Sample Database

Install Sample Database

- Go to
  - https://www.mysqltutorial.org/mysql-sample-database.aspx
- Should download an sql file
- Called classicmodels

Install Sample Databases

- Method 1:
    - Open MySQL Workbench
    - Connect to MySQL server
    - File —> Run SQL script
        - Choose the downloaded file

Install Sample Databases

- Method 2
    - Connect to the MySQL server with a terminal

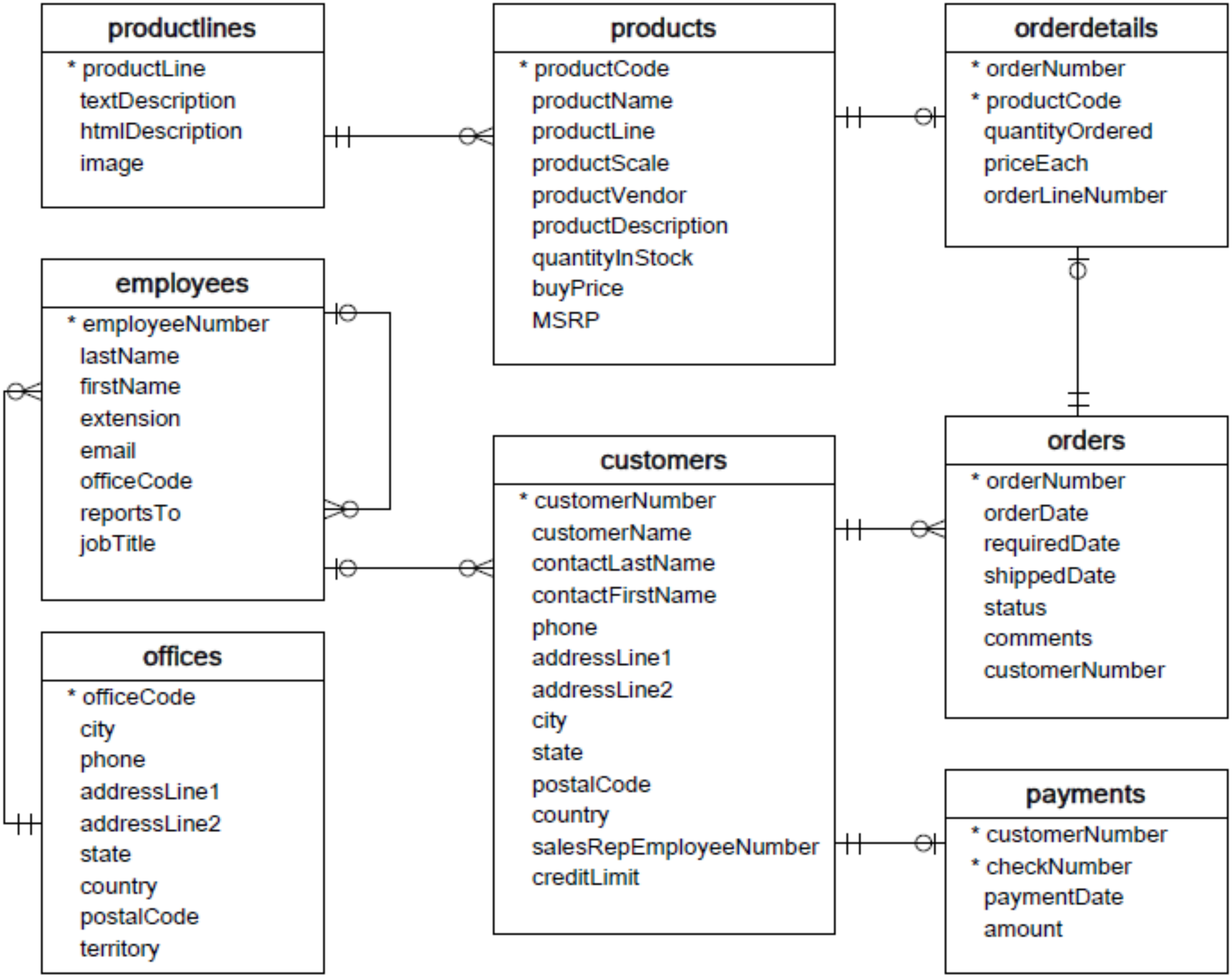
```
mysql -u root -p
```

    - Should prompt for your password
    - Use the source program

```
mysql> source c:\myPath\to\myfile
```

    - Check with

```
mysql> show databases;
```



productlines

- * productLine
- textDescription
- htmlDescription
- image

products

- * productCode
- productName
- productLine
- productScale
- productVendor
- productDescription
- quantityInStock
- buyPrice
- MSRP

orderdetails

- * orderNumber
- * productCode
- quantityOrdered
- priceEach
- orderLineNumber

employees

- * employeeNumber
- lastName
- firstName
- extension
- email
- officeCode
- reportsTo
- jobTitle

customers

- * customerNumber
- customerName
- contactLastName
- contactFirstName
- phone
- addressLine1
- addressLine2
- city
- state
- postalCode
- country
- salesRepEmployeeNumber
- creditLimit

orders

- * orderNumber
- orderDate
- requiredDate
- shippedDate
- status
- comments
- customerNumber

offices

- * officeCode
- city
- phone
- addressLine1
- addressLine2
- state
- country
- postalCode
- territory

payments

- * customerNumber
- * checkNumber
- paymentDate
- amount

Install Sample Databases

- You can download the diagram and bring a printed copy to the next class

SQL

Repetition

- Creating Schemas
- Inserting
- Selection
- Constraints

Data Definition Language

SQL DDL

- Create a database with CREATE DATABASE

```
CREATE DATABASE IF NOT EXISTS USNavy;
```

SQL DDL

- Three type of tables in SQL
  - Stored Relations, called tables
  - Views: relations calculated by computation
  - Temporary tables: created during query execution

SQL DDL

- Data Types
    - Character strings of fixed or varying length
        - CHAR(n) - fixed length string of up to *n* characters
        - VARCHAR(n) - fixed length string of up to *n* characters
            - Uses and endmarker or string-length for storage efficiency
    - Bit strings
        - BIT(n) strings of length exactly *n*
        - BIT VARYING(n) - strings of length up to *n*

SQL DDL

- Data Types:
    - Boolean: BOOLEAN: TRUE, FALSE, UNKNOWN
    - Integers: INT = INTEGER, SHORTINT
    - Floats: FLOAT = REAL, DOUBLE, DECIMAL(n,m)
    - Dates: DATE
        - SQL Standard: ‘1948-05-14’)
    - Times: TIME
        - SQL Standard: 19:20:02.4

SQL DDL

- Data Types:
  - MySQL: ENUM('M', 'F')

SQL DDL

- CREATE TABLE creates a table

```
CREATE TABLE Movies(
   title        CHAR(100),
   year         INT,
   length       INT,
   genre        CHAR(10),
   studioName   CHAR(30),
   producerC#   INT
);
```

SQL DDL

```
CREATE TABLE MovieStar(
   name               CHAR(30),
   address            VARCHAR(255),
   gender             CHAR(1),
   birthday           DATE
);
```

SQL DDL

- Drop Table drops a table

```
DROP TABLE Movies;
```

SQL DDL

- Altering a table with ALTER TABLE
  - with ADD followed by attribute name and data type
  - with DROP followed by attribute name

```
ALTER TABLE MovieStar ADD phone CHAR(16);
```

```
ALTER TABLE MovieStar DROP Birthday;
```

SQL DDL

- Default Values
  - Conventions for unknown data
    - Usually, NULL
  - Can use other values for unknown data

```
CREATE TABLE MovieStar(
   name            CHAR(30),
   address         VARCHAR(255),
   gender          CHAR(1) DEFAULT '?',
   birthday        DATE DEFAULT '0000-00-00'
);
```

SQL DDL

- Declaring Keys

    1. Declare one attribute to be a key

    2. Add one additional declaration:

        - Particular set of attributes is a key

    - Can use

    1. PRIMARY KEY

    2. UNIQUE

SQL DDL

- UNIQUE for a set S:
  - Two tuples cannot agree on all attributes of S unless one of them is NULL
    - Any attempted update that violates this will be rejected
- PRIMARY KEY for a set S:
  - Attributes in S cannot be NULL

SQL DDL

```
CREATE TABLE MovieStar(
   name            CHAR(30) PRIMARY KEY,
   address         VARCHAR(255),
   gender          CHAR(1),
   birthday        DATE
);
```

SQL DDL

```
CREATE TABLE MovieStar(
   name               CHAR(30),
   address            VARCHAR(255),
   gender             CHAR(1) DEFAULT '?',
   birthday           DATE DEFAULT '0000-00-00',
   PRIMARY KEY (name)
);
```

SQL DDL

```
CREATE TABLE Movies(
   title           CHAR(100),
   year            INT,
   length          INT,
   genre           CHAR(10),
   studioName      CHAR(30),
   producerC#      INT,
   PRIMARY KEY (title, year)
);
```

Simple Diagrams

- A schema is represented by a networked diagram
    - Nodes represent tables
        - Name of the table labels the node
        - Interior of the node are the name of the attributes
        - Underline the primary key
        - Optionally, add domain to each attribute

Simple Diagrams

Customers

customer_id :	int
first_name :	varchar(255)
last_name :	varchar(255)
email_address :	varchar(10)
number of complaints :	int

Sales

purchase_number :	int
date_of_purchase :	date
customer_id:	int
item_code:	varchar(10)

Items

item_code :	int
item :	varchar(255)
unit_price:	decimal(10,2)
company_id:	int

Companies

company_id :	int
company_name :	varchar(63)
headquarters_ph_nr:	char(25)

Constraints in MySQL

- Constraints in MySQL have names
  - Often automatically generated
  - Use the SHOW CREATE TABLE query

```
Table,"Create Table"
customers,"CREATE TABLE `customers` (
  `customer_id` int NOT NULL AUTO_INCREMENT,
  `first_name` varchar(255) DEFAULT NULL,
  `last_name` varchar(255) DEFAULT NULL,
  `email_address` varchar(255) DEFAULT NULL,
  `number_of_complaints` int DEFAULT (0),
  PRIMARY KEY (`customer_id`),
  UNIQUE KEY `email_address` (`email_address`)
) ENGINE=InnoDB AUTO_INCREMENT=3 DEFAULT CHARSET=utf8mb4
COLLATE=utf8mb4_0900_ai_ci"
```

Constraints in MySQL

- Missing values are usually a NULL
    - Can automatically assign INT with AUTO_INCREMENT
    - Used widely to assign artificial primary keys

Constraints in MySQL

- NOT NULL constraint
  - When inserting a tuple with NULL value in the constrained column, error will be thrown

```
CREATE TABLE tasks (
    id INT AUTO_INCREMENT PRIMARY KEY,
    title VARCHAR(255) NOT NULL,
    start_date DATE NOT NULL,
    end_date DATE
);
```

  - Considered good practice to include in all columns where a NULL value is not expected

Constraints in MySQL

- ALTER TABLE allows to introduce new / remove old constraint
  - Need to check that the inserted values comply

```
ALTER TABLE tasks
CHANGE
    end_date
    end_date DATE NOT NULL;
```

```
ALTER TABLE tasks
MODIFY
    end_date
    end_date DATE NOT NULL;
```

Constraints in MySQL

- UNIQUE
  - Values in a single attribute are different
  - Value groups in a group of attributes are different
- Creating a constraint:
  - Specify in CREATE TABLE for a single attribute
  - Add a CONSTRAINT cstr_name UNIQUE(attr1, attr2, …)
    - Can leave out constraint name, will be replaced by an automatically created name
  - Use ALTER TABLE ADD CONSTRAINT

Constraints in MySQL

- UNIQUE

```sql
CREATE TABLE suppliers (
    supplier_id INT AUTO_INCREMENT,
    name VARCHAR(255) NOT NULL,
    phone VARCHAR(15) NOT NULL UNIQUE,
    address VARCHAR(255) NOT NULL,
    PRIMARY KEY (supplier_id),
    CONSTRAINT uc_name_address UNIQUE (name , address)
);
```

Constraints in MySQL

- UNIQUE constraint creates an *index*
  - Index is a data structure with quick look-up
- Access indices through the SHOW INDEX FROM table command

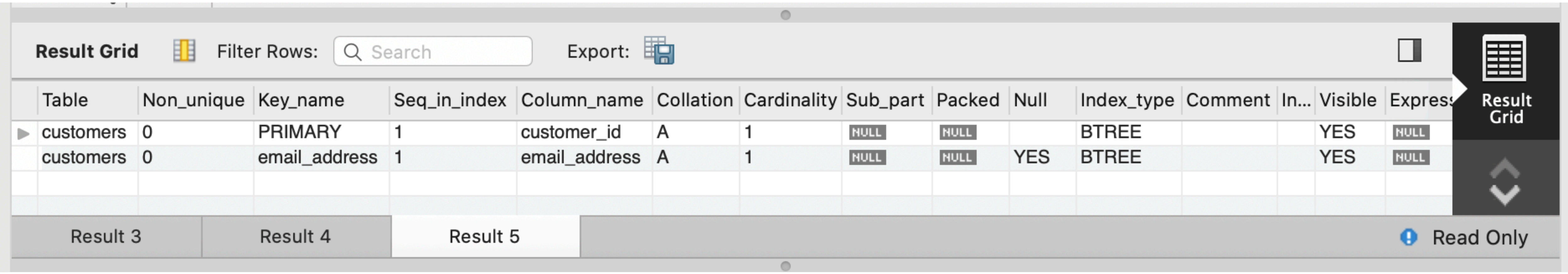
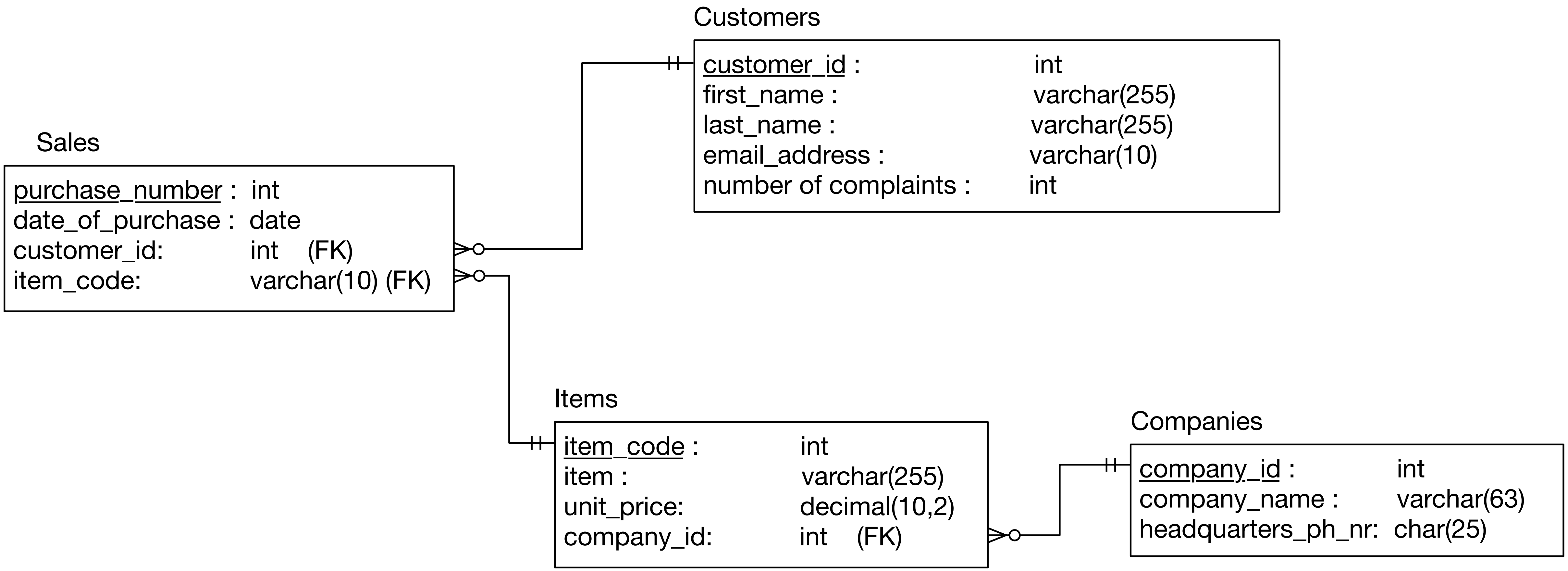


Table	Non_unique	Key_name	Seq_in_index	Column_name	Collation	Cardinality	Sub_part	Packed	Null	Index_type	Comment	In...	Visible	Expres
customers	0	PRIMARY	1	customer_id	A	1	NULL	NULL		BTREE			YES	NULL
customers	0	email_address	1	email_address	A	1	NULL	NULL	YES	BTREE			YES	NULL

Foreign Keys

- Relationships between tables are sometimes constructed with shared values
  - Sales has an attribute client_id
  - Customers has a primary key client_id
    - Need not be named the same
      - But it is usually convenient to do so

Constraints in MySQL



Customers

customer_id :	int
first_name :	varchar(255)
last_name :	varchar(255)
email_address :	varchar(10)
number of complaints :	int

Sales

purchase_number :	int
date_of_purchase :	date
customer_id:	int (FK)
item_code:	varchar(10) (FK)

Items

item_code :	int
item :	varchar(255)
unit_price:	decimal(10,2)
company_id:	int (FK)

