SQL Lesson 1

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Introduction

Introduction

Roadmap

- Introducing Scenario
- Database Concepts & Motivation
- Data Model
- SQL
  - Language
  - SELECT
  - WHERE
  - GROUP BY

Introduction

Our Scenario Today

We are running a bookstore collectively (just like the left-wing leaning bookstore on campus **The Groundwork Books Collective**). How do you manage your book inventory?

- What are some **common operations** that you want to do to your inventory? (CRUD)
- What are some **tool(s)** that you can think of to support your operation on the inventory?
- With these tool(s), what are some **problems** that might emerge in the foreseeable future?

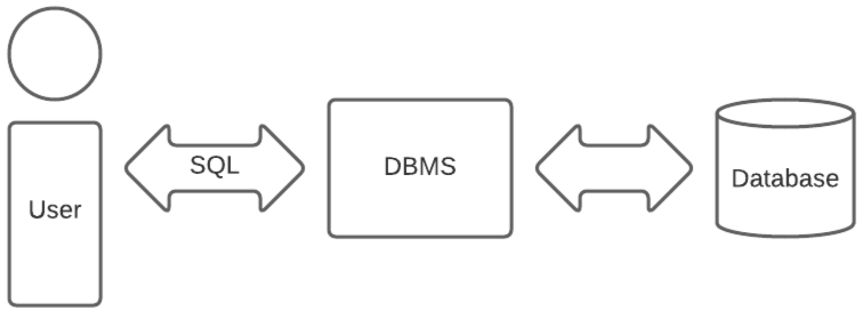
Using database and database management system, many of these concerns will be addressed.

Note: These problems and solutions are generalizable.

Introduction

Database related concepts

- **Database**: Shared collection of related data used to support the activities of a particular organization.
- **Database Management System(DBMS)**: Programs that support CRUD operations and control all access to databases.
    - Provide an environment that is both **convenient** and **efficient** for users to retrieve and store information
- **SQL**: Structured Query Language - language used to talk to DBMS



Introduction

Formalized Motivation

- **Automation**. Interface linking to other programs
- **Summary Statistics**. Help you generate the report
- **Enforcement of Integrity constraints**. Rules to constraints that users enter valid information (**data type!**)
- **Multiuser system**. Control for access, data sharing
    - e.g. Read and write, read-only
- **Backup and recovery facilities**.

Data Model

Data model

A bird-eye view of our data

```
books
```

```
## # A tibble: 13 x 5
##    title              author        ISBN13    avg_rating publisher
##    <chr>              <chr>         <chr>          <dbl> <chr>
##  1 Beyond Good and Ev~ Friedrich Ni~ 97806797~       3.99 Vintage
##  2 Sanshiro           Natsume Sose~ 97819292~       3.83 Center for Japanese S~
##  3 The World of Yeste~ Stefan Zweig  97808032~       4.49 University of Nebrask~
##  4 Chronicle of the N~ Alvar Nunez ~ 97801424~       3.66 Penguin Classics
##  5 The Epic of Gilgam~ Anonymous     97801410~       3.7  Penguin Books Limited
##  6 Letter from an Unk~ Stefan Zweig  97819065~       4.23 Pushkin Press
##  7 Gorgias            Plato         97801404~       3.96 Penguin Classics
##  8 Twelfth Night      William Shak~ 97807434~       3.98 Simon Schuster
##  9 Leviathan          Thomas Hobbes 97801404~       3.71 Penguin Books
## 10 The Essays: A Sele~ Michel de Mo~ 97801404~       4.07 Penguin Classics
## 11 The Prince         Niccolo Mach~ 97801404~       3.82 Penguin Group
## 12 Second Treatise of~ John Locke    97809151~       3.77 Hackett Publishing Co~
## 13 Candide and Relate~ Voltaire      97808722~       3.81 Hackett Publishing Co~
```

```
customers
```

