SQL

DSI, Galvanize

Moses Marsh

purchases

🔑	**id**	INTEGER
	customer_id	INTEGER
	product_id	INTEGER
	date	TIMESTAMP(6) WITHOUT TIME ZONE
	quantity	INTEGER

products

🔑	**id**	INTEGER
	name	CHARACTER VARYING(50)
	price	DOUBLE PRECISION

customers

🔑	**id**	INTEGER
	name	CHARACTER VARYING(50)
	age	INTEGER
	gender	CHARACTER VARYING(1)
	city	CHARACTER VARYING(255)
	state	CHARACTER VARYING(2)

visits

🔑	**id**	INTEGER
	created_at	TIMESTAMP(6) WITHOUT TIME ZONE
	customer_id	INTEGER

licenses

🔑	**id**	INTEGER
	state	CHARACTER VARYING(2)
	number	CHARACTER VARYING(20)
	uploaded_at	TIMESTAMP(6) WITHOUT TIME ZONE
	customer_id	INTEGER

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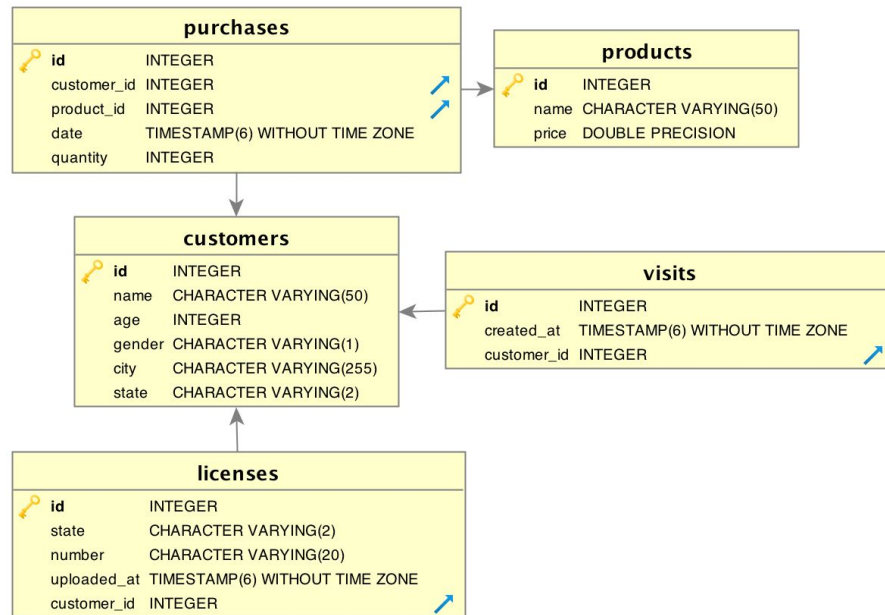# SQL

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OBJECTIVES

- **Connect** to a Postgres database

- **Design** and **write** queries to answer questions using an RDBMS (i.e. Postgres)

By the end of today, you will be able to...

- Connect to a SQL database via command line (i.e. Postgres).
- State the function of basic SQL commands.
- Write simple queries on a single table including SELECT, FROM, WHERE, CASE... clauses and aggregates.
- Write complex queries including JOINS and subqueries.
- Explain how indexing works in Postgres.
- Create and dump tables.
- Format a query to follow a standard style.

Relational Database Management System (RDBMS)

It is a **persistent data storage system**

- survives after the process in which it was created has ended

- is written to non-volatile storage

- is infrequently accessed and unlikely to be changed

RDBMS was the de facto standard for storing data

- Examples: Oracle, MySQL, SQLServer, Postgres
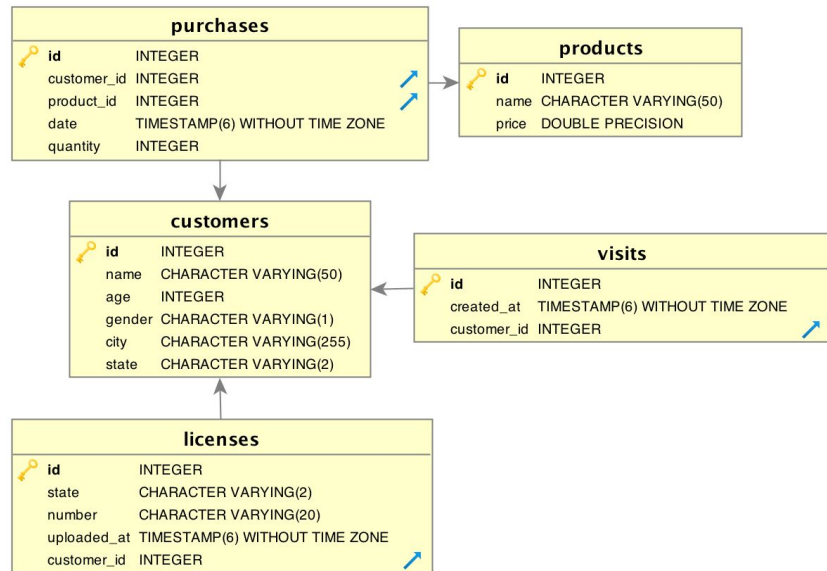
- With "Big Data", this is beginning to change

