IT125 SQL: SUMMARY QUERIES & SUBQUERIES

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TONIGHT

- Review a few **Proj05** issues
- Discuss **generating data** for Proj08
- Learn to write **summary queries** that do common math operations like count, sum, average, min, and max
  - Use these to return table-wide stats or apply them to grouped data
  - Add the HAVING clause to filter on grouped data
- Learn how to use **subqueries** in various SELECT clauses

PROJ05 ISSUES

PROJ08: GENERATING DATA

SAMPLE DATA FOR PROJ08

We want enough realistic data for a proof-of-concept demo. Our first task is to populate the more **independent tables**. Where do we get data?

- Find *real* data (internet?)
- Generate *mock* data, e.g., https://www.mockaroo.com/
- Make up *fake* data, or add fake data in certain columns
  - If you're handy with Excel, a random number plus IF or VLOOKUP, perhaps
- Munge data into usable form (parenthesized, comma-separated column values)
  - Excel formulas or a script (Python?)

Linking tables are harder

- For a small amount of demo data, make it up
- If bigger and/or fancier, some scripting might be required
  - Adding in some probabilities can make data feel more realistic

PART I: SUMMARY QUERIES

THE NEED FOR SUMMARY QUERIES

Queries Thus Far

- We've so far written queries that dump out raw data—perhaps joined, perhaps filtered, perhaps renamed—but raw row data nonetheless
- For example, we can easily answer questions like "How many customers live in Bellevue, WA?" or requests like "Get a list of customers who live in Kirkland, WA"

Wanting More

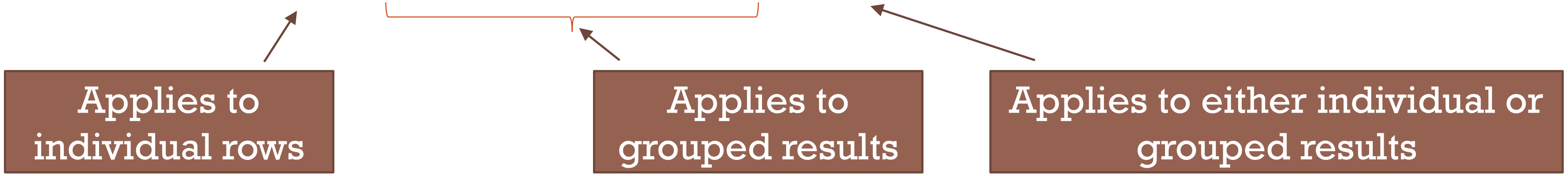
- What about "Get a count of customers in *each* WA city." How many queries would you need to find that data? Yipes!
- Being a clever techie, you might paste into Excel and use formulas or Pivot Tables, but can't SQL be of more help?

The Bottom Line

- Raw data insufficient to handle many business requests; your manager will often want summaries to support or validate business decisions

WHAT SUMMARY QUERIES OFFER

- Summary Queries give us a way to apply common mathematical operations and show the *summarized results*
- These queries can not only show us the mathematical results on a *whole* table's data, but can also show us results on *groups* of data; this adds the GROUP BY clause to our SELECT toolbox
- On top of that, we can also filter based on those *grouped results*; we'll add the HAVING clause on top of the GROUP BY
- Order of clauses:
  - `SELECT, FROM, WHERE, GROUP BY, HAVING, ORDER BY`



Applies to individual rows

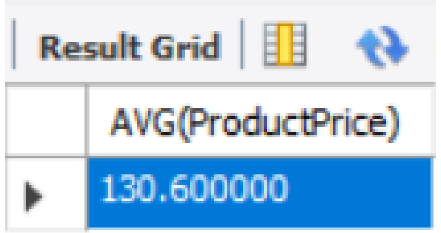
Applies to grouped results

Applies to either individual or grouped results

SAMPLE SUMMARY QUERY

- Using Cathy's Cakes, here's a typical summary query:

```
SELECT AVG(ProductPrice)
FROM Product;
```



AVG(ProductPrice)
130.600000

- It's a summary query because it contains an aggregate function, AVG in this case
- As is typical with aggregate functions, this will return exactly one cell of data (never more, never less); this will be important later when we study subqueries

