIME MANIPULATION

I. Time Zones.

(Time zone may be localized or referred to the universal standard: UTC / older GMT)

a. Convert time zone from UTC to PST

```
SELECT '2020-09-01 00:00:00 -0' at time zone 'pst';
```

b. Some databases offer dedicated functions

```
SELECT CONVERT_TIMEZONE('pst', '2020-09-01 00:00:00 -0')
```

* UTC time may be convenient, but it doesn't reflect the actual moment of the day to an activity.
(Look out for timezone offset / database's documentation for the exact specification)

Note: Timestamp values won't necessarily have the time zone embedded, and you may require consulting with the source / vendor to figure out how the data was stored.

II. Date / Timestamp Format.

a. Convert string / Unix epoach with the right datetime format:

`STR_TO_DATE(c1, '%m/%d/%Y')` *or,* `TO_TIMESTAMP(c1, format)`

b. Truncate a date to the desired period:

`DATE_TRUNC('unit', c1)` *or,* `DATE_FORMAT(c1, '%Y-%m-01')` MySQL
::2020-10-01 00:00:00

c. Extract individual date / time part:

`DATE_PART('unit', c1)` *or,* `EXTRACT('YEAR_MONTH' FROM c1)`
::return float dtype :: 202002

d. Compose date & time from separate columns into a timestamp:

```
SELECT date_col + time_col AS timestamp
```

The standard time unit incl. — microsecond, millisecond, second, minute, hour, day, week, dayofweek, month, quarter, year, decade, century, millennium.

III. Datetime math

It can involve: `dt1 - dt2 / INTERVAL` *ie.* Python timedelta

—*the numeral system of date & time unit* [# year(s), month(s), day(s), hours, minute(s) & second(s)]

① `SELECT c1 FROM t WHERE c1 < current_date - INTERVAL '3 months'`

② `SELECT DATEDIFF('unit', dt1, dt2) FROM t` (Refer. PostgreSQL for complete functions & operators)

Some databases don't require INTERVAL {eg. SELECT date '2020-06-01' + 7}, but it's generally a good practice for cross-database compatibility & code readability.

There are few areas on datetime records needed particular attention when aligning data from different sources with uniform JOIN / UNION.

(1) **Consistent formatting & time zone** to serialize the data (eg. UTC), or isolate time zone to a separate field so that timestamp can be converted as needed.

(2) **Look out for timestamps from different sources that are slightly out of sync** (eg. recorded on client devices instead of common server), and can be fixed by adjusting the time window for complete records with BETWEEN & date math.

(3) **When dealing with data from mobile apps, pay particular attention to how the timestamps were recorded**- when the action happened on the device or arrived in the database (eg. real-time / store & forward) which datetime can be corrupted.

IV. Exploring trends of time series data

With time series data, we often want to look for trends- ① to examine for unusual events and/or ② depict the typical pattern in parts as comparisons or whole component in the data.

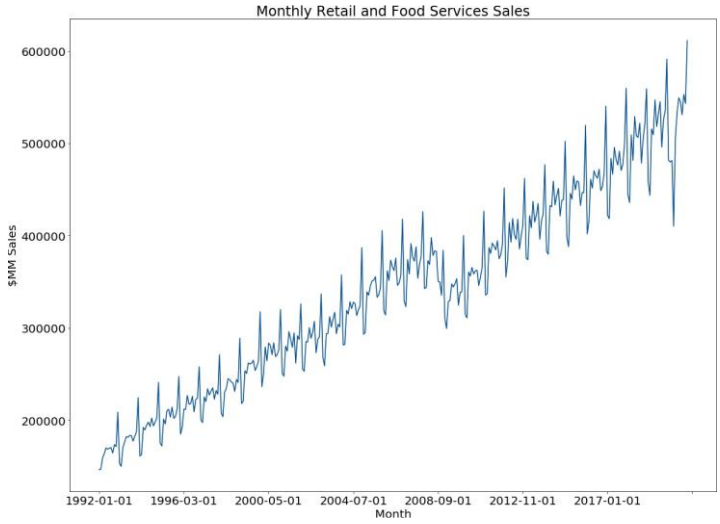
— (ie. how a measured property / metric changes over time)

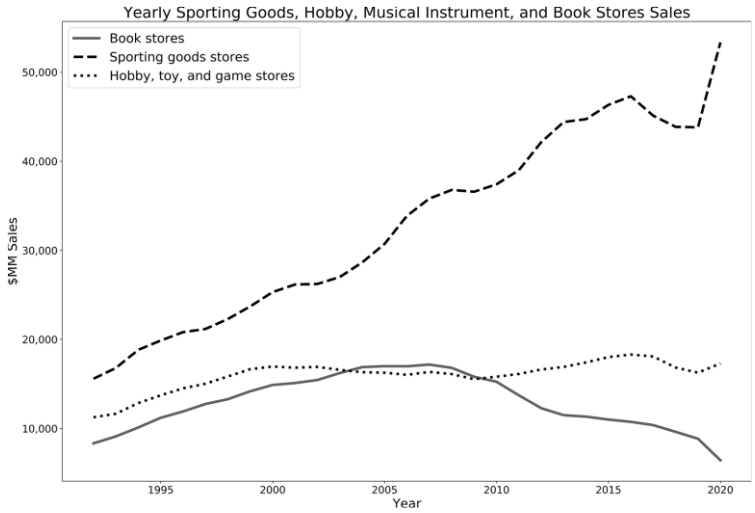
```
SELECT DATE_PART('year', sales_month) AS sales_year ---- Simple trends
,kind_of_business, SUM(sales) AS sales
FROM RetailSales
WHERE kind_of_business
IN ('Book stores','Sporting goods stores', 'Hobby, toy, and game stores')
GROUP BY 1,2
;
```

```
:: sales_year  kind_of_business              sales     -- X: dates / timestamps ( here, yearly )
   1992.0      Book stores                   8327      -- Y: numerical values
   1992.0      Hobby, toy, and game stores   11251
   1992.0      Sporting goods stores         15583
   ...         ...                           ...
```

[# Usually, data is prepared in SQL and fed into other charting tool to create visualizations.]

