library-management-system

A frontend application for managing the resources and memberships of a university library stored in MySQL Server.

`Optimization Tasks of Assignment 8 is at the end.`

Steps to run this project

Installation requirements :

```
python3 -m venv env_flask
pip3 install flask
pip3 install flask-mysqldb
pip3 install pyyaml
```

MySQL Server (Workbench) should also be installed. Dump the library schema with dummy values using the following command in MySQL:

```
source dumpfile.sql;
```

One must configure the db.yaml file to connect to the MySQL Server.

```
mysql_host: 'localhost'
mysql_user: 'root'
mysql_password: '<enter your password>'
mysql_db: '<enter the name of the database which can be imported from the
dump file>'
```

After cloning the repository and entering into the `library-management-system` folder :

```
cd flask-website
python app.py
```

Click on the URL `http://127.0.0.1:5000` to visit the Library Management System website.

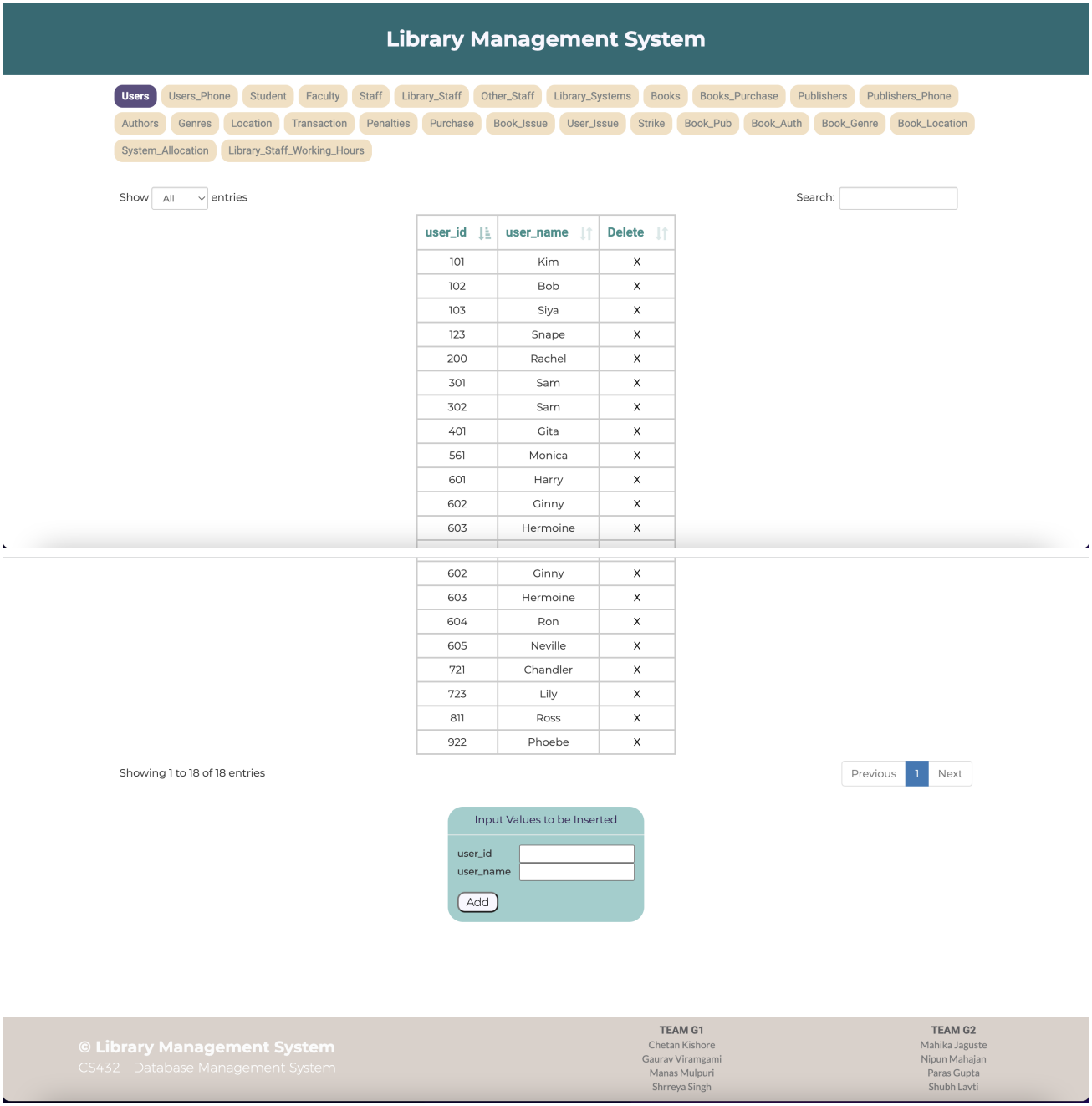
Contents of this repository

- The relations were added to the database from the MySQL client command line. The schema with dummy values of our database can be found in the `final_values_final.sql` file.
- A Python script was used to add dummy data to our tables. This script can be found in the `insert_dummy_values.py` file.
- The Flask website code is found inside the `flask-website` folder.

