Hands-on Lab: Normalization, Keys and Constraints in Relational Database

Estimated time needed: 25 minutes

In this lab, you will learn about normalization, keys, and constraints in Datasette. First, you will learn how to minimize data redundancy and inconsistency in a database by normalizing tables. Next, you will learn how to use keys to uniquely identify a record in a table, to establish a relationship between tables, and to identify the relation between them. Lastly, you will learn about different kinds of relational model constraints that help to maintain data integrity in a relational data model.

Software Used in this Lab

In this lab, you will use Datasette , an open source multi-tool for exploring and publishing data.

Dataset Used in this Lab

In this lab, you will use a **BookShop** dataset.

Objectives

After completing this lab, you will be able to:

- Minimize data redundancy and inconsistency in a database by using normalization.
- Use keys to uniquely identify a record in a table, establish a relationship between tables, and identify the relation between them.
- Maintain data integrity in a relational data model using constraints.

Exercise 1: Normalization

In this exercise, you will learn about first normal form (1NF) and implement second normal form (2NF).

Task A: First normal form (1NF)

In this task of normalization, you will be working with the **BookShop** table. The following image shows the **BookShop** table:

BOOK_ID	TITLE	AUTHOR_NAME	AUTHOR_BIO	AUTHOR_ID	PUBLICATION_DATE	PRICE_USD
B101	Introduction to Algorithms	Thomas H. Cormen	Thomas H. Cormen is the co-author of Introd...	123	2001-09-01	125.00
B201	Structure and Interpretation of Computer Pro...	Harold Abelson, G. J. Sussman		456, 567	1996-07-25	65.50
B301	Deep Learning	Ian Goodfellow	Ian J. Goodfellow is a researcher working in ...	369	2016-11-01	82.70
B401	Algorithms Unlocked	Thomas H. Cormen	Thomas H. Cormen is the co-author of Introd...	123	2013-05-15	36.50
B501	Machine Learning: A Probabilistic Perspective	Kevin P. Murphy		157	2012-08-24	46.00

You will answer some questions to determine if the table above is in 1NF.

1. Does the above table have unique rows?

▼ Hint

> Check if you can uniquely identify each row.

▼ Answer

> Yes. Each row can be uniquely identified.

2. Does each cell of the above table have single/atomic value?

▼ Hint

> A single/atomic value cannot be divided and does not include any delimiter character.

▼ Answer

> No. The columns AUTHOR_NAME and AUTHOR_ID contain multi valued cell.

3. By definition, a table is in 1NF if every attribute in that relation contains single valued data and every tuple in that relation is unique. Does the above table fall in first normal form?

▼ Hint

> Follow the stated definition of 1NF above. Your answer for this question should be based on the answers of the previous two questions.

▼ Answer

> No, the table is not in 1NF since it has unique rows but not all single valued cell.

4. If your answer to question 3 is No, how can you normalize the table to ensure first normal form?

▼ Hint

> Watch the video on Normalization.

▼ Answer

> To normalize this table, add an extra row, and split the multiple author names as well as multiple author IDs of the row containing multi-valued data into their own row.

Task B: Second normal form (2NF)

1. Download the `BookShop-CREATE-INSERT.sql` script below, copy and paste it to the Datasette lab, and run it. The script will drop any previous BookShop table that exists, create the new BookShop table, and populate it with the sample data required for this lab.

BOOK_ID	TITLE	AUTHOR_NAME	AUTHOR_BIO	AUTHOR_ID	PUBLICATION_DATE	PRICE_USD
B101	Introduction to Algorithms	Thomas H. Cormen	Thomas H. Cormen is the co-author of Introd...	123	2001-09-01	125.00
B201	Structure and Interpretation of Computer Pro...	Harold Abelson	Harold Abelson, Ph.D., is Class of 1922 Profe...	456	1996-07-25	65.50
B301	Deep Learning	Ian Goodfellow	Ian J. Goodfellow is a researcher working in ...	369	2016-11-01	82.70
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B501	Machine Learning: A Probabilistic Perspective	Kevin P. Murphy		157	2012-08-24	46.00