! All currency trx / operations are usually adjusted for inflation to reflect their true nature.





- Create a smoother time series data (trend) by transforming datetime & aggregating at yearly level to help us gain a better understanding of the pattern, separating from the noise.

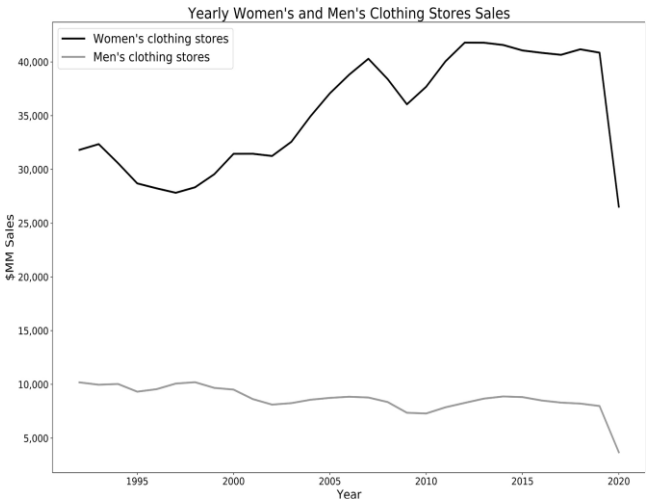
Comparing Components

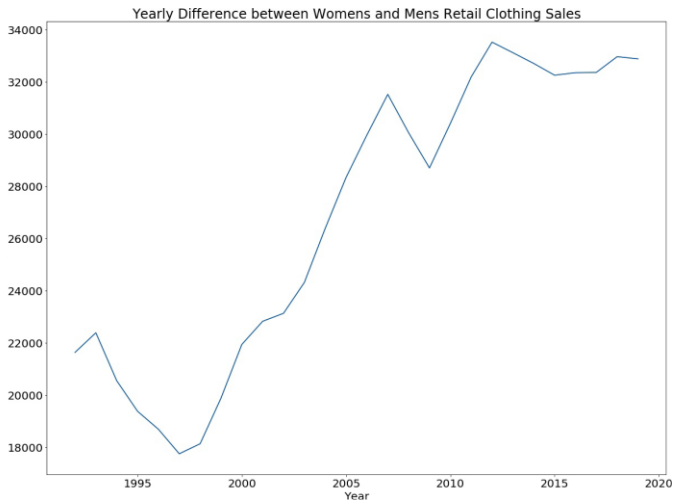
(eg. to quantify the difference over time by: [1] size / [2] ratio – sales amt or, pct of total**)**

```
SELECT DATE_PART('year', sales_month) AS sales_year   ----(1)
  ,SUM(CASE WHEN kind_of_business = "Women's clothing stores" THEN sales END)
   -
  SUM(CASE WHEN kind_of_business = "Men's clothing stores" THEN sales END)
AS womens_minus_mens
FROM RetailSales
WHERE kind_of_business IN ("Men's clothing stores", "Women's clothing stores")
AND sales_date <= '2019-12-01'
GROUP BY 1
;
```

```
   sales_year   womens_minus_mens  /  womens_pct_of_mens
   1992.0        21636                212.5552608311229000
   1993.0        22388                224.7339891588034500
   1994.0        20553                204.8744019138756000
   ...           ...                  ...
```

```
SELECT sales_year, (womens_sales / mens_sales - 1) * 100 AS womens_pct_of_mens
FROM                          ----(2)
(
  SELECT DATE_PART('year', sales_month) AS sales_year
  ,SUM(CASE WHEN kind_of_business = "Womens's clothing stores" THEN sales
            END) AS womens_sales
  ,SUM(CASE WHEN kind_of_business = "mens's clothing stores" THEN sales
            END) AS mens_sales
  FROM RetailSales
  WHERE kind_of_business IN ("Men's clothing stores", "Women's clothing stores")
  AND sales_month <= '2019-12-01'
  GROUP BY 1
) derived_t
;
```





[# It shows that the gap decreased btw 1992 and about 1997, began a long increase through about 2011 (with a brief dip in 2007), and then was moving more or less flat through 2019.]

