

Object Oriented Programming (Using Python)

UNIT- V

Using Databases with Python:

- Using Databases
- Single Table CRUD (Create, Read, Update, and Delete)
- Designing and representing a data model
- Reconstructing data with JOIN
- Many-to-many relationships

Prof. R. MADANA MOHANA

Professor, Artificial Intelligence & Data Science

<http://rmadanamohana.com/>

References

<https://www.coursera.org/learn/python-databases/home/info>

<https://www.py4e.com/book>

http://do1.dr-chuck.com/pythonlearn/EN_us/pythonlearn.pdf

<https://www.py4e.com/code3/>

<https://www.py4e.com/lectures3/>

<https://www.youtube.com/playlist?list=PLIRFEj9H3Oj7Bp8-DfGpfAfDBibIRfl5p>

<http://sqlitebrowser.org/>

Designing a Data Model

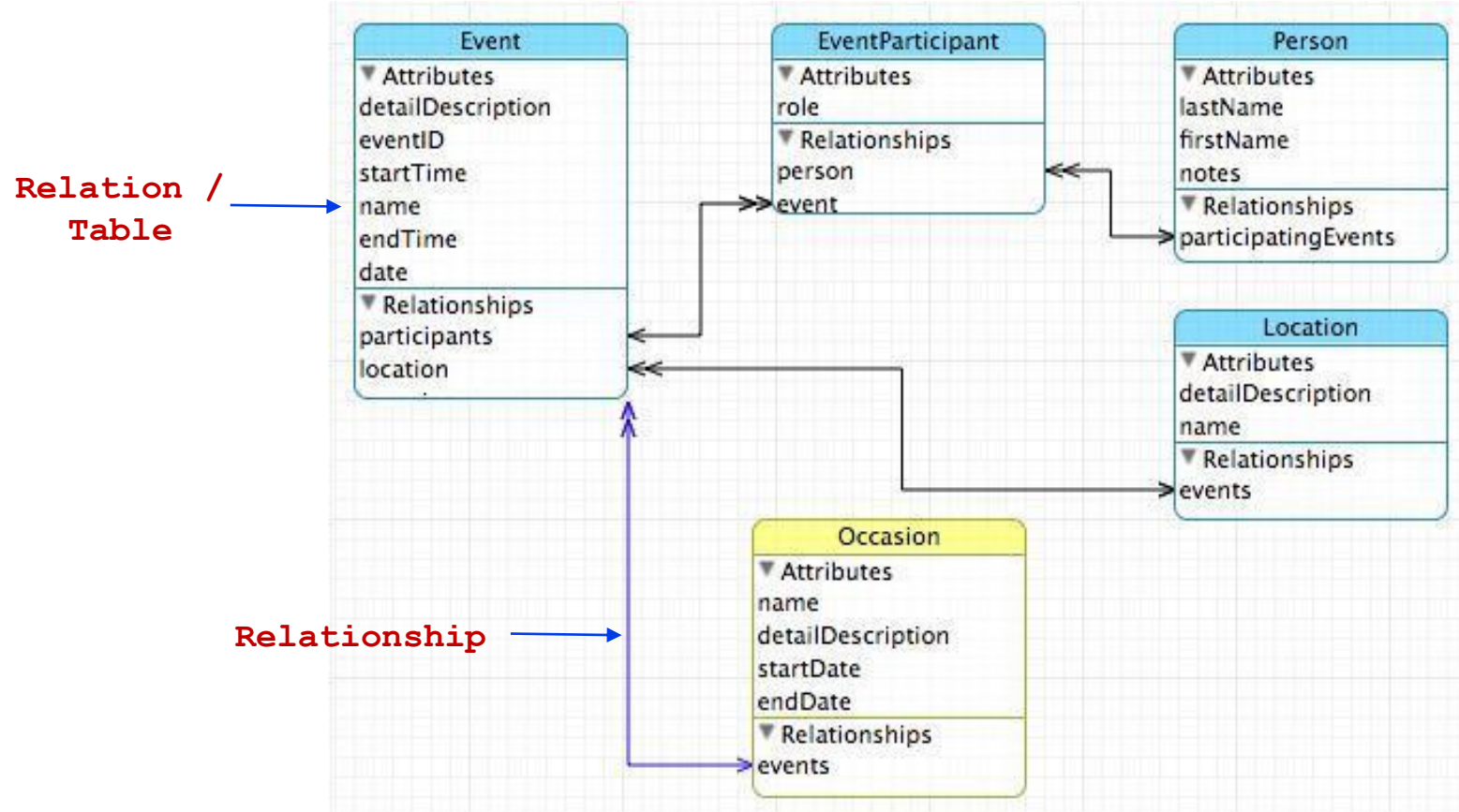
Database Model

- A **database model** or **database schema** is the **structure** or **format of a database**, described in a formal language supported by the **database management system**.
- In other words, a “**database model**” is the application of a data model when used in conjunction with a **database management system**.

Database Design

- **Database design** is an **art form** of its own with particular skills and experience
- Our **goal** is to **avoid** the really **bad mistakes** and **design clean** and easily understood databases
- Others may performance tune things later
- **Database design** starts with a picture...

Database Design



Building a Data Model

- Drawing a picture of the data objects for our application and then figuring out how to represent the objects and their relationships
- **Basic Rule:** Don't put the same string data in twice - use a relationship instead
- When there is one thing in the “**real world**” there should be one copy of that thing in the database