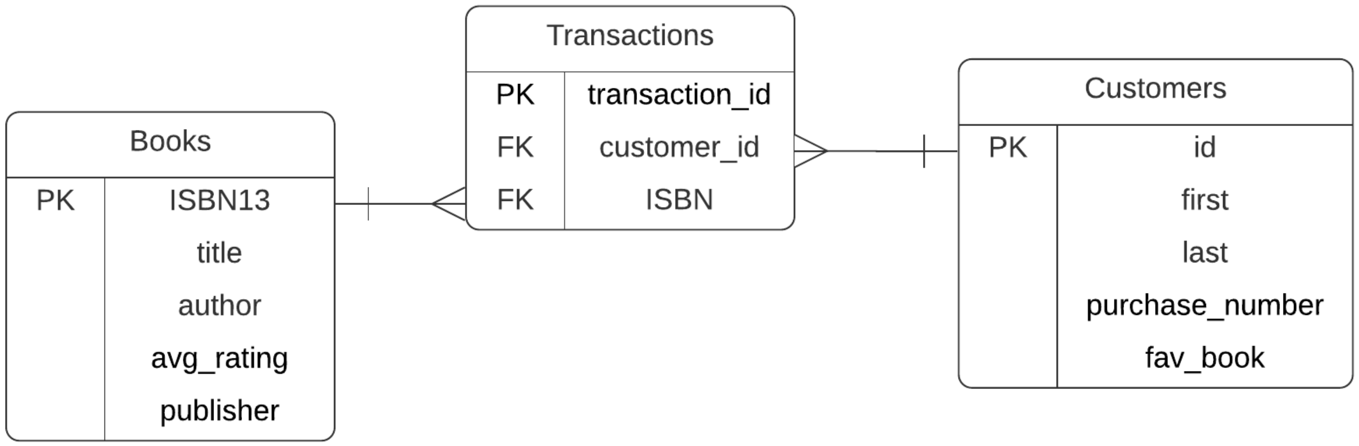
```
## # A tibble: 5 x 5
##      id first   last       purchase_number      fav_book
##   <dbl> <chr>   <chr>                <dbl>         <dbl>
## 1 11111 Philip  Fry                      2 9780872205468
## 2 11112 Turanga Leela                    1 9780141026282
## 3 11113 Hubert  Farnsworth               3 9780140449150
## 4 11114 Amy     Wong                     2 9781929280100
## 5 11115 Hermes  Conrad                   1 9780142437070
```

```
transactions
```

```
## # A tibble: 8 x 3
##   transaction_id customer_id          ISBN
##            <dbl>       <dbl>         <dbl>
## 1              1       11111 9780872205468
## 2              2       11111 9780140449044
## 3              3       11112 9780141026282
## 4              4       11113 9780140449150
## 5              5       11113 9780872205468
## 6              6       11114 9781929280100
## 7              7       11114 9780743482776
## 8              8       11115 9780142437070
```

Data Model

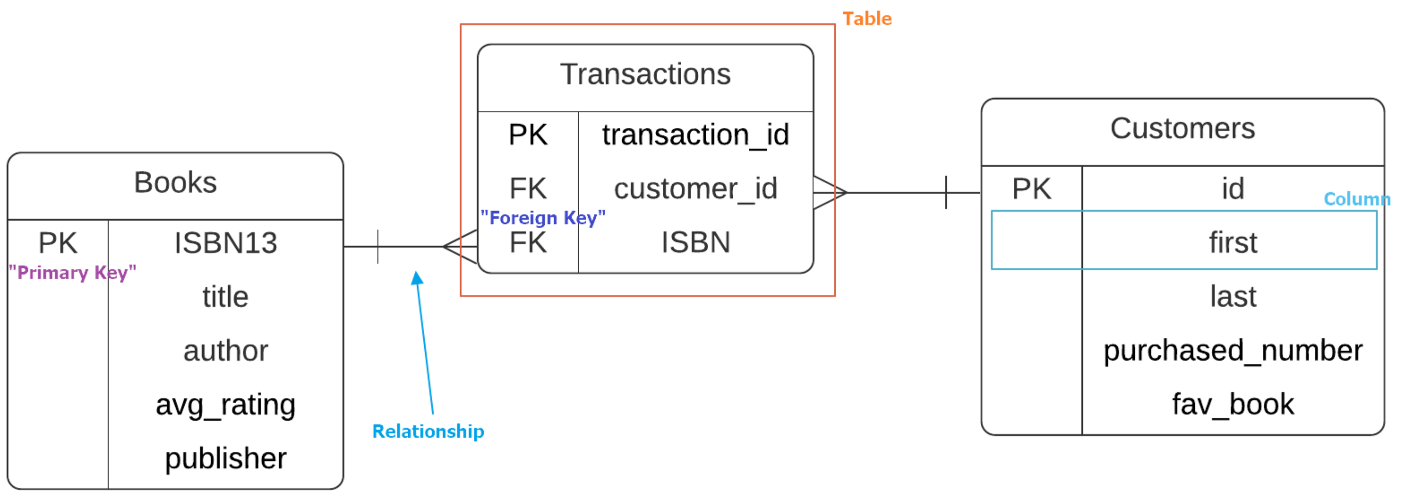
Entity-Relationship Diagram



Data Model

Anatomy of a Database

- **Primary Key**: The column that uniquely identify each row in a table
- **Foreign Key**: A column in a table that references the primary key in another table



Question: There is a missing relation. Can you spot it?