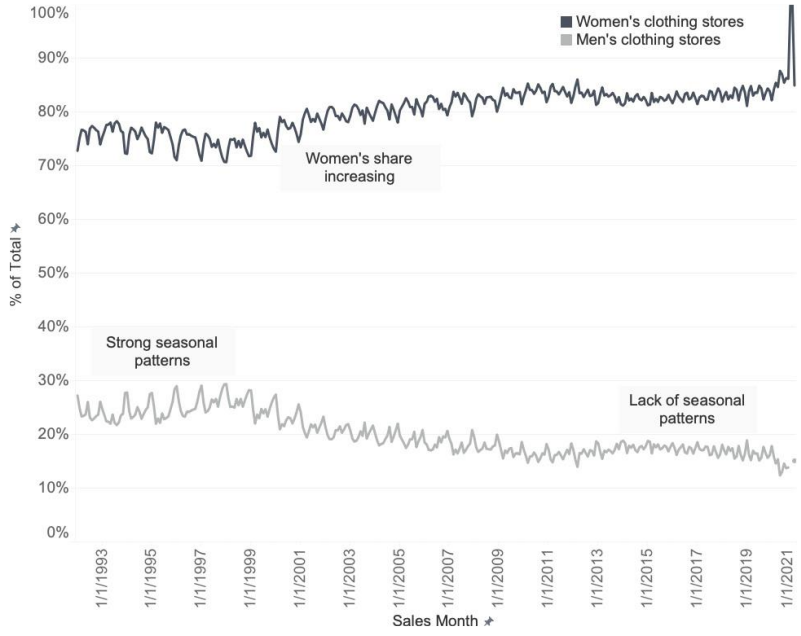
NOTE: Percentage / Ratio is used to quantify sales under influence of the market on both categories than simple comparison.

Percentage of segment / category to Total

(eg. men's & women's clothing sales from Total / monthly sales from each year sales)

```
#1 Computing combined men's & women's sales from total sales:
SELECT sales_month, kind_of_business, sales, total_sales
,SUM(sales) OVER (PARTITION BY sales_month) AS total_sales
,sales / SUM(sales) * 100 OVER (PARTITION BY sales_month) AS pct_total
FROM RetailSales
WHERE kind_of_business IN ("Men's clothing stores", "Women's clothing stores")
;

                                    --  OR    --

SELECT sales_month, kind_of_business, sales / total_sales * 100 pct_total_sales
FROM
(
    SELECT a.sales_month, a.kind_of_business, a.sales, SUM(b.sales) total_sales
    FROM RetailSales t1
    JOIN RetailSales t2 ON  --Cartesian JOIN of 2 rows from t2 for each row of t1- total clothing
      t1.sales_month = t2.sales_month
      AND t2.kind_of_businness IN ("Men's clothing stores"
        , "Women's clothing stores")
    WHERE t1.kind_of_business IN ("Men's clothing stores"
      , "Women's clothing stores")
    GROUP BY 1,2,3
) subquery
;
```

sales_month	kind_of_business	sales *optional*	total_sales *optional*	pct_total_sales
1992-01-01	Men's clothing stores	701	2574	27.23
1992-01-01	Women's clothing stores	1873	2574	72.77
1992-02-01	Men's clothing stores	1991	2649	75.16
...	...	...		



- Women's clothing sales became an increasing pct of the total starting in the late 1990s.
- Seasonal patterns in men's sales spike as pct of total in DEC & JAN, but by the late of 2010s they're damped almost to the point of randomness.

DATA ANALYSIS APPLICATIONS

- Data analysts often retrieve & manipulate sample data on database server apart from applications that rely on user's machine power to optimize the computational resources.

When working with a new project, we need to first familiarize with the available data:

1. **How the data is arranged in schemas & tables, and**
2. **Check the fields & sort out how they are related in the organization's process.**

—Often databases keep only the current datasets (ie. collected data of one full / several working days);
Check data warehouse for the daily snapshots of changing data fields- the history, if at all.

DO NOT rush into writing query, instead draft & visualize your idea first.

(1) **Sketch out Tables:** Draw out the structure of each table involved in the query.
(2) **Map Relationships:** When working with joins, visualizing how data flows btw tables can make complex joins easier to handle.
(3) **Plan the Logic:** Outline the main steps— aggregations, conditionals, filters, or unions you plan to apply. This helps organizing thoughts & spot any logic gaps.

! The hard part about SQL is not syntax writing, but what questions to ask of the data.

For example, to answer the question of—

" How many people were of the official age for secondary education broken down by region of the world in 2015? "

For this query, some additional tasks need to be performed before returning the result:

- Exclude rows with a missing region.
- Use the `SUM(value)` to calculate the total population for a given grain size.
- Sort by highest population region first.

```
SELECT summary.region, SUM(edu.value) secondary_edu_population
FROM
    `bigquery-public-data.world_bank_intl_education.internation_education` AS edu
INNER JOIN
    `bigquery-public-data.world_bank_intl_education.country_summary` AS summary
ON edu.country_code = summary.country_code
    WHERE summary.region IS NOT NULL
    AND edu.indicator_name = 'Population of the official age for secondary
    education, both sexes (number)'
    AND edu.year = 2015
GROUP BY summary.region
ORDER BY secondary_edu_population DESC
```

I. Profiling: Feature Distributions

a. Histogram / Frequency distribution:

```
SELECT fruit, COUNT(* / DISTINCT col_name) AS quantity   --(1)
FROM fruit_inventory
GROUP BY 1;        --output that facilitates data visualizations: histogram / bar chart
```

[# Output the feature distributions, or examine how frequently a typical class / value: unusual, sparse, missing etc. appear in the data.]

To return the distribution of orders from a table that needs to be aggregated beforehand, with date, customer identifier, order identifier, & an amount, instead of simple unique identifier counting:

```
SELECT orders, COUNT(*) AS num_customers   --(2)
FROM
(
   SELECT customer_id, COUNT(order_id) AS orders
   FROM orders
   GROUP BY 1
) a
GROUP BY 1;
```

CREATE TABLE with roundtrip

A	B	(A-B)
B	A	(A-B)
A	A	(A-A)

LEAST(c1,c2)||'-'||GREATEST(c1,c2) and aggregate by c3.

[# Count the no. of orders by each customer_id, then work out how many customers with the same size.]