   - BookShop-CREATE-INSERT.sql

▼ Click here to view the queries inside the script

```
-- Drop the tables in case they exist

DROP TABLE IF EXIXTS BookShop;
DROP TABLE IF EXISTS BookShop_AuthorDetails;

-- Create the table

CREATE TABLE BookShop (
    BOOK_ID VARCHAR(4) NOT NULL,
    TITLE VARCHAR(100) NOT NULL,
    AUTHOR_NAME VARCHAR(30) NOT NULL,
    AUTHOR_BIO VARCHAR(250),
    AUTHOR_ID INTEGER NOT NULL,
    PUBLICATION_DATE DATE NOT NULL,
    PRICE_USD DECIMAL(6,2) CHECK(Price_USD>0) NOT NULL
    );

-- Insert sample data into the table

INSERT INTO BookShop VALUES
('B101', 'Introduction to Algorithms', 'Thomas H. Cormen', 'Thomas H. Cormen is the co-author of Introduction to
Algorithms, along with Charles Leiserson, Ron Rivest, and Cliff Stein. He is a Full Professor of computer science at
Dartmouth College and currently Chair of the Dartmouth College Writing Program.', 123 , '2001-09-01', 125),
('B201', 'Structure and Interpretation of Computer Programs', 'Harold Abelson', ' Harold Abelson, Ph.D., is Class of 1922
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('B401', 'Algorithms Unlocked', 'Thomas H. Cormen', 'Thomas H. Cormen is the co-author of Introduction to Algorithms, along
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currently Chair of the Dartmouth College Writing Program.', 123, '2013-05-15', 36.5),
('B501', 'Machine Learning: A Probabilistic Perspective', 'Kevin P. Murphy', '', 157, '2012-08-24', 46);

-- Retrieve all records from the table

SELECT * FROM BookShop;
```

Tip: If you are unsure how to upload and run the script in Datasette, follow the given steps:

1. Download the script file to your computer:

   BookShop-CREATE-INSERT.sql

2. Open the script file using **Notepad** or any **text editor**.
   - **Copy** the contents of the **script** file and paste it in the datasette **text area**.
   - Click on **Submit query** button.
   - The queries get executed.

Practice SQL

Database: SanFranciscoFilmLocations

```
-- Create the table

CREATE TABLE BookShop (
    BOOK_ID VARCHAR(4) NOT NULL,
    TITLE VARCHAR(100) NOT NULL,
    AUTHOR_NAME VARCHAR(30) NOT NULL,
    AUTHOR_BIO VARCHAR(250),
    AUTHOR_ID INTEGER NOT NULL,
    PUBLICATION_DATE DATE NOT NULL,
    PRICE_USD DECIMAL(6,2) CHECK(Price_USD>0) NOT NULL
    );

-- Insert sample data into the table

INSERT INTO BookShop VALUES
('B101', 'Introduction to Algorithms', 'Thomas H. Cormen', 'Thomas H. Cormen is the co-author of Introduction to Algorithms, along with Charles Leiserson, Ron Rivest, and Cliff Stein. He is a Full Professor of computer science at Dartmouth College and currently Chair of the Dartmouth College Writing Program.', 123 , '2001-09-01', 125),
('B201', 'Structure and Interpretation of Computer Programs', 'Harold Abelson', 'Harold Abelson, Ph.D., is Class of 1922 Professor of Computer Science and Engineering in the Department of Electrical Engineering and Computer Science at MIT and a fellow of the IEEE.', 456, '1996-07-25', 65.5),
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('B501', 'Machine Learning: A Probabilistic Perspective', 'Kevin P. Murphy', '', 157, '2012-08-24', 46);

-- Retrieve all records from the table

SELECT * FROM BookShop;
```

Tip: Autocomplete with Ctrl+Enter or Cmd+Enter

Submit query

Results

All commands ran successfully

```
-- Drop the tables in case they exist

DROP TABLE IF EXISTS BookShop
Query executed
```

```
DROP TABLE IF EXISTS BookShop_AuthorDetails
Query executed
```

```
-- Create the table

CREATE TABLE BookShop (
BOOK_ID VARCHAR(4) NOT NULL,
TITLE VARCHAR(100) NOT NULL,
AUTHOR_NAME VARCHAR(30) NOT NULL,
AUTHOR_BIO VARCHAR(250),
AUTHOR_ID INTEGER NOT NULL,
PUBLICATION_DATE DATE NOT NULL,
PRICE_USD DECIMAL(6,2) CHECK(Price_USD>0) NOT NULL
)
Query executed
```

2. By definition, a relation is in second normal form if it is already in 1NF and does not contain any partial dependencies. If you look at the BookShop table, you will find every column in the table is single or atomic valued, but it has multiple books by the same author. This means that the AUTHOR_ID, AUTHOR_NAME and AUTHOR_BIO details for BOOK_ID B101 and B401 are the same. As the number of rows in the table increase, you will be needlessly storing more and more occurrences of these same pieces of information. And if an author updates their bio, you must update all of these occurrences.