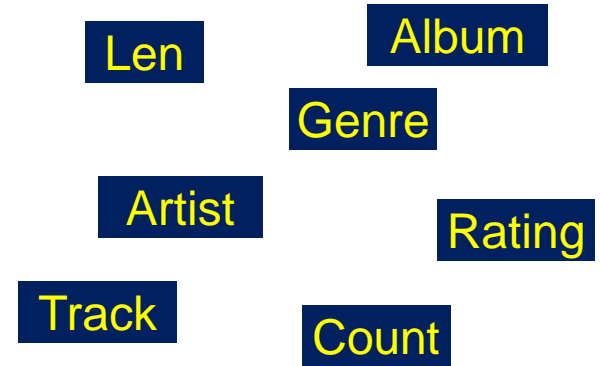
Building a Data Model - Example

Track	Len	Artist	Album	Genre	Rating	Count
<input checked="" type="checkbox"/> Hells Bells	5:13	AC/DC	Who Made Who	Rock	★★★★★	61
<input checked="" type="checkbox"/> Shake Your Foundations	3:54	AC/DC	Who Made Who	Rock	★★★★★	70
<input checked="" type="checkbox"/> Chase the Ace	3:01	AC/DC	Who Made Who	Rock		56
<input checked="" type="checkbox"/> For Those About To Rock (We ...	5:54	AC/DC	Who Made Who	Rock	★★★★★	61
<input checked="" type="checkbox"/> Dúlamán	3:43	Altan	Natural Wonders M...	New Age		31
<input checked="" type="checkbox"/> Rode Across the Desert	4:10	America	Greatest Hits	Easy Listen...	★★★★★	23
<input checked="" type="checkbox"/> Now You Are Gone	3:08	America	Greatest Hits	Easy Listen...	★★★★★	18
<input checked="" type="checkbox"/> Tin Man	3:30	America	Greatest Hits	Easy Listen...	★★★★★	23
<input checked="" type="checkbox"/> Sister Golden Hair	3:22	America	Greatest Hits	Easy Listen...	★★★★★	24
<input checked="" type="checkbox"/> Track 01	4:22	Billy Price	Danger Zone	Blues/R&B	★★★★★	26
<input checked="" type="checkbox"/> Track 02	2:45	Billy Price	Danger Zone	Blues/R&B	★★★★★	18
<input checked="" type="checkbox"/> Track 03	3:26	Billy Price	Danger Zone	Blues/R&B	★★★★★	22
<input checked="" type="checkbox"/> Track 04	4:17	Billy Price	Danger Zone	Blues/R&B	★★★★★	18
<input checked="" type="checkbox"/> Track 05	3:50	Billy Price	Danger Zone	Blues/R&B	★★★★★	21
<input checked="" type="checkbox"/> War Pigs/Luke's Wall	7:58	Black Sabbath	Paranoid	Metal	★★★★★	25
<input checked="" type="checkbox"/> Paranoid	2:53	Black Sabbath	Paranoid	Metal	★★★★★	22
<input checked="" type="checkbox"/> Planet Caravan	4:35	Black Sabbath	Paranoid	Metal	★★★★★	25
<input checked="" type="checkbox"/> Iron Man	5:59	Black Sabbath	Paranoid	Metal	★★★★★	26
<input checked="" type="checkbox"/> Electric Funeral	4:53	Black Sabbath	Paranoid	Metal	★★★★★	22
<input checked="" type="checkbox"/> Hand of Doom	7:10	Black Sabbath	Paranoid	Metal	★★★★★	23
<input checked="" type="checkbox"/> Rat Salad	2:30	Black Sabbath	Paranoid	Metal	★★★★★	31
<input checked="" type="checkbox"/> Jack the Stripper/Fairies Wear ...	6:14	Black Sabbath	Paranoid	Metal	★★★★★	24
<input checked="" type="checkbox"/> Bomb Squad (TECH)	3:28	Brent	Brent's Album			1
<input checked="" type="checkbox"/> clay techno	4:36	Brent	Brent's Album			2
<input checked="" type="checkbox"/> Heavy	3:08	Brent	Brent's Album			1
<input checked="" type="checkbox"/> Hi metal man	4:20	Brent	Brent's Album			1
<input checked="" type="checkbox"/> Mistro	2:58	Brent	Brent's Album			1

Building a Data Model - Example

For each “piece of info”...

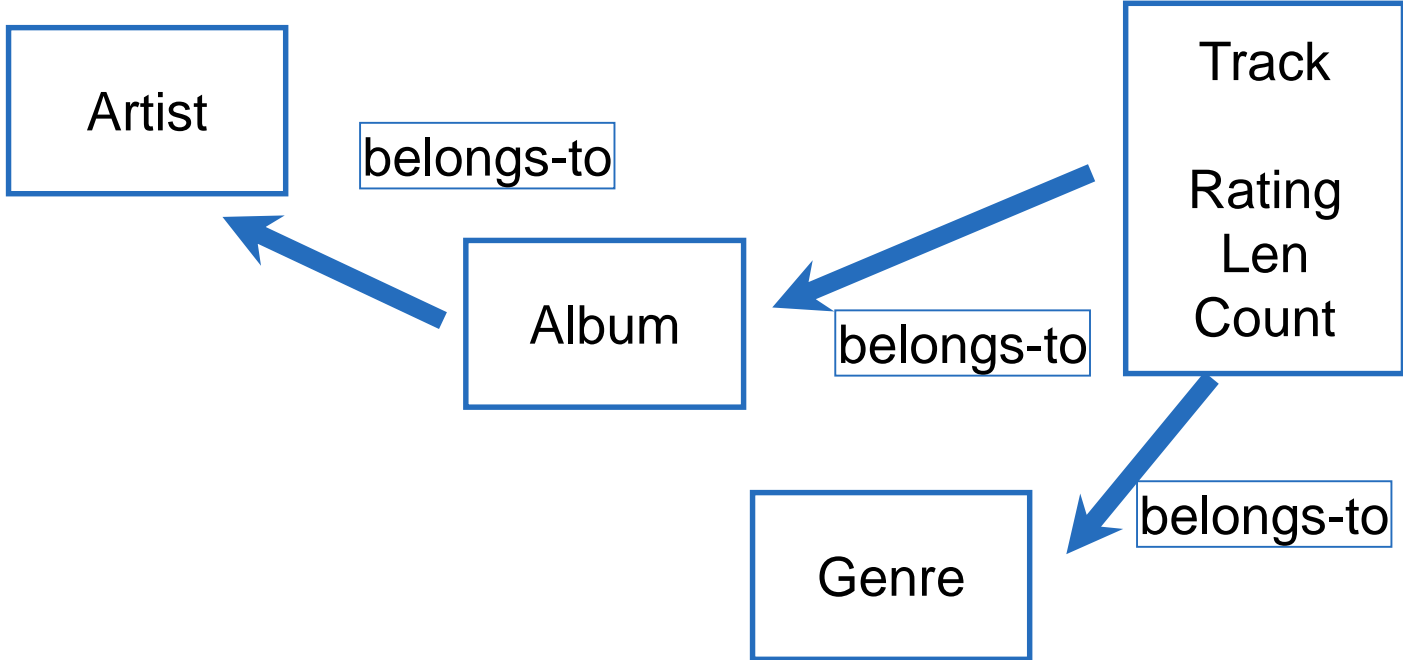
- Is the **column** an **object** or an **attribute** of another object?
- Once we define **objects**, we need to define the **relationships** between **objects**



<input checked="" type="checkbox"/> Hells Bells	5:13	AC/DC	Who Made Who	Rock	★★★★★	61
<input checked="" type="checkbox"/> Shake Your Foundations	3:54	AC/DC	Who Made Who	Rock	★★★★★	70
<input checked="" type="checkbox"/> Chase the Ace	3:01	AC/DC	Who Made Who	Rock		56
<input checked="" type="checkbox"/> For Those About To Rock (We ...	5:54	AC/DC	Who Made Who	Rock	★★★★★	61
<input checked="" type="checkbox"/> Dúlamán	3:43	Altan	Natural Wonders M...	New Age		31
<input checked="" type="checkbox"/> Rode Across the Desert	4:10	America	Greatest Hits	Easy Listen...	★★★★★	23
<input checked="" type="checkbox"/> Now You Are Gone	3:08	America	Greatest Hits	Easy Listen...	★★★★★	18
<input checked="" type="checkbox"/> Tin Man	3:30	America	Greatest Hits	Easy Listen...	★★★★★	22