To evaluate a few monthly sales statistics for —
" How many of each product is sold at each store? " AND relates to inventory if needed.

```
WITH sales_history AS (
  SELECT
    EXTRACT('YEAR' FROM Date) AS YEAR --time grouping
  , EXTRACT('MONTH' FROM Date) AS MONTH --time grouping
  , ProductId --need to know which products are sold
  , StoreID --need to know which stores are selling
  , SUM(quantity) AS UnitsSold --how many (impacts inventory)
  , AVG(UnitPrice) AS UnitPriceProxy --can be interesting
  , COUNT(DISTINCT salesID) AS NumTransactions --unique transactions
  FROM [project_name].sales.sales_info
  GROUP BY YEAR, MONTH, ProductId, StoreID)

SELECT  --create inventory with monthly sales ref to verify stock level
 inventory.*
 , (SELECT AVG(UnitsSold) FROM sales_history
    WHERE inventory.ProductID = sales_history.ProductID
    AND inventory.StoreID = sales_history.StoreID) AS avg_quantity_sold_in_a_month
FROM [project_name].sales.inventory AS inventory
```

For each ProductID + StoreID, you'll find:

- The current inventory of every product for each store
- The average monthly sales quantity for each product at every store

b. Binning:

```
# Discretize a continuous feature into a defined finite no. of bins / groups.
SELECT
    CASE WHEN order_amount <= 100 THEN 'up to 100'
         WHEN order_amount <= 500 THEN '100 - 500'
         ELSE '500+' END AS amount_bin,
    CASE WHEN order_amount <= 100 THEN 'small'
         WHEN order_amount <= 500 THEN 'medium'
         ELSE 'large' END AS amount_category,
    COUNT(customer_id) AS customer
    FROM orders
    GROUP BY 1,2
    ;
```

c. n-Tiles:

```
# Instead of arbitrary-sized bins, particular shape bins can be achieved by
# using {rounding / logarithms / n-tiles} numeric function.
```

```
SELECT ROUND(sales,-1) AS bin
,COUNT(customer_id) AS customers
FROM table
GROP BY 1
;
```

[# Create equal-width bins.]

Decimal places	Formula	Result
2	round(123456.789,2)	123456.79
1	round(123456.789,1)	123456.8
0	round(123456.789,0)	123457
-1	round(123456.789,-1)	123460
-2	round(123456.789,-2)	123500
-3	round(123456.789,-3)	123000

```
SELECT LOG(10,sales) AS bin   # for skewed dist.
,COUNT(customer_id) AS customers
FROM table
GROUP BY 1
;
```

[# Create increase size bins following a useful pattern.]

Formula	Result
log(1)	0
log(10)	1
log(100)	2
log(1000)	3
log(10000)	4

Note: Logarithm function will return null / error on >=0 value depending on database.

```
# Create n-quantiles of the data
SELECT ntile,
       MIN(order_amount) AS lower_bound,
       MAX(order_amount) AS upper_bound,
       COUNT(order_id) AS orders
FROM
(
    SELECT customer_id, order_id, order_amount,
           NTILE(10) OVER (ORDER BY order_amount) AS ntile
    FROM orders
) a
GROUP BY 1
;
```

**** Both NTILE & PERCENT_RANK can be expensive to compute over large dataset as it requires sorting of rows.**
(filter to only data needed can help optimize process)

II. Profiling: Data Quality

- One common consistency check is, comparing data against what is known to be true.

(eg. Compare the row counts in each system to verify that the data is complete with all rows arrived & received when working with a replica of production database)

a. Detecting Duplicates:

(Often figuring out why duplicate occurs from its repeated trait is useful for improving work process)

—*eg. accident with a hidden many-to-many JOIN, multiple tracking call in ETL, or manual steps* etc.

```
WITH Duplicate_rows AS
(
  SELECT *
  , ROW_NUMBER() OVER(
  PARTITION BY c1, c2, …) AS row_count
  FROM t
)

SELECT *
FROM duplicate_rows
WHERE row_count > 1
;
```

[# List out all the partially duplicate rows in data.]

OR

```
SELECT c1, c2, c3, ..., COUNT(*)
FROM table
GROUP BY 1,2,3...
HAVING COUNT(*) > 1
 ;
```

[# List out all the fully duplicate rows.]

b. Removing duplications by DISTINCT / GROUP BY:

```
# For nonduplicate records in a single table:
SELECT DISTINCT * FROM t  /  DELETE FROM duplicate_cte WHERE row_num > 1  --(1)

# For nonduplicate records of customers that appear in the other table only:
SELECT DISTINCT a.customer_id, a.customer_name, a.customer_email  --(2)
FROM customers a  --alias
JOIN transaction b ON a.customer_id = b.customer_id
```

Another useful approach is to perform an aggregation that returns 1-row per entity:

—*eg. we can return 1-record per customer with any aggregated info when we have a no. of transactions by the same customers.*

```
SELECT customer_id
, MIN(transaction_date) AS first_transaction_date
, MAX(transaction_date) AS last_transaction_date
, COUNT(*) AS total_orders
FROM table
GROUP BY 1
;
```

c. Return most recent records with Min / Max value Filtering

```sql
-- Return the most recent sales date for each sales rep
SELECT   sales_rep, MAX(date) AS most_recent_date
FROM     sales
GROUP BY sales_rep;
```

(1)

```sql
-- Number of sales on most recent date: Group by + join approach
WITH rd AS (SELECT   sales_rep, MAX(date) AS most_recent_date
            FROM     sales
            GROUP BY sales_rep)

SELECT  rd.sales_rep, rd.most_recent_date, s.sales
FROM    rd LEFT JOIN sales s
        ON rd.sales_rep = s.sales_rep
        AND rd.most_recent_date = s.date;
```