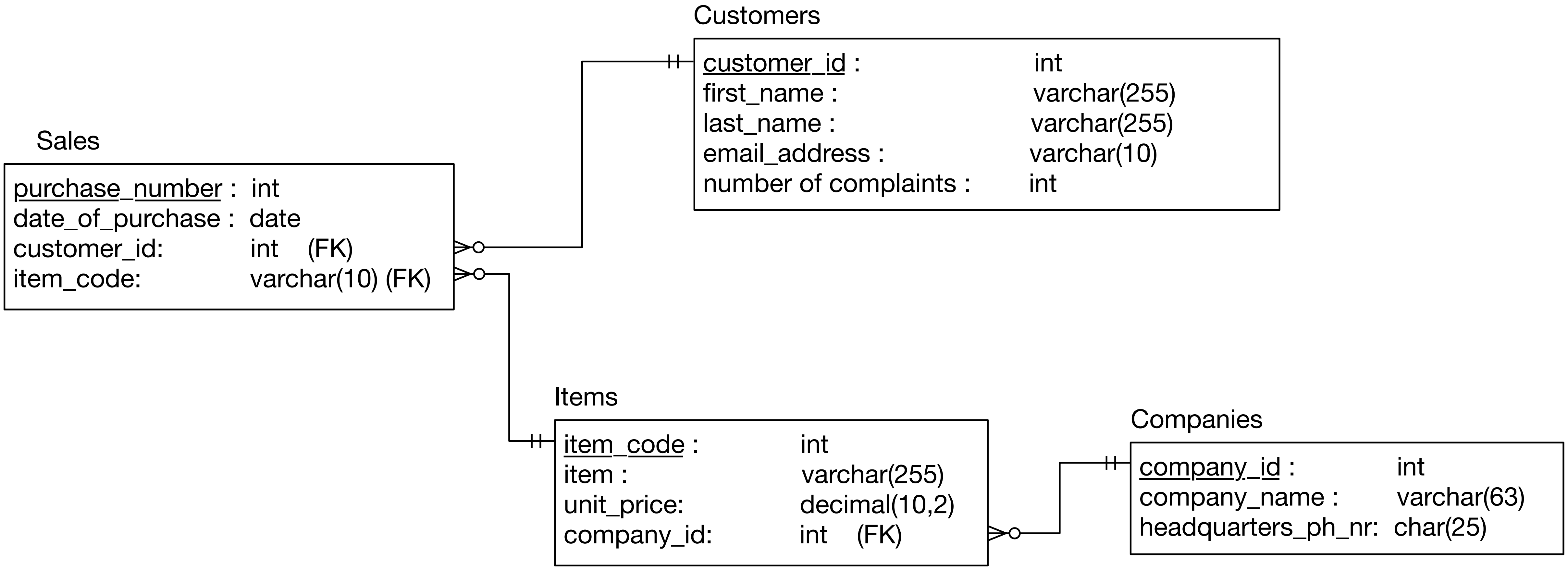
Companies

company_id :	int
company_name :	varchar(63)
headquarters_ph_nr:	char(25)

Constraints in MySQL

- Example:
  - A customer can have many sales
  - But each sale has only one customer
  - Relationship customers sales is a **one-to-many** relationship
  - customers is the *referenced* (or parent) table
  - sales is the *referencing* (or child) table
  - As is typical, the referenced attribute is a primary key in the referenced table

Constraints in MySQL



Customers

customer_id :	int
first_name :	varchar(255)
last_name :	varchar(255)
email_address :	varchar(10)
number of complaints :	int

Sales

purchase_number :	int	
date_of_purchase :	date	
customer_id:	int	(FK)
item_code:	varchar(10)	(FK)

Items

item_code :	int	
item :	varchar(255)	
unit_price:	decimal(10,2)	
company_id:	int	(FK)

Companies

company_id :	int
company_name :	varchar(63)
headquarters_ph_nr:	char(25)

Constraints in MySQL

- In a diagram:
  - crow-feet with ball indicate many
  - double bar indicates one

Constraints in MySQL

- Foreign key constraint
    - Once established, insures that action is taken upon insertion or deletion of a record affecting the other table

Constraints in MySQL

- Possible Actions:
  - CASCADE: if a tuple from the referenced table is deleted or updated, the corresponding tuple in the referencing table is also deleted / updated
  - SET NULL: If a row from the referenced table is deleted or updated, the values of the foreign key in the referencing table are set to NULL

Constraints in MySQL

- Possible Actions:
    - RESTRICT: if a row from the referenced table has a matching row in the referencing table, then deletion and updates are rejected
    - SET DEFAULT: Accepted by MySQL parser but action not performed

Constraints in MySQL

- Foreign keys constraint actions
  - Are for
    - ON UPDATE
    - ON DELETE

Constraints in MySQL

- Creating foreign key constraints:

```
CREATE TABLE categories(
    categoryId INT AUTO_INCREMENT PRIMARY KEY,
    categoryName VARCHAR(100) NOT NULL
);

CREATE TABLE products(
    productId INT AUTO_INCREMENT PRIMARY KEY,
    productName varchar(100) not null,
    categoryId INT,
    CONSTRAINT fk_category
    FOREIGN KEY (categoryId)
        REFERENCES categories(categoryId)
        ON UPDATE CASCADE
        ON DELETE CASCADE
);
```

Constraints in MySQL

- You can drop a foreign key restraint using the ALTER TABLE statement

```
ALTER TABLE table_name
DROP FOREIGN KEY constraint_name;
```

Constraints in MySQL

- When loading a database from (e.g.) .csv files
  - Can carefully create referenced tables before referencing tables
  - Temporarily disable foreign key checks

```
SET foreign_key_checks = 0;
```

```
SET foreign_key_checks = 1;
```

Insert Operations

- Insert Syntax
  - No need to insert into automatic values
  - If only a few attributes are set,

```
INSERT INTO
table(attr1, attr2, …)
Values(v1, v2, …)
```

  - If all attributes are set, just list the values
  - Can set many tuples at once

```
INSERT INTO served
VALUES
('William Howe', 'Great Britain', '1746-1-1', '1778-4-1'),
('Benedict Arnold', 'Great Britain', '1757-1-1', '1775-1-1'),
('Benedict Arnold', 'United States', '1775-1-1', '1780-9-1'),
('Benedict Arnold', 'Great Britain', '1780-9-1', '1787-1-1')
```

Select

Select

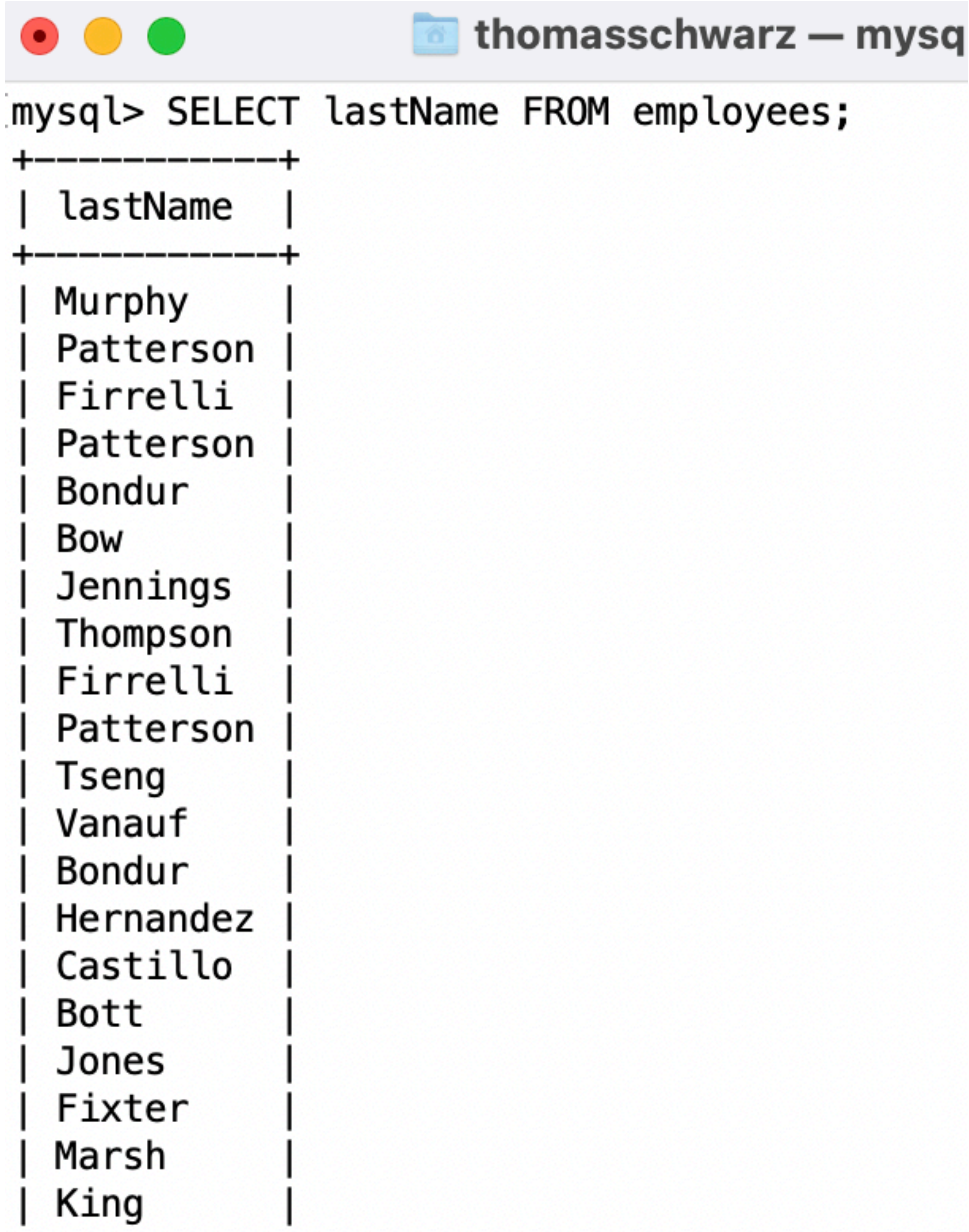
- In order to avoid having to prefix the database name to tables, use the Use command:

    -
      ```
      USE classicmodels;
      ```

Select

- SELECT * FROM table
- SELECT col1, col2 FROM table
- SELECT * FROM table WHERE conditions

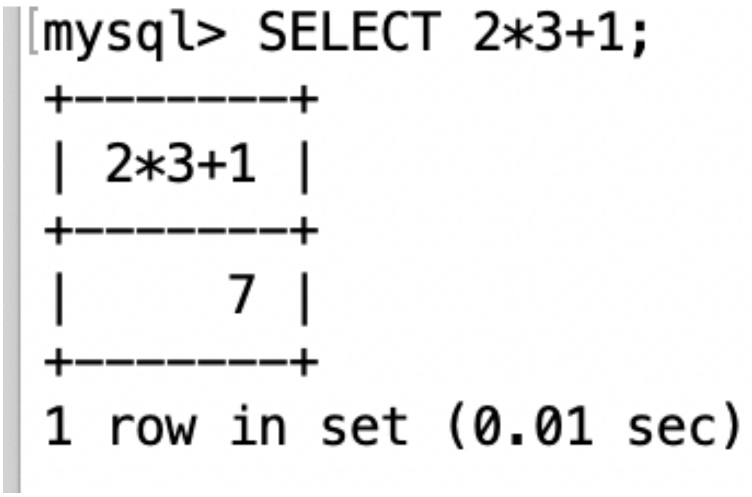
Select



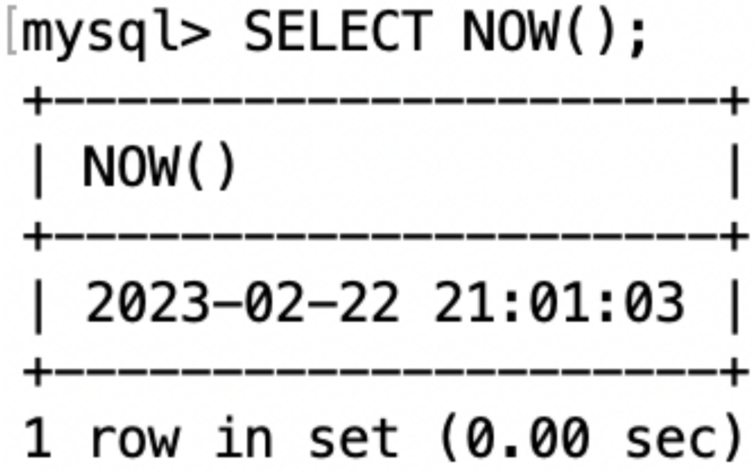
```
mysql> SELECT lastName FROM employees;
+-----------+
| lastName  |
+-----------+
| Murphy    |
| Patterson |
| Firrelli  |
| Patterson |
| Bondur    |
| Bow       |
| Jennings  |
| Thompson  |
| Firrelli  |
| Patterson |
| Tseng     |
| Vanauf    |
| Bondur    |
| Hernandez |
| Castillo  |
| Bott      |
| Jones     |
| Fixter    |
| Marsh     |
| King      |
```

Select

- You do not need to specify a table to obtain values



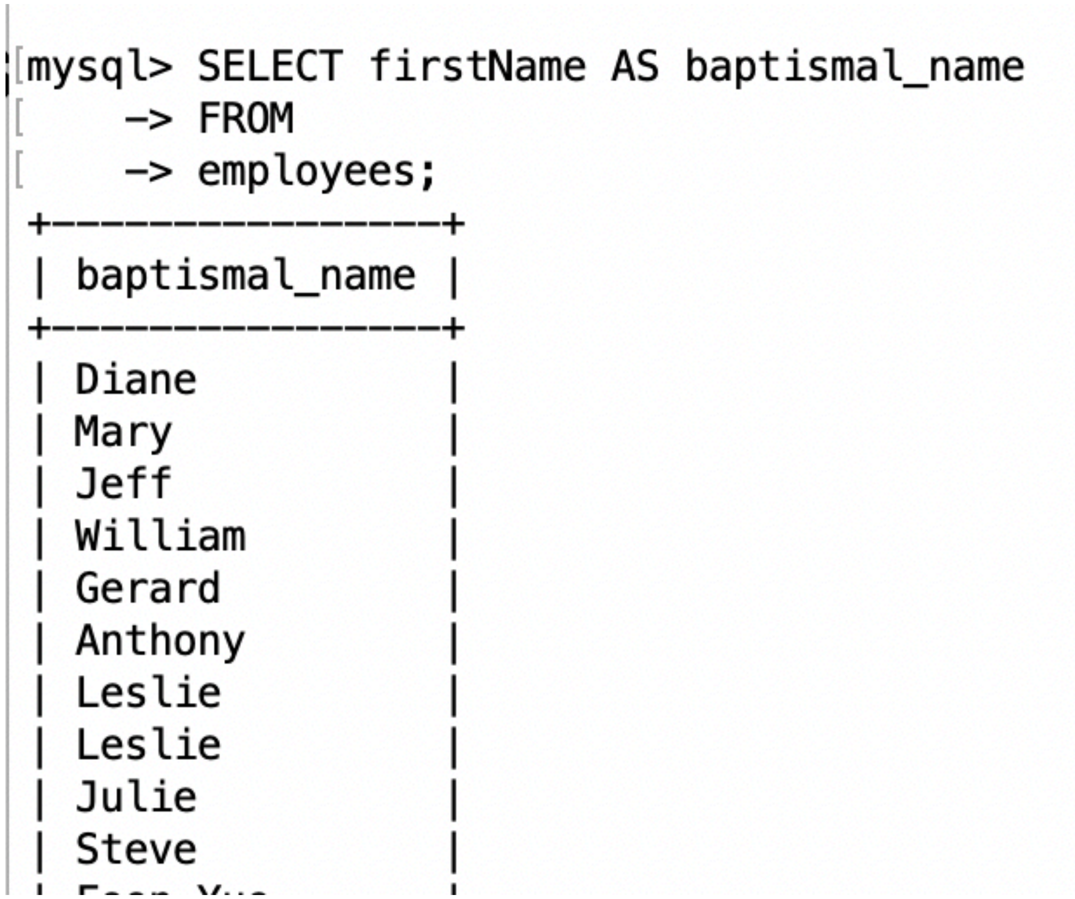
```
[mysql> SELECT 2*3+1;
+-------+
| 2*3+1 |
+-------+
|     7 |
+-------+
1 row in set (0.01 sec)
```



```
[mysql> SELECT NOW();
+---------------------+
| NOW()               |
+---------------------+
| 2023-02-22 21:01:03 |
+---------------------+
1 row in set (0.00 sec)
```

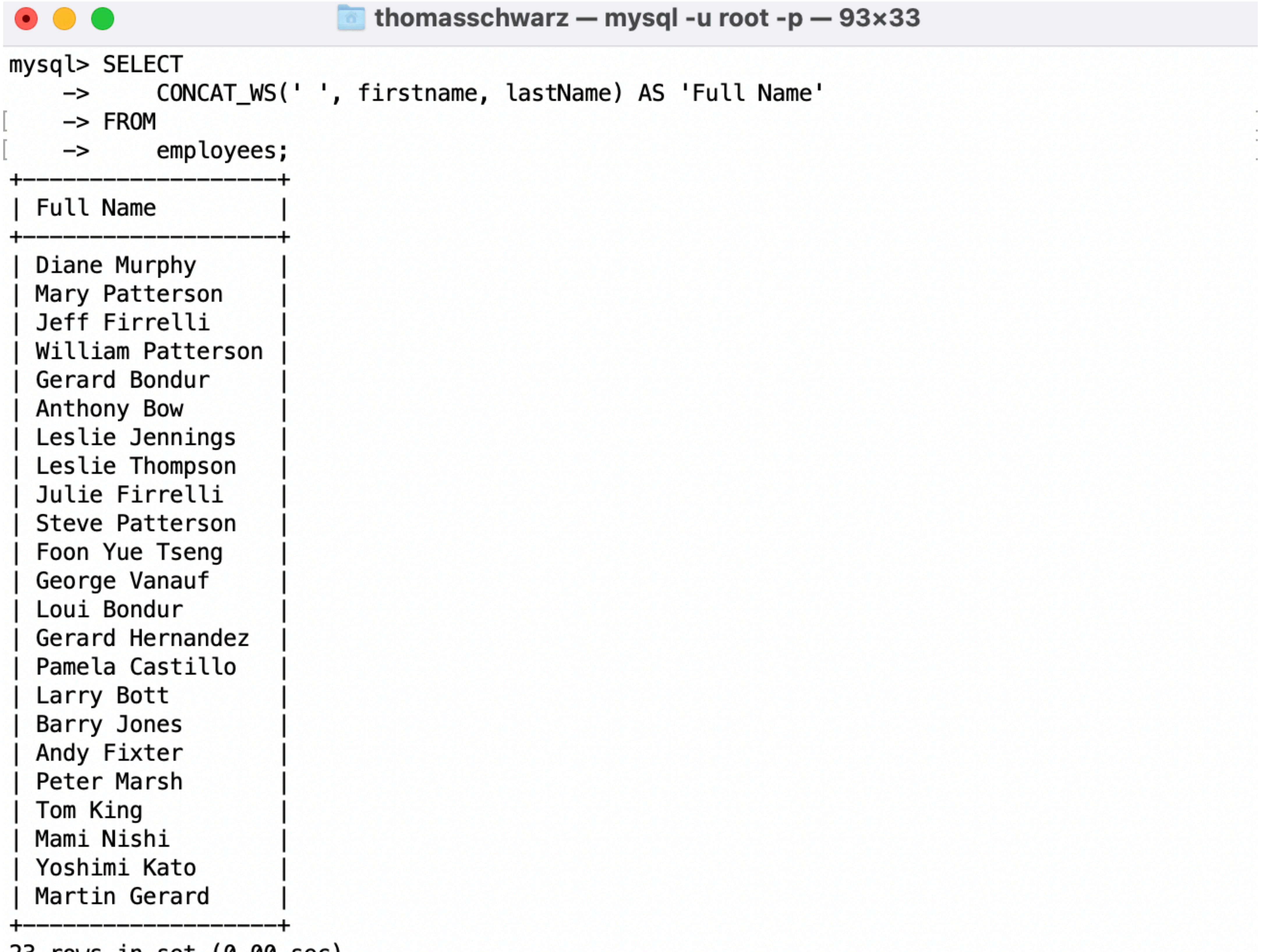
Select

- To make SELECT list work you can use the dummy table name dual
- To rename expressions, use AS



```
mysql> SELECT firstName AS baptismal_name
    -> FROM
    -> employees;
+----------------+
| baptismal_name |
+----------------+
| Diane          |
| Mary           |
| Jeff           |
| William        |
| Gerard         |
| Anthony        |
| Leslie         |
| Leslie         |
| Julie          |
| Steve          |
| Foon Yue       |
```