SQL

SQL

Introduction

- SQL stands for **S**tructured **Q**uery **L**anguage
- Use SQL to talk to a DBMS
- Pronounced “SQL” or “Sequel”
- It is the amalgamation of
  - a data query Language (R)
    Our Focus
  - a data definition language (C)
  - a data control language (Access)
  - a data manipulation language (UD)

SQL

Introduction

- SQL is formally defined, but implemented differently
    - **Incompatibility**, but very similar. You only need to learn it once.
    - Popular Extensions: MySQL, PostgreSQL,
    - We will be using **SQLite**
- Run from

1. command line prompt
2. Dedicated Program like DB Browser
3. Other programming languages such as Python and R, with dedicated libraries

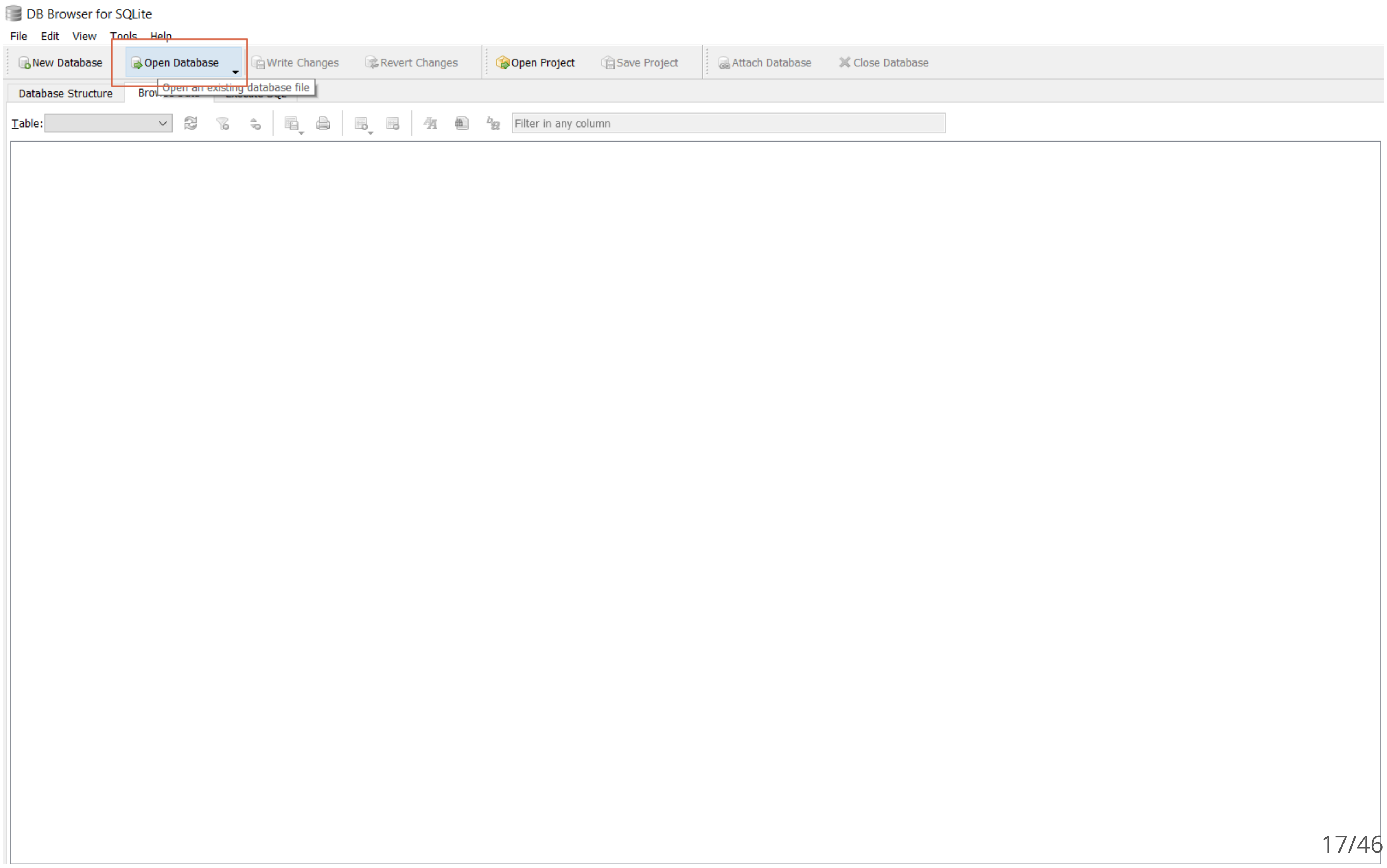
SQL

Language & Syntax

- **Case Insensitive!**
  - UPPERCASE FOR KEYWORDS
  - lowercase for anything else
- End your statement with ‘;’
  - empowers nice formatting