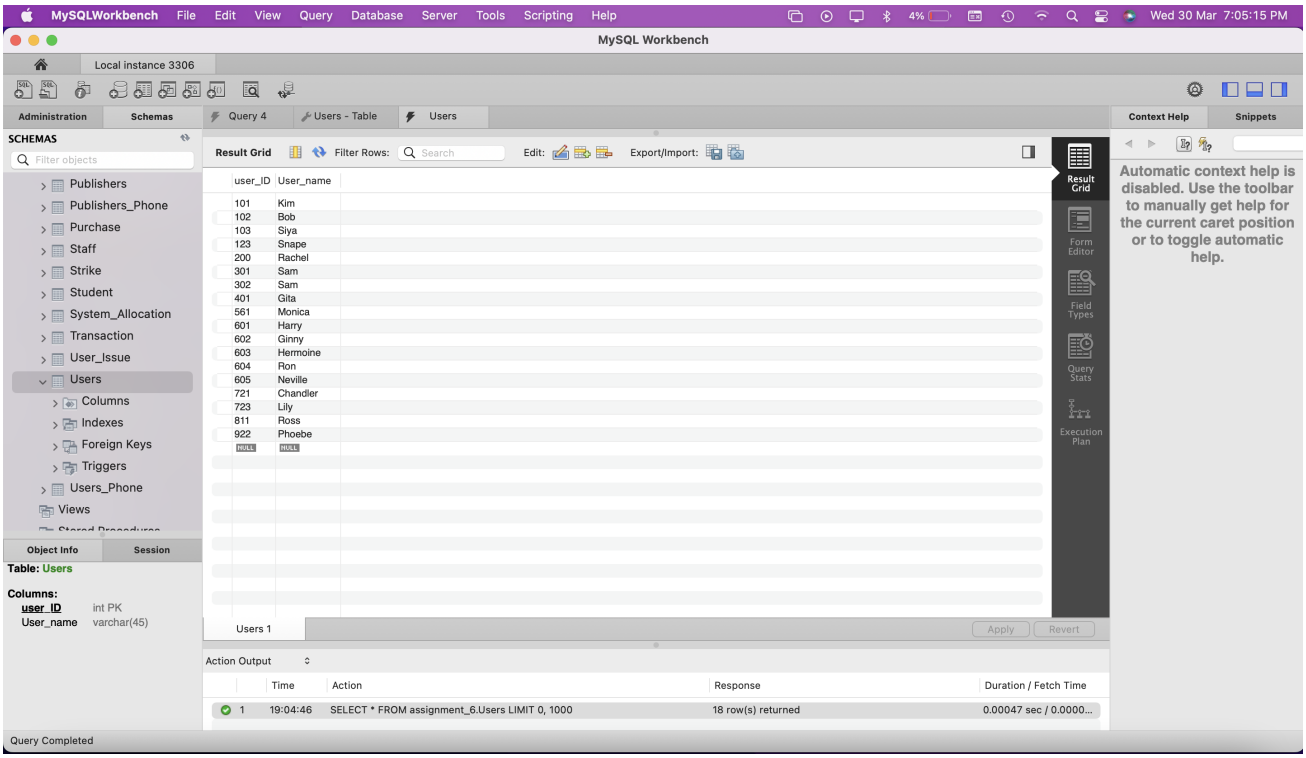
Snapshots of the functioning of the website

The functioning of the INSERT, DELETE and UPDATE queries has been shown through the following snapshots of the website. We have also shown some cases where our web app gives errors like foreign key constraints are violated, duplicate primary keys, etc.