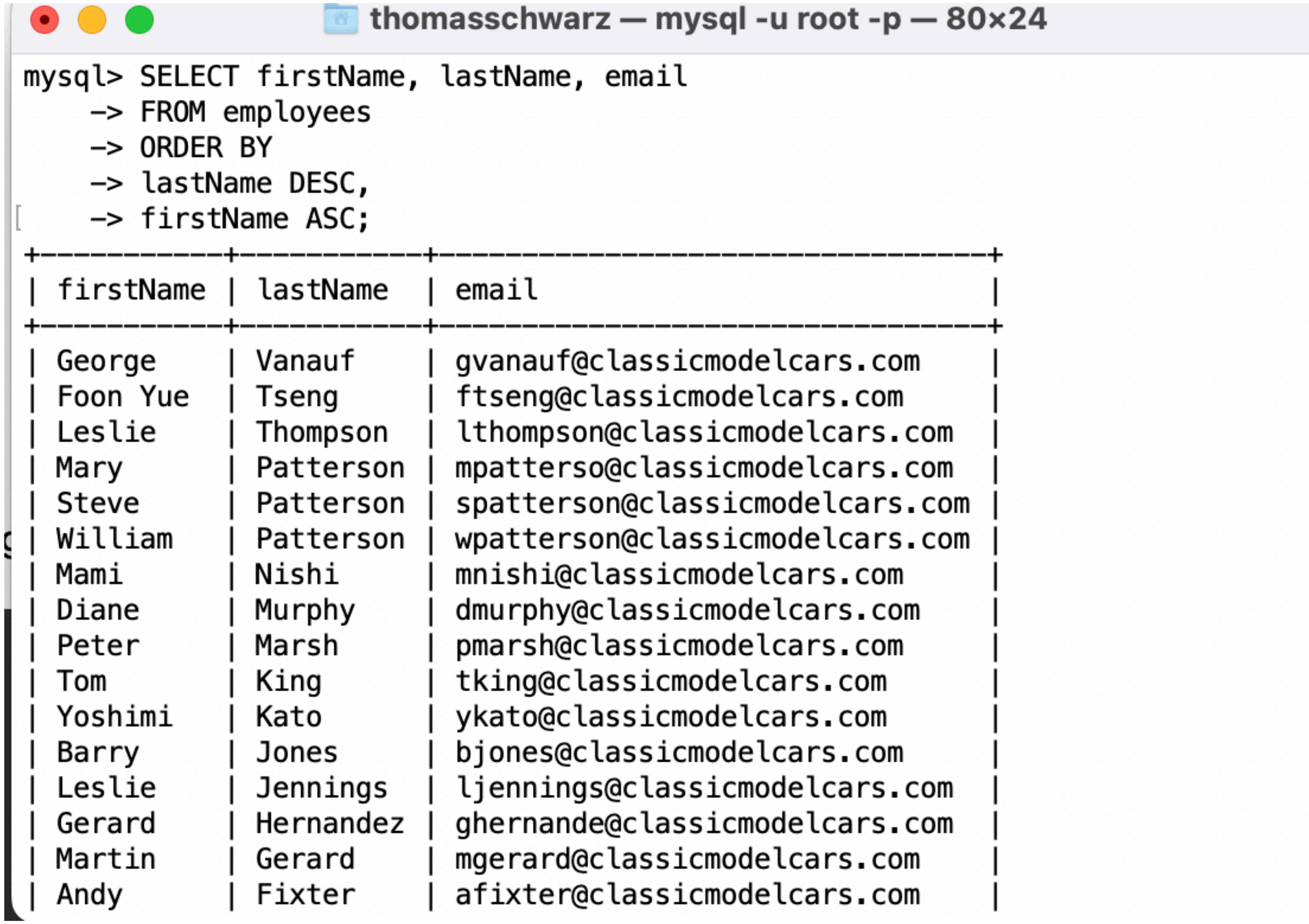
Select



```
mysql> SELECT
    ->     CONCAT_WS(' ', firstname, lastName) AS 'Full Name'
    -> FROM
    ->     employees;
+-------------------+
| Full Name         |
+-------------------+
| Diane Murphy      |
| Mary Patterson    |
| Jeff Firrelli     |
| William Patterson |
| Gerard Bondur     |
| Anthony Bow       |
| Leslie Jennings   |
| Leslie Thompson   |
| Julie Firrelli    |
| Steve Patterson   |
| Foon Yue Tseng    |
| George Vanauf     |
| Loui Bondur       |
| Gerard Hernandez  |
| Pamela Castillo   |
| Larry Bott        |
| Barry Jones       |
| Andy Fixter       |
| Peter Marsh       |
| Tom King          |
| Mami Nishi        |
| Yoshimi Kato      |
| Martin Gerard     |
+-------------------+
23 rows in set (0.00 sec)
```

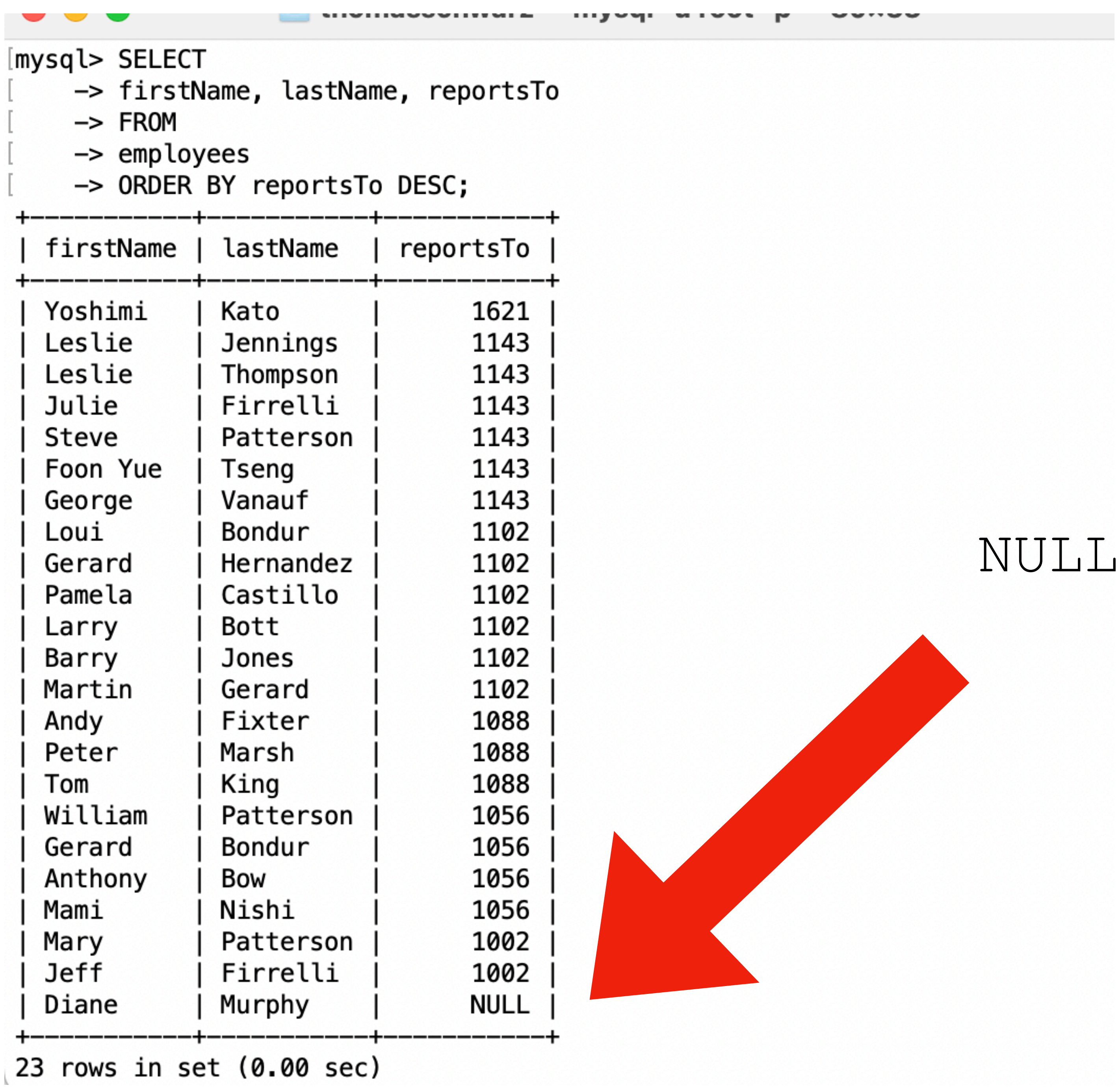
Select

- Use ordering with ORDER BY and ASC / DESC



```
mysql> SELECT firstName, lastName, email
    -> FROM employees
    -> ORDER BY
    -> lastName DESC,
    -> firstName ASC;
+-----------+-----------+---------------------------------+
| firstName | lastName  | email                           |
+-----------+-----------+---------------------------------+
| George    | Vanauf    | gvanauf@classicmodelcars.com    |
| Foon Yue  | Tseng     | ftseng@classicmodelcars.com     |
| Leslie    | Thompson  | lthompson@classicmodelcars.com  |
| Mary      | Patterson | mpatterso@classicmodelcars.com  |
| Steve     | Patterson | spatterson@classicmodelcars.com |
| William   | Patterson | wpatterson@classicmodelcars.com |
| Mami      | Nishi     | mnishi@classicmodelcars.com     |
| Diane     | Murphy    | dmurphy@classicmodelcars.com    |
| Peter     | Marsh     | pmarsh@classicmodelcars.com     |
| Tom       | King      | tking@classicmodelcars.com      |
| Yoshimi   | Kato      | ykato@classicmodelcars.com      |
| Barry     | Jones     | bjones@classicmodelcars.com     |
| Leslie    | Jennings  | ljennings@classicmodelcars.com  |
| Gerard    | Hernandez | ghernande@classicmodelcars.com  |
| Martin    | Gerard    | mgerard@classicmodelcars.com    |
| Andy      | Fixter    | afixter@classicmodelcars.com    |
```

Select

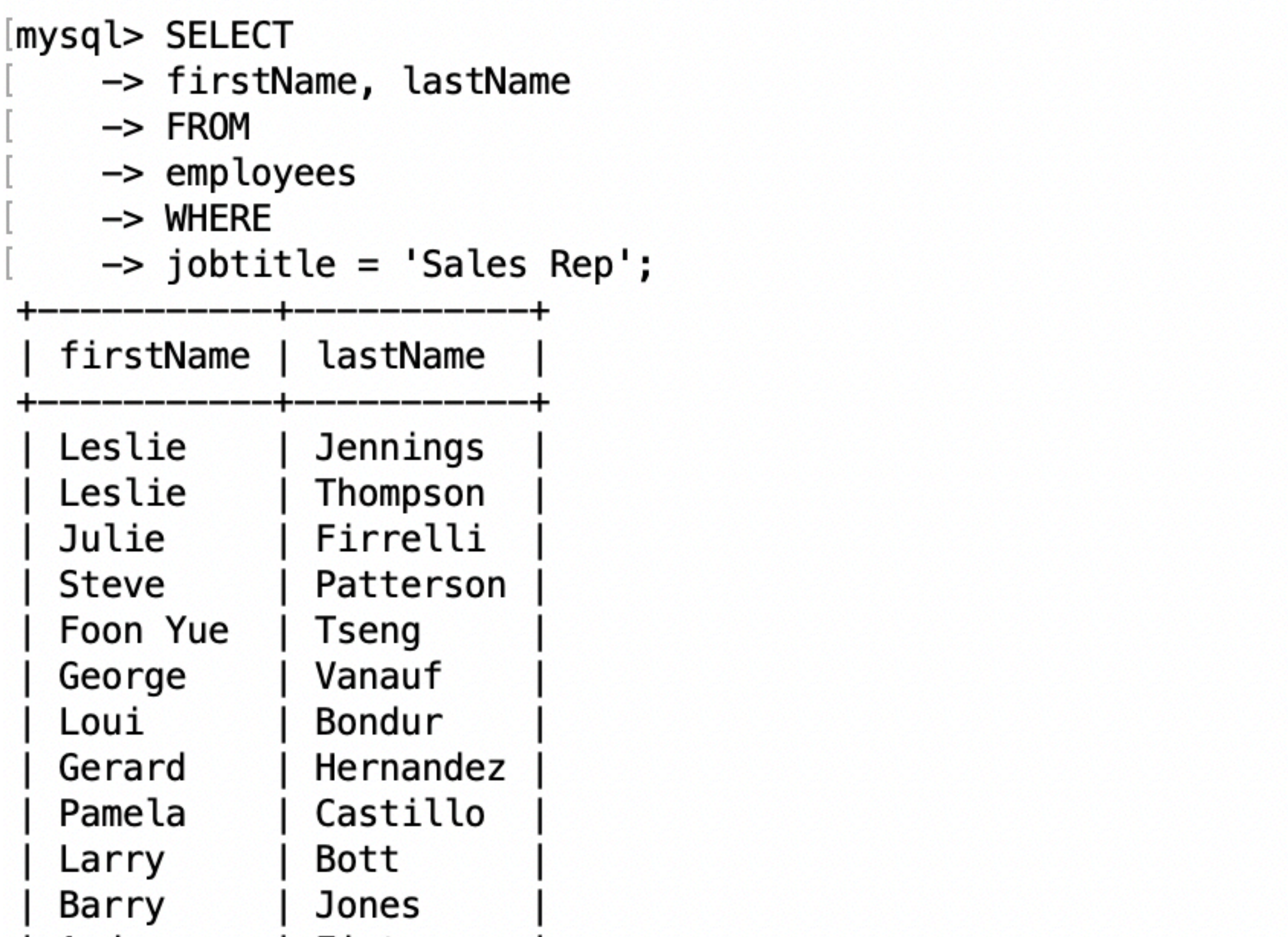


```
mysql> SELECT
    -> firstName, lastName, reportsTo
    -> FROM
    -> employees
    -> ORDER BY reportsTo DESC;
+-----------+-----------+-----------+
| firstName | lastName  | reportsTo |
+-----------+-----------+-----------+
| Yoshimi   | Kato      |      1621 |
| Leslie    | Jennings  |      1143 |
| Leslie    | Thompson  |      1143 |
| Julie     | Firrelli  |      1143 |
| Steve     | Patterson |      1143 |
| Foon Yue  | Tseng     |      1143 |
| George    | Vanauf    |      1143 |
| Loui      | Bondur    |      1102 |
| Gerard    | Hernandez |      1102 |
| Pamela    | Castillo  |      1102 |
| Larry     | Bott      |      1102 |
| Barry     | Jones     |      1102 |
| Martin    | Gerard    |      1102 |
| Andy      | Fixter    |      1088 |
| Peter     | Marsh     |      1088 |
| Tom       | King      |      1088 |
| William   | Patterson |      1056 |
| Gerard    | Bondur    |      1056 |
| Anthony   | Bow       |      1056 |
| Mami      | Nishi     |      1056 |
| Mary      | Patterson |      1002 |
| Jeff      | Firrelli  |      1002 |
| Diane     | Murphy    |      NULL |
+-----------+-----------+-----------+
23 rows in set (0.00 sec)
```

NULL is always smallest

Select

- We use a WHERE clause in order to specify search conditions
    - Employees whose job title is 'Sales Rep'

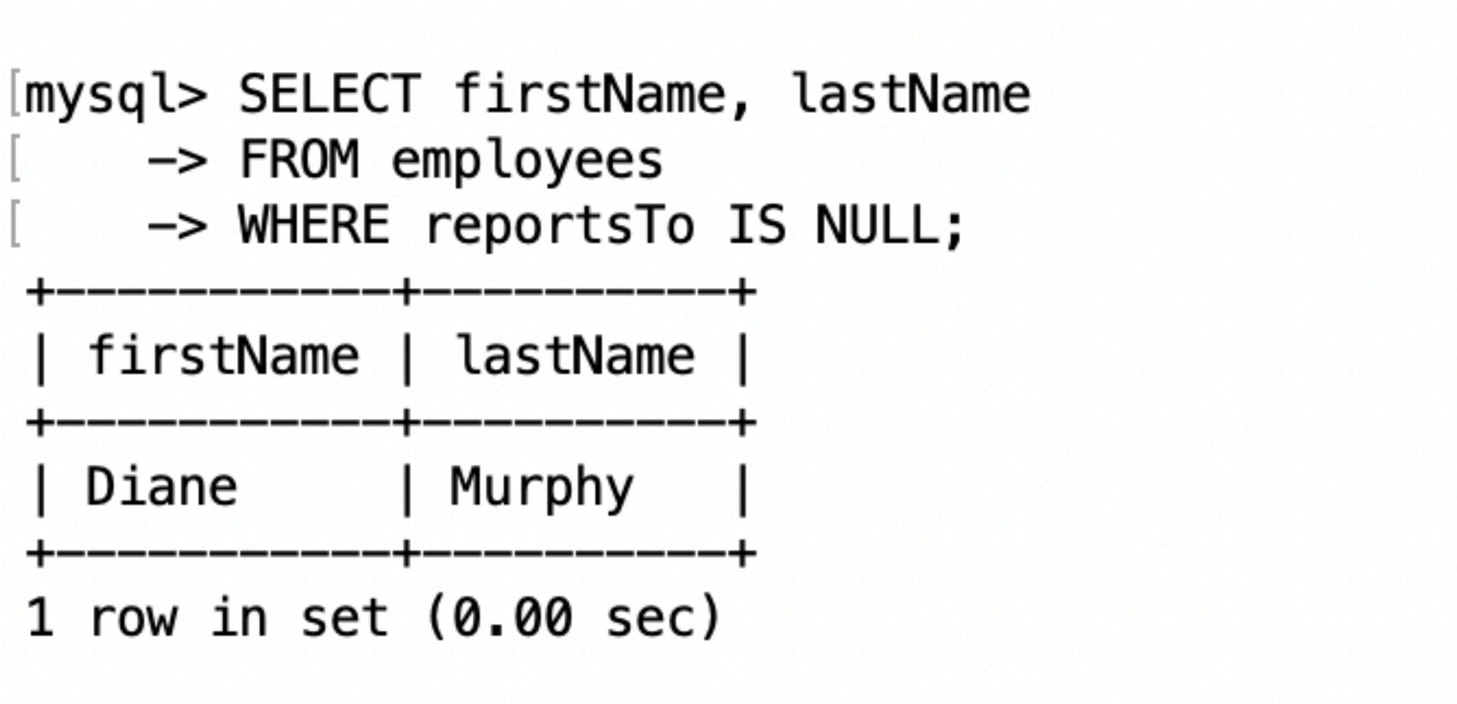


```
[mysql> SELECT
[    -> firstName, lastName
[    -> FROM
[    -> employees
[    -> WHERE
[    -> jobtitle = 'Sales Rep';
+-----------+-----------+
| firstName | lastName  |
+-----------+-----------+
| Leslie    | Jennings  |
| Leslie    | Thompson  |
| Julie     | Firrelli  |
| Steve     | Patterson |
| Foon Yue  | Tseng     |
| George    | Vanauf    |
| Loui      | Bondur    |
| Gerard    | Hernandez |
| Pamela    | Castillo  |
| Larry     | Bott      |
| Barry     | Jones     |
```