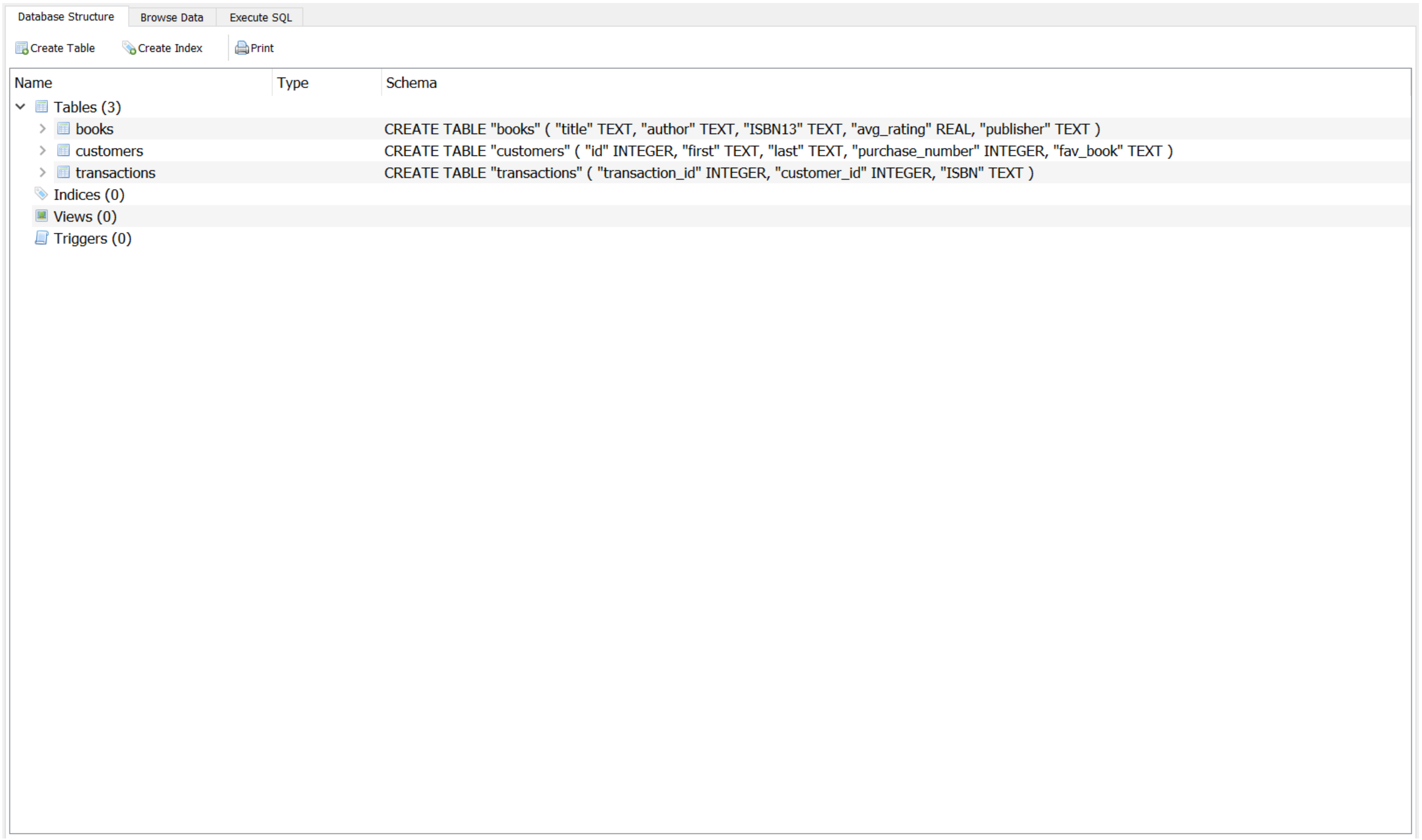
A Tour of DB Browser

Open Existing Database



A Tour of DB Browser

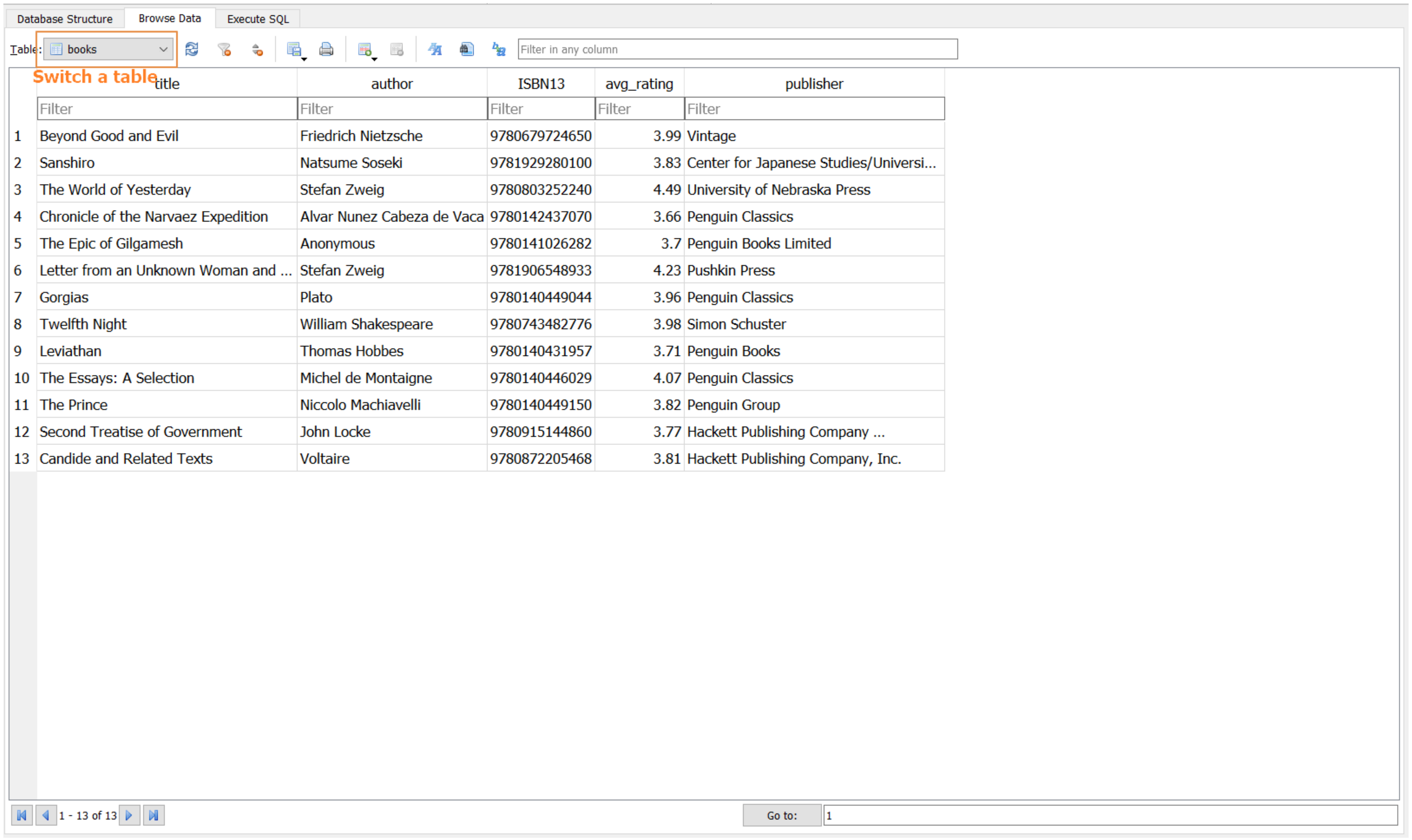
Database Structure



Name	Type	Schema
Tables (3)		
books		CREATE TABLE "books" ("title" TEXT, "author" TEXT, "ISBN13" TEXT, "avg_rating" REAL, "publisher" TEXT)
customers		CREATE TABLE "customers" ("id" INTEGER, "first" TEXT, "last" TEXT, "purchase_number" INTEGER, "fav_book" TEXT)
transactions		CREATE TABLE "transactions" ("transaction_id" INTEGER, "customer_id" INTEGER, "ISBN" TEXT)
Indices (0)		
Views (0)		
Triggers (0)		