View Of `Users` Relation



View Of `Users` Relation in Workbench



Adding Entry in `Users` Relation

301	Sam	X
302	Sam	X
401	Gita	X
561	Monica	X
601	Harry	X
602	Ginny	X
603	Hermoine	X
604	Ron	X
605	Neville	X
721	Chandler	X
723	Lily	X
811	Ross	X
922	Phoebe	X

Showing 1 to 18 of 18 entries

Previous 1 Next

Input Values to be Inserted

user_id 989

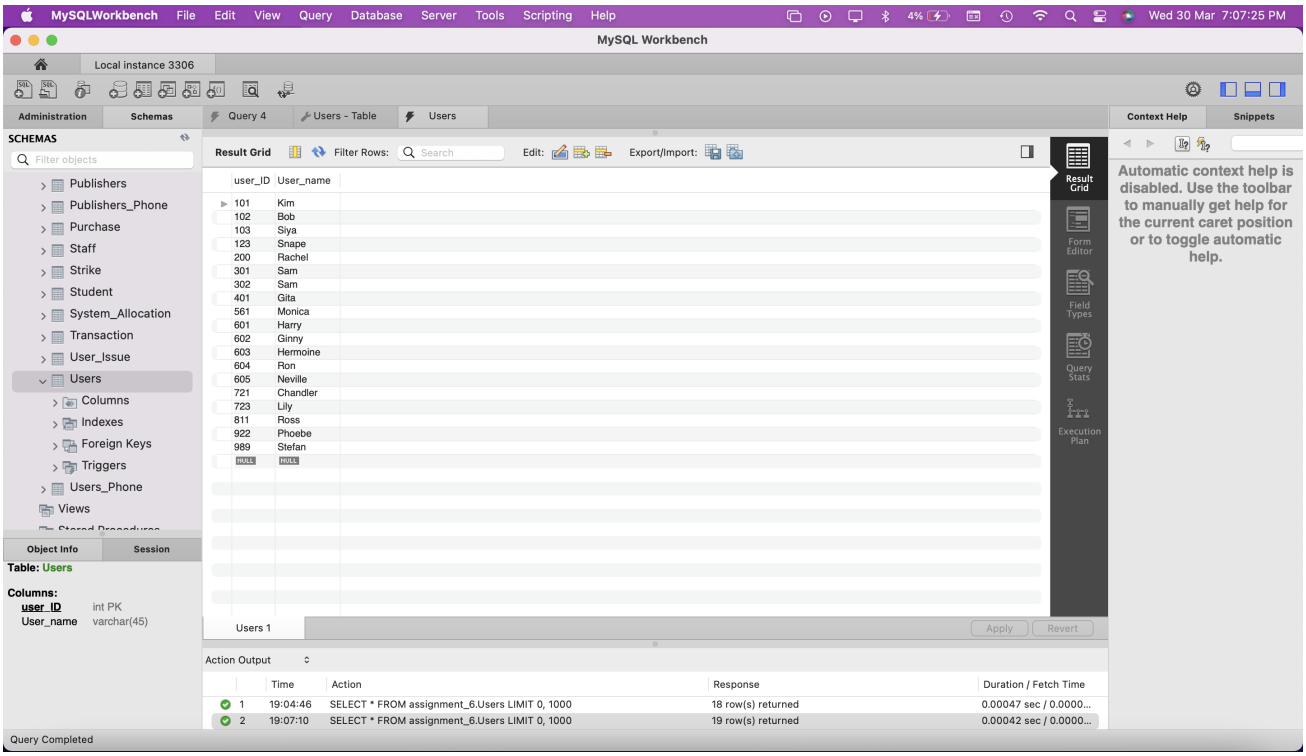
user_name Stefan

Add

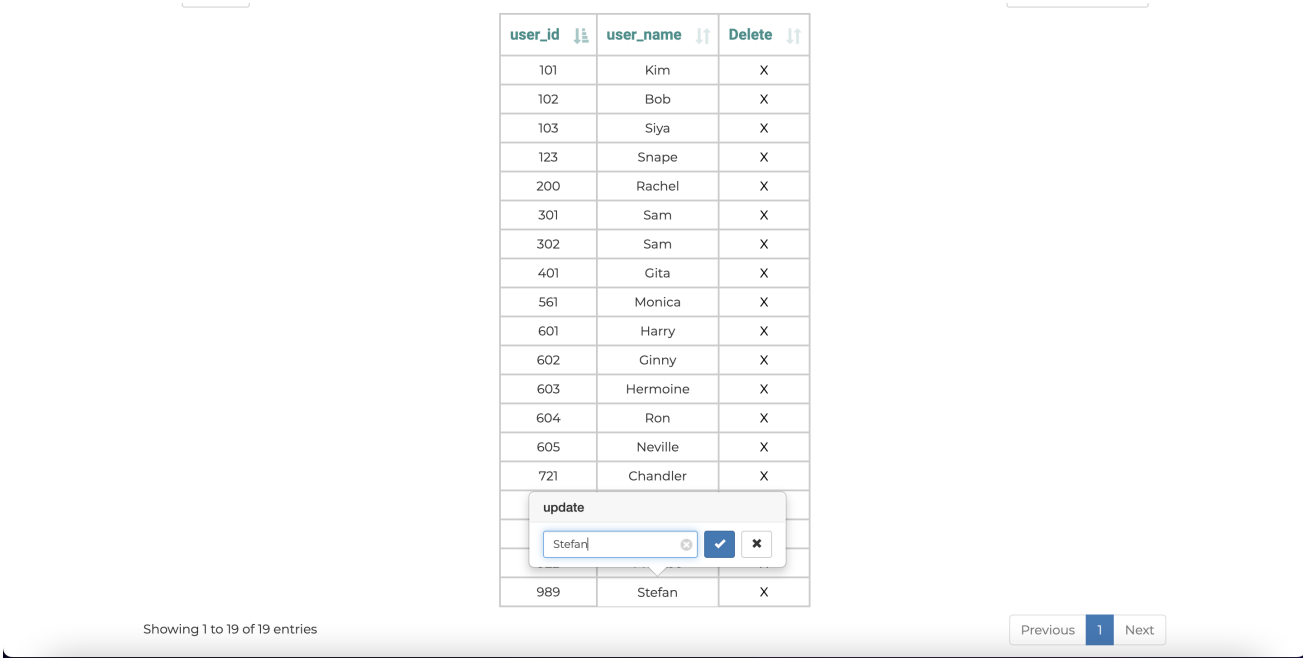
user_id	user_name	Delete
101	Kim	X
102	Bob	X
103	Siya	X
123	Snape	X
200	Rachel	X
301	Sam	X
302	Sam	X
401	Gita	X
561	Monica	X
601	Harry	X
602	Ginny	X
603	Hermoine	X
604	Ron	X
605	Neville	X
721	Chandler	X
723	Lily	X
811	Ross	X
922	Phoebe	X
989	Stefan	X