AGGREGATE FUNCTIONS

These are "column" functions; not scalar functions like we've seen before

`AVG(expression)`	average of non-null values
`SUM(expression)`	sum of non-null values
`MIN(expression)`	lowest non-null value
`MAX(expression)`	highest non-null value
`COUNT(*)`	number of rows in the query
`COUNT(expression)`	number of non-null values

You'll use this version of COUNT far less frequently

Also available: `STDDEV_POP(expression), STDDEV_SAMP(expression), VAR_POP(expression), VAR_SAMP(expression)`

Complete list: https://dev.mysql.com/doc/refman/5.7/en/group-by-functions.html#function_std

PRACTICE #1: SUMMARY OF TABLE DATA

- Aggregate function list: AVG, SUM, MIN, MAX, COUNT
- Set as the default database: Cathy’s Cakes
- In one query, gather, from the **Product** table:
  - A count of the products in the table (call this “Count")
  - A total of all product prices (call this "Total") (doesn’t really make sense, but it’s practice)
  - The average product price (call this "Average") rounded to the nearest penny
  - The lowest product price in the table (call this "Lowest")
  - The highest product price in the table (call this "Highest")

PRACTICE #1: SUMMARY OF TABLE DATA

- Gather typical summary data on the Cathy's Cakes Product table
- Solution

```
SELECT       COUNT(*)                         AS  `Count`,
             SUM(ProductPrice)                AS  `Total`,
             ROUND(AVG(ProductPrice), 2)      AS  `Average`,
             MIN(Productprice)                AS  `Lowest`,
             MAX(ProductPrice)                AS  `Highest`
FROM Product;
```

Note that COUNT rarely needs an argument other than *; you're almost always counting rows, not non-null values in a column

GROUPING RESULT DATA

Instead of yielding one row of summary results for the whole table, it's common to want a list of *subtotals* instead. To do this, just add a GROUP BY after the FROM clause. Syntax:

- `GROUP BY group_by_list [WITH ROLLUP]`

This is usually a column of interest, e.g.,

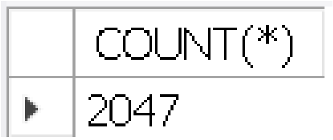
- `GROUP BY CustId   // in Invoices table, the "many" side of a relationship`
- `GROUP BY AreaCode`
- `GROUP BY State, City`

- The result set will have one row per group, e.g., one summary row for each Customer ID, Area Code, or State/City; all summary functions will be applied
- Include at WITH ROLLUP at the end of the SELECT line to request a grand total line
- Note: don't include non-summary columns included in the SELECT clause unless they are used in the GROUP BY clause; they make no sense

GROUPING EXAMPLE (CATHY'S CAKES)

- No grouping: "How many cake orders are represented in ProductOrder?"

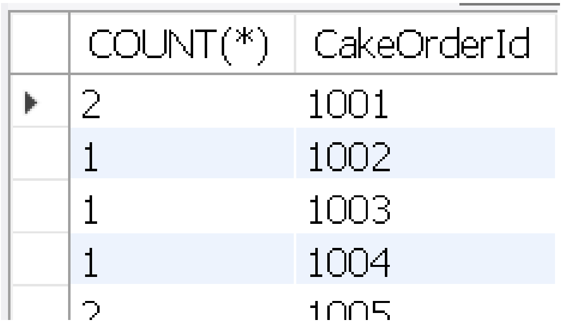
```
SELECT COUNT(*)
FROM ProductOrder;
```



	COUNT(*)
▸	2047

- Grouping: "How many cake orders do we see within *each* ProductOrder?"

```
SELECT COUNT(*), CakeOrderId
FROM ProductOrder
GROUP BY CakeOrderId;
```



	COUNT(*)	CakeOrderId
▸	2	1001
	1	1002
	1	1003
	1	1004
	2	1005

Could also use
GROUP BY 2
(positions are allowed in this clause, as in ORDER BY)

CakeOrderId makes sense in SELECT; other columns won't

PRACTICE #2: GROUPING

Here's a typical, reasonable request from Cathy (of Cathy's Cakes):