BOOK_ID	TITLE	AUTHOR_NAME	AUTHOR_BIO	AUTHOR_ID	PUBLICATION_DATE	PRICE_USD
B101	Introduction to Algorithms	Thomas H. Cormen	Thomas H. Cormen is the co-author of Introd...	123	2001-09-01	125.00
B201	Structure and Interpretation of Computer Pro...	Harold Abelson	Harold Abelson, Ph.D., is Class of 1922 Profe...	456	1996-07-25	65.50
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3. In this scenario, to enforce 2NF you can take the author information such as AUTHOR_ID, AUTHOR_NAME and AUTHOR_BIO out of the BookShop table into another table, for example a table named **BookShop_AuthorDetails**. You then link each book in the BookShop table to the relevant row in the BookShop_AuthorDetails table, using a unique common column such as AUTHOR_ID to link the tables. To create the new **BookShop_AuthorDetails** table, copy the code below and paste it to datasette **text area**. Click on **Submit query** button.

```
CREATE TABLE BookShop_AuthorDetails
(AUTHOR_ID INTEGER NOT NULL,AUTHOR_NAME VARCHAR(30) NOT NULL,
 AUTHOR_BIO VARCHAR(250),PRIMARY KEY (AUTHOR_ID)) ;

-----Insert the records of Bookshop to this table.

insert into BookShop_AuthorDetails select DISTINCT AUTHOR_ID, AUTHOR_NAME, AUTHOR_BIO FROM BookShop;

select * from BookShop_AuthorDetails;
```

Practice SQL

Database: SanFranciscoFilmLocations

```
CREATE TABLE BookShop_AuthorDetails(AUTHOR_ID INTEGER NOT NULL,AUTHOR_NAME VARCHAR(30) NOT NULL,AUTHOR_BIO VARCHAR(250)) ;

-----Insert the records of Bookshop to this table.

insert into BookShop_AuthorDetails select DISTINCT AUTHOR_ID, AUTHOR_NAME, AUTHOR_BIO FROM BookShop;

select * from BookShop_AuthorDetails;
```

Tip: Autocomplete with Ctrl+Enter or Cmd+Enter

Submit query

Results

All commands ran successfully

```
-- Drop the tables in case they exist

DROP TABLE IF EXISTS BookShop
Query executed
```

```
DROP TABLE IF EXISTS BookShop_AuthorDetails
```

4. Now you are only storing the author information once per author and only have to update it in one place; reducing redundancy and increasing consistency of data. Thus 2NF is ensured.

```
SELECT * FROM BookShop
```

BOOK_ID	TITLE	AUTHOR_NAME	AUTHOR_BIO	AUTHOR_ID	PUBLICATION_DATE	PRICE_USD
B101	Introduction to Algorithms	Thomas H. Cormen	Thomas H. Cormen is the co-author of Introduction to Algorithms, along with Charles Leiserson, Ron Rivest, and Cliff Stein. He is a Full Professor of computer science at Dartmouth College and currently Chair of the Dartmouth College Writing Program.	123	2001-09-01	125
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B501	Machine Learning: A Probabilistic Perspective	Kevin P. Murphy		157	2012-08-24	46

```
SELECT * FROM BookShop_AuthorDetails
```

AUTHOR_ID	AUTHOR_NAME	AUTHOR_BIO
123	Thomas H. Cormen	Thomas H. Cormen is the co-author of Introduction to Algorithms, along with Charles Leiserson, Ron Rivest, and Cliff Stein. He is a Full Professor of computer science at Dartmouth College and currently Chair of the Dartmouth College Writing Program.
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157	Kevin P. Murphy	

Exercise 2: Keys

In this exercise, you will see how to use a primary key to uniquely identify a record in a table, how to use a foreign key to establish a relationship between tables, and how to identify the relation between them.

Task A: Primary Key

1. By definition, a primary key is a column or group of columns that uniquely identify every row in a table. A table cannot have more than one primary key. The rules for defining a primary key are:

    - No two rows can have a duplicate primary key value.
    - Every row must have a primary key value.
    - No primary key field can be null.