Building a Data Model - Example

Track
 Album
 Artist
 Genre
 Rating
 Len
 Count



<input checked="" type="checkbox"/>	Hells Bells	5:13	AC/DC	Who Made Who	Rock	★★★★★	61
<input checked="" type="checkbox"/>	Shake Your Foundations	3:54	AC/DC	Who Made Who	Rock	★★★★★	70
<input checked="" type="checkbox"/>	Chase the Ace	3:01	AC/DC	Who Made Who	Rock		56
<input checked="" type="checkbox"/>	For Those About To Rock (We ...	5:54	AC/DC	Who Made Who	Rock	★★★★★	61
<input checked="" type="checkbox"/>	Dúlamán	3:43	Altan	Natural Wonders M...	New Age		31
<input checked="" type="checkbox"/>	Rode Across the Desert	4:10	America	Greatest Hits	Easy Listen...	★★★★★	23
<input checked="" type="checkbox"/>	Now You Are Gone	3:08	America	Greatest Hits	Easy Listen...	★★★★★	18
<input checked="" type="checkbox"/>	Tip Man	7:20	America	Greatest Hits	Easy Listen...	★★★★★	22

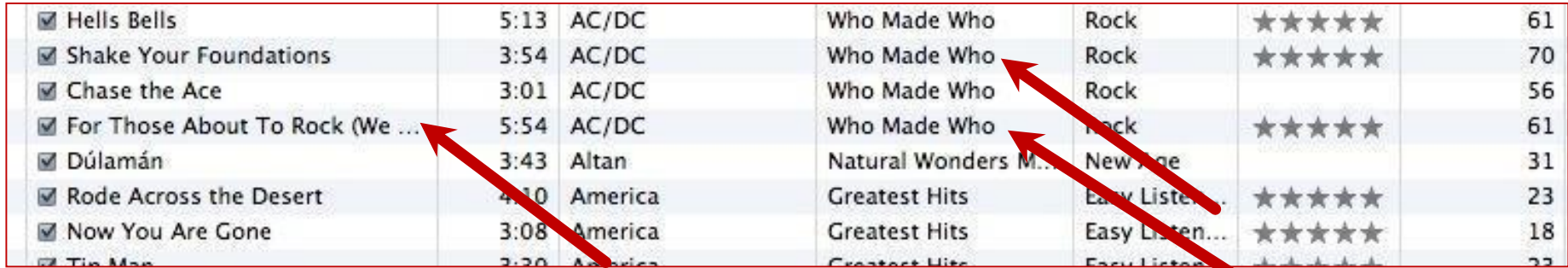
Representing Relationships in Database

Database Normalization (3NF)

- There is ***tons*** of database theory - way too much to understand without excessive predicate calculus
- **Do not replicate data** - reference data - point at data
- Use **integers for keys** and for references
- Add a special **“key”** column to each table which we will make references to. By convention, many programmers call this column **“id”**

Database Normalization (3NF)

<input checked="" type="checkbox"/> Hells Bells	5:13	AC/DC	Who Made Who	Rock	★★★★★	61
<input checked="" type="checkbox"/> Shake Your Foundations	3:54	AC/DC	Who Made Who	Rock	★★★★★	70
<input checked="" type="checkbox"/> Chase the Ace	3:01	AC/DC	Who Made Who	Rock	★★★★★	56
<input checked="" type="checkbox"/> For Those About To Rock (We ...	5:54	AC/DC	Who Made Who	Rock	★★★★★	61
<input checked="" type="checkbox"/> Dúlamán	3:43	Altan	Natural Wonders M...	New Age	★★★★★	31
<input checked="" type="checkbox"/> Rode Across the Desert	4:10	America	Greatest Hits	Easy Listen...	★★★★★	23
<input checked="" type="checkbox"/> Now You Are Gone	3:08	America	Greatest Hits	Easy Listen...	★★★★★	18
<input checked="" type="checkbox"/> Tip Man	3:20	America	Greatest Hits	Easy Listen...	★★★★★	22



We want to keep track of which band is the “creator” of each music track...

What album does this song “belong to”??

Which album is this song related to?

Integer Reference Pattern

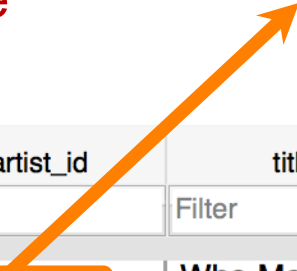
We use integers to reference rows in another table

id	name
Filter	Filter
1	Led Zeppelin
2	AC/DC

Artist

id	artist_id	title
Filter	Filter	Filter
1	2	Who Made Who
2	1	IV

Album



Three Kinds of Keys

Primary key - generally an integer auto-increment field

Logical key - What the outside world uses for lookup

Foreign key - generally an integer key pointing to a row in another table



Key Rules

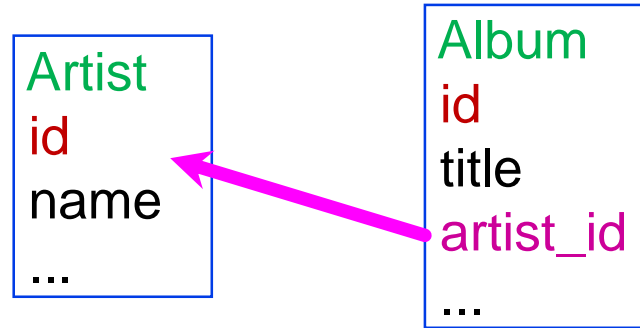
Best practices

- Never use your **logical key** as the **primary key**
- **Logical keys** can and do change, although slowly
- **Relationships** that are based on matching string fields are less efficient than integers

```
User
id
login
password
name
email
created_at
modified_at
login_at
```