(2)

```sql
-- Number of sales on most recent date: Window function approach
SELECT * FROM

(SELECT sales_rep, date, sales,
        ROW_NUMBER() OVER (PARTITION BY sales_rep ORDER BY date DESC) AS row_num
FROM    sales) AS rn

WHERE row_num = 1;
```

id	sales_rep	date	sales
1	Emma	2024-08-01	6
2	Emma	2024-08-02	17
3	Jack	2024-08-02	14
4	Emma	2024-08-04	20
5	Jack	2024-08-05	5
6	Emma	2024-08-07	1
NULL	NULL	NULL	NULL

sales_rep	date	sales	row_num
Emma	2024-08-07	1	1
Jack	2024-08-05	5	1

III. Data Cleaning

a. Handling missing value

```
-- Examine records with NULL / Blank values
SELECT *
FROM StagingTable
WHERE c1 IS NULL OR c1 = '';
```

```
-- Drop rows with missing value
DELETE
FROM StagingTable
WHERE c1 IS NULL OR c2 IS NULL;
```

```
-- Drop columns
ALTER TABLE StagingTable
DROP COLUMN c1;
```

```
-- Validate Outcome & Populate with known data
SELECT t1.industry, t2.industry
FROM layoffs_staging2 t1
JOIN layoffs_staging2 t2
  ON t1.company = t2.company
WHERE (t1.industry IS NULL OR t1.industry = '')
AND t2.industry IS NOT NULL;
```

```
UPDATE layoffs_staging2 t1
JOIN layoffs_staging2 t2
  ON t1.company = t2.company
SET t1.industry = t2.industry
WHERE ...
AND ...
```

```
-- Sometimes, we can detect missing data by comparing values from two tables
SELECT DISTINCT t1.emp_name, t1.emp_dept, t2.location_name
FROM Employee_Data AS t1
RIGHT JOIN Department_Data AS t2 ON t1.emp_dept = t2.department_name
WHERE t1.emp_name IS NULL
;
```

```
emp_name   emp_dept     location_name
Gaurav       HR           Building 1    =>  NULL  Marketing/Sales  Building 3
Anjali       IT           Building 2        ...
NULL     Marketing/Sales  Building 3
...
```

Before making any changes, it is essential to evaluate the missing data first.

—Missing data is not always an ill-condition that needed to be fixed right away, but can be an important signal to reveal underlying design flaws or biases in the data collection process.

IMPUTING NULL VALUES BY:

1. Hard coded value (*integer*)
2. Average of a column (*subquery*)
3. Prior row's value (*window function*)
4. Smoothed value (*two window functions*)

```
#1   - CASE WHEN c1 IS NULL AND c2 = 'name' THEN 600 ELSE c1 END
     - SELECT *, COALESCE(c1, 600) AS updated_by_600

#2.  SELECT *, COALESCE(c1, (SELECT AVG(c1) FROM t) AS updated_by_avg

#3.  SELECT *, COALESCE(c1, LAG/LEAD(price) OVER(PARTITION BY product
                                                 ORDER BY order_date))
               AS updated_price_avg

#4.  SELECT *, COALESCE(c1, (LAG(price) OVER() + LEAD(price) OVER())/2)
               AS updated_price_smooth
```

::Imputing values based on statistical metric/interpolation/ insightful assumption about typical value (eg. price of the same date).

Note: [1] Similar to Python, null value is contagious where any operation with it will result in null.

[2] In **PostgreSQL & Oracle**, NULL is considered larger than any non-NULL value when ordered; Vice-versa for SQLite, MySQL & SQL Server.

Beware of empty strings disguise as NULL, where there is no visible value present in a cell.

(Sometimes, empty string - ' ' is appropriate as value overcoming NOT NULL constraint when there is no explicit / suitable answer to a question and leaving it empty is not an option.)

 # Collectively, LENGTH() & TRIM() can be used to check and remove unintended chr / spaces.

b. Standardize the data

```
-- Trim excessive chr, whitespace, or carriage return
UPDATE t SET c1 = TRIM(TRAILING '.' FROM c1) / REPLACE(c1, '\r', '')

-- Rectify string of a class
CASE WHEN gender = 'F' THEN 'Female'
     WHEN gender = 'female' THEN 'Female'
     WHEN gender = 'femme' THEN 'Female'
     ELSE gender
     END AS gender_cleaned
```

```
CASE WHEN likelihood IN (0,1,2,3,4,5,6) THEN 'Detractor'
     WHEN likelihood IN (7,8) THEN 'Passive'
     WHEN likelihood IN (9,10) THEN 'Promoter'
     END
```

@ for multiple columns consideration,

```
CASE WHEN likelihood <= 6 AND country = 'US' AND high_value = TRUE
THEN 'US high value detractor'
     WHEN likelihood >= 9 AND (country IN ('CA', 'JP') OR high_value = TRUE)
THEN 'some other label'
     END
```

Note: The CASE statement works well only for a relatively short list of values that isn't expected to change. Otherwise, the utility table would be a better option.