2. You will create a primary key for the BookShop and BookShop_AuthorDetails tables to uniquely identify every row in each of the tables. You will set the BOOK_ID column of the BookShop table and AUTHOR_ID column of the BookShop_AuthorDetails table as a primary key for each of the tables. Both of the columns were declared as NOT NULL when the tables were created (Check the the sql script or table definition of the tables to verify the NOT NULL constraint. Because the BookShop_AuthorDetails table was created from the BookShop table, it inherits all the data types and column constraints like NOT NULL from the BookShop parent table).

3. To set the BOOK_ID column of the BookShop table as a primary key for each of the tables, copy the code below and paste it to datasette **text area**. Click on **Submit query** button.

```
--Drop the table.

DROP TABLE IF EXISTS BookShop;

-----Recreate it with Primary Key -------


CREATE TABLE BookShop (
 BOOK_ID VARCHAR(4) NOT NULL,
 TITLE VARCHAR(100) NOT NULL,
 AUTHOR_NAME VARCHAR(30) NOT NULL,
 AUTHOR_BIO VARCHAR(250),
 AUTHOR_ID INTEGER NOT NULL,
 PUBLICATION_DATE DATE NOT NULL,
 PRICE_USD DECIMAL(6,2) CHECK(Price_USD>0) NOT NULL,PRIMARY KEY (BOOK_ID));

INSERT INTO BookShop VALUES
('B101', 'Introduction to Algorithms', 'Thomas H. Cormen', 'Thomas H. Cormen is the co-author of Introduction to
Algorithms, along with Charles Leiserson, Ron Rivest, and Cliff Stein. He is a Full Professor of computer science at
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('B501', 'Machine Learning: A Probabilistic Perspective', 'Kevin P. Murphy', '', 157, '2012-08-24', 46);

-- Retrieve all records from the table

SELECT * FROM BookShop;
```
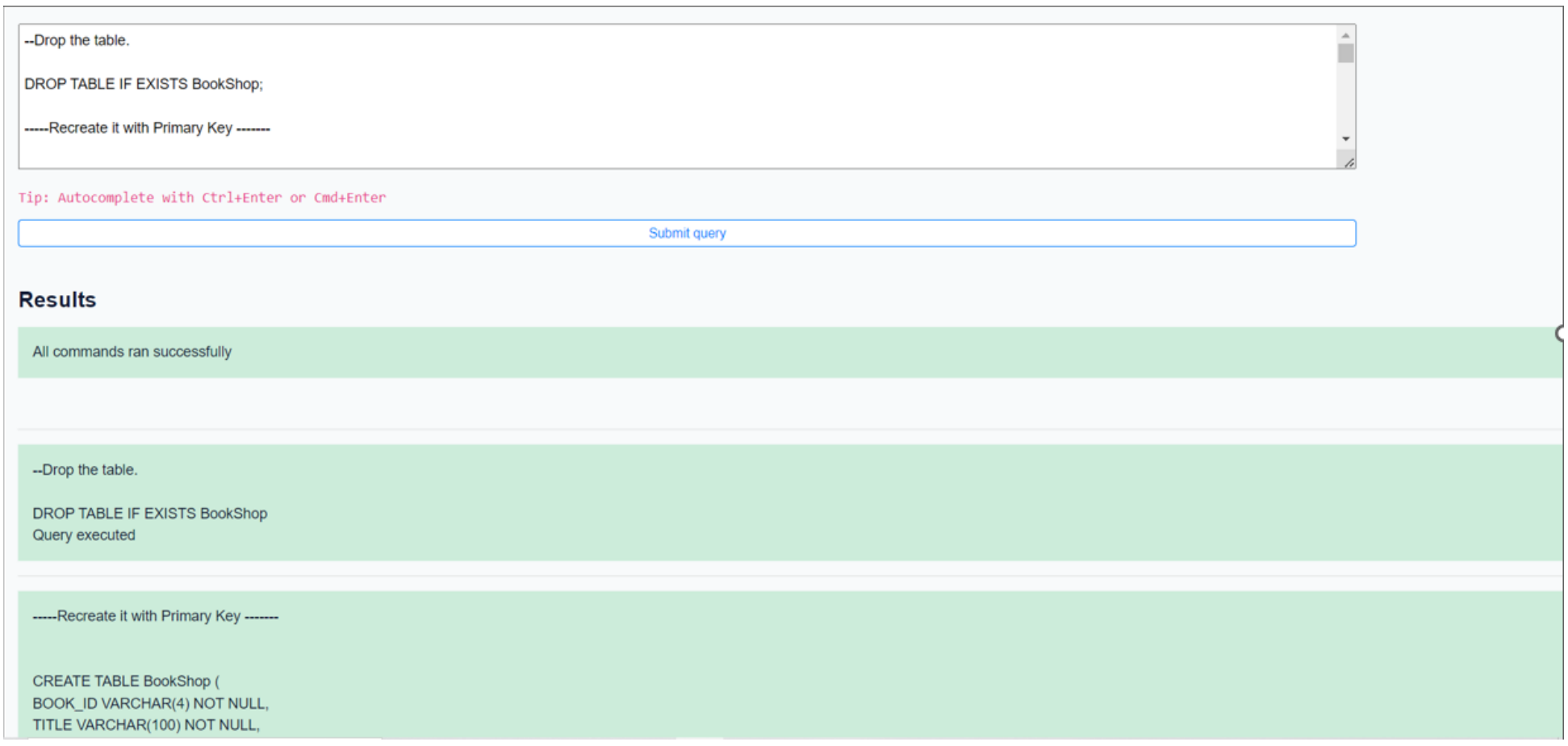
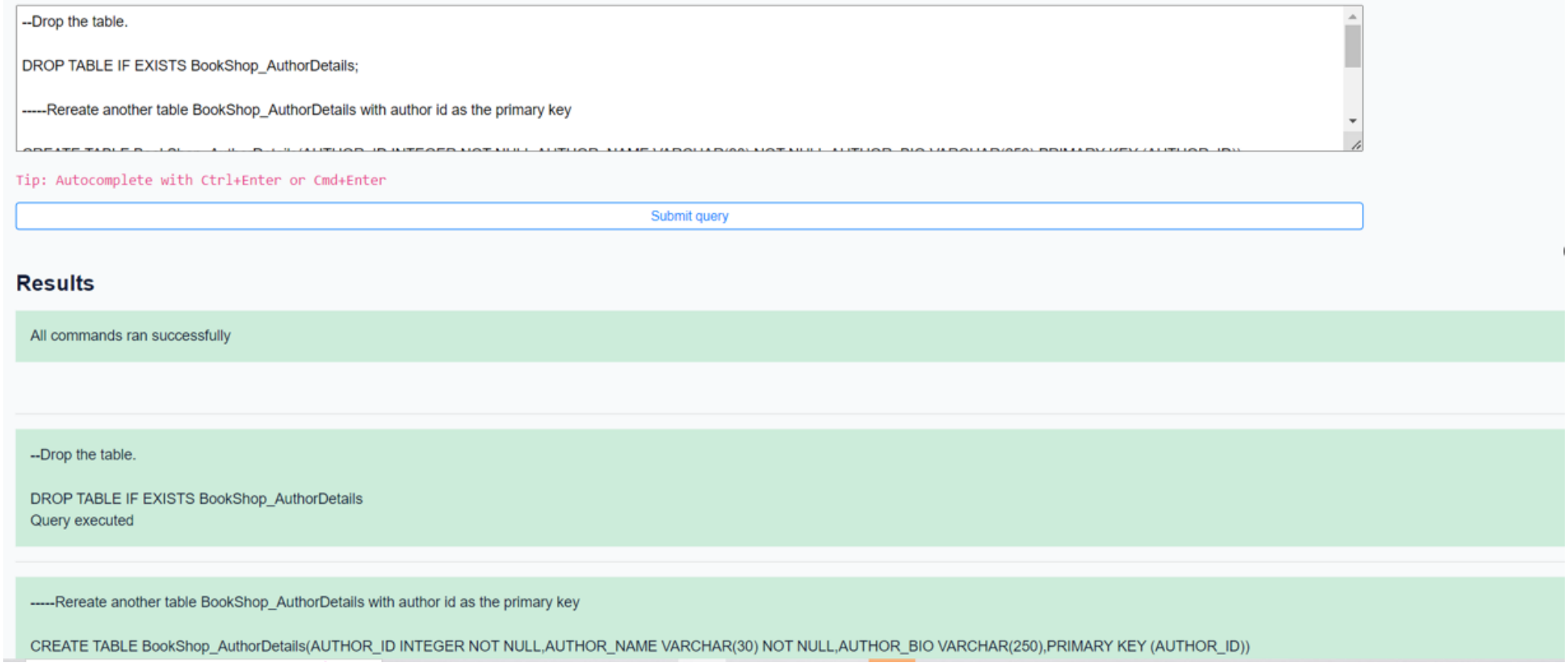