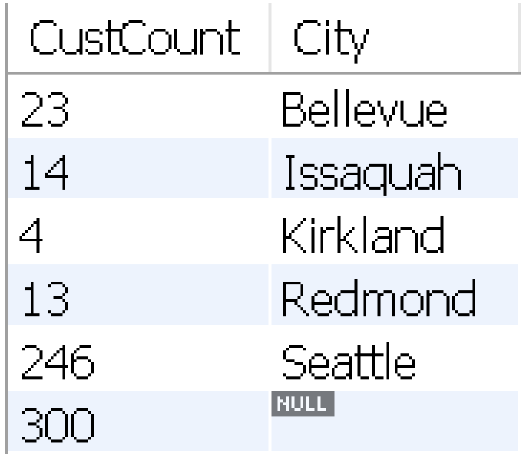
Find out how many customers live in each city

Show a grand total row at the bottom

PRACTICE #2: GROUPING

- Task:
  - Find out how many customers live in each city
  - Show a grand total row at the bottom
- Solution

```
SELECT COUNT(*) AS CustCount, ZipCodeCity AS City
FROM Customer JOIN ZipCode USING (ZipCode)
GROUP BY ZipCodeCity WITH ROLLUP;
```



CustCount	City
23	Bellevue
14	Issaquah
4	Kirkland
13	Redmond
246	Seattle
300	NULL

The ZipCodeCity column only makes sense because of ZipCodeCity in GROUP BY; try putting another column in the SELECT clause to see why (e.g., CustomerPhone)

FILTERING ANALOGY: CRUISE SHIP

On a cruise ship, there are two different kinds of "filters" you might experience:

- The first is the **security guard** who checks your id when you try to board the ship; if you don't have the right credentials, you aren't allowed to board
- The second is the **activity director** who might put you into groups based on what state you're from, then eliminate (or combine) groups smaller than 5 people

While these are both filtering activities, they happen at *different times*; the first says whether you're included at all, and the second happens later, *after you've been put into groups*

The first is an example of how WHERE works; it keeps non-matching rows from being part of the results to begin with; they aren't grouped, aren't totaled, etc. It works on *rows*

The second is an example of how HAVING works; it takes *grouped data* and applies a filter on the *results* of that grouping. It works on *grouped results*

FILTERING SUMMARY DATA

We've long known how to filter row data; we just use WHERE

But we may need to filter on *summary* (grouped) results. To accomplish that, we add a HAVING clause after the GROUP BY clause:

  - `HAVING condition`

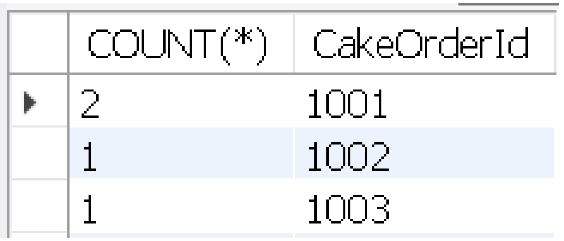
- It's legal to have both a WHERE and a HAVING clause; if so, put the WHERE in the usual spot but before GROUP BY and HAVING

  -
    ```
    SELECT select_list
    FROM table_name
    WHERE row_filter_condition        // selects which rows to include
    GROUP BY group_by_list            // creates summary grouping
    HAVING summary_filter_condition   // selects which summary data to include
    ORDER BY order_by_list            // sets sort order for results
    ```

GROUP FILTERING EXAMPLE (CATHY'S CAKES)

- No filtering: "How many cake orders do we see within *each* ProductOrder?"

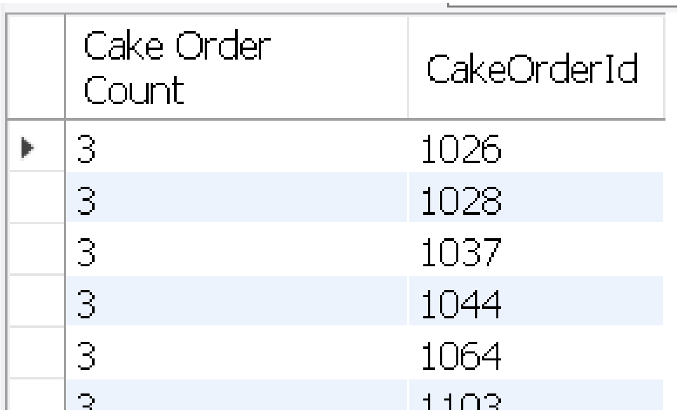
```
SELECT COUNT(*), CakeOrderId
FROM ProductOrder
GROUP BY CakeOrderId;
```



COUNT(*)	CakeOrderId
2	1001
1	1002
1	1003

- Group filtering: "…but show only Product Orders with more than 2 Cake Orders"