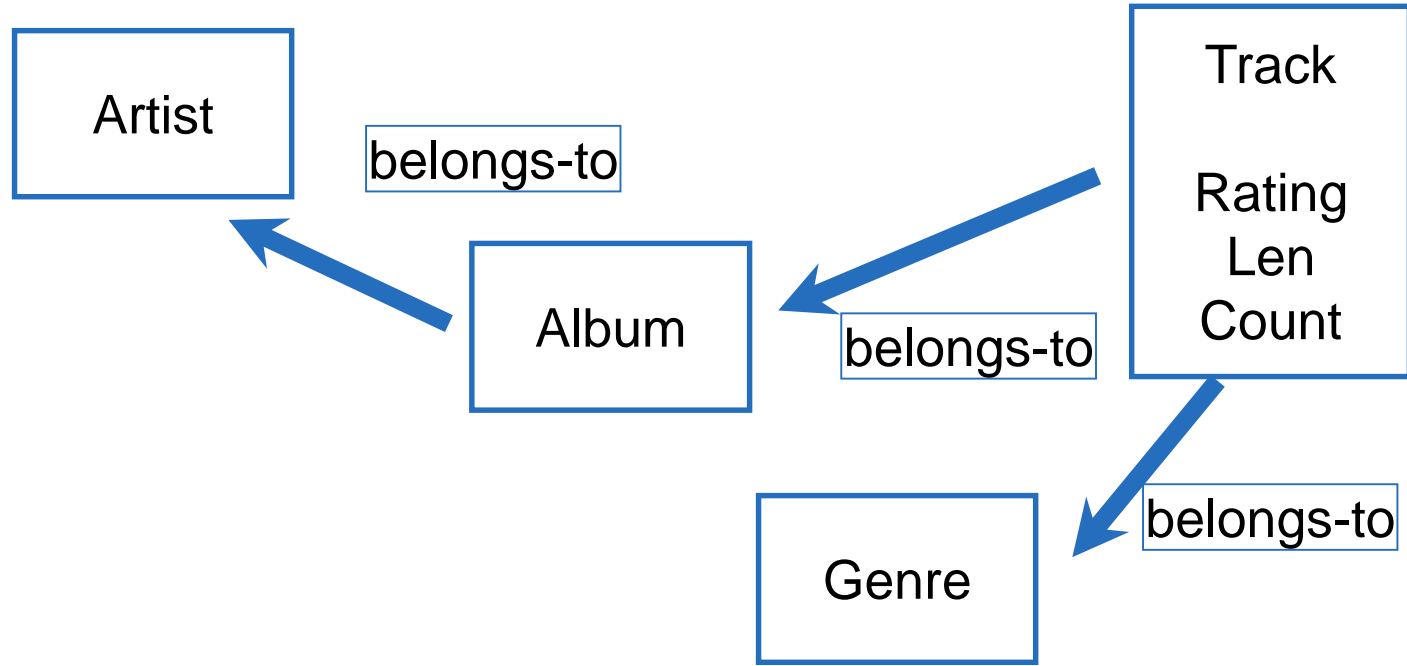

Foreign Keys

- A **foreign key** is when a table has a column that contains a key which points to the **primary key** of another table.
- When all **primary keys** are **integers**, then all **foreign keys** are **integers** - this is good - very good

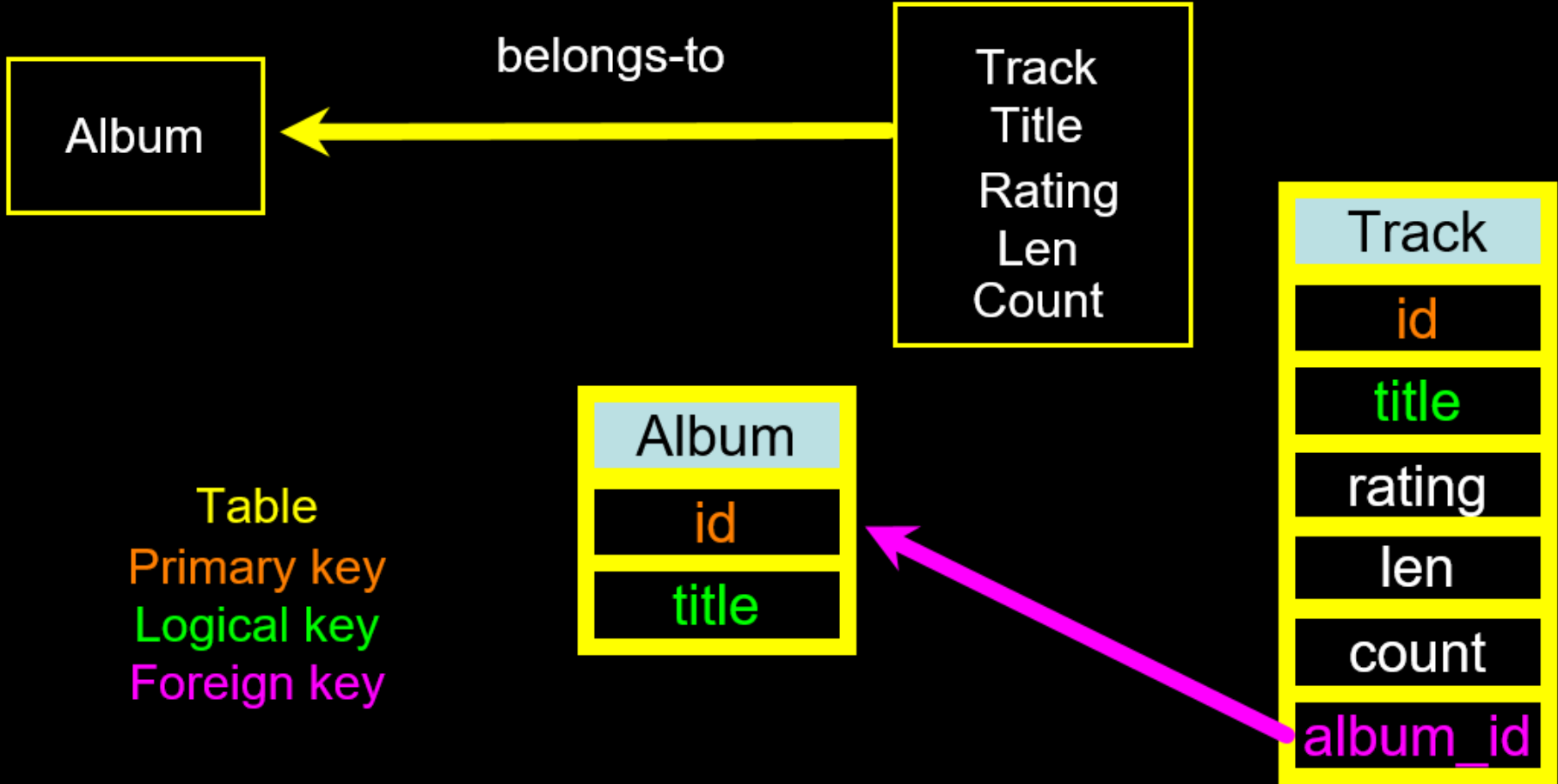


Representing a Data Model / Relationship Building (in Tables)

Track
 Album
 Artist
 Genre
 Rating
 Len
 Count



<input checked="" type="checkbox"/>	Hells Bells	5:13	AC/DC	Who Made Who	Rock	★★★★★	61
<input checked="" type="checkbox"/>	Shake Your Foundations	3:54	AC/DC	Who Made Who	Rock	★★★★★	70
<input checked="" type="checkbox"/>	Chase the Ace	3:01	AC/DC	Who Made Who	Rock		56
<input checked="" type="checkbox"/>	For Those About To Rock (We ...	5:54	AC/DC	Who Made Who	Rock	★★★★★	61
<input checked="" type="checkbox"/>	Dúlamán	3:43	Altan	Natural Wonders M...	New Age		31
<input checked="" type="checkbox"/>	Rode Across the Desert	4:10	America	Greatest Hits	Easy Listen...	★★★★★	23
<input checked="" type="checkbox"/>	Now You Are Gone	3:08	America	Greatest Hits	Easy Listen...	★★★★★	18
<input checked="" type="checkbox"/>	The Man	7:20	America	Greatest Hits	Easy Listen...	★★★★★	22