{: codeblock}



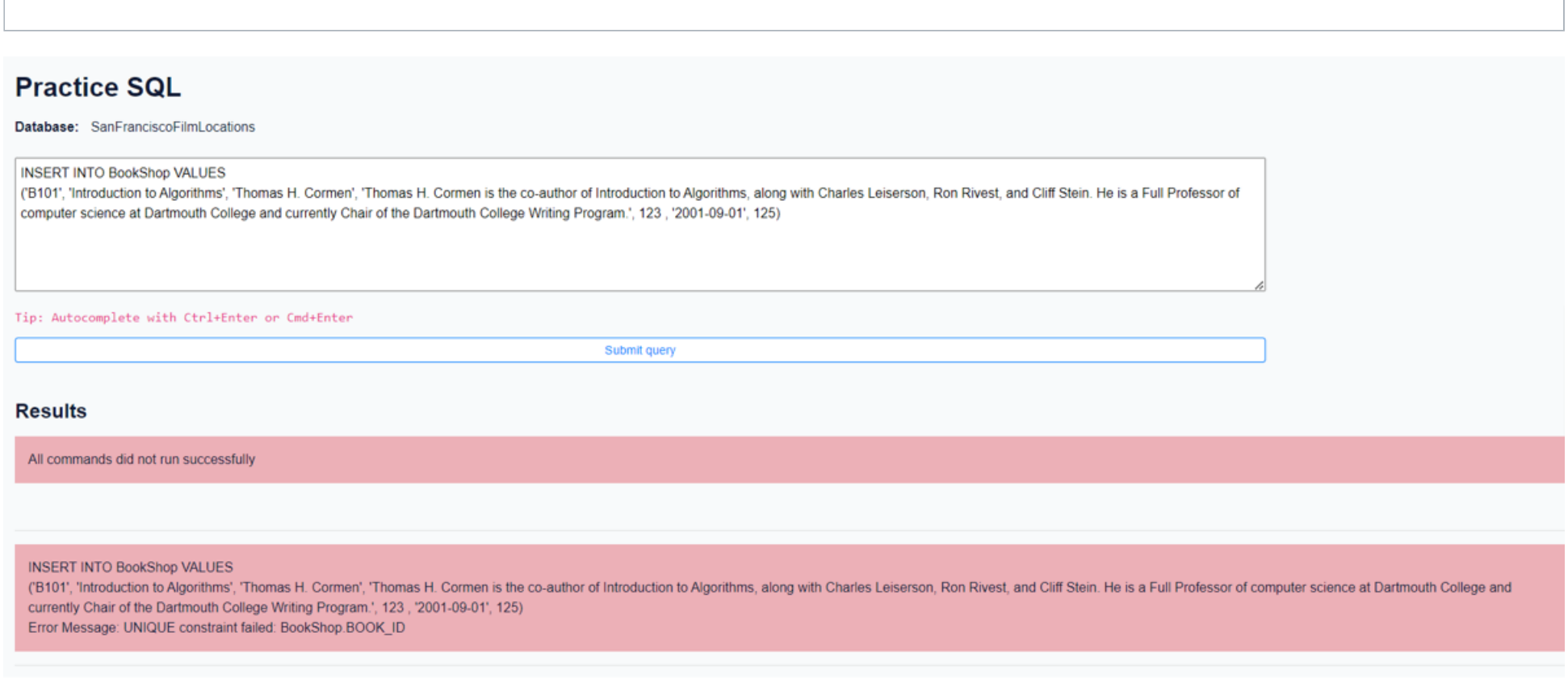
4. To set the AUTHOR_ID column of the BookShop_AuthorDetails table as a primary key for each of the tables, copy the code below and paste it to datasette **text area**. Click on **Submit query** button.

```
--Drop the table.

DROP TABLE IF EXISTS BookShop_AuthorDetails;

-----Rereate another table BookShop_AuthorDetails with author id as the primary key


CREATE TABLE BookShop_AuthorDetails(AUTHOR_ID INTEGER NOT NULL,AUTHOR_NAME VARCHAR(30) NOT NULL,AUTHOR_BIO
VARCHAR(250),PRIMARY KEY (AUTHOR_ID)) ;

-----Insert the records of Bookshop to this table.

insert into BookShop_AuthorDetails select DISTINCT AUTHOR_ID, AUTHOR_NAME, AUTHOR_BIO FROM BookShop;

select * from BookShop_AuthorDetails;
```