```
SELECT COUNT(*) AS `Cake Order Count`, CakeOrderId
FROM ProductOrder
GROUP BY CakeOrderId
HAVING `Cake Order Count` > 2;
```



Cake Order Count	CakeOrderId
3	1026
3	1028
3	1037
3	1044
3	1064
3	1103

Could also write:
`HAVING COUNT(*) > 2`

PRACTICE #3: FILTERING SUMMARY DATA

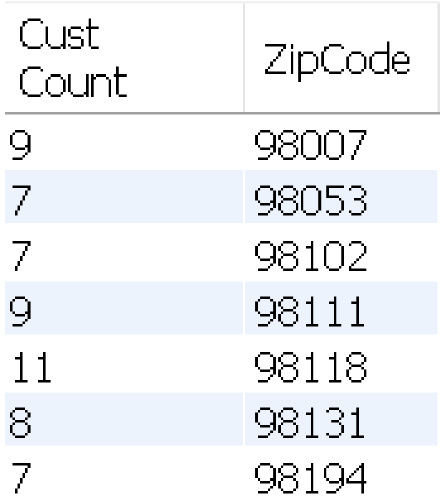
For Cathy's Cakes, get a list of the zip codes that have 7 or more customers in them, along with the number of customers in that zip code

Out of curiosity, use WITH ROLLUP and see why you might not want that here

PRACTICE #3: FILTERING SUMMARY DATA

ANSWERS

- Task:
  - For Cathy's Cakes, get a list of the zip codes that have 7 or more customers in them, along with the number of customers in that zip code



Cust Count	ZipCode
9	98007
7	98053
7	98102
9	98111
11	98118
8	98131
7	98194

- Solution

```
SELECT COUNT(*) AS `Cust Count`, ZipCode
FROM Customer JOIN ZipCode USING (ZipCode)
GROUP BY ZipCode
HAVING `Cust Count` >= 7;
```

Could also do this:
HAVING COUNT(*) >= 7

Make sure you're super clear on why HAVING solves a problem that WHERE can't solve

PRACTICE #4: SORTING SUMMARY DATA

Copy and paste the previous query and alter the copy

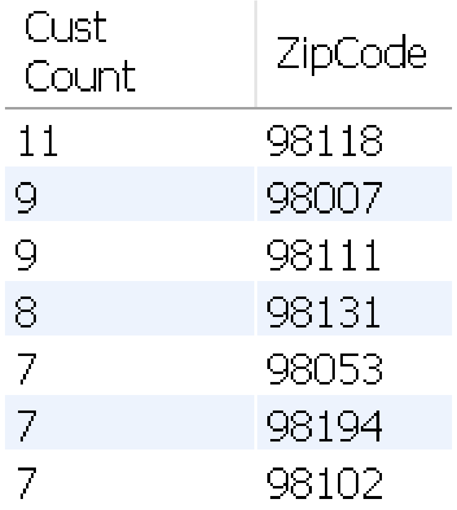
Sort so that the zip code with the highest number of customers is listed first

PRACTICE #4: SORTING SUMMARY DATA

- Task:
  - Starting with the previous query, sort so that the zip code with the highest number of customers is listed first

- Solution