A Tour of DB Browser

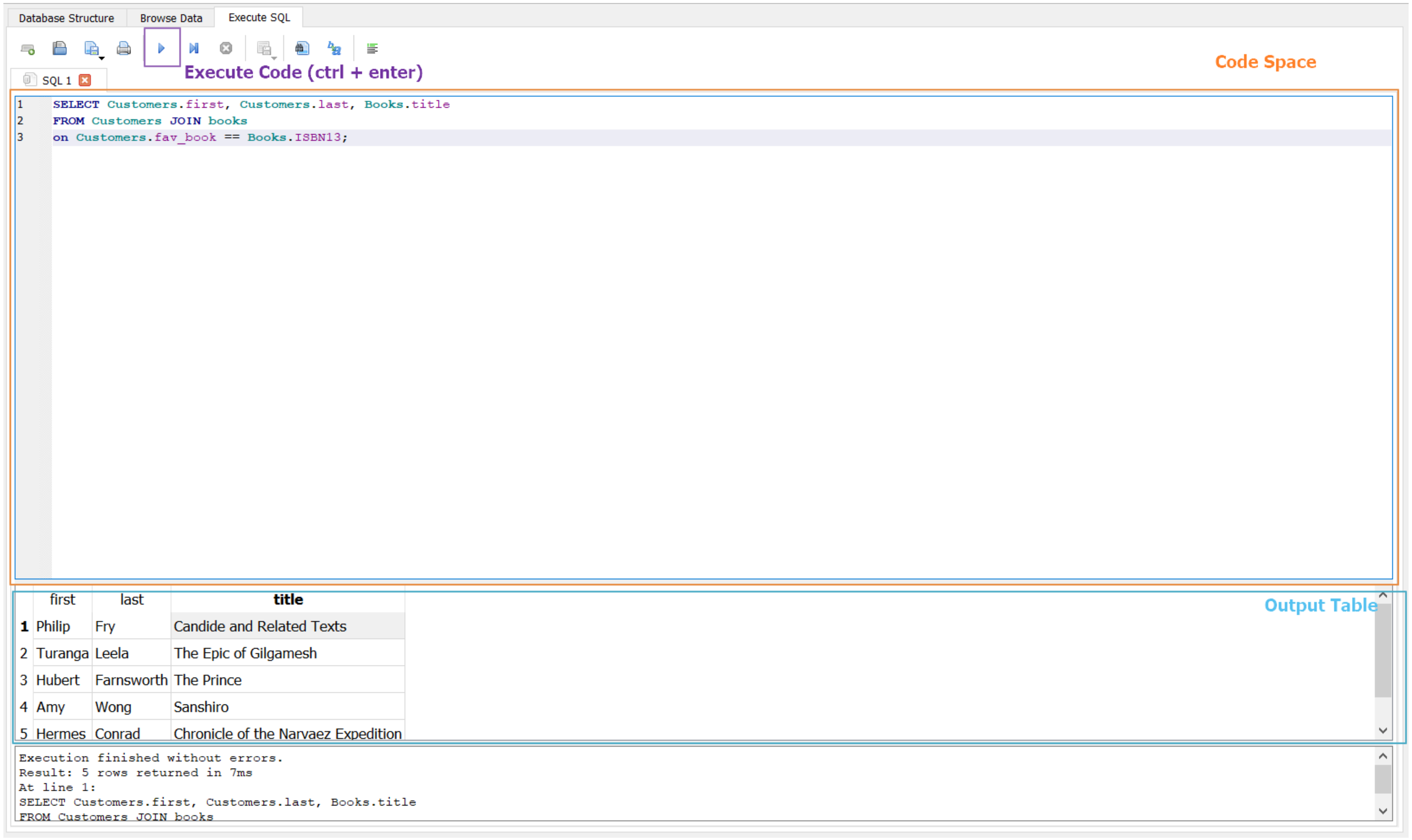
Browse Data



	title	author	ISBN13	avg_rating	publisher
1	Beyond Good and Evil	Friedrich Nietzsche	9780679724650	3.99	Vintage
2	Sanshiro	Natsume Soseki	9781929280100	3.83	Center for Japanese Studies/Universi...
3	The World of Yesterday	Stefan Zweig	9780803252240	4.49	University of Nebraska Press
4	Chronicle of the Narvaez Expedition	Alvar Nunez Cabeza de Vaca	9780142437070	3.66	Penguin Classics
5	The Epic of Gilgamesh	Anonymous	9780141026282	3.7	Penguin Books Limited
6	Letter from an Unknown Woman and ...	Stefan Zweig	9781906548933	4.23	Pushkin Press
7	Gorgias	Plato	9780140449044	3.96	Penguin Classics
8	Twelfth Night	William Shakespeare	9780743482776	3.98	Simon Schuster
9	Leviathan	Thomas Hobbes	9780140431957	3.71	Penguin Books
10	The Essays: A Selection	Michel de Montaigne	9780140446029	4.07	Penguin Classics
11	The Prince	Niccolo Machiavelli	9780140449150	3.82	Penguin Group
12	Second Treatise of Government	John Locke	9780915144860	3.77	Hackett Publishing Company ...
13	Candide and Related Texts	Voltaire	9780872205468	3.81	Hackett Publishing Company, Inc.

A Tour of DB Browser

Execute SQL



```
SELECT Customers.first, Customers.last, Books.title
FROM Customers JOIN books
on Customers.fav_book == Books.ISBN13;
```

	first	last	title
1	Philip	Fry	Candide and Related Texts
2	Turanga	Leela	The Epic of Gilgamesh
3	Hubert	Farnsworth	The Prince
4	Amy	Wong	Sanshiro
5	Hermes	Conrad	Chronicle of the Narvaez Expedition

```
Execution finished without errors.
Result: 5 rows returned in 7ms
At line 1:
SELECT Customers.first, Customers.last, Books.title
FROM Customers JOIN books
```

Non-relational Operations

Overview

- If you have taken the R module, you know them all already

WHEN YOU REALIZED
YOUR R SKILL HELPS YOUR SQL
imgflip.com

Non-relational Operations

Overview

- Select columns: SELECT column(s) FROM table