Why RDBMS ?

An RDBMS provides the ability to

- **Model** relations in data

- **Query** data and their relations efficiently

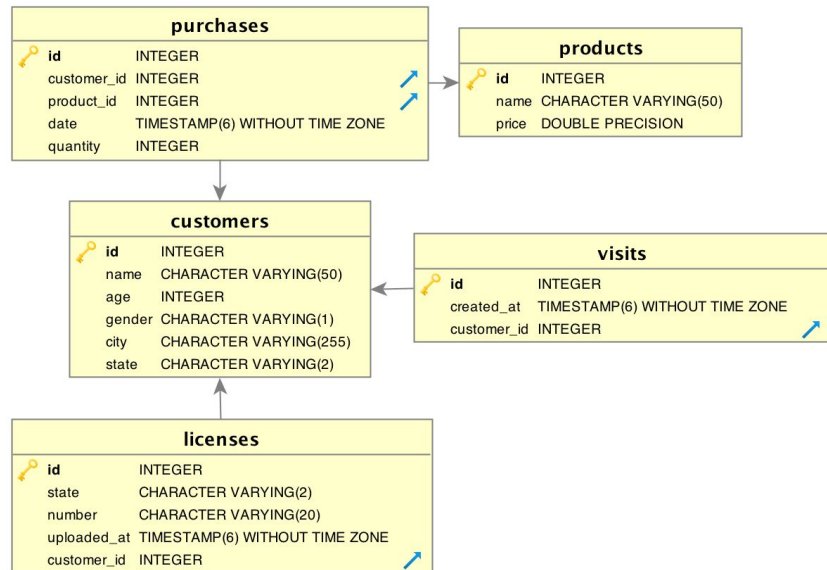- **Maintain** data consistency and integrity

It will require a Data Model

RDBMS Data Model

- **Schema** defines the structure of the data

- The **database** is composed of a number of user-defined **tables**

- Each **table** will have **columns** (aka fields) and **rows** (aka records)

- A column is of a given **data type**

- A row is an entry in a table with data for each column of that table

RDBMS and SQL (Structured Query Language)

- SQL is the language used to query relational databases

- **All RDBMS use SQL** and the syntax and keywords are the same for the most part, across systems

- **SQL is used to interact** with RDBMS, allowing you to create tables, alter tables, insert records, update records, delete records, and query records within and across tables.

- Even non-relational databases like **Hadoop** usually have a SQL-like interface available.

Question !

As a data scientist, what are the advantages of

storing, querying, and maintaining data in a SQL database

over curating your own flat files (e.g. csv files) ?

...

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PostGres Basics
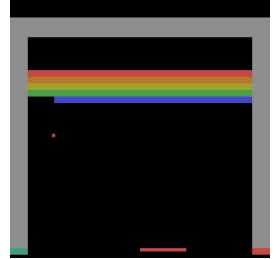
Ways to use psql in the shell/term:

`$ psql`   connects to postgres server

`$ psql -U [USERNAME]`   connects with given username

`$ psql [DBNAME]`   connects to a given database

`$ psql < script.sql`   reads file script.sql and send commands to psql

Try it live:
- *Open file sql/lecture_create.sql with a text editor*
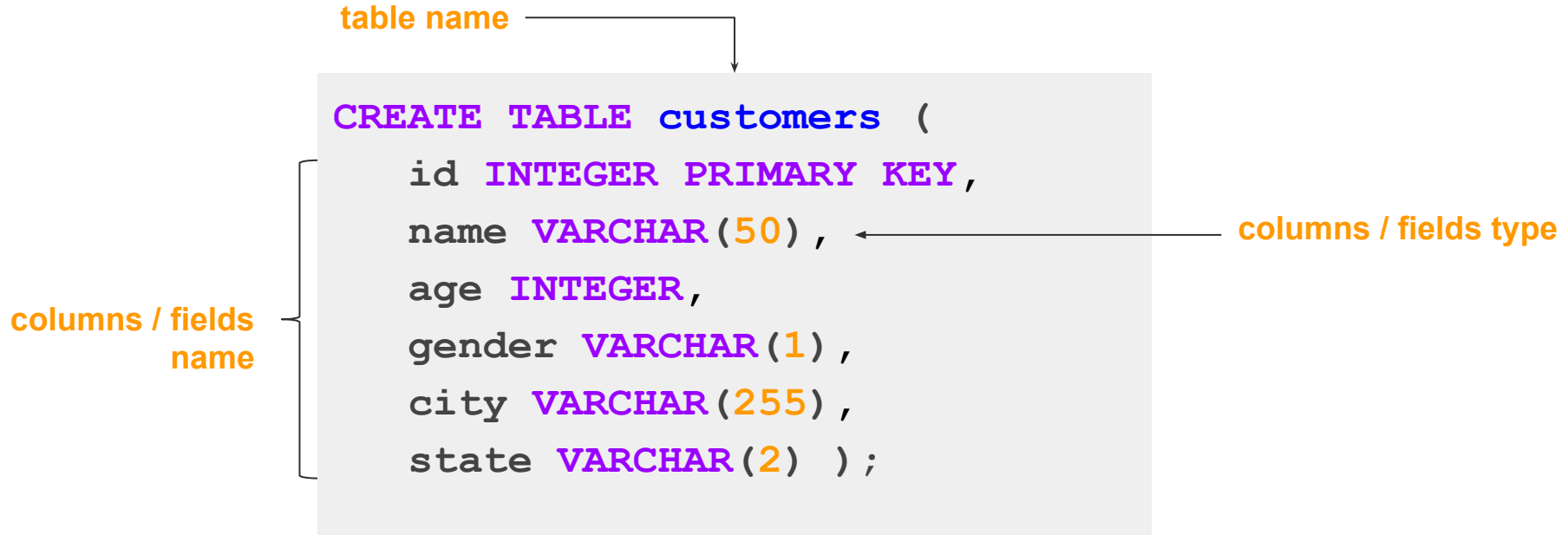- *Use it to create a "dsilecture" database on your psql server*

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PostGres Basics

Useful psql commands at the prompt [link]:

#	`\h`	SQL help
#	`\?`	psql commands help
#	`\l`	List all the tables in the database
#	`\d`	Describe the table schema
#	`\d db_name`	Describe tables for a specific db
#	`\connect db_name`	Connects to a database

Try it live: Connect to "dsilecture" and describe schema of table "customer"

Creating a table with a schema

table name

columns / fields type

columns / fields name

```sql
CREATE TABLE customers (
    id INTEGER PRIMARY KEY,
    name VARCHAR(50),
    age INTEGER,
    gender VARCHAR(1),
    city VARCHAR(255),
    state VARCHAR(2) );
```

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Inserting values in a table

table name

```
INSERT INTO products (id, name, price) VALUES
    (1, 'soccer ball', 20.5),
    (2, 'iPod', 200),
    (3, 'headphones', 50);
```

records
and their values

SQL Queries for table creation / maintenance

Creating a table from query:

```
CREATE [TEMPORARY] TABLE table AS <SQL query>;
```

Inserting records in a table:

```
INSERT INTO table [(c1,c2,c3,…)] VALUES (v1,v2,v3,…);
```

Updating records:

```
UPDATE table SET c1=v1,c2=v2,… WHERE cX=vX;
```

Delete records:

```
DELETE FROM table WHERE cX=vX;
```

Change model (add, drop, modify columns):

```
ALTER TABLE table [DROP/ADD/ALTER] column [datatype];
```

Delete a table:

```
DROP TABLE table;
```
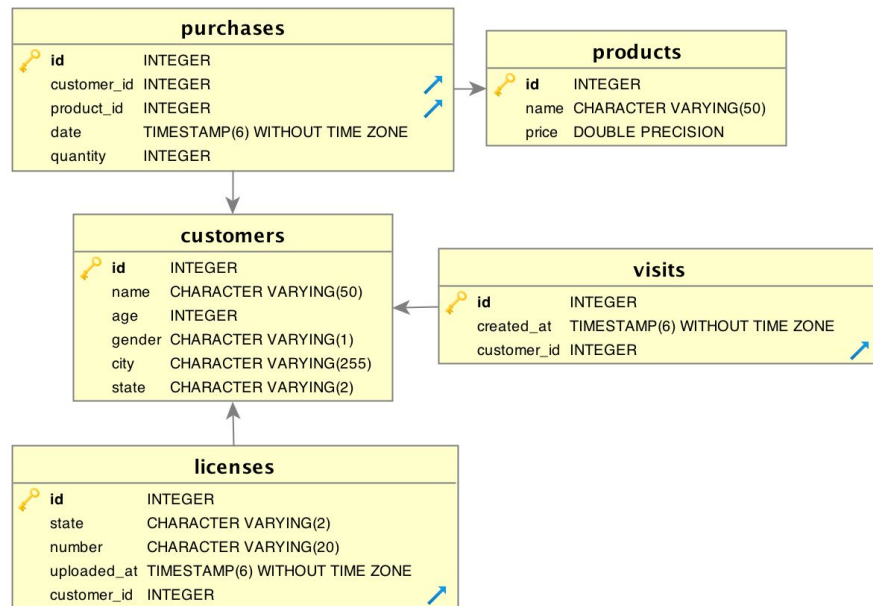
Designing a database with keys