Artist
id
name

Album
id
title
artist_id

Track
id
title
rating
len
count
album_id
genre_id

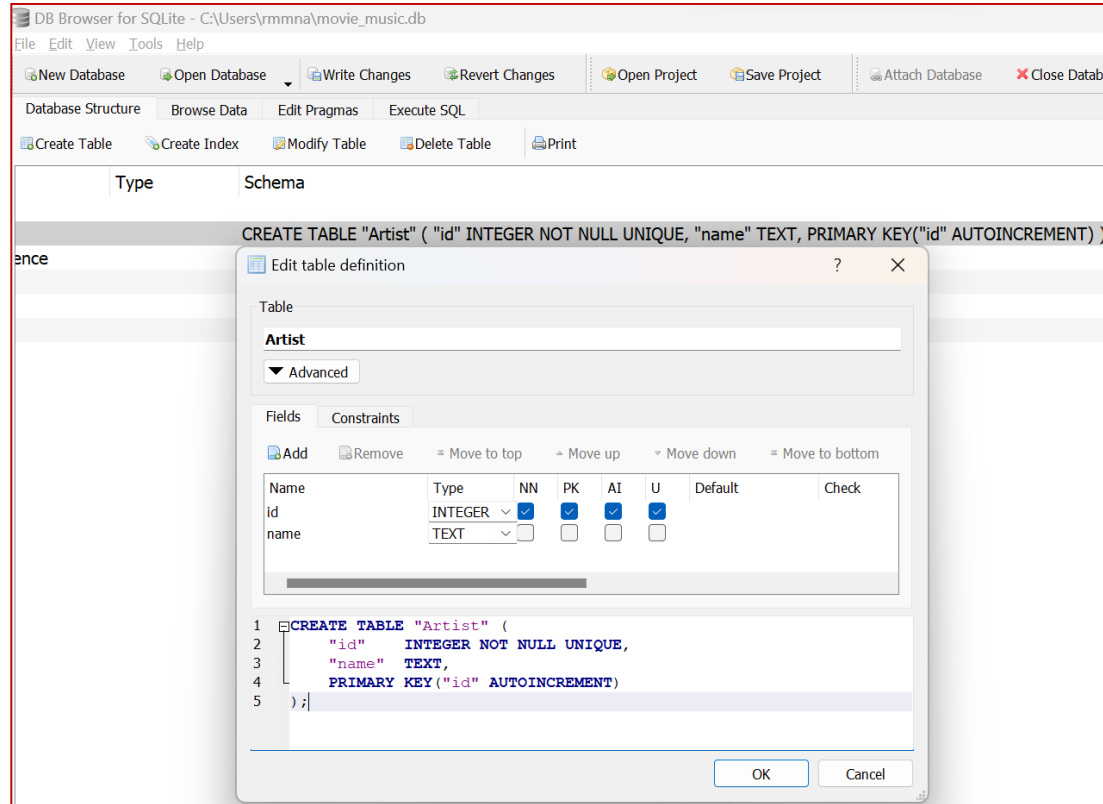
Genre
id
name

Table
Primary key
Logical key
Foreign key

Naming FK artist_id is a convention

Creating Tables using SQLite

```
CREATE TABLE "Artist" ("id" INTEGER NOT NULL UNIQUE,  
"name" TEXT, PRIMARY KEY("id" AUTOINCREMENT));
```



DB Browser for SQLite - C:\Users\ymmna\movie_music.db

File Edit View Tools Help

New Database Open Database Write Changes Revert Changes Open Project Save Project Attach Database Close Database

Database Structure Browse Data Edit Pragma Execute SQL

Create Table Create Index Modify Table Delete Table Print

Type Schema

CREATE TABLE "Artist" ("id" INTEGER NOT NULL UNIQUE, "name" TEXT, PRIMARY KEY("id" AUTOINCREMENT))

nce

Edit table definition

Table

Artist

Advanced

Fields Constraints

Add Remove Move to top Move up Move down Move to bottom

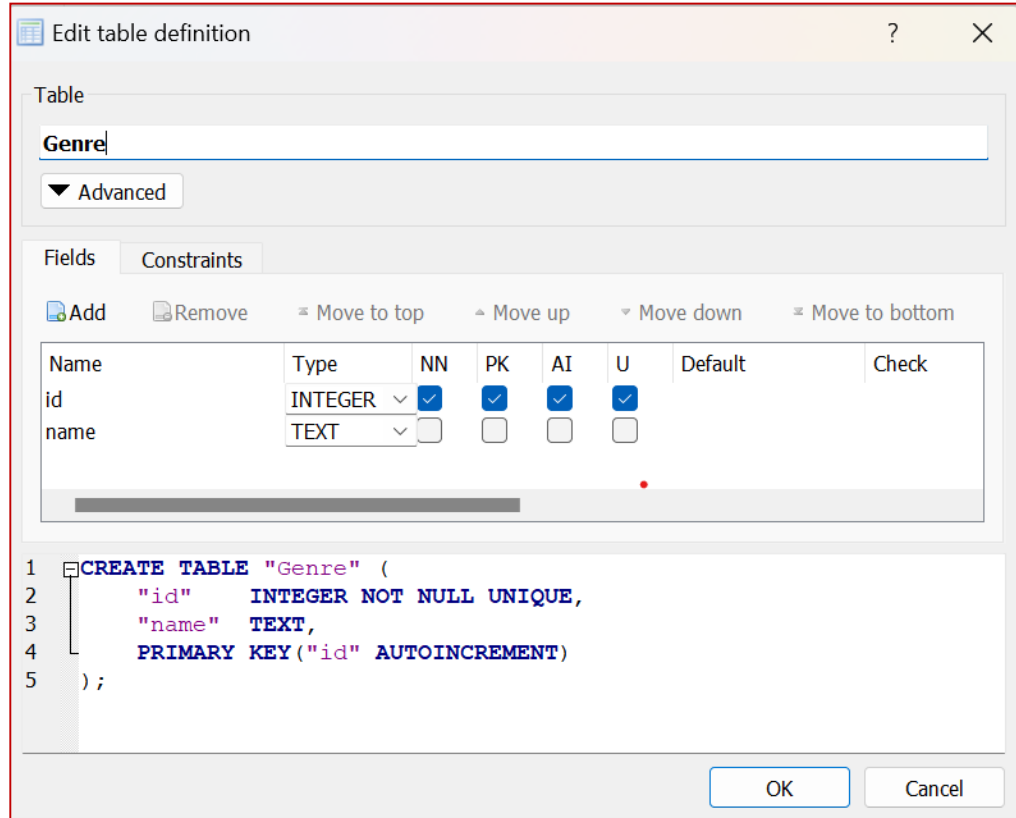
Name	Type	NN	PK	AI	U	Default	Check
id	INTEGER	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		
name	TEXT	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		

```
1 CREATE TABLE "Artist" (  
2   "id"    INTEGER NOT NULL UNIQUE,  
3   "name"  TEXT,  
4   PRIMARY KEY("id" AUTOINCREMENT)  
5 );
```