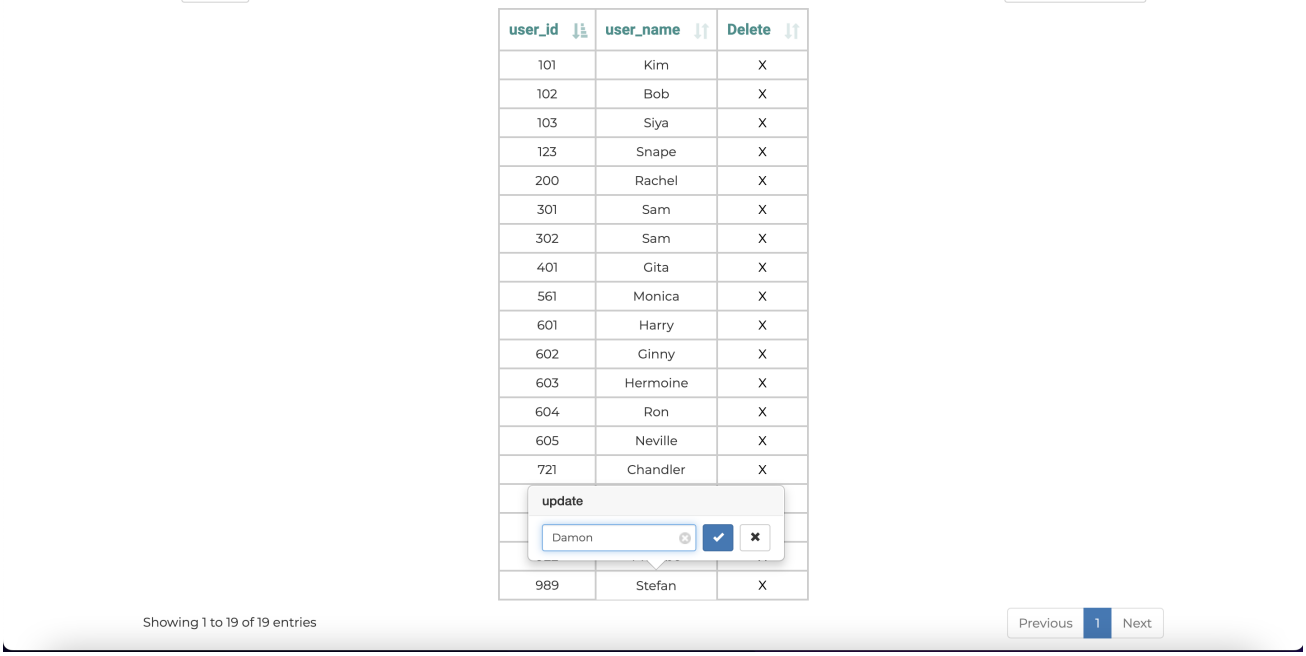
Showing 1 to 19 of 19 entries

Previous 1 Next



Updating Entry in `Users` Relation

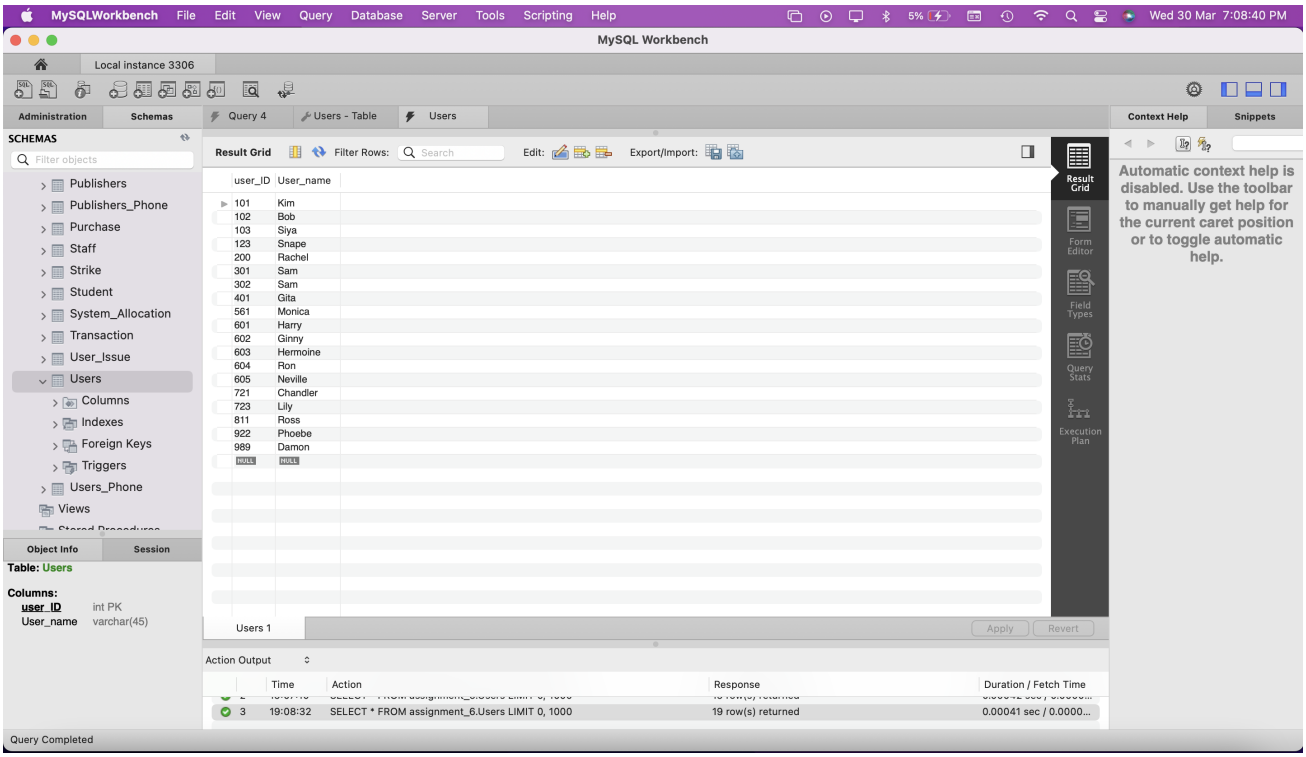

user_id
user_name
Delete
101 Kim X
102 Bob X
103 Siya X
123 Snape X
200 Rachel X
301 Sam X
302 Sam X
401 Gita X
561 Monica X
601 Harry X
602 Ginny X
603 Hermoine X
604 Ron X
605 Neville X
721 Chandler X
update
Stefan
989 Stefan X
Showing 1 to 19 of 19 entries
Previous 1 Next


user_id
user_name
Delete
101 Kim X
102 Bob X
103 Siya X
123 Snape X
200 Rachel X
301 Sam X
302 Sam X
401 Gita X
561 Monica X
601 Harry X
602 Ginny X
603 Hermoine X
604 Ron X
605 Neville X
721 Chandler X
update
Damon
989 Stefan X
Showing 1 to 19 of 19 entries
Previous 1 Next

user_id	user_name	Delete
101	Kim	X
102	Bob	X
103	Siya	X
123	Snape	X
200	Rachel	X
301	Sam	X
302	Sam	X
401	Gita	X
561	Monica	X
601	Harry	X
602	Ginny	X
603	Hermoine	X
604	Ron	X
605	Neville	X
721	Chandler	X
723	Lily	X
811	Ross	X
922	Phoebe	X
989	Damon	X