Another use is to create dummy vars for statistical / numerical analysis.

```
SELECT customer_id
,CASE WHEN gender = 'F' THEN 1 ELSE 0 END AS is_female
,CASE WHEN likelihood IN (9,10) THEN 1 ELSE 0 END AS is_promoter
FROM table
;
```

c. Creating flags

—eg. identify if a customer belongs to a treatment group based on the no. of matching conditions from various transactions in a dataset that has multiple rows per entity: name / id.

```
SELECT customer_id,
       MAX(CASE WHEN fruit = 'apple' AND quantity > 5 THEN 1 ELSE 0
                END) AS loves_apples
       MAX(CASE WHEN fruit = 'orange' AND quantity > 5 THEN 1 ELSE 0
                END) AS loves_oranges
FROM t
GROUP BY 1
;
```

d. Datetype Conversion

(Type conversion function): `cast(c1 AS VARCHAR)` or, `c1::VARCHAR`

```
# To manipulate a string field for numerical application:
SELECT REPLACE('$19.99', '$', '')::float  or,  CAST(REPLACE('$19.99', '$', '') AS float)
```

```
# To concatenate strings from different fields: (eg. time-series data)
SELECT (year || ',' || month || '-' || day)::date or, CAST(CONCAT(year, '-', month, '-', day) AS date);
, COUNT(transactions) AS num_trx          MAKE_DATE(2020, 09, 01);
FROM table
GROUP BY 1
;
```

[# Double pipe ||, is a concatenation operator to assemble values from separate columns.]

```
# If categorization of numeric values w/ upper / lower bound is needed:
CASE WHEN order_items <= 3 THEN order_items::VARCHAR
     ELSE '4+'
     END
```

[# This is especially handy when database does not support type coercion (eg. INT -> FLOAT)
— `population / 5.0` **dividing integer by a float**, and requires data to be explicitly converted.]

`to_char ( timestamp, text ) → text`
`to_char ( timestamp with time zone, text ) → text`
Converts time stamp to string according to the given format.
`to_char(timestamp '2002-04-20 17:31:12.66', 'HH12:MI:SS') → 05:31:12`

`to_char ( interval, text ) → text`
Converts interval to string according to the given format.
`to_char(interval '15h 2m 12s', 'HH24:MI:SS') → 15:02:12`

`to_char ( numeric_type, text ) → text`
Converts number to string according to the given format; available for `integer`, `bigint`, `numeric`, `real`, `double precision`.
`to_char(125, '999') → 125`
`to_char(125.8::real, '999D9') → 125.8`
`to_char(-125.8, '999D99S') → 125.80-`

`to_date ( text, text ) → date`
Converts string to date according to the given format.
`to_date('05 Dec 2000', 'DD Mon YYYY') → 2000-12-05`

`to_number ( text, text ) → numeric`
Converts string to numeric according to the given format.
`to_number('12,454.8-', '99G999D9S') → -12454.8`

`to_timestamp ( text, text ) → timestamp with time zone`
Converts string to time stamp according to the given format. (See also `to_timestamp(double precision)` in Table 9.33.)
`to_timestamp('05 Dec 2000', 'DD Mon YYYY') → 2000-12-05 00:00:00-05`

(For more pointed behavior, the dedicated datatype conversion function may be used.)

e. Converting datetime field into different levels of granularity

date	day_of_month	day_of_year	day_of_week	day_name	week	month_number	month_name	quarter_number	quarter_name	year	decade
2000-01-01	1	1	6	Saturday	1999-12-27	1	January	1	Q1	2000	2000
2000-01-02	2	2	0	Sunday	1999-12-27	1	January	1	Q1	2000	2000
2000-01-03	3	3	1	Monday	2000-01-03	1	January	1	Q1	2000	2000
2000-01-04	4	4	2	Tuesday	2000-01-03	1	January	1	Q1	2000	2000
2000-01-05	5	5	3	Wednesday	2000-01-03	1	January	1	Q1	2000	2000
2000-01-06	6	6	4	Thursday	2000-01-03	1	January	1	Q1	2000	2000
2000-01-07	7	7	5	Friday	2000-01-03	1	January	1	Q1	2000	2000
2000-01-08	8	8	6	Saturday	2000-01-03	1	January	1	Q1	2000	2000
2000-01-09	9	9	0	Sunday	2000-01-03	1	January	1	Q1	2000	2000
2000-01-10	10	10	1	Monday	2000-01-10	1	January	1	Q1	2000	2000
2000-01-11	11	11	2	Tuesday	2000-01-10	1	January	1	Q1	2000	2000
2000-01-12	12	12	3	Wednesday	2000-01-10	1	January	1	Q1	2000	2000
2000-01-13	13	13	4	Thursday	2000-01-10	1	January	1	Q1	2000	2000
2000-01-14	14	14	5	Friday	2000-01-10	1	January	1	Q1	2000	2000
2000-01-15	15	15	6	Saturday	2000-01-10	1	January	1	Q1	2000	2000
2000-01-16	16	16	0	Sunday	2000-01-10	1	January	1	Q1	2000	2000
2000-01-17	17	17	1	Monday	2000-01-17	1	January	1	Q1	2000	2000
2000-01-18	18	18	2	Tuesday	2000-01-17	1	January	1	Q1	2000	2000
2000-01-19	19	19	3	Wednesday	2000-01-17	1	January	1	Q1	2000	2000
2000-01-20	20	20	4	Thursday	2000-01-17	1	January	1	Q1	2000	2000
2000-01-21	21	21	5	Friday	2000-01-17	1	January	1	Q1	2000	2000
2000-01-22	22	22	6	Saturday	2000-01-17	1	January	1	Q1	2000	2000
2000-01-23	23	23	0	Sunday	2000-01-17	1	January	1	Q1	2000	2000
2000-01-24	24	24	1	Monday	2000-01-24	1	January	1	Q1	2000	2000
2000-01-25	25	25	2	Tuesday	2000-01-24	1	January	1	Q1	2000	2000
2000-01-26	26	26	3	Wednesday	2000-01-24	1	January	1	Q1	2000	2000

- A sample data dimension table with extensible breakdown of date components since a given date.