SELECT

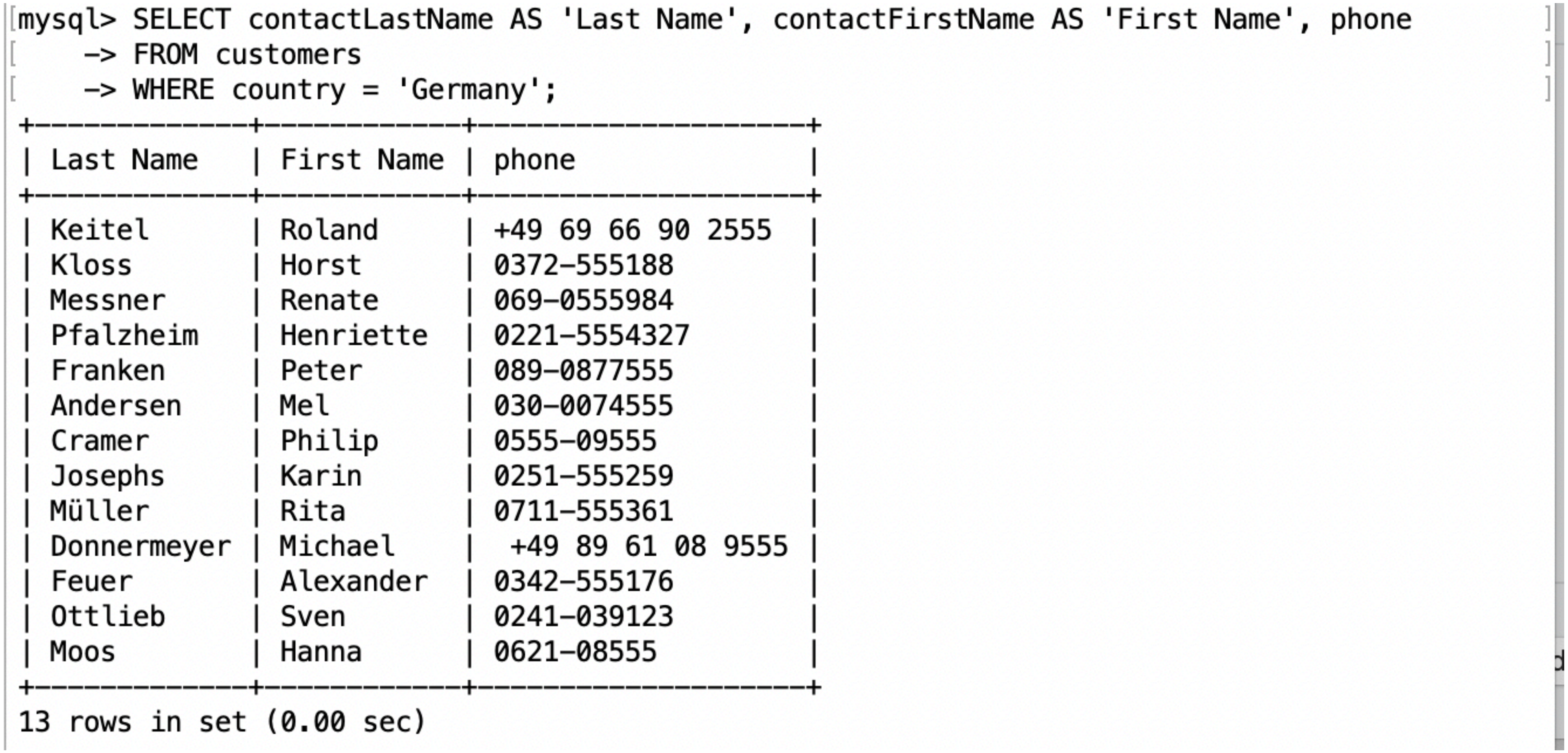
- There are a number of comparison operators:
  - =   equals (comparison operator)
  - AND, OR
  - IN, NOT IN
  - LIKE, NOT LIKE
  - BETWEEN … AND
  - EXISTS, NOT EXISTS
  - IS NULL, IS NOT NULL

Select

- Examples:
  - 

```
[mysql> SELECT firstName, lastName
[    -> FROM employees
[    -> WHERE reportsTo IS NULL;
+-----------+----------+
| firstName | lastName |
+-----------+----------+
| Diane     | Murphy   |
+-----------+----------+
1 row in set (0.00 sec)
```

Select



```
mysql> SELECT contactLastName AS 'Last Name', contactFirstName AS 'First Name', phone
    -> FROM customers
    -> WHERE country = 'Germany';
+-------------+------------+--------------------+
| Last Name   | First Name | phone              |
+-------------+------------+--------------------+
| Keitel      | Roland     | +49 69 66 90 2555  |
| Kloss       | Horst      | 0372-555188        |
| Messner     | Renate     | 069-0555984        |
| Pfalzheim   | Henriette  | 0221-5554327       |
| Franken     | Peter      | 089-0877555        |
| Andersen    | Mel        | 030-0074555        |
| Cramer      | Philip     | 0555-09555         |
| Josephs     | Karin      | 0251-555259        |
| Müller      | Rita       | 0711-555361        |
| Donnermeyer | Michael    |  +49 89 61 08 9555 |
| Feuer       | Alexander  | 0342-555176        |
| Ottlieb     | Sven       | 0241-039123        |
| Moos        | Hanna      | 0621-08555         |
+-------------+------------+--------------------+
13 rows in set (0.00 sec)
```

Comparisons with NULL

- NULL in any expression gives NULL
    - If you compare anything with NULL in MySQL, you get NULL
- In other SQL dialects: depends

SELECT

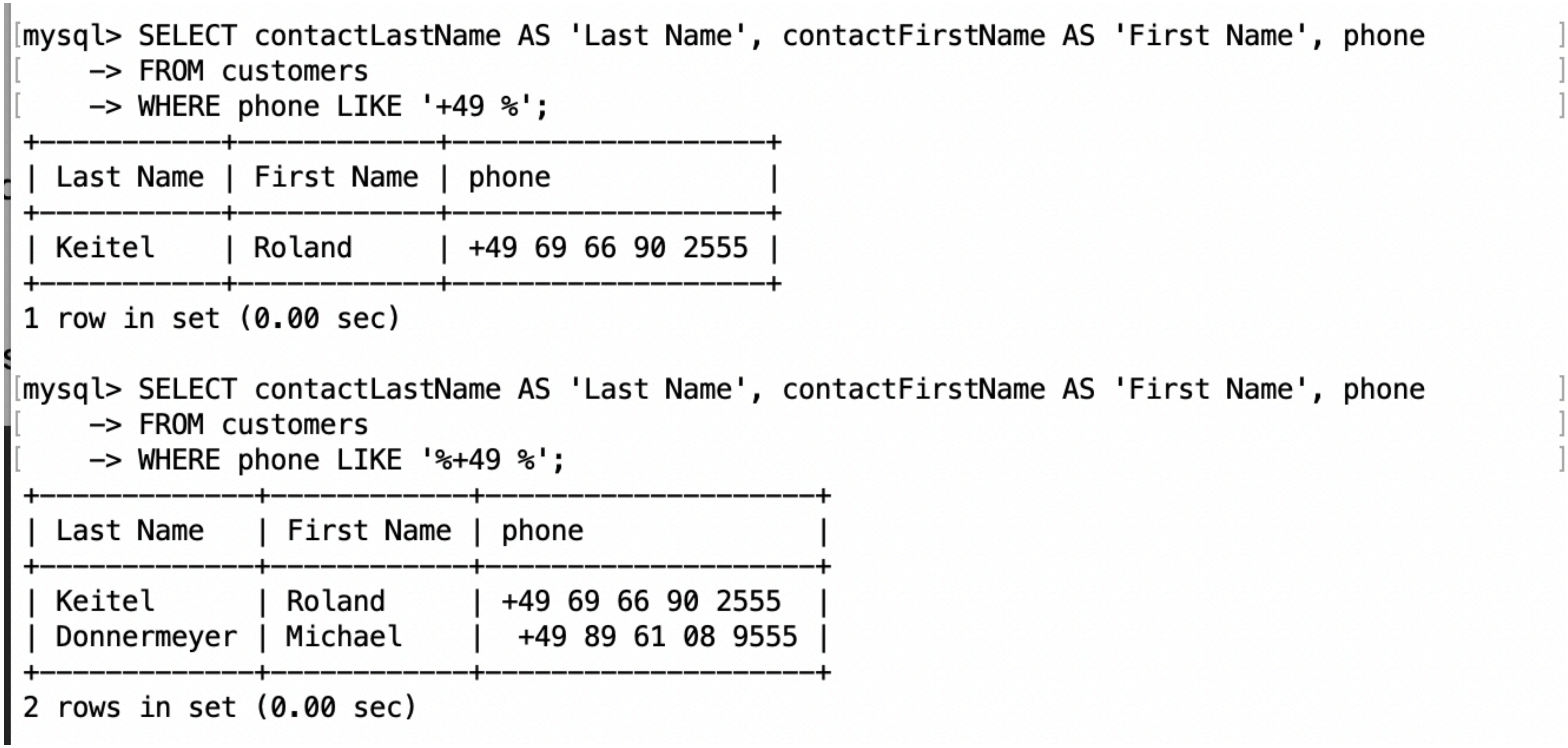
- LIKE
  - Pattern matching
    - Wild cards
      - % means zero or more characters
      - _ means a single letter
      - [ ] means any single character within the bracket
      - ^ means any character not in the bracket
      - - means a range of characters

Like Examples

- WHERE name LIKE 't%'
  - any values that start with 't'
- WHERE name LIKE '%t'
  - any values that end with 't'
- WHERE name LIKE '%t%'
  - any value with a 't' in it
- WHERE name LIKE '_t%'
  - any value with a 't' in second position

Select

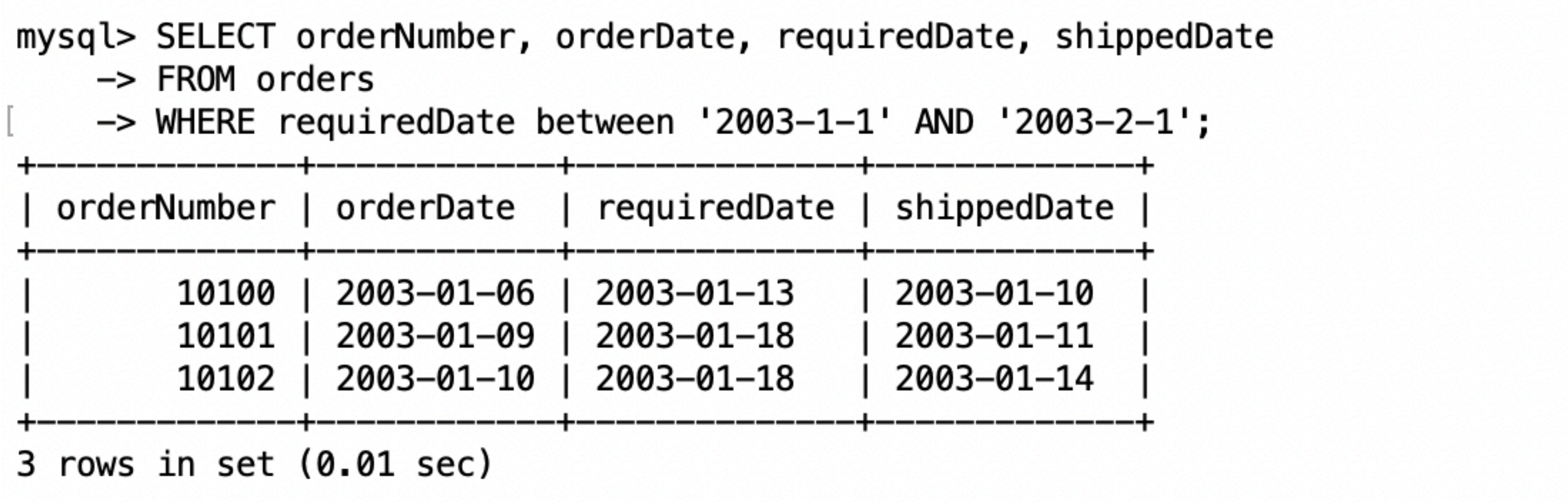
- Beware of bad data when you make searches



```
mysql> SELECT contactLastName AS 'Last Name', contactFirstName AS 'First Name', phone
    -> FROM customers
    -> WHERE phone LIKE '+49 %';
+-----------+------------+-------------------+
| Last Name | First Name | phone             |
+-----------+------------+-------------------+
| Keitel    | Roland     | +49 69 66 90 2555 |
+-----------+------------+-------------------+
1 row in set (0.00 sec)

mysql> SELECT contactLastName AS 'Last Name', contactFirstName AS 'First Name', phone
    -> FROM customers
    -> WHERE phone LIKE '%+49 %';
+-------------+------------+--------------------+
| Last Name   | First Name | phone              |
+-------------+------------+--------------------+
| Keitel      | Roland     | +49 69 66 90 2555  |
| Donnermeyer | Michael    |  +49 89 61 08 9555 |
+-------------+------------+--------------------+
2 rows in set (0.00 sec)
```

SELECT

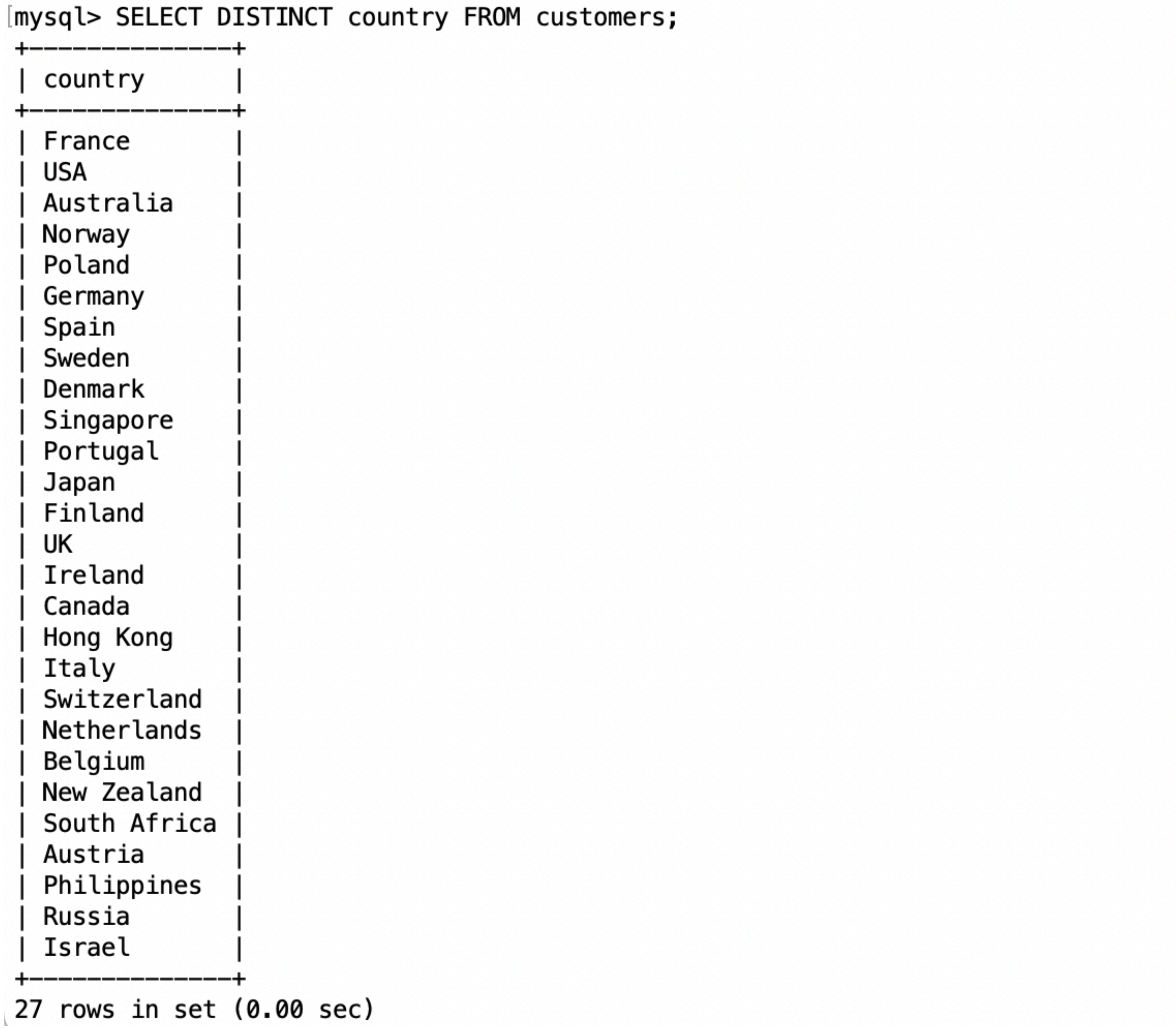
- BETWEEN … AND …
    - Selects records with a value in the range
        - endpoints included



```
mysql> SELECT orderNumber, orderDate, requiredDate, shippedDate
    -> FROM orders
[   -> WHERE requiredDate between '2003-1-1' AND '2003-2-1';
+-------------+------------+--------------+-------------+
| orderNumber | orderDate  | requiredDate | shippedDate |
+-------------+------------+--------------+-------------+
|       10100 | 2003-01-06 | 2003-01-13   | 2003-01-10  |
|       10101 | 2003-01-09 | 2003-01-18   | 2003-01-11  |
|       10102 | 2003-01-10 | 2003-01-18   | 2003-01-14  |
+-------------+------------+--------------+-------------+
3 rows in set (0.01 sec)
```