OK Cancel

Creating Tables using SQLite

```
CREATE TABLE "Genre" ("id" INTEGER NOT NULL UNIQUE,  
"name" TEXT, PRIMARY KEY("id" AUTOINCREMENT));
```



Creating Tables using SQLite

```
CREATE TABLE "Album" ("id" INTEGER NOT NULL UNIQUE,  
    "artist_id" INTEGER, "title" TEXT, PRIMARY KEY("id"  
AUTOINCREMENT));
```

Table: **Album**

Advanced

Fields Constraints

Add Remove Move to top Move up Move down Move to bottom

Name	Type	NN	PK	AI	U	Default	Check
id	INTEGER	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		
artist_id	INTEGER	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
title	TEXT	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		

```
1 CREATE TABLE "Album" (  
2     "id"    INTEGER NOT NULL UNIQUE,  
3     "artist_id" INTEGER,  
4     "title" TEXT,  
5     PRIMARY KEY("id" AUTOINCREMENT)  
6 );
```

OK Cancel

Creating Tables using SQLite

```
CREATE TABLE "Track" (  
    "id"    INTEGER NOT NULL UNIQUE,  
    "title"    TEXT,  
    "album_id"    INTEGER,  
    "genre_id"    INTEGER,  
    "len"    INTEGER,  
    "rating"    INTEGER,  
    "count"    INTEGER,  
    PRIMARY KEY ("id" AUTOINCREMENT)  
);
```

Creating Tables using SQLite

Table: **Track**

Advanced

Fields Constraints

Add Remove Move to top Move up Move down Move to bottom

Name	Type	NN	PK	AI	U	Default	Check	Collation	Foreign
id	INTEGER	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>				
title	TEXT	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>				
album_id	INTEGER	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>				
genre_id	INTEGER	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>				
len	INTEGER	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>				
rating	INTEGER	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>				
count	INTEGER	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>				

```
1 CREATE TABLE "Track" (  
2     "id"    INTEGER NOT NULL UNIQUE,  
3     "title" TEXT,  
4     "album_id" INTEGER,  
5     "genre_id" INTEGER,  
6     "len"   INTEGER,  
7     "rating" INTEGER,  
8     "count" INTEGER,  
9     PRIMARY KEY("id" AUTOINCREMENT)  
10 );
```

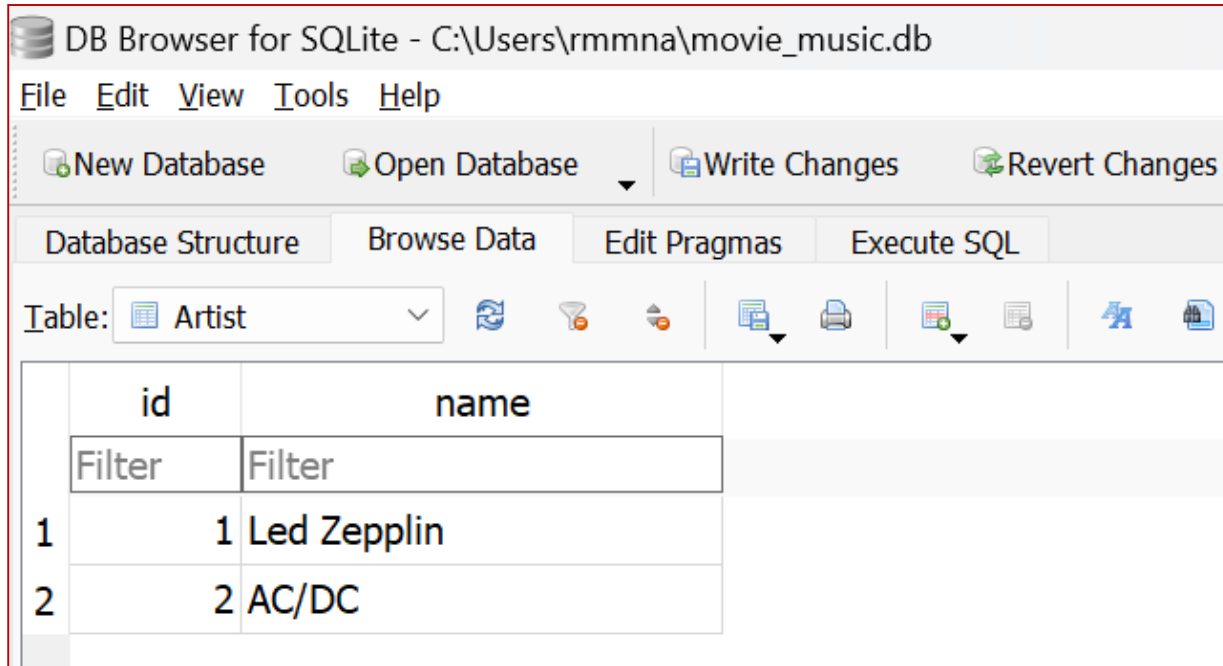
OK Cancel

Inserting Relational Data

	Type	Schema
Tables (5)		
Album		CREATE TABLE "Album" ("id" INTEGER NOT NULL UNIQUE, "artist_id" INTEGER, "title" TEXT, PRIMARY KEY("id" AUTOINCREMENT))
id	INTEGER	"id" INTEGER NOT NULL UNIQUE
artist_id	INTEGER	"artist_id" INTEGER
title	TEXT	"title" TEXT
Artist		CREATE TABLE "Artist" ("id" INTEGER NOT NULL UNIQUE, "name" TEXT, PRIMARY KEY("id" AUTOINCREMENT))
id	INTEGER	"id" INTEGER NOT NULL UNIQUE
name	TEXT	"name" TEXT
Genre		CREATE TABLE "Genre" ("id" INTEGER NOT NULL UNIQUE, "name" TEXT, PRIMARY KEY("id" AUTOINCREMENT))
id	INTEGER	"id" INTEGER NOT NULL UNIQUE
name	TEXT	"name" TEXT
Track		CREATE TABLE "Track" ("id" INTEGER NOT NULL UNIQUE, "title" TEXT, "album_id" INTEGER, "genre_id" INTEGER, "len" INTEGER, "rating" INTEGER, "count" INTEGER, PRIMARY KEY("id" AUTOINCREMENT))
id	INTEGER	"id" INTEGER NOT NULL UNIQUE
title	TEXT	"title" TEXT
album_id	INTEGER	"album_id" INTEGER
genre_id	INTEGER	"genre_id" INTEGER
len	INTEGER	"len" INTEGER
rating	INTEGER	"rating" INTEGER
count	INTEGER	"count" INTEGER

Inserting Relational Data

```
insert into Artist (name) values ('Led Zeppelin')  
insert into Artist (name) values ('AC/DC')
```