Through a JOIN to the created or manually generated date dimension table using **generate_series(start, stop, step)** function as followed:

```
SELECT a.generate_series AS order_date, b.customer_id, b.items    ----(1)
FROM
(
   SELECT * FROM GENERATE_SERIES('2020-01-01'::date, '2020-12-31'::date, '1 day')
) a
LEFT JOIN
(
  SELECT customer_id, order_date, COUNT(item_id) AS items
  FROM Orders
  GROUP BY 1,2
) b ON a.generate_series = b.order_date
```

Note: With such a table we can ensure that a query returns a result for every date of interest, whether or not there was a record for that date in the underlying dataset.

If a date dimension is not available in database, a subquery can be used to simulate one by *SELECT* -ing the *DISTINCT* dates from any source that has the timeseries needed and *JOIN*.

```
SELECT                ----(2)
  a.date, b.customer_id
, b.subscription_date, b.annual_amount / 12 AS monthly_subscription
FROM
(
   SELECT DISTINCT sales_month
   FROM RetailSales
   WHERE sales_month BETWEEN '2020-01-01' AND '2020-12-31'
) a
JOIN CustomerSubscriptions b ON a.date BETWEEN b.subscription_date
  AND b.subscription_date + INTERVAL '11 months'
```

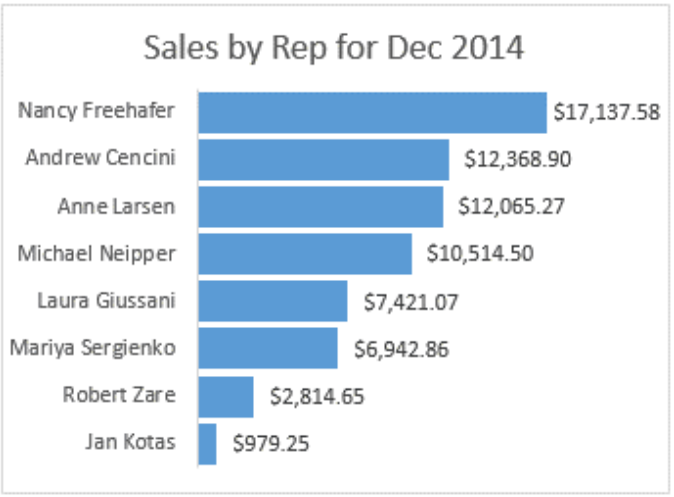
** For sample code to create the date dimension utility table, refer.* GitHub site.

IV. Pivot Table

- This can be achieved using CASE statements
- PIVOT is available in some RDBMS's like SQL Server and Oracle

a. Pivoting

Row Labels	Sum of Revenue
Nancy Freehafer	$17,137.58
Andrew Cencini	$12,368.90
Anne Larsen	$12,065.27
Michael Neipper	$10,514.50
Laura Giussani	$7,421.07
Mariya Sergienko	$6,942.86
Robert Zare	$2,814.65
Jan Kotas	$979.25
Grand Total	**$70,244.08**



- **Summarize data by transforming unique values in rows into columns.**

It is typically done with conditional aggregations to shape data in a more readable format:

```
SELECT order_date
,SUM(CASE WHEN product = 'shirt' THEN order_amount ELSE 0 END) AS shirts_amount
,SUM(CASE WHEN product = 'shoes' THEN order_amount ELSE 0 END) AS shoes_amount
,SUM(CASE WHEN product = 'hat' THEN order_amount ELSE 0 END) AS hats_amount
FROM orders
GROUP BY 1
;
```

```
order_date  shirts_amount  shoes_amount  hats_amount
----------  -------------  ------------  -----------
2020-05-01  5268.56        1211.65       562.25
2020-05-02  5533.84        522.25        325.62
2020-05-03  5986.85        1088.62       858.35
...         ...            ...           ...
```

[# As SQL pivoting employs explicit categorization with CASE statement, it is not suitable for rapid changing / expanding datasets and advisable to compute in other analysis tool.]

Note: ELSE statement is included for sum aggregation to avoid NULL, otherwise ignored in COUNT where a substitute value could inflate unneccesary count.

b. Unpivoting

```
# To move data stored in columns into rows to create tidy data:
SELECT country,'1980' AS year,year_1980 AS population FROM country_populations
UNION ALL
SELECT country,'1990' AS year,year_1990 AS population FROM country_populations
UNION ALL
SELECT country,'2000' AS year,year_2000 AS population FROM country_populations
UNION ALL
SELECT country,'2010' AS year,year_2010 AS population FROM country_populations
;
```

```
Postgres -> SELECT country
            ,UNNEST(array['1980', '1990', '2000', '2010']) AS year
            ,UNNEST(array[year_1980, year_1990, year_2000, year_2010]) AS pop
            FROM country_populations
            ;
```

* PostgresSQL offers array data structure for minor elements collection as object relational database.

Country	year_1980	year_1990	year_2000	year_2010
Canada	24,593	27,791	31,100	34,207
Mexico	68,347	84,634	99,775	114,061
United States	227,225	249,623	282,162	309,326

```
country        year  population
-------------  ----  ----------
Canada         1980  24593
Mexico         1980  68347
United States  1980  227225
...            ...   ...
```

[# Integrate selections from multiple queries w/ compatible dtype using UNION statement.]