5. After adding primary key lets try add the same record in BookShop table, copy the code below and paste it to datasette **text area**. Click on **Submit query** button.

```
INSERT INTO BookShop VALUES
('B101', 'Introduction to Algorithms', 'Thomas H. Cormen', 'Thomas H. Cormen is the co-author of Introduction to
Algorithms, along with Charles Leiserson, Ron Rivest, and Cliff Stein. He is a Full Professor of computer science at
Dartmouth College and currently Chair of the Dartmouth College Writing Program.', 123 , '2001-09-01', 125)

---You will get unique constraint violation.

select * from BookShop;
```



6. Now you can use the BOOK_ID column to uniquely identify every row in the BookShop table and the AUTHOR_ID column to uniquely identify every row in the BookShop_AuthorDetails table.

Task B: Foreign Key

1. By definition, a foreign key is a column that establishes a relationship between two tables. It acts as a cross-reference between two tables because it points to the primary key of another table. A table can have multiple foreign keys referencing primary keys of other tables. Rules for defining a foreign key:

    - A foreign key in the referencing table must match the structure and data type of the existing primary key in the referenced table.
    - A foreign key can only have values present in the referenced primary key
    - Foreign keys do not need to be unique. Most often they aren't.
    - Foreign keys can be null.

2. You will create a foreign key for the BookShop table by setting its AUTHOR_ID column as a foreign key, to establish a relationship between the BookShop and BookShop_AuthorDetails tables. copy the code below and paste it to datasette **text area**. Click on **Submit query** button..

```
-----Foreign key addition in bookshop

DROP TABLE IF EXISTS BookShop;

CREATE TABLE BookShop (
 BOOK_ID VARCHAR(4) NOT NULL,
 TITLE VARCHAR(100) NOT NULL,
 AUTHOR_NAME VARCHAR(30) NOT NULL,
 AUTHOR_BIO VARCHAR(250),
 AUTHOR_ID INTEGER NOT NULL,
 PUBLICATION_DATE DATE NOT NULL,
 PRICE_USD DECIMAL(6,2) CHECK(Price_USD>0) NOT NULL,PRIMARY KEY (BOOK_ID),
FOREIGN KEY (AUTHOR_ID)
REFERENCES BookShop_AuthorDetails(AUTHOR_ID)
ON UPDATE NO ACTION
ON DELETE NO ACTION);
```