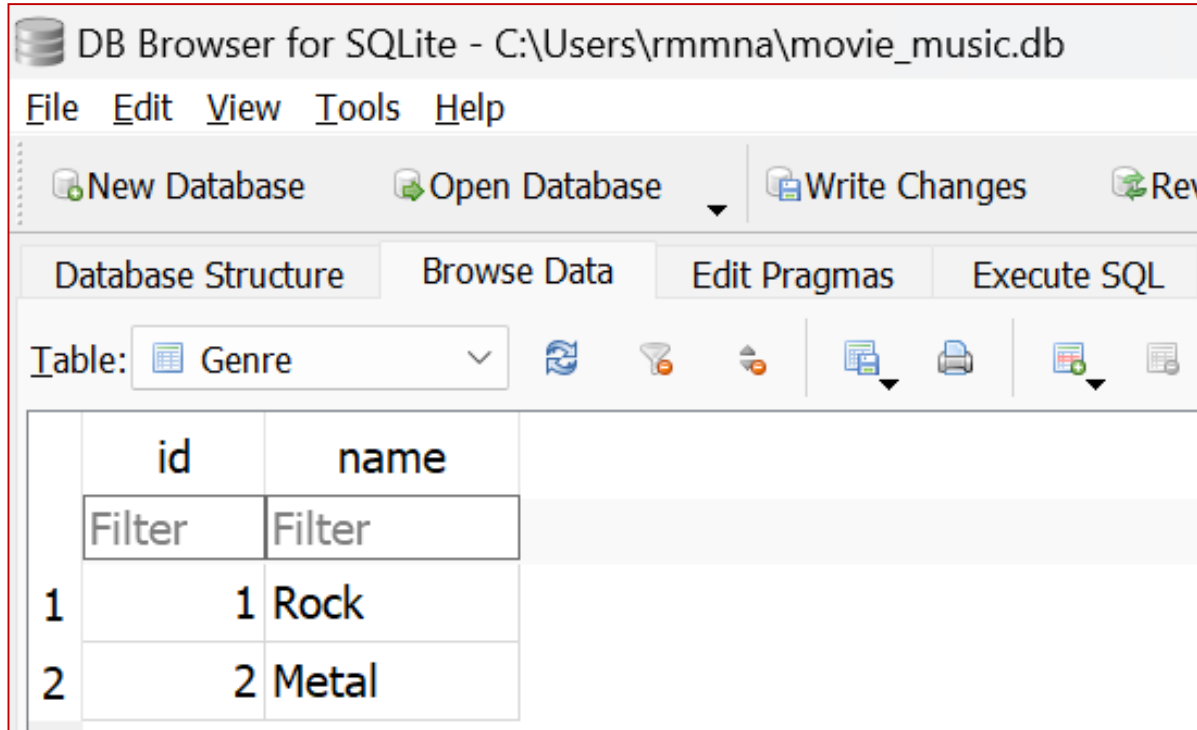
The screenshot shows the DB Browser for SQLite interface. The title bar indicates the database is 'C:\Users\rmmna\movie_music.db'. The menu bar includes File, Edit, View, Tools, and Help. The toolbar contains buttons for 'New Database', 'Open Database', 'Write Changes', and 'Revert Changes'. Below the toolbar are tabs for 'Database Structure', 'Browse Data', 'Edit Pragmas', and 'Execute SQL'. The 'Table:' dropdown is set to 'Artist'. The main area displays a table with two columns: 'id' and 'name'. The table contains two rows of data: one with id '1' and name 'Led Zeppelin', and another with id '2' and name 'AC/DC'. Filter boxes are present above the data rows.

	id	name
	Filter	Filter
1	1	Led Zeppelin
2	2	AC/DC

Inserting Relational Data

```
insert into Genre (name) values ('Rock')
```

```
insert into Genre (name) values ('Metal')
```

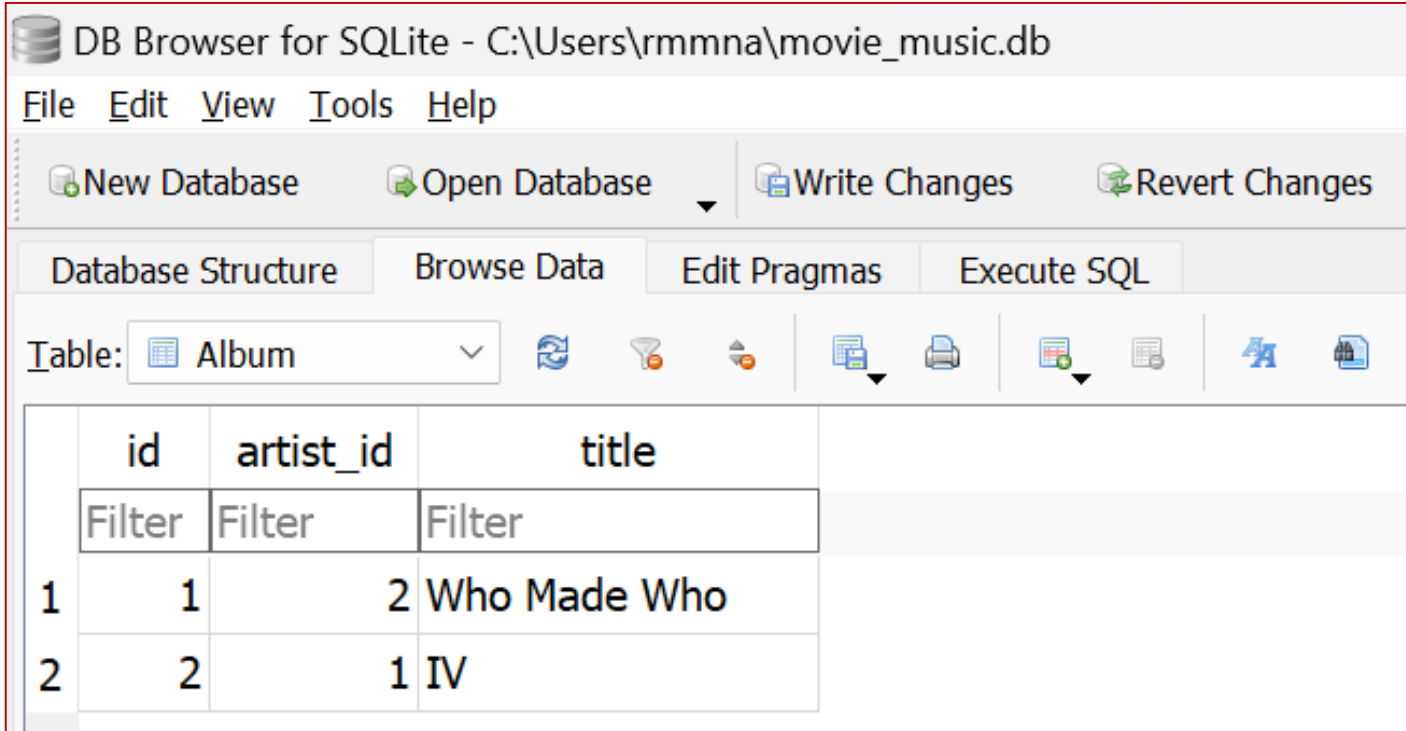


The screenshot shows the DB Browser for SQLite interface. The title bar indicates the database is 'C:\Users\rmmna\movie_music.db'. The menu bar includes File, Edit, View, Tools, and Help. The toolbar contains icons for New Database, Open Database, Write Changes, and Refresh. The main window has tabs for Database Structure, Browse Data, Edit Pragmas, and Execute SQL. The 'Table:' dropdown is set to 'Genre'. Below the toolbar, a table displays the data:

	id	name
	Filter	Filter
1	1	Rock
2	2	Metal

Inserting Relational Data

```
insert into Album (title, artist_id) values ('Who Made Who', 2)
insert into Album (title, artist_id) values ('IV', 1)
```