Recognizing that the pivot & unpivot are common, some databases have created its dedication functions that operate in similar manner: **(Microsoft SQL Server & Snowflake)**

```
SELECT ...
FROM ...
     pivot(aggregation(value_c1)
          for label_c2 in ('cate1', 'cate2', ...))
GROUP BY ...
;
```

```
SELECT *
FROM country_populations
     unpivot(population)
          for year in (year_1980, year_1990, ...)
;
```

(Although the syntax is more compact than CASE construction, the desired cols still need to be specified and it doesn't solve the problem for newly arriving or rapidly changing sets of fields.)

V. Rolling Calculations

a. Subtotals

order_id	customer_name	order_date	pizza_name	price
1	Jack	2024-12-01	Pepperoni	18.75
2	Jack	2024-12-02	Pepperoni	18.75
3	Jack	2024-12-03	Pepperoni	18.75
4	Jack	2024-12-04	Pepperoni	18.75
5	Jack	2024-12-05	Spicy Italian	22.75
6	Jill	2024-12-01	Five Cheese	18.50
7	Jill	2024-12-03	Margherita	19.50
8	Jill	2024-12-05	Garden Delight	21.50
9	Jill	2024-12-05	Greek	21.50
10	Tom	2024-12-02	Hawaiian	19.50
11	Tom	2024-12-04	Chicken Pesto	20.75
12	Tom	2024-12-05	Spicy Italian	22.75
13	Jerry	2024-12-01	California Chi…	21.75
14	Jerry	2024-12-02	Margherita	19.50
15	Jerry	2024-12-04	Greek	21.50

Subtotals

customer_name	order_date	total_sales
Jack	2024-12-01	18.75
Jack	2024-12-02	18.75
Jack	2024-12-03	18.75
Jack	2024-12-04	18.75
Jack	2024-12-05	22.75
Jack	NULL	97.75
Jerry	2024-12-01	21.75
Jerry	2024-12-02	19.50
Jerry	2024-12-04	21.50
Jerry	NULL	62.75
Jill	2024-12-01	18.50
Jill	2024-12-03	19.50
Jill	2024-12-05	43.00
Jill	NULL	81.00
Tom	2024-12-02	19.50
Tom	2024-12-04	20.75
Tom	2024-12-05	22.75
Tom	NULL	63.00
NULL	NULL	304.50

```sql
SELECT customer_name, order_date, SUM(price) AS total_sales
FROM PizzaOrders
GROUP BY customer_name, order_date WITH ROLLUP;
```

b. Cumulative sum

order_id	customer_name	order_date	pizza_name	price
1	Jack	2024-12-01	Pepperoni	18.75
2	Jack	2024-12-02	Pepperoni	18.75
3	Jack	2024-12-03	Pepperoni	18.75
4	Jack	2024-12-04	Pepperoni	18.75
5	Jack	2024-12-05	Spicy Italian	22.75
6	Jill	2024-12-01	Five Cheese	18.50
7	Jill	2024-12-03	Margherita	19.50
8	Jill	2024-12-05	Garden Delight	21.50
9	Jill	2024-12-05	Greek	21.50
10	Tom	2024-12-02	Hawaiian	19.50
11	Tom	2024-12-04	Chicken Pesto	20.75
12	Tom	2024-12-05	Spicy Italian	22.75
13	Jerry	2024-12-01	California Chi…	21.75
14	Jerry	2024-12-02	Margherita	19.50
15	Jerry	2024-12-04	Greek	21.50

Cumulative sum

order_date	cumulative_sum
2024-12-01	59.00
2024-12-02	116.75
2024-12-03	155.00
2024-12-04	216.00
2024-12-05	304.50

```sql
WITH ts AS (SELECT order_date, SUM(price) AS total_sales
            FROM   PizzaOrders
            GROUP BY order_date)

SELECT order_date,
       SUM(total_sales) OVER(ORDER BY order_date) AS cumulative_sum
FROM ts;
```

c. Moving Averages

country	year	happiness_score
Afghanistan	2015	3.575
Afghanistan	2016	3.360
Afghanistan	2017	3.794
Afghanistan	2018	3.632
Afghanistan	2019	3.203
Afghanistan	2020	2.567
Afghanistan	2021	2.523
Afghanistan	2022	2.404
Afghanistan	2023	1.859
Albania	2015	4.959
Albania	2016	4.655
Albania	2017	4.644
Albania	2018	4.586
Albania	2019	4.719
Albania	2020	4.883

Moving average

country	year	happiness_score	moving_average
Afghanistan	2015	3.575	3.575
Afghanistan	2016	3.360	3.468
Afghanistan	2017	3.794	3.576
Afghanistan	2018	3.632	3.595
Afghanistan	2019	3.203	3.543
Afghanistan	2020	2.567	3.134
Afghanistan	2021	2.523	2.764
Afghanistan	2022	2.404	2.498
Afghanistan	2023	1.859	2.262
Albania	2015	4.959	4.959
Albania	2016	4.655	4.807
Albania	2017	4.644	4.753
Albania	2018	4.586	4.628
Albania	2019	4.719	4.650
Albania	2020	4.883	4.729

- Calculate the 3 year moving average of happiness score for each country.

```
SELECT country, year, happiness_score,
       ROUND(AVG(happiness_score)
       OVER(PARTITION BY country ORDER BY year
            ROWS BETWEEN 2 PRECEDING AND CURRENT ROW), 3) AS moving_average
FROM happiness_scores
ORDER BY country, year;
```