SELECT

- SELECT DISTINCT



```
mysql> SELECT DISTINCT country FROM customers;
+--------------+
| country      |
+--------------+
| France       |
| USA          |
| Australia    |
| Norway       |
| Poland       |
| Germany      |
| Spain        |
| Sweden       |
| Denmark      |
| Singapore    |
| Portugal     |
| Japan        |
| Finland      |
| UK           |
| Ireland      |
| Canada       |
| Hong Kong    |
| Italy        |
| Switzerland  |
| Netherlands  |
| Belgium      |
| New Zealand  |
| South Africa |
| Austria      |
| Philippines  |
| Russia       |
| Israel       |
+--------------+
27 rows in set (0.00 sec)
```

SELECT

- LIMIT gives the maximum number of rows returned
    - Can be used for a sample
    - Can be used with ORDER BY ASC

Queries with more than one Table

Naming Tables

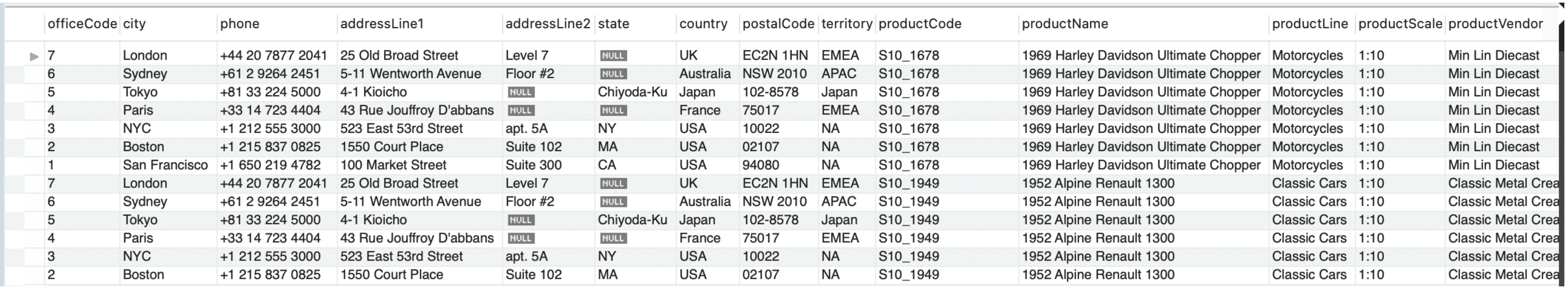
- We can name tables in the WHERE clause

```
SELECT
    e.firstName,
    e.lastName
FROM
    employees e
ORDER BY e.firstName;
```

Simple Joins

- Cartesian product of two tables is called CROSS JOIN:

```
SELECT
    *
FROM
    offices
        CROSS JOIN
    products;
```

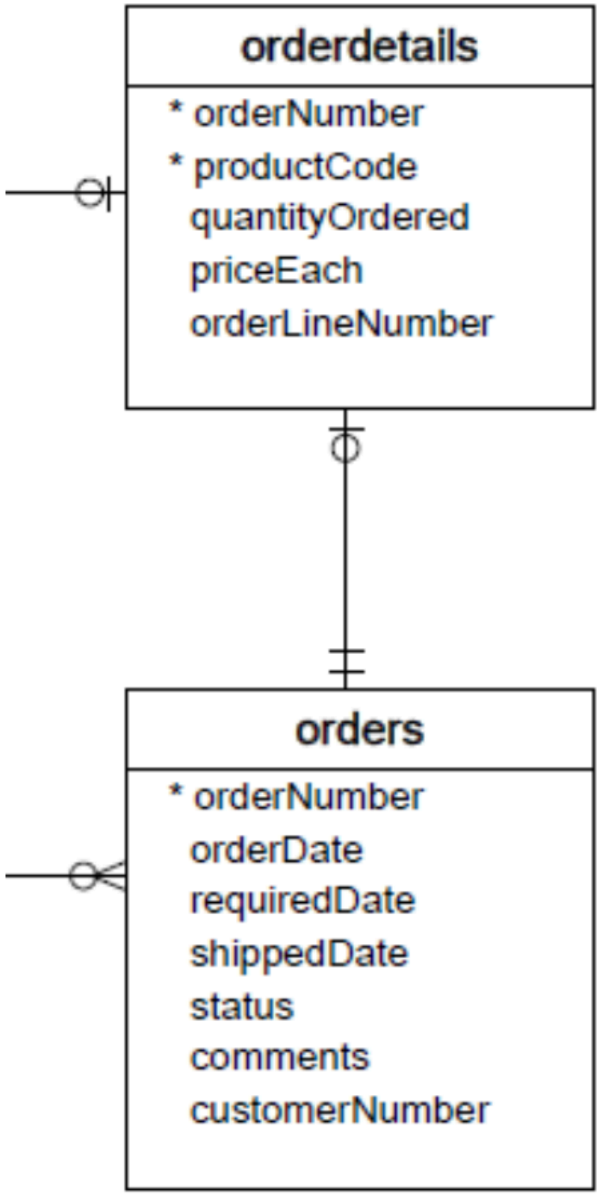


	officeCode	city	phone	addressLine1	addressLine2	state	country	postalCode	territory	productCode	productName	productLine	productScale	productVendor
▶	7	London	+44 20 7877 2041	25 Old Broad Street	Level 7	NULL	UK	EC2N 1HN	EMEA	S10_1678	1969 Harley Davidson Ultimate Chopper	Motorcycles	1:10	Min Lin Diecast
	6	Sydney	+61 2 9264 2451	5-11 Wentworth Avenue	Floor #2	NULL	Australia	NSW 2010	APAC	S10_1678	1969 Harley Davidson Ultimate Chopper	Motorcycles	1:10	Min Lin Diecast
	5	Tokyo	+81 33 224 5000	4-1 Kioicho	NULL	Chiyoda-Ku	Japan	102-8578	Japan	S10_1678	1969 Harley Davidson Ultimate Chopper	Motorcycles	1:10	Min Lin Diecast
	4	Paris	+33 14 723 4404	43 Rue Jouffroy D'abbans	NULL	NULL	France	75017	EMEA	S10_1678	1969 Harley Davidson Ultimate Chopper	Motorcycles	1:10	Min Lin Diecast
	3	NYC	+1 212 555 3000	523 East 53rd Street	apt. 5A	NY	USA	10022	NA	S10_1678	1969 Harley Davidson Ultimate Chopper	Motorcycles	1:10	Min Lin Diecast
	2	Boston	+1 215 837 0825	1550 Court Place	Suite 102	MA	USA	02107	NA	S10_1678	1969 Harley Davidson Ultimate Chopper	Motorcycles	1:10	Min Lin Diecast
	1	San Francisco	+1 650 219 4782	100 Market Street	Suite 300	CA	USA	94080	NA	S10_1678	1969 Harley Davidson Ultimate Chopper	Motorcycles	1:10	Min Lin Diecast
	7	London	+44 20 7877 2041	25 Old Broad Street	Level 7	NULL	UK	EC2N 1HN	EMEA	S10_1949	1952 Alpine Renault 1300	Classic Cars	1:10	Classic Metal Crea
	6	Sydney	+61 2 9264 2451	5-11 Wentworth Avenue	Floor #2	NULL	Australia	NSW 2010	APAC	S10_1949	1952 Alpine Renault 1300	Classic Cars	1:10	Classic Metal Crea
	5	Tokyo	+81 33 224 5000	4-1 Kioicho	NULL	Chiyoda-Ku	Japan	102-8578	Japan	S10_1949	1952 Alpine Renault 1300	Classic Cars	1:10	Classic Metal Crea
	4	Paris	+33 14 723 4404	43 Rue Jouffroy D'abbans	NULL	NULL	France	75017	EMEA	S10_1949	1952 Alpine Renault 1300	Classic Cars	1:10	Classic Metal Crea
	3	NYC	+1 212 555 3000	523 East 53rd Street	apt. 5A	NY	USA	10022	NA	S10_1949	1952 Alpine Renault 1300	Classic Cars	1:10	Classic Metal Crea
	2	Boston	+1 215 837 0825	1550 Court Place	Suite 102	MA	USA	02107	NA	S10_1949	1952 Alpine Renault 1300	Classic Cars	1:10	Classic Metal Crea

Simple Joins

- You can convert a cross join to an inner join with a where clause

```
SELECT
    productcode, comments
FROM
    orderdetails orde
        CROSS JOIN
    orders ord
WHERE
    orde.ordernumber = ord.ordernumber
AND
    ord.comments IS NOT NULL;
```



orderdetails

* orderNumber
* productCode
quantityOrdered
priceEach
orderLineNumber

orders

* orderNumber
orderDate
requiredDate
shippedDate
status
comments
customerNumber

Simple Joins

- But that just gives code harder to read

```
SELECT
    productcode, comments
FROM
    orderdetails orde
        INNER JOIN
    orders ord
ON
   orde.ordernumber = ord.ordernumber
WHERE
    ord.comments IS NOT NULL;
```

Simple Joins

- When the column names are the same, we can use the USING clause
    - Notice the parentheses

```
SELECT
    productcode, comments
FROM
    orderdetails orde
        INNER JOIN
    orders ord
USING
   (ordernumber)
WHERE
    ord.comments IS NOT NULL;
```

Simple Joins

- You can also use the pre-1992 SQL92 notation

```
SELECT
    productcode, comments
FROM
    orderdetails orde, orders ord
WHERE
    orde.orderNumber = ord.orderNumber
AND
    ord.comments IS NOT NULL;
```

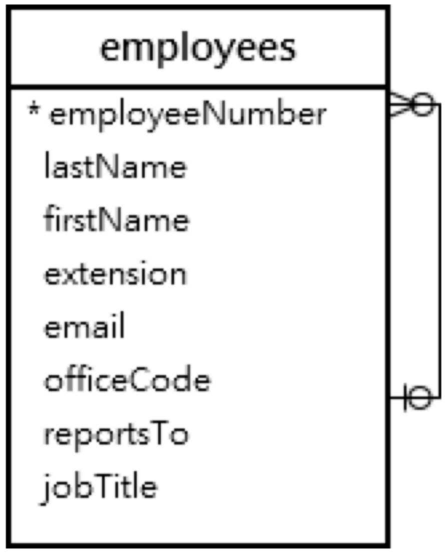
Simple Joins

- The SQL-92 is clearer whenever the joins are complex

```
SELECT
    customerName, city, cus.country,
quantityOrdered*priceEach AS 'volume'
FROM
    customers cus
    INNER JOIN orders ord ON cus.customerNumber =
ord.customerNumber
    INNER JOIN orderdetails orddet ON orddet.orderNumber =
ord.orderNumber
WHERE
   ord.comments IS NOT NULL AND orddet.productCode =
'S18_2325'
;
```

Simple Joins

- Self-joins: Use different table aliases



employees

* employeeNumber

lastName

firstName

extension

email

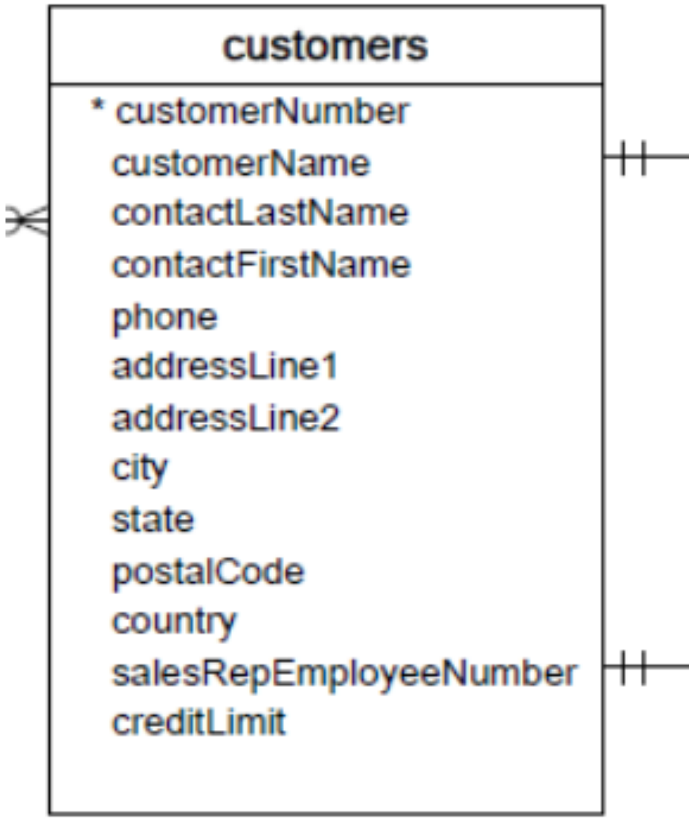
officeCode

reportsTo

jobTitle

```
SELECT
    CONCAT(m.firstName, ' ', m.lastName) AS manager,
    CONCAT(e.firstName, ' ', e.lastName) AS managee
FROM
   employees e
    INNER JOIN employees m
    ON
     m.employeeNumber = e.reportsTo
ORDER BY manager;
```

Simple Joins



customers

* customerNumber
customerName
contactLastName
contactFirstName
phone
addressLine1
addressLine2
city
state
postalCode
country
salesRepEmployeeNumber
creditLimit

- Find pairs of clients that are in the same city

```
SELECT
    c1.city, c1.customerName, c2.customerName
FROM
   customers c1 INNER JOIN customers c2 ON
      c1.city = c2.city
       AND c1.customerName > c2.customerName
ORDER BY
   c1.city
```

Examples

- SQL has explicit commands for the various joins and products
- Normally, combine tables by listing them in the FROM clause

```
SELECT name
FROM movies, moviesExec
WHERE title = 'Star Wars'
        AND movies.producerC# = moviesExec.cert#
```

Examples

- Find all movie execs that live with a star

-
  ```
  MovieStar(name, address, gender, birthdate)
  MovieExec(name, address, cert#, netWorth)
  ```

```
SELECT MovieStar.name, MovieExec.name)
FROM MovieStar, MovieExec
WHERE
   MovieStar.address = MovieExec.address
```

Examples

- Tuple Variables
  - Sometimes need to combine two tuples in the same table
  - Can extend the FROM clause

```
SELECT Star1.name, Star2.name
FROM MovieStars Star1, MovieStars Star2
WHERE
  Star1.address = Star2.address
  AND  Star1.name < Star2.name
```

Updates

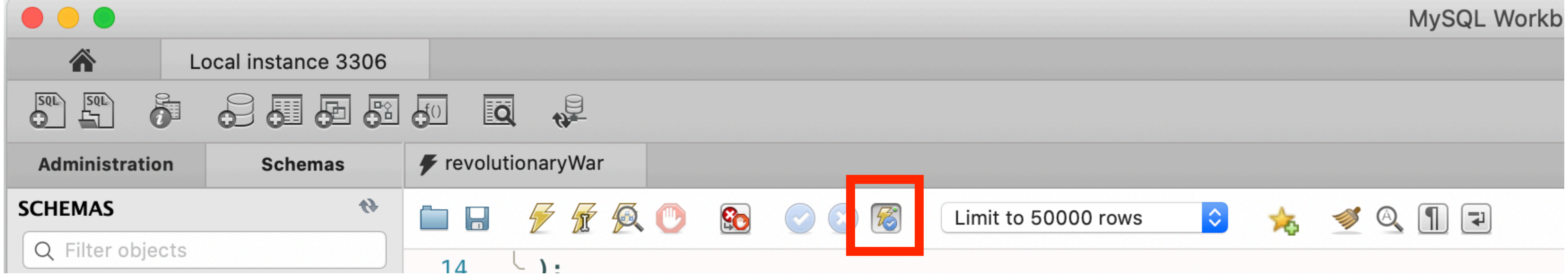
- Changes existing records
- Syntax:

```
UPDATE tablename
SET attr1=val1, attr2=val2, …
WHERE conditions;
```

- Does not need to change all attributes
- If there is no WHERE condition, all records are updated

Commit and Rollback

- A database allows us to rollback to a previous state unless we have committed
- MySQLWorkbench has an auto-commit button