Primary Key

A primary key is a special column of a table that uniquely identifies that entry.

A primary key is not always an integer; it could be a combination of columns, hash, timestamp..etc.,

Foreign Keys

Foreign Keys are columns that reference some other entry in the database.

purchases

id	INTEGER
customer_id	INTEGER
product_id	INTEGER
date	TIMESTAMP(6) WITHOUT TIME ZONE
quantity	INTEGER

products

id	INTEGER
name	CHARACTER VARYING(50)
price	DOUBLE PRECISION

customers

id	INTEGER
name	CHARACTER VARYING(50)
age	INTEGER
gender	CHARACTER VARYING(1)
city	CHARACTER VARYING(255)
state	CHARACTER VARYING(2)

visits

id	INTEGER
created_at	TIMESTAMP(6) WITHOUT TIME ZONE
customer_id	INTEGER

licenses

id	INTEGER
state	CHARACTER VARYING(2)
number	CHARACTER VARYING(20)
uploaded_at	TIMESTAMP(6) WITHOUT TIME ZONE
customer_id	INTEGER

SQL Syntax

All SQL queries have three main ingredient :

SELECT   *What* data do you want?

FROM   *Where* do you want to get the data from?

WHERE   *Under what* conditions?

SQL is Declarative rather than Imperative. That is, you tell the machine what you want and it (database optimizer) decides how to do it

Advanced: You can use `EXPLAIN` to look at the how

Select the columns name, age from the table users.

```
SELECT name, age
FROM customers
```

SQL always returns a table, so the output of the query above is a sub-table of users with 2 columns.
Select name and age for every user in users who live in CA.

```
SELECT name, age
FROM customers
WHERE state = 'CA'
```

SQL Examples

Open file sql/lecture_examples.sql

Run them in psql

JOIN

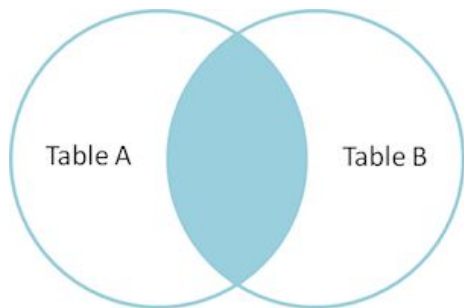JOIN clause used to query across multiple tables using foreign keys

Every JOIN has two segments:

Specifying the tables to JOIN
Specifying the columns to match

JOIN types

INNER JOIN
discards any entries
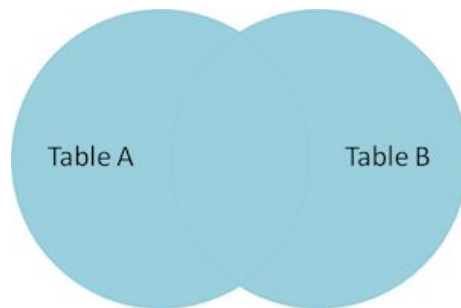that do not have a match
between the tables
based on the given keys.

LEFT OUTER JOIN
keeps all entries
in the left table
regardless of
whether a match is found
in the right table
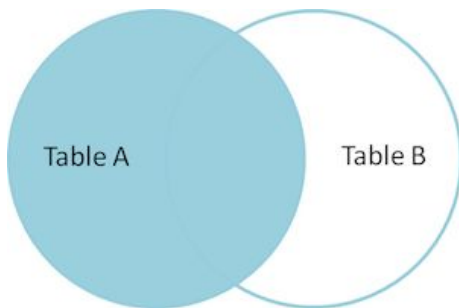
FULL OUTER JOIN
will keep the rows
of both tables
no matter what

copied from http://blog.codinghorror.com/a-visual-explanation-of-sql-joins/
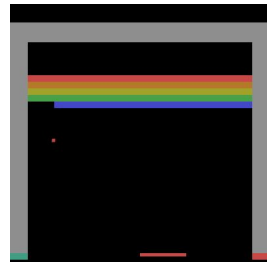
Question ! (JOIN the fun)