```
SELECT COUNT(*) AS `Cust Count`, ZipCode
FROM Customer JOIN ZipCode USING (ZipCode)
GROUP BY ZipCode
HAVING COUNT(*) >= 7
ORDER BY `Cust Count` DESC;
```



Cust Count	ZipCode
11	98118
9	98007
9	98111
8	98131
7	98053
7	98194
7	98102

Can't use WITH ROLLUP and ORDER BY together; choose one or the other

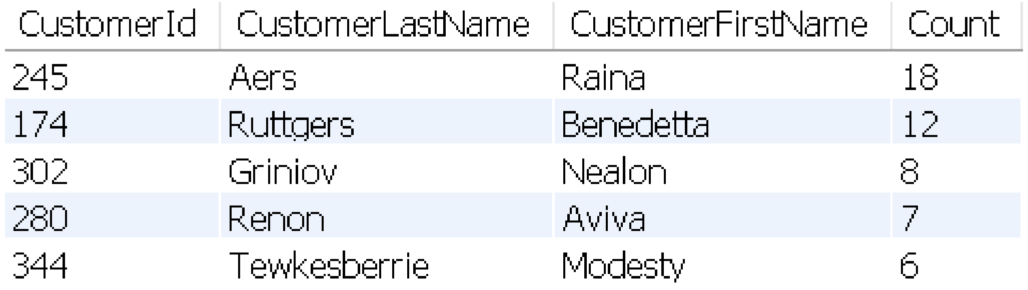
PRACTICE #5: ALL TOGETHER NOW

- Now let's tie in what we've studied *before* with what we've learned *tonight*
  - For example, some joining of tables is required for more complex scenarios
- Get a list of Redmond customers who have ordered the most products
  - Note that this isn't the same as having placed *the most orders*; we're asking about products within those orders, for all time and all orders
- In the results list, show the customer id, customer first name, last name, and how many products they have ordered
- Show only the customers who have ordered over 5 products
- Sort by the number of product ordered, highest first

PRACTICE #5: ALL TOGETHER NOW

- Task:
  - Get a list of Redmond customers who have ordered the most products
  - In the results list, show the customer id, customer first name, last name, and how many products they have ordered
  - Show only the customers who have ordered over 5 products
  - Sort by the number of product ordered, highest first
- Solution