- Rollback puts database into the state of the last commit

Delete

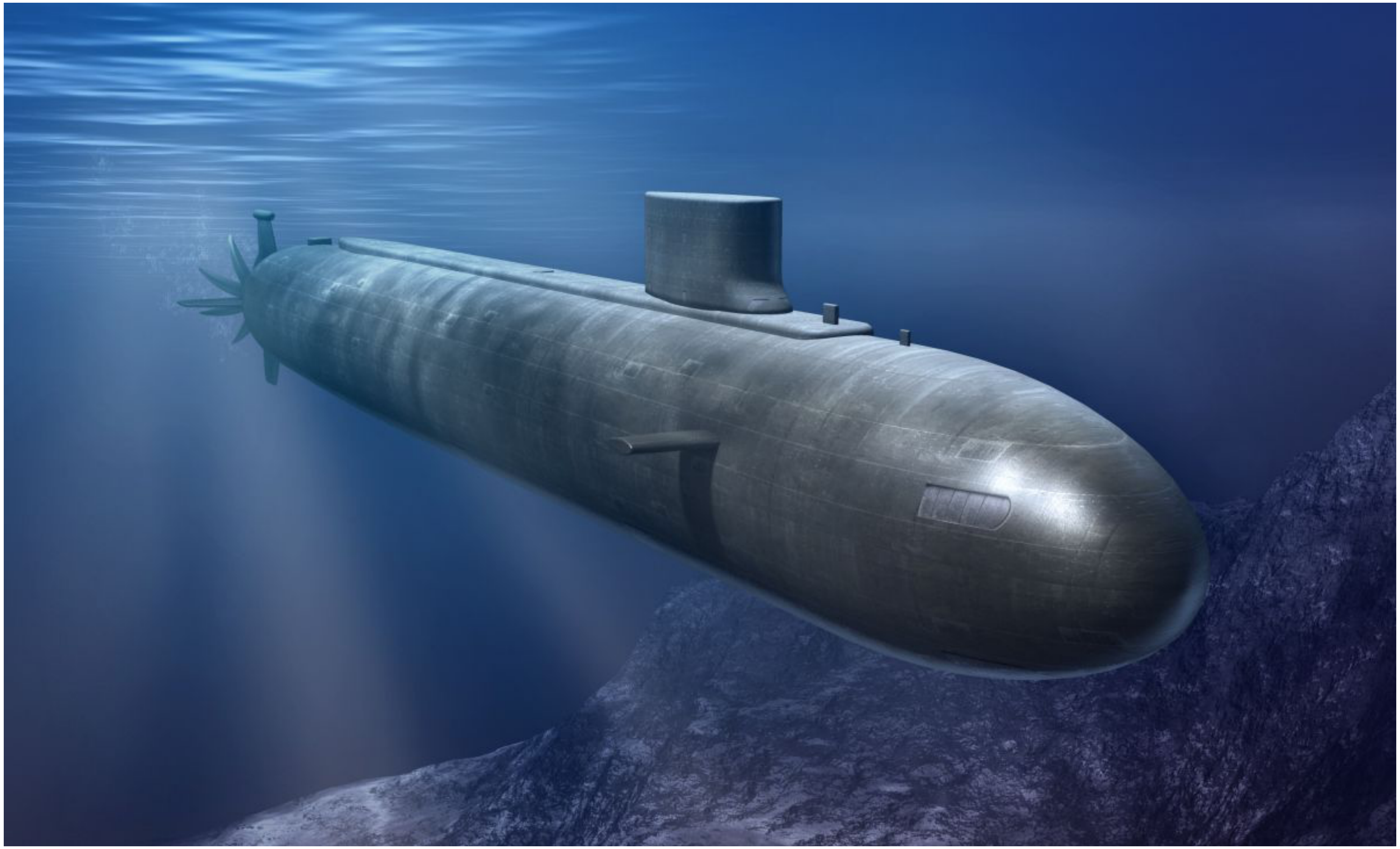
- Just like an update

```
DELETE FROM tablename
WHERE condition
```

- The Where clause is not necessary

Delete, Drop, Truncate

- Drop Table:
  - Definite action: cannot recover with rollback
- Truncate:
  - All records removed
  - Auto-increment values reset
  - Table description stays
- Delete:
  - Delete removes records row by row
  - Auto-increment values remain
  - Slower than truncate



Sub-Queries

Subqueries

- Subqueries are helper queries

Subqueries

- Subqueries producing a scalar value
  - Example: Producer of Star Wars

```
SELECT name
From movies, movieExec
WHERE title = 'Star Wars'
        AND
      producerC# = cert#;
```

  - Can achieve the same effect by first looking for the producerC#

Subqueries

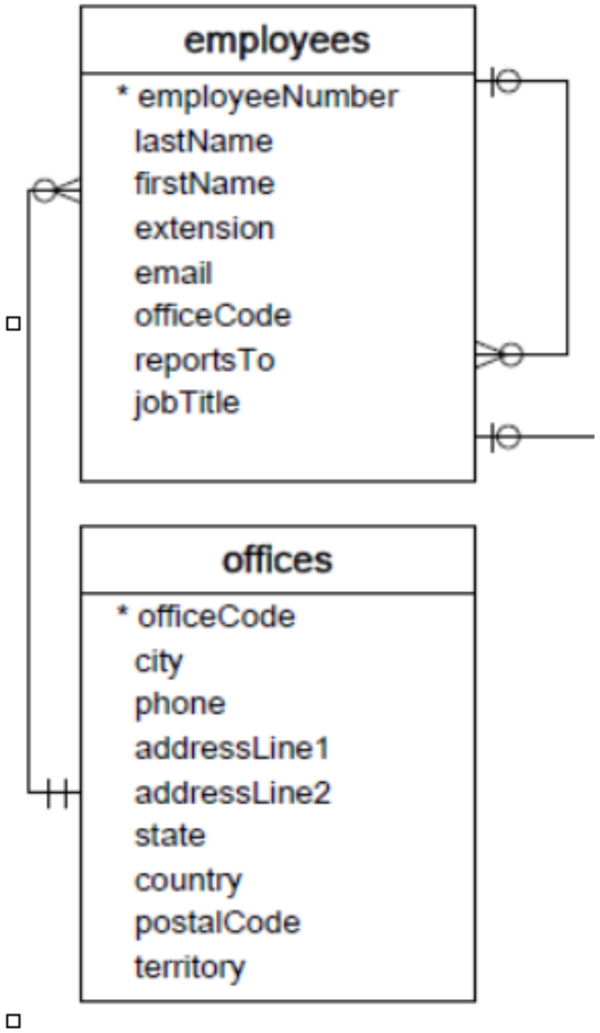
- Example: Producer of Star Wars

```
SELECT name
FROM movieExec
WHERE cert# =
        (SELECT producerC#
         FROM movies
         WHERE title = 'star wars'
        )
```

- While the queries are different, their execution can be the same

Subqueries

- You can create sub-tables
  - Find employees working in the US
    - First: Find officeCodes with country = US



employees

* employeeNumber
lastName
firstName
extension
email
officeCode
reportsTo
jobTitle

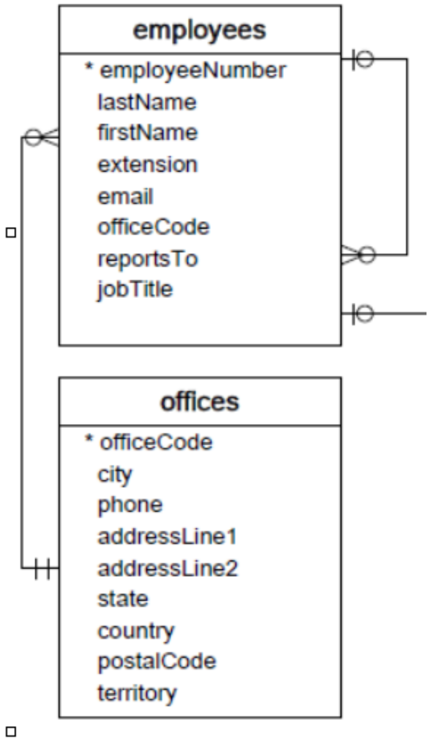
offices

* officeCode
city
phone
addressLine1
addressLine2
state
country
postalCode
territory

```
SELECT
    officeCode
FROM
    offices
WHERE
    country = 'USA';
```

Subqueries

- Second: Connect employees to these office codes

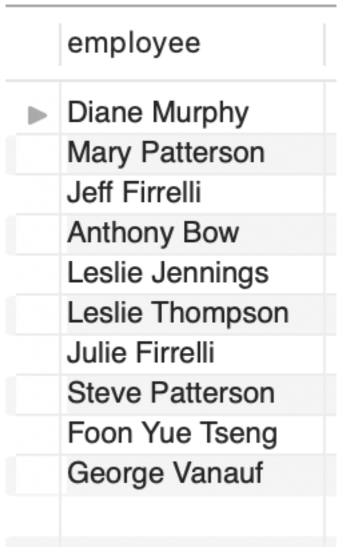

employees

* employeeNumber
lastName
firstName
extension
email
officeCode
reportsTo
jobTitle

offices

* officeCode
city
phone
addressLine1
addressLine2
state
country
postalCode
territory

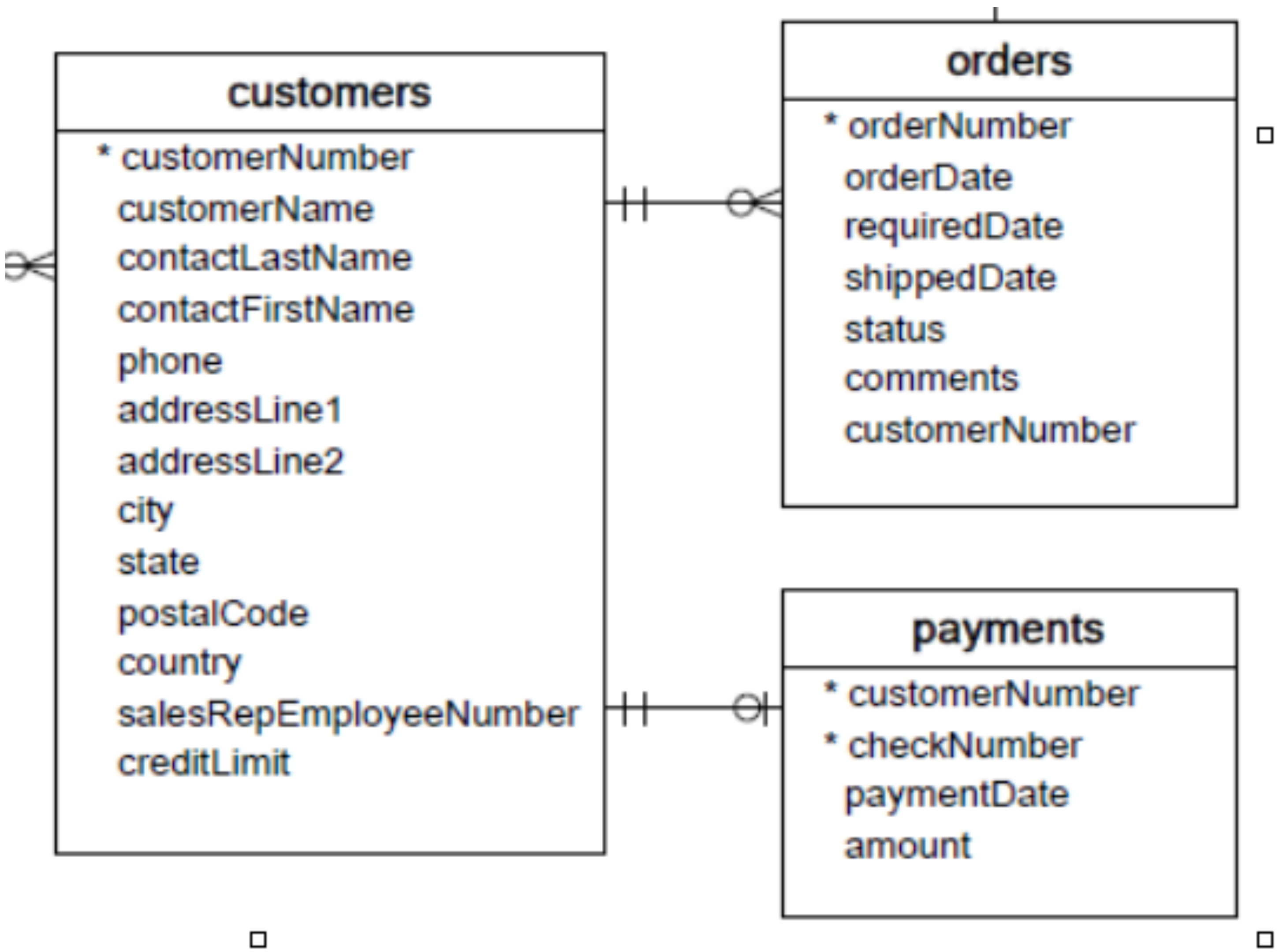
```
SELECT
   CONCAT(firstName, ' ', lastName) AS 'employee'
FROM
   employees
WHERE
   officeCode IN (
   SELECT
      officeCode
   FROM
      offices
   WHERE
      country = 'USA');
```



employee
Diane Murphy
Mary Patterson
Jeff Firrelli
Anthony Bow
Leslie Jennings
Leslie Thompson
Julie Firrelli
Steve Patterson
Foon Yue Tseng
George Vanauf

Subqueries

- Find the contact that made the largest payment



customers

* customerNumber
customerName
contactLastName
contactFirstName
phone
addressLine1
addressLine2
city
state
postalCode
country
salesRepEmployeeNumber
creditLimit

orders

* orderNumber
orderDate
requiredDate
shippedDate
status
comments
customerNumber

payments

* customerNumber
* checkNumber
paymentDate
amount

Subqueries

- Step 1:
    - Need to find maximum payment

Subqueries

- Step 1:
  - Need to find maximum payment

```
SELECT MAX(amount) FROM payments
```

Subqueries

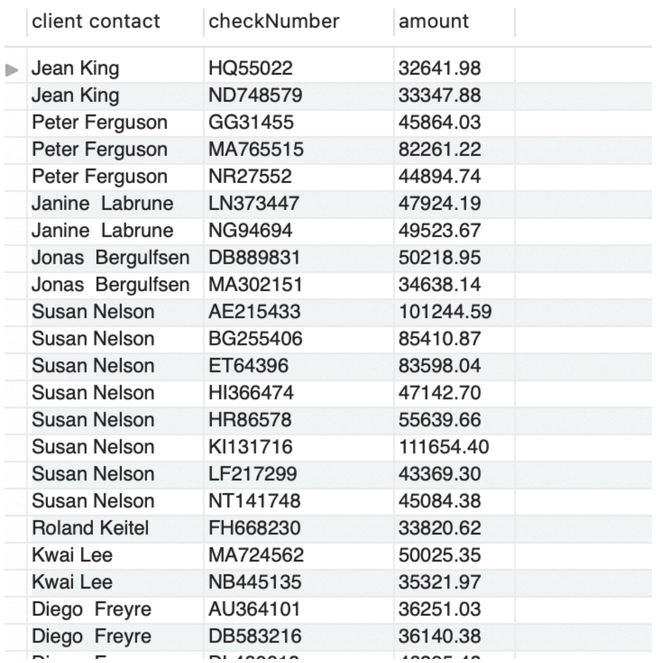
- Step 2:
  - Display the details

```
SELECT
   CONCAT(c.contactFirstName, ' ', c.contactLastName) AS
'client contact', checkNumber, amount
FROM
   customers c, payments p
WHERE
   amount = (SELECT MAX(amount) FROM payments)
   AND c.customerNumber = p.customerNumber;
```

Subqueries

- Same, but payments larger than the average amount

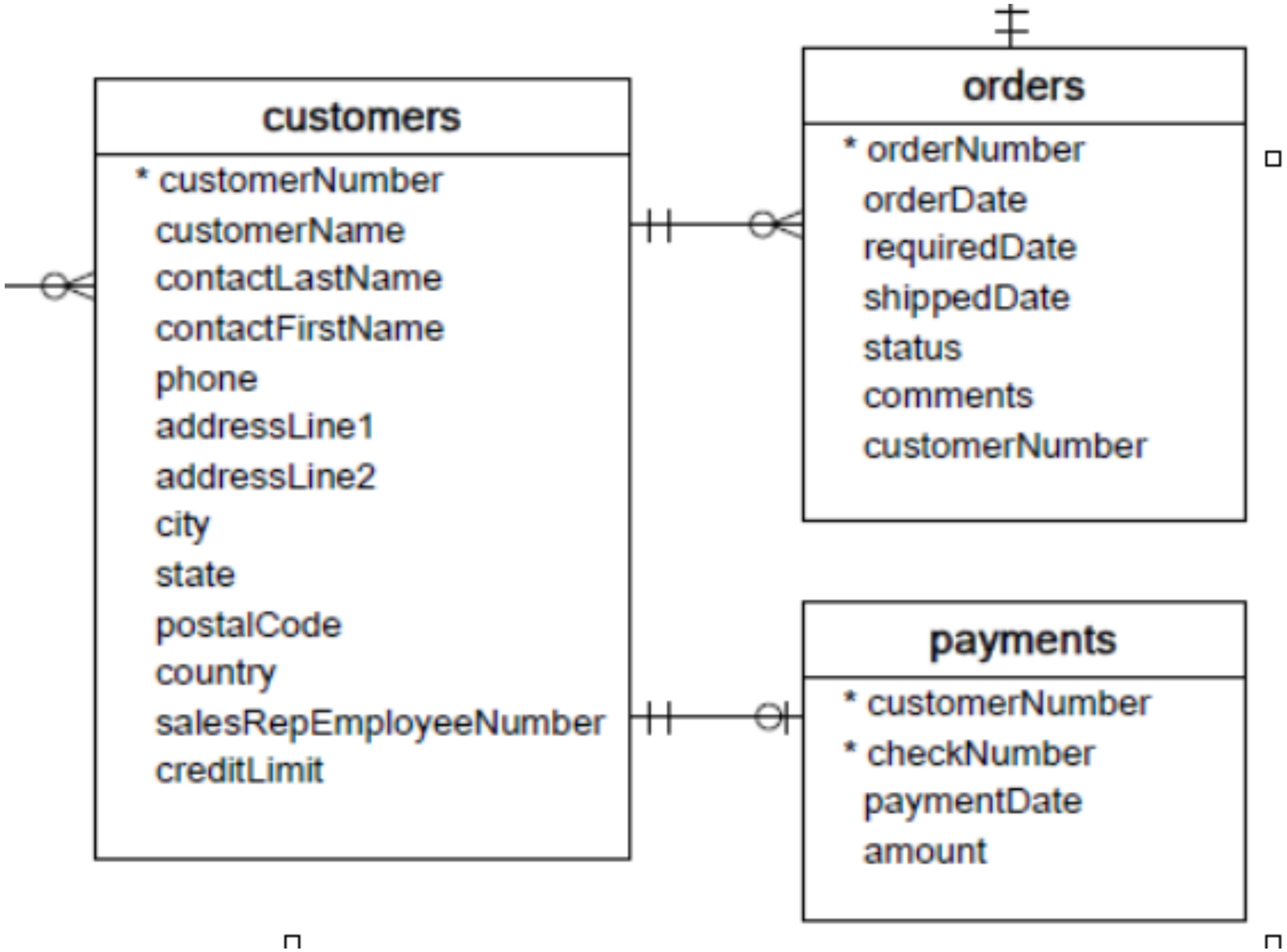
```
SELECT
   CONCAT(c.contactFirstName, ' ', c.contactLastName) AS
'client contact', checkNumber, amount
FROM
   customers c, payments p
WHERE
   amount > (SELECT AVG(amount) FROM payments) AND
c.customerNumber = p.customerNumber;
```



client contact	checkNumber	amount
Jean King	HQ55022	32641.98
Jean King	ND748579	33347.88
Peter Ferguson	GG31455	45864.03
Peter Ferguson	MA765515	82261.22
Peter Ferguson	NR27552	44894.74
Janine Labrune	LN373447	47924.19
Janine Labrune	NG94694	49523.67
Jonas Bergulfsen	DB889831	50218.95
Jonas Bergulfsen	MA302151	34638.14
Susan Nelson	AE215433	101244.59
Susan Nelson	BG255406	85410.87
Susan Nelson	ET64396	83598.04
Susan Nelson	HI366474	47142.70
Susan Nelson	HR86578	55639.66
Susan Nelson	KI131716	111654.40
Susan Nelson	LF217299	43369.30
Susan Nelson	NT141748	45084.38
Roland Keitel	FH668230	33820.62
Kwai Lee	MA724562	50025.35
Kwai Lee	NB445135	35321.97
Diego Freyre	AU364101	36251.03
Diego Freyre	DB583216	36140.38