Showing 1 to 19 of 19 entries

Previous 1 Next



Deleting Entry in `Users` Relation

user_id	user_name	Delete
101	Kim	X
102	Bob	X
103	Siya	X
123	Snape	X
200	Rachel	X
301	Sam	X
302	Sam	X
401	Gita	X
561	Monica	X
601	Harry	X
602	Ginny	X
603	Hermoine	X
604	Ron	X
605	Neville	X
721	Chandler	X
723	Lily	X
811	Ross	X
922	Phoebe	X
989	Damon	X

Showing 1 to 19 of 19 entries

Previous 1 Next

127.0.0.1:5000/delete/Users?Users_user_id=989&Users_user_name=Stefan&

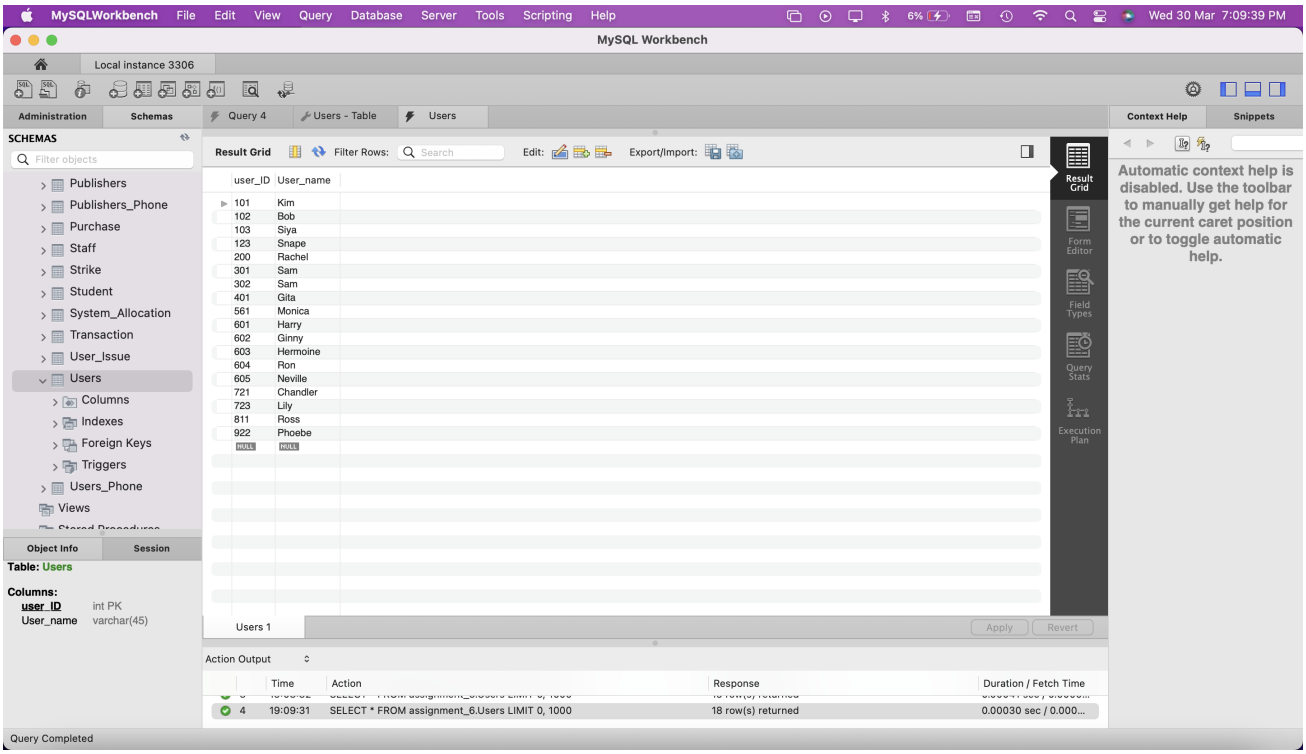
Show All entries

Search:

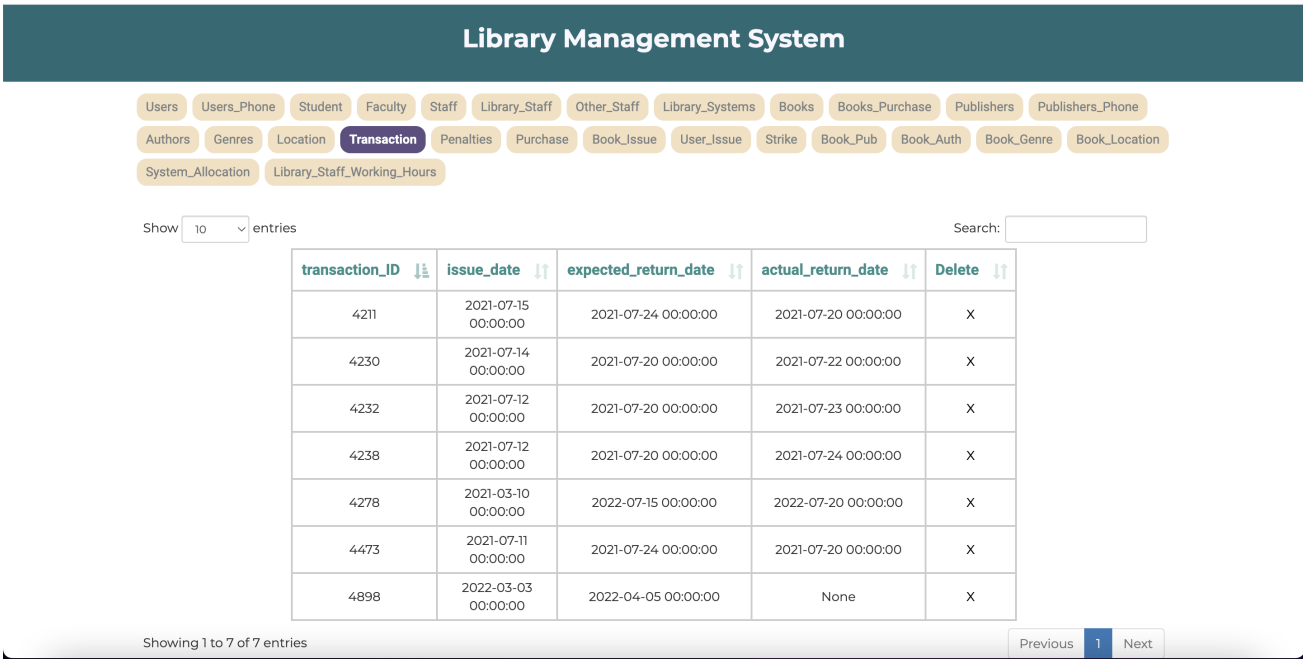
user_id	user_name	Delete
101	Kim	X
102	Bob	X
103	Siya	X
123	Snape	X
200	Rachel	X
301	Sam	X
302	Sam	X
401	Gita	X
561	Monica	X
601	Harry	X
602	Ginny	X
603	Hermoine	X
604	Ron	X
605	Neville	X
721	Chandler	X
723	Lily	X
811	Ross	X
922	Phoebe	X

Showing 1 to 18 of 18 entries

Previous 1 Next



View Of `Transactions` Relation



Adding Entry in `Transactions` Relation

Show 10 entries Search:

transaction_ID	issue_date	expected_return_date	actual_return_date	Delete
4211	2021-07-15 00:00:00	2021-07-24 00:00:00	2021-07-20 00:00:00	X
4230	2021-07-14 00:00:00	2021-07-20 00:00:00	2021-07-22 00:00:00	X
4232	2021-07-12 00:00:00	2021-07-20 00:00:00	2021-07-23 00:00:00	X
4238	2021-07-12 00:00:00	2021-07-20 00:00:00	2021-07-24 00:00:00	X
4278	2021-03-10 00:00:00	2022-07-15 00:00:00	2022-07-20 00:00:00	X
4473	2021-07-11 00:00:00	2021-07-24 00:00:00	2021-07-20 00:00:00	X
4898	2022-03-03 00:00:00	2022-04-05 00:00:00	None	X

Showing 1 to 7 of 7 entries Previous 1 Next

Input Values to be Inserted

transaction_ID 4980
issue_date 2022-03-30
expected_return_date 2022-04-05
actual_return_date NULL