How many rows would result after an
(inner join, left join, right join, full outer join) on `department_id` ?

employee_id	department_id	name	salary
2	1	Jon	40000
7	1	Linda	50000
12	2	Ashley	15000
1	0	Mike	80000

department_id	location
1	NY
2	SF
3	Austin

Given the following query, number what order the commands are executed:

```sql
SELECT a.userid, count(0) as recent_visits
FROM users a
LEFT JOIN visits b
ON a.userid = b.userid
WHERE b.dt > '2012-01-01'
GROUP BY a.userid
HAVING count(0) < 10
ORDER BY recent_visits;
```

Order of Evaluation of a SQL SELECT Statement

1. FROM + JOIN: first the product of all tables is formed

2. WHERE: the where clause filters rows that do not meet the search condition

3. GROUP BY + (COUNT, SUM, etc): the rows are grouped using the columns in the group by clause and the aggregation functions are applied on the grouping

4. HAVING: like the WHERE clause, but can be applied after aggregation

5. SELECT: the targeted list of columns are evaluated and returned

6. DISTINCT: duplicate rows are eliminated

7. ORDER BY: the resulting rows are sorted

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Subqueries

In general, you can replace any table name with a SELECT statement.
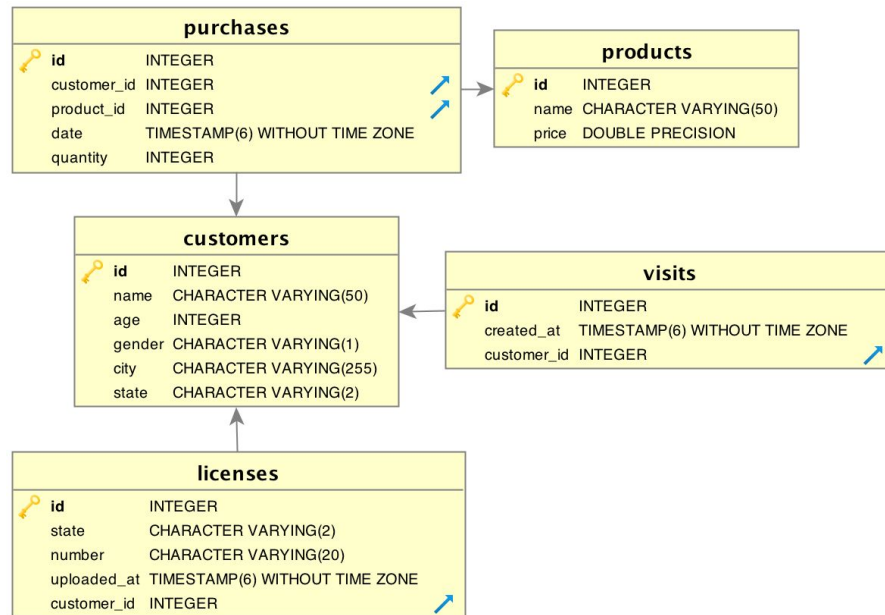
```
SELECT ..... FROM (SELECT ....)
```

If a query returns a **single value**, you can treat it as such.

```
WHERE var1 = (SELECT ...)
```

If a query returns a **single column**, you can treat it sort of like a list/vector

```
WHERE var1 IN (SELECT ...)
```

Database Normalization

- Minimizes Redundancy, for example:
  - Details about a user(address, age) are only stored once (in a users table)
  - Any other table (eg. purchases) where this data might be relevant, only references the user_id
  - Choose Normalized or Denormalized Schemas based on the use case:
    - Heavy reporting (Data Warehouse)
    - Transactional Systems (Ordering System)

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Advanced SQL

- "self join": JOIN a table with itself:
  https://www.w3resource.com/sql/joins/perform-a-self-join.php
- CROSS JOIN: join each row in table A with every row in table B:
  https://www.w3resource.com/sql/joins/cross-join.php
- window functions:
  https://www.postgresql.org/docs/9.1/static/tutorial-window.html
- COALESCE: often used to turn NULL values into non-null values:
  https://www.postgresql.org/docs/9.5/static/functions-conditional.html
- EXCEPT: return rows from one SELECT statement that are NOT returned by a second SELECT statement:
  https://www.tutorialspoint.com/sql/sql-except-clause.htm