Subqueries

- Find customers that did not order anything:
  - Find the connection!



customers

* customerNumber
customerName
contactLastName
contactFirstName
phone
addressLine1
addressLine2
city
state
postalCode
country
salesRepEmployeeNumber
creditLimit

orders

* orderNumber
orderDate
requiredDate
shippedDate
status
comments
customerNumber

payments

* customerNumber
* checkNumber
paymentDate
amount

Subqueries

- The set of customers with orders is given by customerNumber

```
SELECT
   customerNumber
FROM
   orders;
```

Subqueries

- We want customer information where the customer number is ***not*** in this set

```
SELECT *
FROM customerS
WHERE customerNumber NOT IN (SELECT
   customerNumber
FROM
   orders);
```

Subqueries

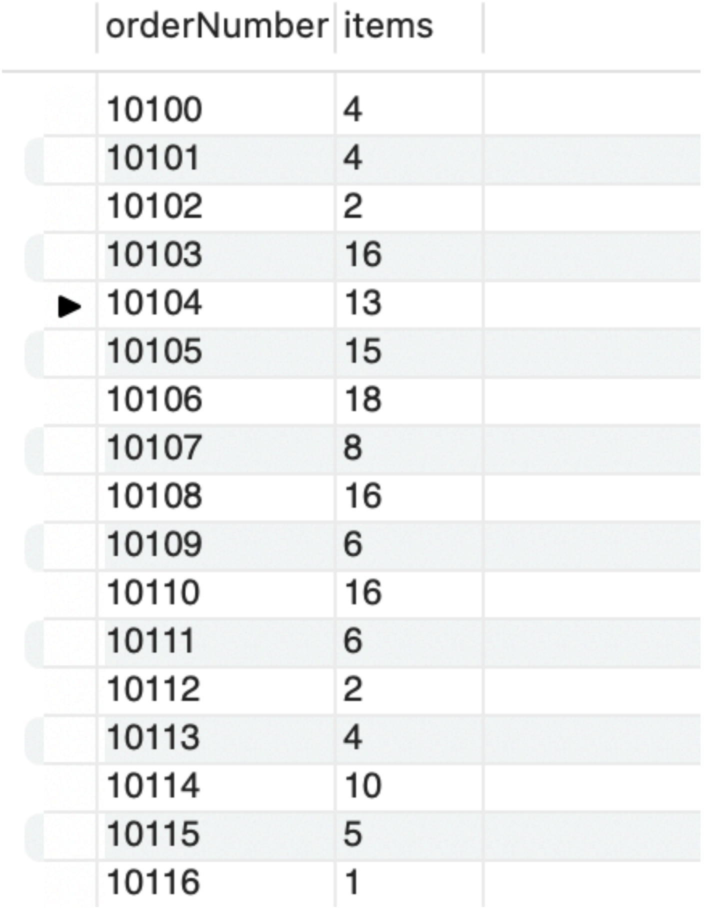
- And then project

```
SELECT customerName,
 concat(contactFirstName, ' ', contactLastName) AS contact,
 city,
 country
FROM customers
WHERE customerNumber NOT IN (SELECT
   customerNumber
FROM
   orders);
```

Subqueries

- How big are orders?

  -
    ```
    SELECT orderNumber, COUNT(orderNumber) AS items
    FROM orderdetails
    GROUP BY orderNumber;
    ```



orderNumber	items
10100	4
10101	4
10102	2
10103	16
10104	13
10105	15
10106	18
10107	8
10108	16
10109	6
10110	16
10111	6
10112	2
10113	4
10114	10
10115	5
10116	1

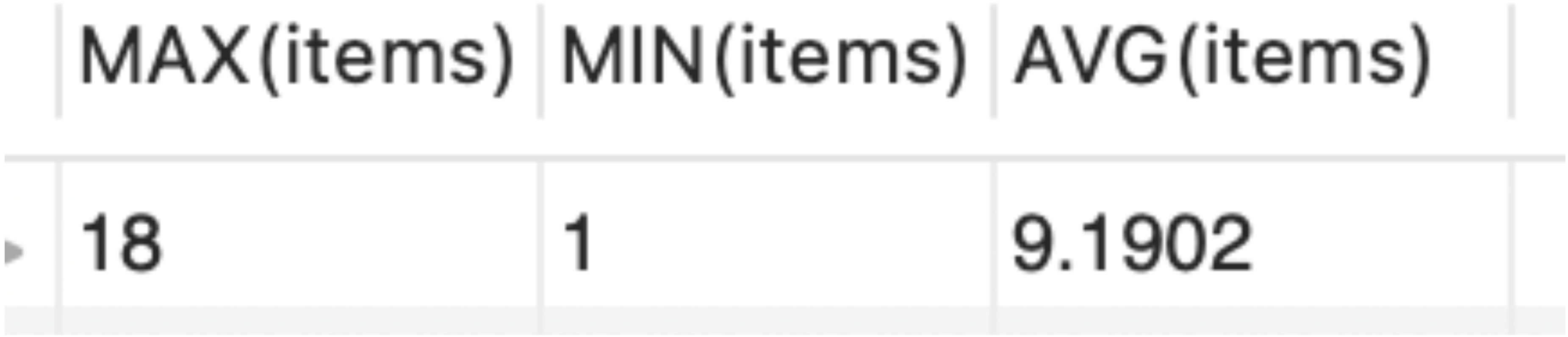
Subqueries

- Now find maximum, minimum, and average

```
SELECT
   MAX(items),
    MIN(items),
    AVG(items)
FROM
   (SELECT orderNumber, COUNT(orderNumber) AS items
    FROM orderdetails
    GROUP BY orderNumber) AS tempTable;
```

Subqueries

- Notice that we need to give a name to the subtable

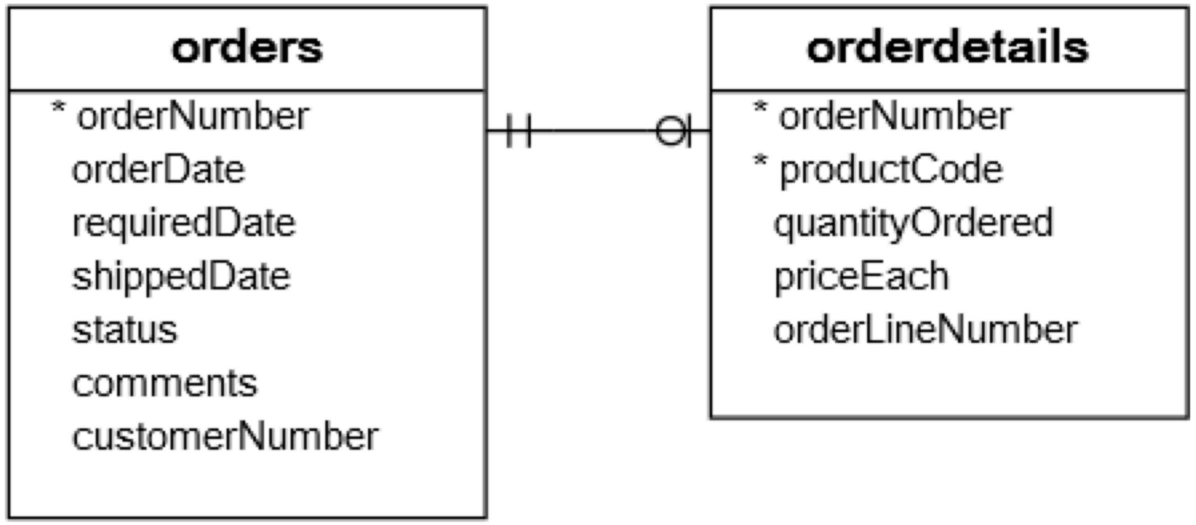


MAX(items)	MIN(items)	AVG(items)
18	1	9.1902

In Class Exercises

- Exercises

  (1) Find the different values for statuses



orders

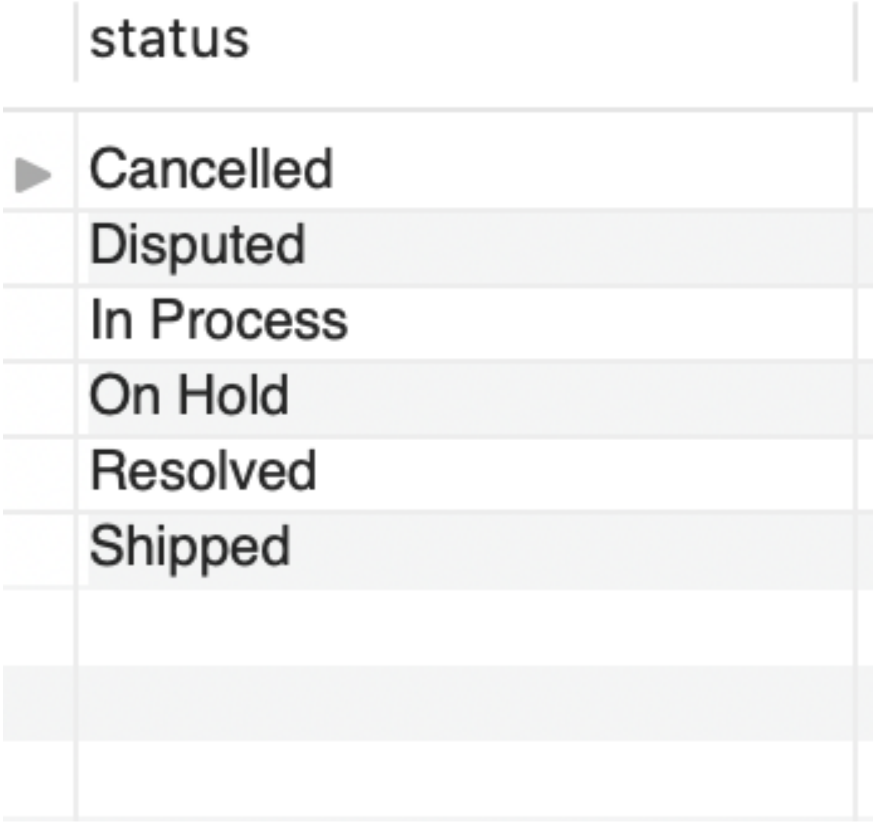
* orderNumber
orderDate
requiredDate
shippedDate
status
comments
customerNumber

orderdetails

* orderNumber
* productCode
quantityOrdered
priceEach
orderLineNumber

In Class Exercises

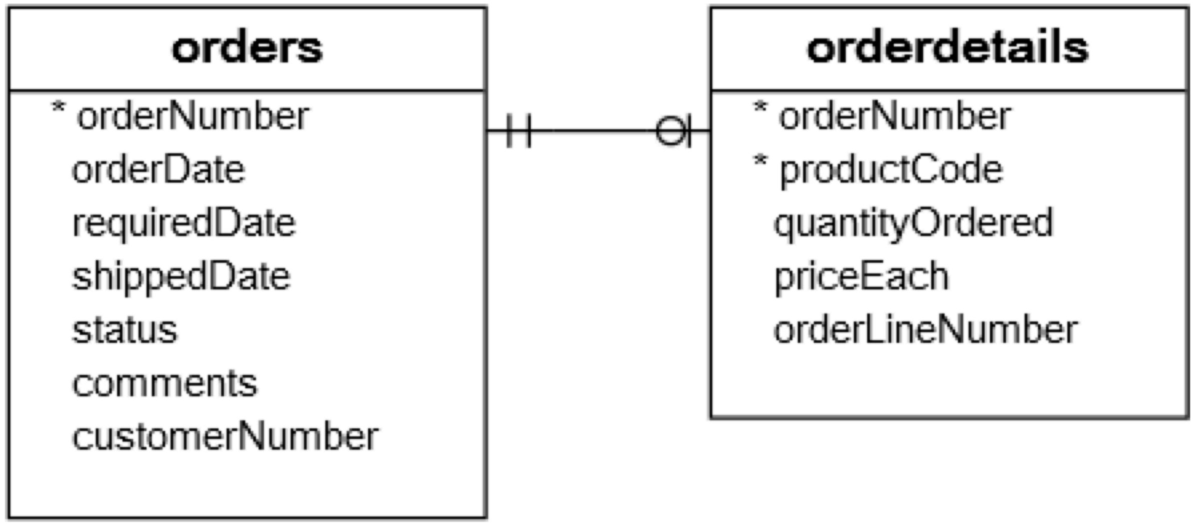
```
use classicmodels;

SELECT DISTINCT
   status
FROM
   orders
ORDER BY status ASC;
```



status
Cancelled
Disputed
In Process
On Hold
Resolved
Shipped

In Class Exercises

(2) Find the sales volume for all values of status



orders

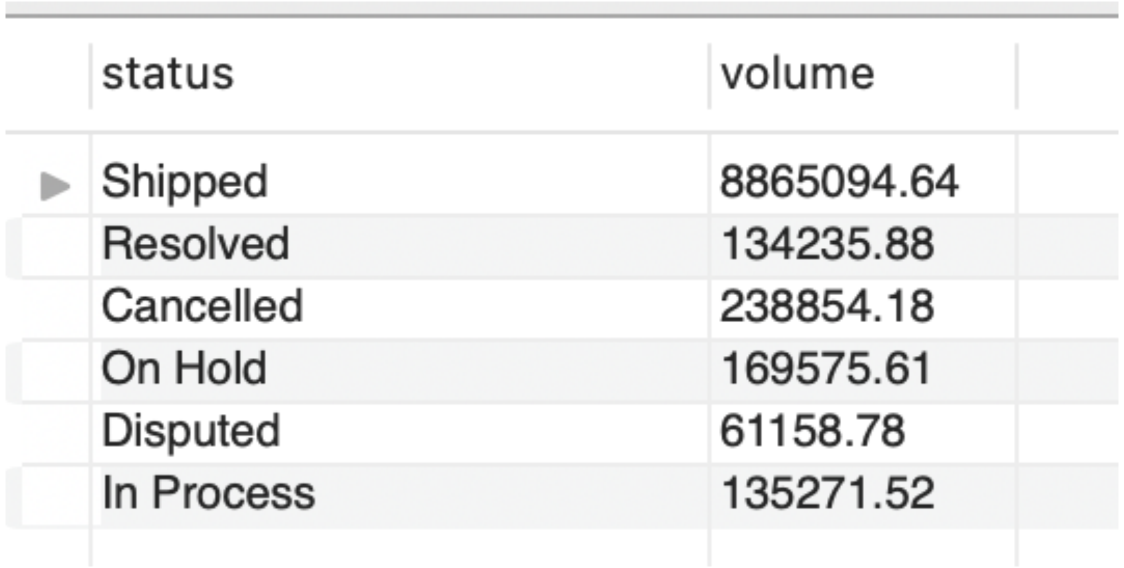
* orderNumber
orderDate
requiredDate
shippedDate
status
comments
customerNumber

orderdetails

* orderNumber
* productCode
quantityOrdered
priceEach
orderLineNumber

In Class Exercises

```
SELECT
   orders.status,
Sum(orderdetails.priceEach*orderdetails.quantityOrdered) AS
volume
FROM
   orders, orderdetails
WHERE
   orders.orderNumber = orderdetails.orderNumber
GROUP BY
   orders.status;
```



status	volume
Shipped	8865094.64
Resolved	134235.88
Cancelled	238854.18
On Hold	169575.61
Disputed	61158.78
In Process	135271.52

In Class Exercises

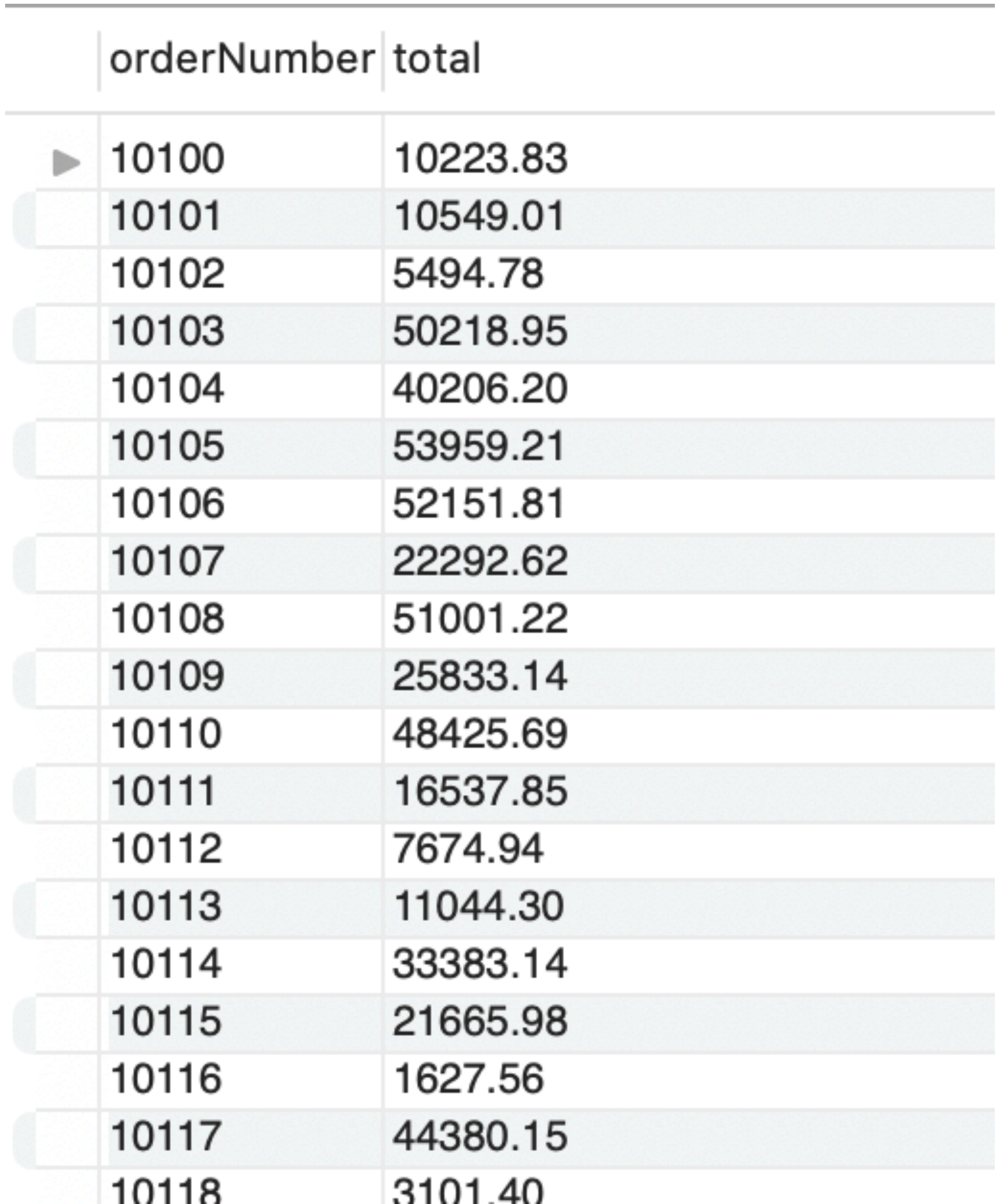
```
SELECT
   orders.status,
Sum(orderdetails.priceEach*orderdetails.quantityOrdered) AS
volume
FROM
   orders INNER JOIN orderdetails
USING
   (orderNumber)
GROUP BY
   orders.status;
```

In Class Exercises

(3) Find the volume for each order by order-number

In Class Exercises