```
SELECT CustomerId, CustomerLastName, CustomerFirstName,
       COUNT(*) AS `Count`
FROM Customer JOIN CakeOrder USING (CustomerId)
              JOIN ProductOrder USING (CakeOrderId)
              JOIN ZipCode USING (ZipCode)
WHERE ZipCodeCity = 'Redmond'
GROUP BY CustomerId
HAVING `Count` > 5
ORDER BY `Count` DESC;
```



CustomerId	CustomerLastName	CustomerFirstName	Count
245	Aers	Raina	18
174	Ruttgers	Benedetta	12
302	Griniov	Nealon	8
280	Renon	Aviva	7
344	Tewkesberrie	Modesty	6

SUMMARY QUERY HINTS AND TROUBLESHOOTING

- Don’t try to do everything at once; get a basic query and it JOINs working first, then incrementally add other requirements
- It’s only a summary query if you use an aggregate function in it
- Only summary queries should use GROUP BY or HAVING
- Only include in the SELECT statement aggregate functions or columns used in GROUP BY (or highly related ones); anything else yields puzzling data
- HAVING only makes sense if you’re using GROUP BY
- Be clear on the purpose of WHERE vs. HAVING; both can participate
  - WHERE filters raw records, saying which ones even participate in the query
  - HAVING filters grouped results, saying which of the groups you want to see displayed

OTHER USEFUL SUMMARY QUERY STUFF

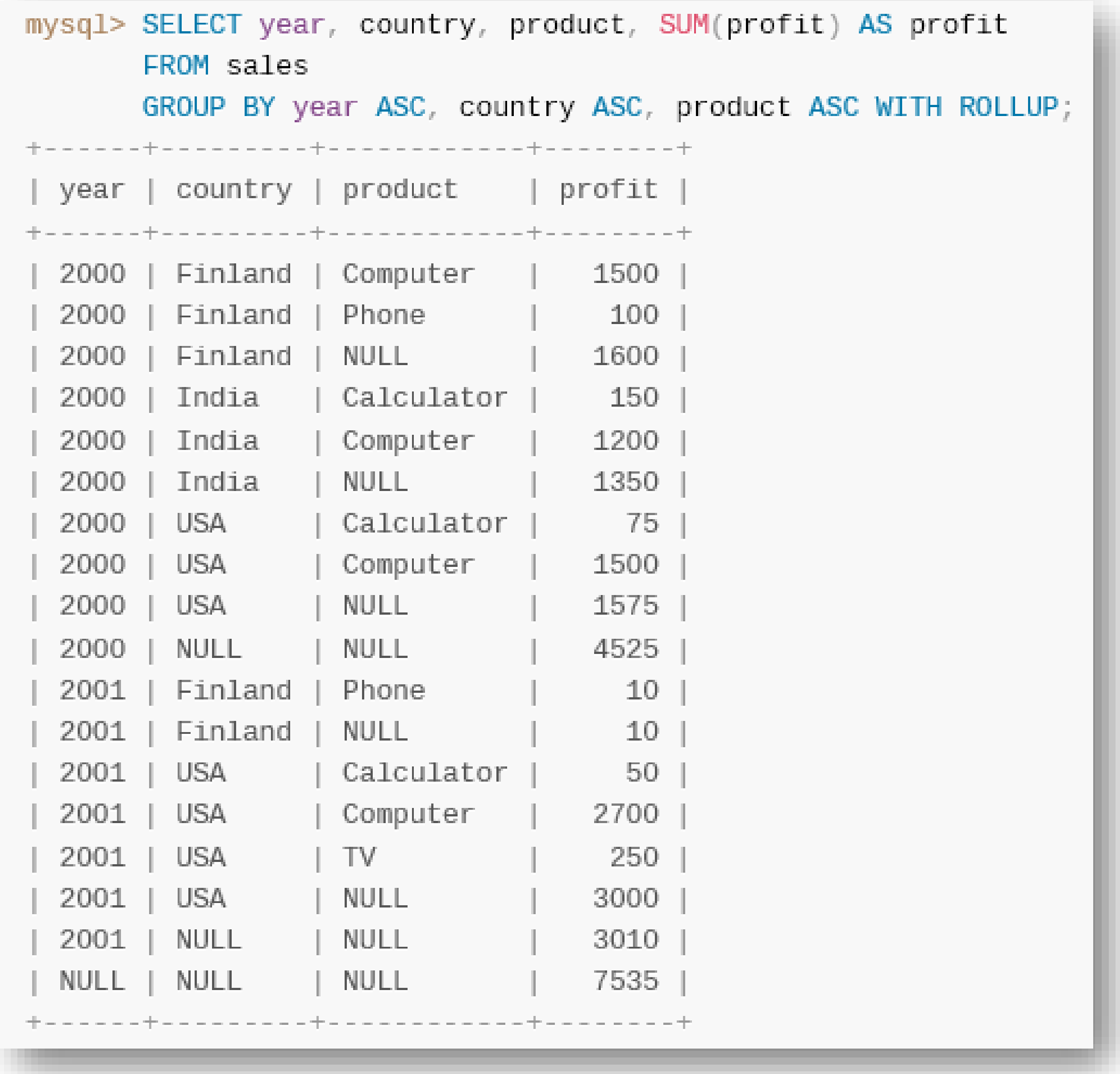
- Use COUNT(DISTINCT *expr*) to find the number of different values, e.g., in OM:
  - SELECT COUNT(DISTINCT order_id) FROM order_details # result = 46
- Make a GROUP_CONCAT column to return a string composed of all the different values in a column, e.g., in OM:
  - SELECT order_id, GROUP_CONCAT(item_id) FROM Order_Details GROUP BY order_id

order_id	group_concat(item_id)
606	8
607	3,10
…	
693	6,7,10
…	

Reference: https://dev.mysql.com/doc/refman/5.7/en/group-by-functions.html

MORE ON WITH ROLLUP

- If WITH ROLLUP is specified in the GROUP BY, you'll also get totaling of results
- If you group by a single column, the ROLLUP data is obvious; you get a total row at the bottom
- If you group by *multiple* columns, you get a total line every time the penultimate grouped column changes, another when the next major column changes, etc., through the most major grouped column
- WITH ROLLUP can't be used with ORDER BY; both do sorting
- See this site for a complete description: https://dev.mysql.com/doc/refman/5.7/en/group-by-modifiers.html