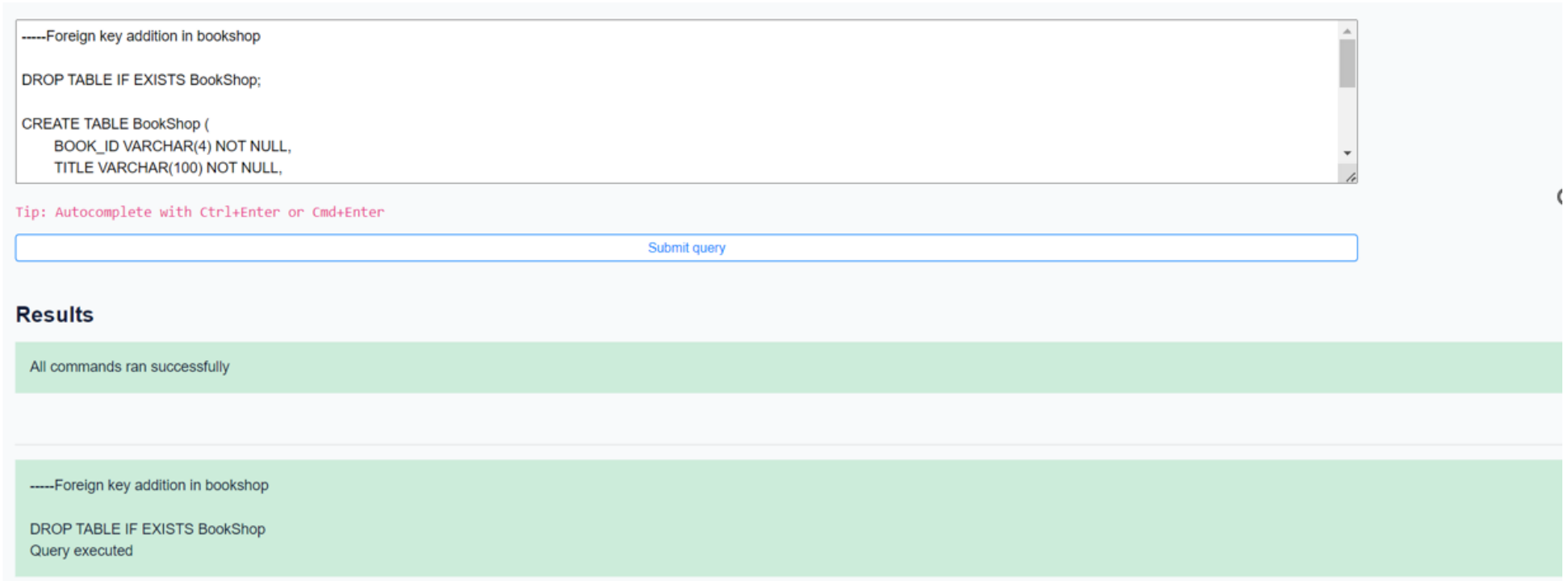
> Note: ON DELETE clause along with Foreign key is used to configure actions that takes place while deleting rows from referencing table. ON UPDATE along with the foreign key are used to take the set actions while modifying the referencing key values of existing rows.

> NO ACTIONS simply means that when a parent key is updated, modified or deleted from the database, there will be no special action taken.

> If the configured action is set to RESTRICT then the application is prohibited for deleteing and modifying a parent key where one or more chil keys are already present.

> On configuring the action to SET NULL when a parent key is deleted or updated then the column of all child keys that are mapped to parent key will set to contain SQL NULL values.

> SET DEFAULT is similar to SET NULL except that the child keys columns will set to contain value as default instead of null.



3. Now that you have created the relationship, each book in the BookShop table is linked to the relevant row in the BookShop_AuthorDetails table through AUTHOR_ID.

Exercise 3: Constraints

In this exercise, you will review different kinds of relational model constraints that help to maintain data integrity in a relational data model.

1. **Entity Integrity Constraint**: Entity integrity ensures that no duplicate records exist within a table and that the column identifing each record within the table is not a duplicate and not null. The existence of a primary key in both the BookShop and BookShop_AuthorDetails tables satisfies this integrity constraint because a primary key mandates NOT NULL constraint as well as ensuring that every row in the table has a value that uniquely denotes the row.

2. **Referential Integrity Constraint**: Referential integrity ensures the existence of a referenced value if a value of one column of a table references a value of another column. The existence of the foreign Key (AUTHOR_ID) in the BookShop table satisfies this integrity constraint because a cross-reference relationship between the BookShop and BookShop_AuthorDetails tables exists. As a result of this relationship, each book in the BookShop table will be linked to the relevant row in the BookShop_AuthorDetails table through the AUTHOR_ID columns.

3. **Domain Integrity Constraint**: Domain integrity ensures that the purpose of a column is clear and the values of a column are consistent as well as valid. The existence of data types, length, date format, check, and null constraints in the CREATE statement of the BookShop table makes sure this integrity constraint is satisfied.

▼ Click here to view queries inside the script

```
-- Drop the table in case it exists

DROP TABLE BookShop;

-- Create the table

CREATE TABLE BookShop (
    BOOK_ID VARCHAR(4) NOT NULL,
    TITLE VARCHAR(100) NOT NULL,
    AUTHOR_NAME VARCHAR(30) NOT NULL,
    AUTHOR_BIO VARCHAR(250),
    AUTHOR_ID INTEGER NOT NULL,
    PUBLICATION_DATE DATE NOT NULL,
    PRICE_USD DECIMAL(6,2) CHECK(Price_USD>0) NOT NULL
    );
```

Congratulations! You have completed this lab, and you are ready for the next topic.

Author(s)

- Pratiksha Verma

Changelog

Date	Version	Changed by	Change Description
2022-06-22	1.0	Pratiksha Verma	Converted intial version to DataSette