```
SELECT
   orderNumber, SUM(priceEach*quantityOrdered) AS total
FROM
   orderdetails
GROUP BY
   orderNumber;
```



orderNumber	total
10100	10223.83
10101	10549.01
10102	5494.78
10103	50218.95
10104	40206.20
10105	53959.21
10106	52151.81
10107	22292.62
10108	51001.22
10109	25833.14
10110	48425.69
10111	16537.85
10112	7674.94
10113	11044.30
10114	33383.14
10115	21665.98
10116	1627.56
10117	44380.15
10118	3101.40

In Class Exercises

- Let's combine this with the customer information
    - The previous answer becomes a subquery

In Class Exercises

```
SELECT
   customerName, total
FROM
   (SELECT
   orderNumber, SUM(priceEach*quantityOrdered) AS total
FROM
   orderdetails
GROUP BY
   orderNumber) totals,
    customers, orders
WHERE customers.customerNumber = orders.customerNumber AND
orders.orderNumber = totals.orderNumber;
```

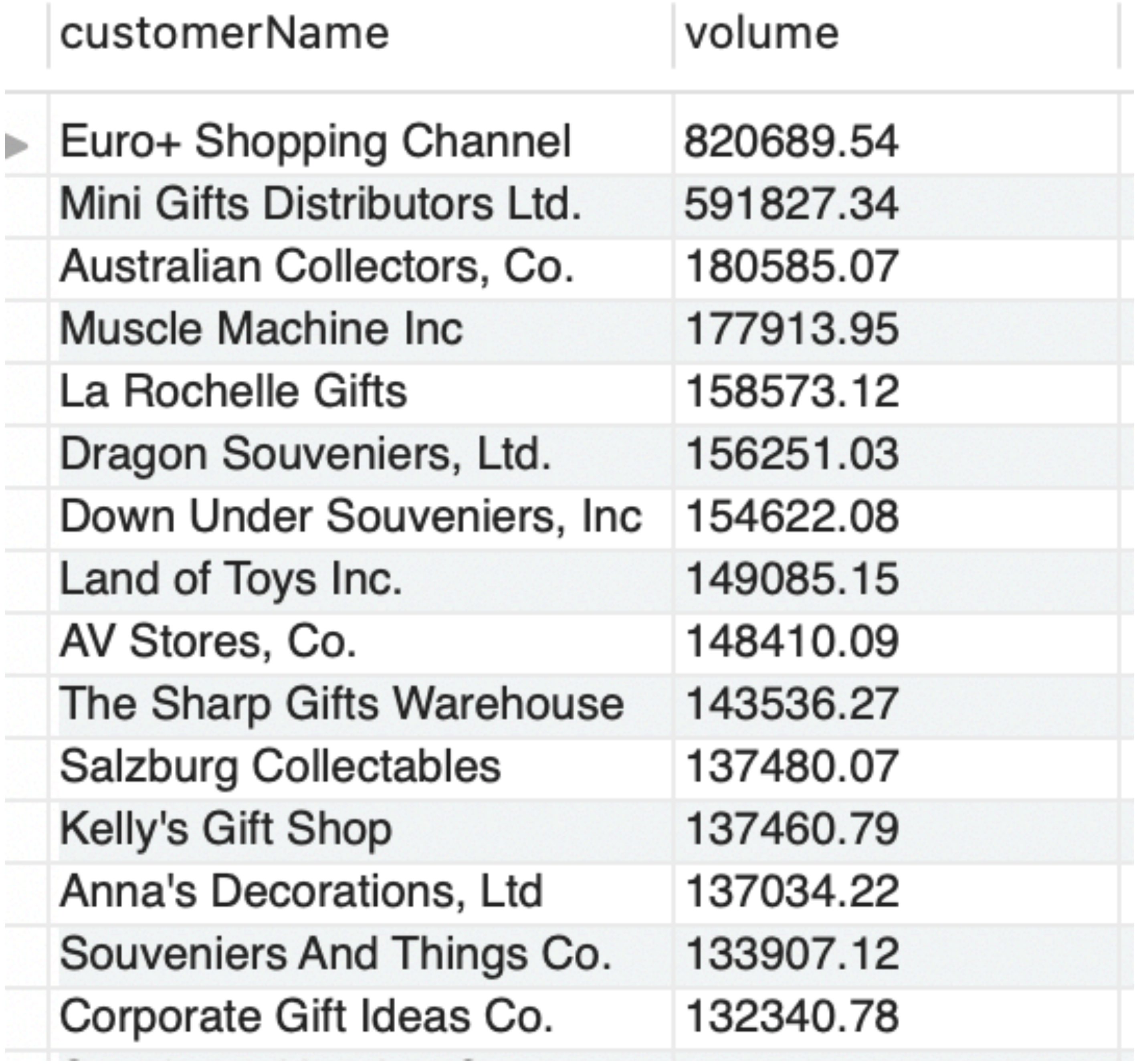
In Class Exercises

- We now sum up the total for each client using another groupby

In Class Exercises

```
SELECT
   customerName, SUM(total) AS volume
FROM
   (SELECT
   orderNumber, SUM(priceEach*quantityOrdered) AS total
FROM
   orderdetails
GROUP BY
   orderNumber) totals, customers, orders
WHERE customers.customerNumber = orders.customerNumber AND
orders.orderNumber = totals.orderNumber
GROUP BY
   customers.customerName
ORDER BY
   volume DESC;
```

In Class Exercises



customerName	volume
Euro+ Shopping Channel	820689.54
Mini Gifts Distributors Ltd.	591827.34
Australian Collectors, Co.	180585.07
Muscle Machine Inc	177913.95
La Rochelle Gifts	158573.12
Dragon Souveniers, Ltd.	156251.03
Down Under Souveniers, Inc	154622.08
Land of Toys Inc.	149085.15
AV Stores, Co.	148410.09
The Sharp Gifts Warehouse	143536.27
Salzburg Collectables	137480.07
Kelly's Gift Shop	137460.79
Anna's Decorations, Ltd	137034.22
Souveniers And Things Co.	133907.12
Corporate Gift Ideas Co.	132340.78

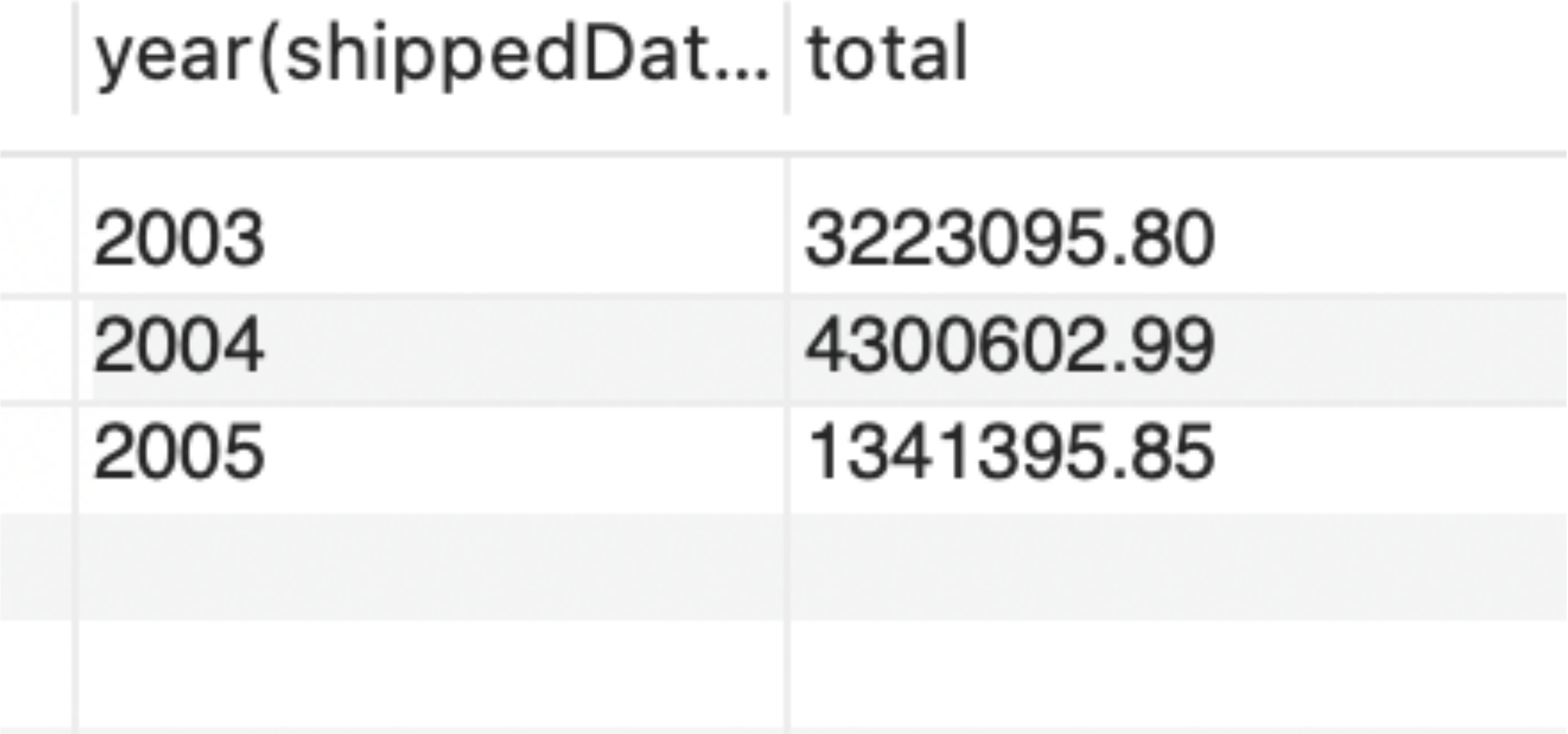
In Class Exercises

- The total sales per year
  - Use the year(of_a_date) expression

In Class Exercises

```
SELECT
   year(shippedDate), SUM(priceEach*quantityOrdered) AS
total
FROM
   orderdetails, orders
WHERE orderdetails.ordernumber = orders.orderNumber and
orders.status = 'Shipped'
GROUP BY
   YEAR(shippedDate);
```

In Class Exercises



year(shippedDat...	total
2003	3223095.80
2004	4300602.99
2005	1341395.85

Set Theoretic Operations

- Unions, intersections, excepts
- To execute the corresponding set operations
-

```
(SELECT name, address
 FROM movieStars
 WHERE gender = 'F'
)
 INTERSECT
(SELECT name, address
 FROM movieExecs
 WHERE netWorth > 1000000
)
```

Set Theoretic Operations

- Intersects are not implemented in MySQL
- Unions require attributes to be equal
  - Use AS as necessary

```
SELECT
    firstName, lastName, extension AS phone
FROM
    employees
UNION SELECT
    contactFirstName, contactLastName, phone
FROM
    customers;
```

Subqueries

- Subqueries with conditions involving relations
  - We obtain a relation R as a subquery
  - E.g. with subquery (SELECT * FROM foobar)
  - Queries are:
    - EXISTS R
    - *s* IN R   *s* NOT IN R
    - *s* > ALL R   NOT   *s* > ALL R
    - *s* > ANY R   NOT *s* > ANY R

Subqueries

- To analyze a query, start with the inmost query

```
SELECT name
FROM movieExec
WHERE cert# IN
    (SELECT producerC#
     FROM movies
     WHERE (title, year) IN
        (SELECT movieTitle, movieYear
         FROM StarsIn
         WHERE starName = 'Harrison Ford'
        )
     );
```

Subqueries

- This query can also be written without nested subqueries

```
SELECT name
FROM movieExec, movies, starsIn
WHERE  cert# = producerC#
     AND starsIn.title = movies.title
     AND starsIn.year = movie.year
     AND starName = 'Harrison Ford'
```

Subqueries

- Correlated subqueries
  - Subquery is evaluated many times
    - Once for each value given
- Example

```
SELECT title
FROM movies Old
WHERE year < ANY (
   SELECT year
   FROM movies
   WHERE title = Old.title
 );
```

Subqueries

- Scoping rules
  - First look for the subquery and tables in that subquery
  - Then go to the nesting subquery
  - etc.

Subqueries

- Subqueries in FROM clauses
    - Here we join on a subquery aliased Prod

```
SELECT name
FROM movieExecs, ( SELECT producerC#
                   FROM movies, starsIn
                   WHERE movies.title = starsIn.title
                      AND movies.year = starsIn.year
                      AND starName = 'Harrison Ford'
                 ) Prod
WHERE cert# = Prod.producerC#
```

Subqueries

- SQL JOIN expression
  - Explicit construction of various joins
    - CROSS JOIN (product)
    - NATURAL JOIN
    - FULL OUTER JOIN
    - NATURAL FULL OUTER JOIN
    - LEFT OUTER JOIN
    - RIGHT OUTER JOIN

Subqueries

- Examples

```
movies FULL OUTER JOIN starsIn ON
movies.title = starsIn.title
```

Subqueries

- Examples

```
movieStar(name, address, gender, birthday)
movieExec(name, address, cert#, netWorth)
```

```
movieStar NATURAL FULL OUTER JOIN movieExec(
   name, address, gender, birthday, cert#, netWorth)
```

Eliminating Duplicates

- Use Distinct

```
SELECT DISTINCT name
FROM movies
```

- Warning: Invoking distinct is costly

Eliminating Duplicates

- Union, intersection, difference usually remove duplicates automatically
- If we do not want this, but bag semantics:
  - Use the keyword all

```
(SELECT title, year
FROM movies)
UNION ALL
(SELECT movieTitle AS title,
        movieYear AS year
 FROM
 starsIn);
```

Aggregate Functions

- COUNT
  - numeric and non-numeric data
  - null values excepted
- SUM, MIN, MAX, AVG - only numeric data

- Exercise: Find the number of different stars in the starsIn table

```
SELECT COUNT(DISTINCT name)
FROM starsIn
```

Aggregate Functions

- Find the combined net-worth of movieExecs

```
SELECT SUM(networth)
FROM movieExecs
```

- Find the average net-worth of movieExecs

```
SELECT ROUND(AVG(networth),2)
FROM movieExecs
```

Aggregate Functions

- Dealing if NULL values
  - IFNULL(EXPR1, EXPR2):
    - Gives EXPR1 if it is not NULL and EXPR2 if not

-
```
SELECT
    name,
    IFNULL(studio, 'not president') AS studio
FROM movieExecs;
```

Aggregate Functions

- COALESCE(EXPR1, EXPR2, EXPR3, … EXPRn)
  - Gives first nonNULL expression

Grouping

- Aggregation happens usually with grouping
    - To group, use GROUP BY followed by a WHERE clause

```
SELECT studioName, SUM(length) AS totalRunTime
FROM movies
GROUP BY studioName;
```

Grouping

- Example
  - Computing the total run time of movies produced by a producer

```
SELECT name, SUM(length) AS totalRunTime
FROM MovieExec, Movies
WHERE producerC# = cert#
GROUP BY name;
```

Grouping

- Aggregation and Nulls
  - NULL does not contribute to a sum, average, or count
- Grouping and Nulls
  - NULL is an ordinary value for grouping purposes
- Aggregation except COUNT over an empty bag gives result NULL

Transactions

Transactions

- Databases have to process many operations in parallel
- This means some support for inter-process communication
    - Usually provided by logging
- DBMS differ in what they provide
    - Serializability:
        - All transactions appear to have been executed one after the other

Transactions

- Atomicity
  - A single query is never interrupted:
    - Example:
      - A transfer of money from one account to another is executed completely or not at all
      - Both accounts have changed or none

Transactions

- Transaction
  - A group of SQL statements that are all processed in the order given or not at all
- SQL:
  - START TRANSACTION
  - either
  - COMMIT
  - ROLLBACK

Transactions

- Read only transactions
  - By declaring a transaction as read-only, SQL can usually perform it quicker
  - SET TRANSACTION READ ONLY;
  - SET TRANSACTION READ WRITE;

Transactions

- Dirty Reads:
    - Reading a record from an update that will be rolled-back
- Are dirty reads bad?
    - Depends
        - Sometimes, it does not matter, and we do not want the DBMS spend time on making sure that there are no dirty reads
        - Sometimes, a dirty read can absolutely mess up things
            - Selling the same commodity to two customers, …

Transactions

- SQL Isolation Levels:
    - Allow dirty reads:
        - SET TRANSACTION READ WRITE
        - SET ISOLATION LEVEL READ UNCOMMITTED

Transactions

- SQL Isolation Levels:
  - Allow reads only of committed data:
    - SET TRANSACTION READ WRITE
    - SET ISOLATION LEVEL READ COMMITTED

Transactions

- SQL Isolation Levels:
  - Disallow dirty reads, but insure that the reads are consistent:
    - SET TRANSACTION READ WRITE
    - SET ISOLATION LEVEL READ REPEATABLE READ

Transactions

- SQL Isolation Levels:
  - Serializability (default):
    - SET TRANSACTION READ WRITE
    - SET TRANSACTION ISOLATION LEVEL SERIALIZABLE