```
mysql> SELECT year, country, product, SUM(profit) AS profit
       FROM sales
       GROUP BY year ASC, country ASC, product ASC WITH ROLLUP;
+------+---------+------------+--------+
| year | country | product    | profit |
+------+---------+------------+--------+
| 2000 | Finland | Computer   |   1500 |
| 2000 | Finland | Phone      |    100 |
| 2000 | Finland | NULL       |   1600 |
| 2000 | India   | Calculator |    150 |
| 2000 | India   | Computer   |   1200 |
| 2000 | India   | NULL       |   1350 |
| 2000 | USA     | Calculator |     75 |
| 2000 | USA     | Computer   |   1500 |
| 2000 | USA     | NULL       |   1575 |
| 2000 | NULL    | NULL       |   4525 |
| 2001 | Finland | Phone      |     10 |
| 2001 | Finland | NULL       |     10 |
| 2001 | USA     | Calculator |     50 |
| 2001 | USA     | Computer   |   2700 |
| 2001 | USA     | TV         |    250 |
| 2001 | USA     | NULL       |   3000 |
| 2001 | NULL    | NULL       |   3010 |
| NULL | NULL    | NULL       |   7535 |
+------+---------+------------+--------+
```

PART II: SUBQUERIES

SUBQUERIES: WHAT AND WHERE

- What is a subquery?
  - A **subquery** is a SELECT query coded inside of another SELECT query
  - Most (but not all) subqueries could alternatively be done via other methods (e.g., JOINs)

- Where can you use a subquery? Within a SELECT statement…
  - …in the SELECT clause
  - …in the FROM clause
  - …in the WHERE clause
  - …in the HAVING clause

SUBQUERIES: SHOULD I USE THEM?

Subqueries, especially nested ones, can make your SELECTs hard to read

- **Don't** Use Them…
  - …if you can easily express the subquery using more traditional logic (e.g., a JOIN)
- **Do** Use Them…
  - …when there is no other way to get what you want
  - …when the subquery seems like the most natural way to express the logic
  - …if your instructor asks you to use them ☺

If you do use them, make them readable with indentation and comments

BILL'S RECOMMENDED STEPS FOR BUILDING A SUBQUERY

Problem: from the OM DB's Items table, we want to a list of unit prices that are higher than the average unit price. The way I'll usually phrase it in projects: "Find the average unit price; use that to get a list of unit prices that are higher than that average"

Always returns a single value; use in a WHERE clause in place of a single value

1. Write and test the subquery

```
SELECT AVG(unit_price) FROM Items;   # result = 16.52
```

2. Use the value that are returned and hardcode them into another query (this is the outer query)

```
SELECT title, artist, unit_price
FROM Items
WHERE unit_price > 16.52
ORDER BY unit_price DESC;
```

3. Replace the hardcoded number with parentheses and the *entire* inner query (no semicolon)

```
SELECT title, artist, unit_price
FROM Items
WHERE unit_price >
    (SELECT AVG(unit_price) FROM Items)
ORDER BY unit_price DESC;
```

This method is foolproof; it **must** work if you follow these steps!

SUBQUERY VS. JOIN: WHICH IS MORE READABLE?

```
SELECT invoice_number,
       invoice_date,
       invoice_total

FROM invoices
    JOIN vendors USING vendor_id

WHERE vendor_state = 'CA'

ORDER BY invoice_date;
```

```
SELECT invoice_number,
       invoice_date,
       invoice_total

FROM invoices

WHERE vendor_id IN

    (SELECT vendor_id
     FROM vendors
     WHERE vendor_state = 'CA')