- Select unique rows: SELECT distinct rows from your table
- Sort by a column: ORDER BY a column
- Filter rows by a condition: WHERE [criteria]
- Calculate new values on the fly
- Calculate summary statistics with functions
- Aggregate over groups: GROUP BY

SELECT

```
-- syntax
SELECT [column(s)] FROM table;
```

Select ‘title’ and ‘author’ column from table ‘books’

```
SELECT title, author FROM books;
```

In R:

```
books %>% select(title, author)
```

SELECT

SELECT *

- Select all columns in a table
- Note '*' is called wild card

```
-- syntax
SELECT * FROM [table]
```

Select all columns in table books

```
SELECT * FROM books;
```

```
books %>% select_all()
```

SELECT

SELECT DISTINCT

Select distinct rows from selected column(s) in a table

```
SELECT DISTINCT [column(s)] FROM [table];
```

Question: How many books are sold (not how many total copies of books)?

```
SELECT DISTINCT ISBN FROM transactions;
```

In R:

```
transactions %>% select(ISBN) %>% unique()
```

SELECT

ORDER BY

- Select out columns from table, ordered by column(s), in ascending order (or descending order)

```
SELECT [column(s)] FROM [table] ORDER BY [column(s)] [DESC];
```

Question: Explain this statement in plain English

```
SELECT title, author FROM books ORDER BY author DESC;
```

```
books %>% select(title, author) %>% arrange(author) # ascending order
books %>% select(title, author) %>% arrange(desc(author)) # descending order
```

Question

Using SELECT and ORDER BY, find out who purchased the most books.

Hint: Sort the customers table by what column? In which order?

Review

Concepts

- What is the distinction between Database, Database Management System, and SQL? How do they relate to each other?
- What is a foreign key? What is a primary key? Why are they important to a relational database?
- What are two language features of SQL (Case sensitive? End statements with?)