The screenshot shows the DB Browser for SQLite interface. The title bar indicates the database is 'C:\Users\rmmna\movie_music.db'. The menu bar includes File, Edit, View, Tools, and Help. The toolbar contains buttons for New Database, Open Database, Write Changes, and Revert Changes. Below the toolbar are tabs for Database Structure, Browse Data, Edit Pragas, and Execute SQL. The 'Table:' dropdown is set to 'Album'. The main area displays a table with the following data:

	id	artist_id	title
	Filter	Filter	Filter
1	1	2	Who Made Who
2	2	1	IV

Inserting Relational Data

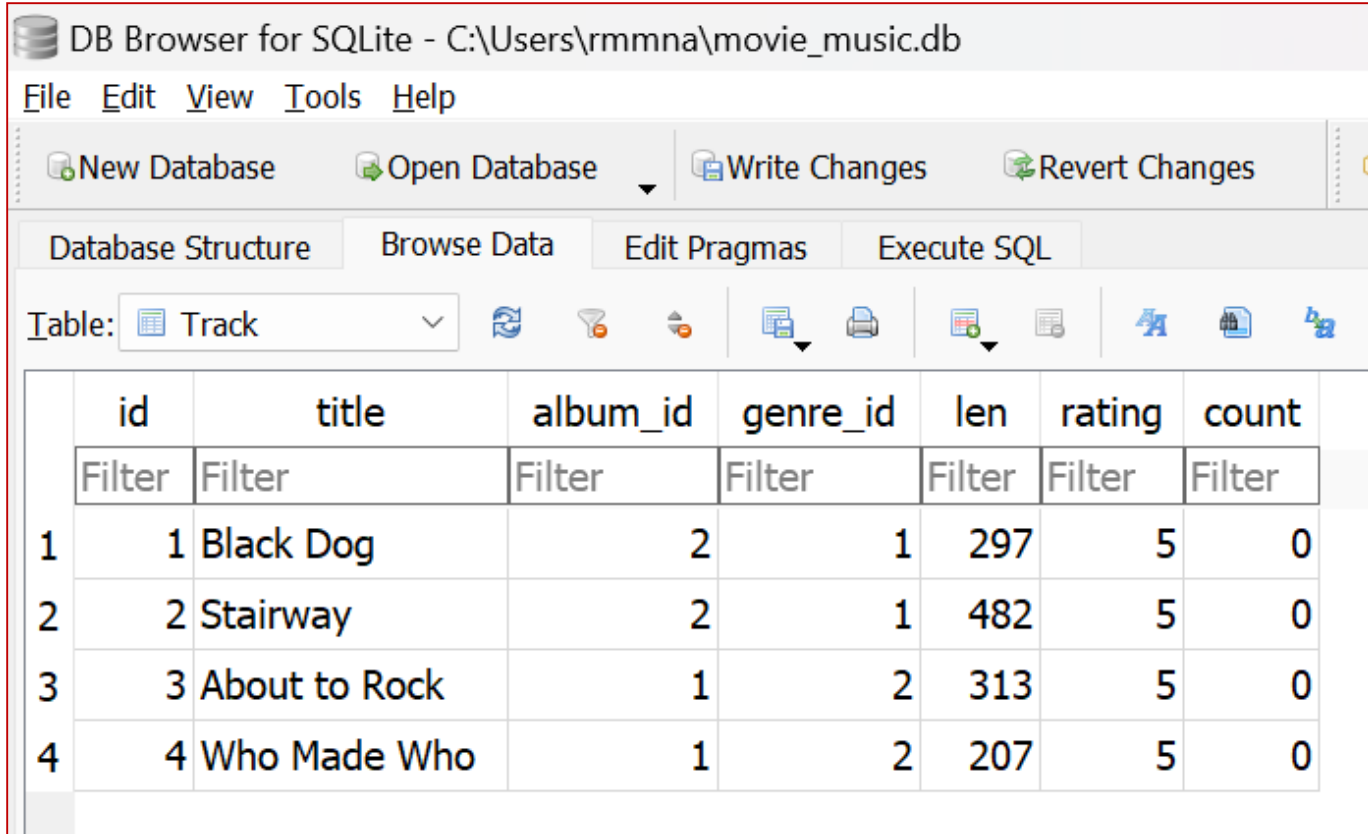
```
insert into Track (title, rating, len, count, album_id,  
genre_id) values ('Black Dog', 5, 297, 0, 2, 1)
```

```
insert into Track (title, rating, len, count, album_id,  
genre_id) values ('Stairway', 5, 482, 0, 2, 1)
```

```
insert into Track (title, rating, len, count, album_id,  
genre_id) values ('About to Rock', 5, 313, 0, 1, 2)
```

```
insert into Track (title, rating, len, count, album_id,  
genre_id) values (' Who Made Who ', 5, 313, 0, 1, 2)
```

Inserting Relational Data



The screenshot shows the DB Browser for SQLite interface. The title bar indicates the database is 'C:\Users\rmmna\movie_music.db'. The menu bar includes File, Edit, View, Tools, and Help. The toolbar contains buttons for New Database, Open Database, Write Changes, and Revert Changes. The main window has tabs for Database Structure, Browse Data, Edit Pragmas, and Execute SQL. The 'Table:' dropdown is set to 'Track'. Below the toolbar is a table with the following data:

	id	title	album_id	genre_id	len	rating	count
	Filter	Filter	Filter	Filter	Filter	Filter	Filter
1	1	Black Dog	2	1	297	5	0
2	2	Stairway	2	1	482	5	0
3	3	About to Rock	1	2	313	5	0
4	4	Who Made Who	1	2	207	5	0

id	title	album_id	genre_id	len	rating	count
Filter	Filter	Filter	Filter	Filter	Filter	Filter
1	Black Dog	2	1	297	5	0
2	Stairway	2	1	482	5	0
3	About to Rock	1	2	313	5	0
4	Who Made Who	1	2	207	5	0

Track

id	artist_id	title
Filter	Filter	Filter
1	2	Who Made Who
2	1	IV

Album

id	name
Filter	Filter
1	Rock
2	Metal

Genre

id	name
Filter	Filter
1	Led Zeppelin
2	AC/DC

Artist