ORDER BY invoice_date;
```

Returns a list

RETURNS FROM SUBQUERIES

Some subqueries return a **single value**

- Use these where you'd use a **literal or expression**
- Example: WHERE invoice_total **>** (*subquery*)

Some subqueries return a **list** (single column) of values

- Use these where you'd use a **list or set**
- Example: WHERE customer_state **IN** (*subquery*)

Some subqueries return a **table** (more than one column) of values

- Use these where you'd use a **table**
- Note: you *must give the resulting subquery table an alias* even if you don't use it in your code
- Example: SELECT cust_name FROM Customer **JOIN** (*subquery*) *alias* ON …

Never return more than absolutely required; it makes more work! Hint: you shouldn't return any tables from subqueries in your assignment

PRACTICE #6: SUBQUERIES THAT RETURN A VALUE

We’ll use Cathy’s Cakes for this exercise

Find the average price for a product

Use that data to get a list of product names and prices for which the product price is greater than the average product price

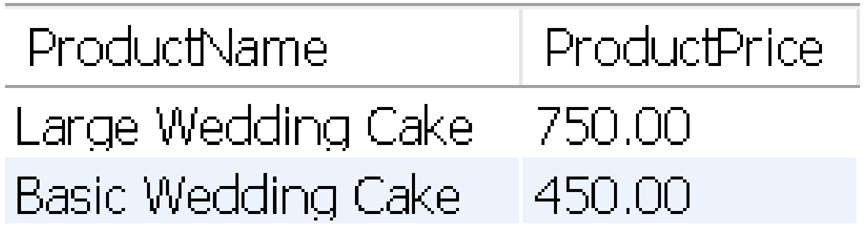
Sort by product price, highest first

The wording here is a helpful hint for your assignment; it’ll often say, “Do this, then use the result to do the next thing.” The “do this” part is the subquery

PRACTICE #6: SUBQUERIES THAT RETURN A VALUE

- Task:
  - Find the average price for a product
  - Use that data to get a list of product names and prices for which the product price is greater than the average product price
  - Sort by product price, highest first
- Solution

```
SELECT ProductName, ProductPrice
FROM Product
WHERE ProductPrice >
    (    SELECT AVG(ProductPrice)
         FROM Product
    )
ORDER BY ProductPrice DESC;
```



ProductName	ProductPrice
Large Wedding Cake	750.00
Basic Wedding Cake	450.00

Alignment and indentation will really help readability on these

PRACTICE #7: SUBQUERIES THAT RETURN LISTS

Use Cathy's Cakes for this exercise

Cathy has a new recipe for a Cinnamon Lover's cake batter; she wants to first promote it to customers who are likely the most interested

Get a list of product id's for products that contain cinnamon as an ingredient

Use that information to get a list of customers who have ordered those products; show customer name and email address

Don't duplicate customer names

Sort by customer name

PRACTICE #7: SUBQUERIES THAT RETURN LISTS

- Task:
  - Generate a list of customers and emails for those most likely to be cinnamon lovers
- Solution

```
SELECT DISTINCT CustomerLastName, CustomerFirstName, CustomerEmail
FROM Customer JOIN CakeOrder    USING (CustomerId)
              JOIN ProductOrder USING (CakeOrderId)
WHERE ProductId IN
    (    SELECT ProductId
         FROM Ingredient JOIN ProductIngredient USING (IngredientId)
                         JOIN Product           USING (ProductId)
         WHERE IngredientName = 'Cinnamon'
    )
ORDER BY CustomerLastName, CustomerFirstName;
```

Yes, a single, complex JOIN could solve this; but this breaks down the tasks nicely, too

READING

On your own, read starting on p. 208, tips for working with complex queries

We won't cover pp. 196-207, which includes…

- ALL and ANY keywords
  - https://www.w3resource.com/mysql/subqueries/index.php#CR
  - https://dev.mysql.com/doc/refman/8.0/en/any-in-some-subqueries.html
- Correlated subqueries
  - https://dev.mysql.com/doc/refman/5.5/en/correlated-subqueries.html
  - http://www.geeksengine.com/database/subquery/correlated-subquery.php
  - EXISTS operator
    - https://dev.mysql.com/doc/refman/5.7/en/exists-and-not-exists-subqueries.html
    - http://www.geeksengine.com/database/subquery/exists.php
- Subqueries in other clauses

WRAP UP

WHAT SHOULD I DO NEXT?

- Take this week's quiz
- Start Proj07
  - Summary queries and subqueries
- Before we meet again…
  - Submit Proj07
  - Read next week's material:
    - Chapter 12: Creating and using views
  - Keep working on Proj08
    - Presentations start in two weeks

QUESTIONS?