Review

SQL

```
SELECT [column(s)] FROM [table];
SELECT * FROM [table];
SELECT DISTINCT [column(s)] FROM [table];
SELECT [column(s)] FROM [table] ORDER BY [column(s)] [DESC];
```

- Write a query to select the first and last name from `Customers` table
- Write a query to select the entirety of the `Customers` table
- Write a query to find out how many **distinct** customers have purchased books from the `Transactions` table
- Write a query to sort the `Books` table using the `title` column, in descending order.

Today

- WHERE
- Calculation on the fly
- Aggregate Function
- Group By

Boolean Algebra

- Two values: TRUE, FALSE
- Operators: AND(&), OR(|), NOT(!)

AND

AND	TRUE	FALSE
TRUE	TRUE	FALSE
FALSE	FALSE	FALSE

OR

OR	TRUE	FALSE
TRUE	TRUE	TRUE
FALSE	TRUE	FALSE

NOT

NOT	TRUE	FALSE
	FALSE	TRUE

Boolean Algebra

Practice

- (1 < -1) OR (0 == 0)
- (1 < -1) AND (-1 < 2)

WHERE

- Use WHERE clause to keep rows according to a certain criteria

```
-- syntax
SELECT [column(s)] FROM [table]
WHERE [criteria return True];
```

Who purchased more than 1 books?

```
-- notice how purchase_number is NOT in the outcome
SELECT first, last FROM customers
WHERE purchase_number >= 2;
```

In R:

```
customers %>% filter(purchase_number >= 2) %>% select(first, last)
```

WHERE

compound criteria, LIKE, IN

Whose First name started with letter A or L?

```
SELECT first, last FROM customers
WHERE (first LIKE 'A%') OR (last LIKE 'L%');
```

What books did customers whose id is 11111 and 11112 purchase?

```
SELECT * FROM transactions
WHERE customer_id IN (11111,11112);
```

Question (manual join): I also want to know who these customers and what books are. Using WHERE, how can I find out about these information?

Question: I want to check who purchased between 1 and 3 books. What is wrong with the following code?

```sql
SELECT first, last, purchase_number FROM customers
WHERE (purchase_number > 1) OR (purchase_number < 3);
```

Or in R:

```r
customers %>% filter(purchase_number > 1 & purchase_number < 3)
```

Calculation on the fly

'||', Renaming using AS

Column-wise operations:

```
SELECT first || ' ' || last AS full_name
FROM customers;
```

Aggregate Function

```sql
-- syntax
SELECT [function(column(s))] FROM [table]
```

What is the average rating of the books?

```sql
SELECT avg(avg_rating) FROM books;
```

- List of aggregate functions
  - avg(X)
  - count(X)
  - min(X)
  - max(X)
  - sum(X)

Aggregate Function

Practice

Question: What is the total number of purchases in *Transactions* table? What is the total number of purchases in *Customers* table? Do they match? This illustrate the principle of **single source of truth**

Group By

- Usually used with aggregate functions

```
-- syntax
SELECT [function(column(s))] FROM table
GROUP BY [column(s)];
```

Example: What is the number of purchases by each person in transaction table?

```
SELECT customer_id, count(*) FROM transactions
GROUP BY customer_id;
```

In R:

```
transactions %>% group_by(customer_id) %>% summarize(n = n())
```

whose record did we miss?

Join

Combine data from multiple tables

```
SELECT [table1.column(s), table2.column(s)] FROM [table1 JOIN table2]
ON [table1.columnX == table2.columnY, ...];
```

How do we get information about each customers’ `fav_book`? Not just the ISBN, but the title, author…

Can we do:

```
SELECT Customers.last || " " || Customers.first, Customers.fav_book, Books.ISBN13, Books.title, Book
FROM Customers JOIN Books;
```

What did that statement do?

Join

To tell SQL the specific columns we are joining, use `ON`:

```
SELECT Customers.first|| " " || Customers.last, Customers.fav_book, Books.ISBN13, Books.title, Books
FROM Customers JOIN Books
ON Customers.fav_book == Books.ISBN13;
```

Question: 1. Use `Where`, filter out all the transactions made to customers whose IDs are `11111` and `11112` 2. Use `JOIN`, find out who they are, and 3. Use `JOIN`, find out what books they purchased.

RSQLite

SQLite in R

Where to go from here?

Software Carpentry

Big data - Google BigQuery!