Add

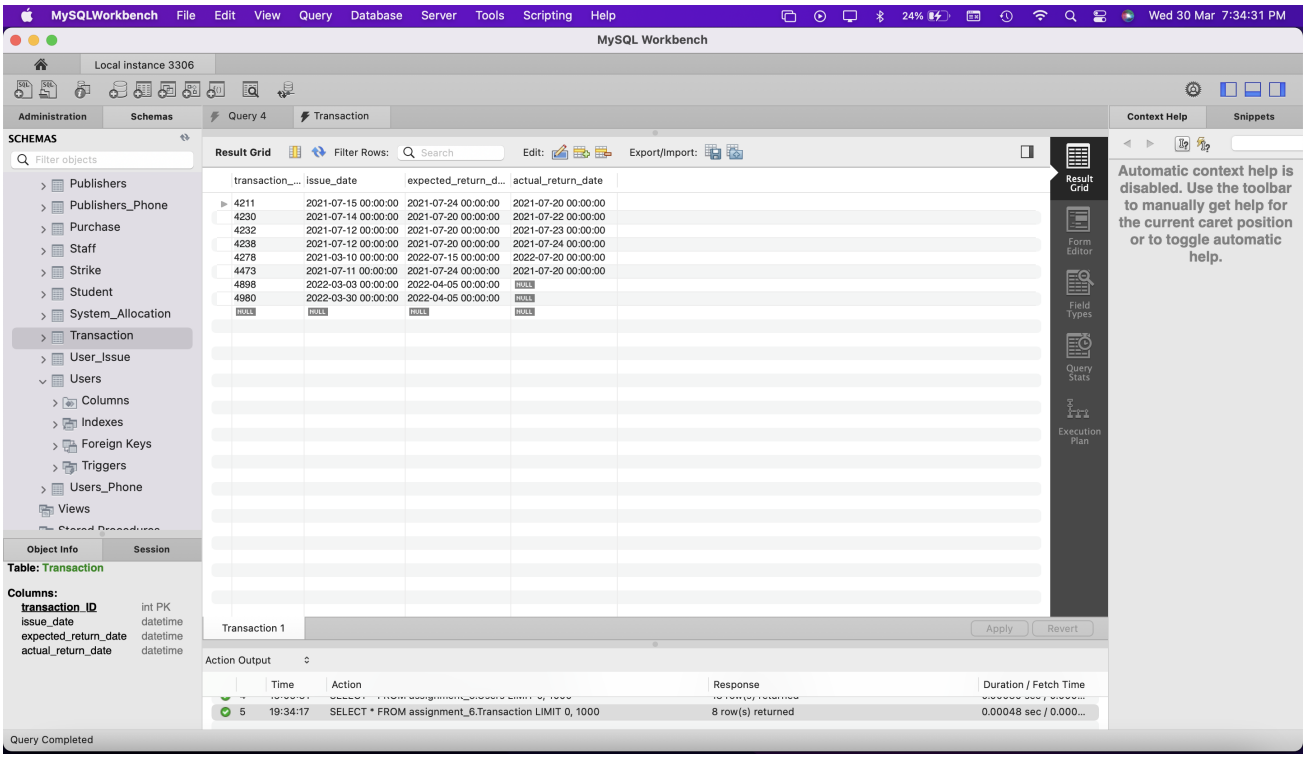
Show 10 entries Search:

transaction_ID	issue_date	expected_return_date	actual_return_date	Delete
4211	2021-07-15 00:00:00	2021-07-24 00:00:00	2021-07-20 00:00:00	X
4230	2021-07-14 00:00:00	2021-07-20 00:00:00	2021-07-22 00:00:00	X
4232	2021-07-12 00:00:00	2021-07-20 00:00:00	2021-07-23 00:00:00	X
4238	2021-07-12 00:00:00	2021-07-20 00:00:00	2021-07-24 00:00:00	X
4278	2021-03-10 00:00:00	2022-07-15 00:00:00	2022-07-20 00:00:00	X
4473	2021-07-11 00:00:00	2021-07-24 00:00:00	2021-07-20 00:00:00	X
4898	2022-03-03 00:00:00	2022-04-05 00:00:00	None	X
4980	2022-03-30 00:00:00	2022-04-05 00:00:00	None	X

Showing 1 to 8 of 8 entries Previous 1 Next

Input Values to be Inserted

transaction_ID
issue_date
expected_return_date
actual_return_date



Adding Entry in `User_Issue` Relation

Library Management System

Users | Users_Phone | Student | Faculty | Staff | Library_Staff | Other_Staff | Library_Systems | Books | Books_Purchase | Publishers | Publishers_Phone | Authors | Genres | Location | Transaction | Penalties | Purchase | Book_Issue | **User_Issue** | Strike | Book_Pub | Book_Auth | Book_Genre | Book_Location | System_Allocation | Library_Staff_Working_Hours

Show 10 entries

Search:

transaction_ID	user_ID	Delete
4238	101	X
4278	103	X
4898	200	X

Showing 1 to 3 of 3 entries

Previous 1 Next

Input Values to be Inserted

transaction_ID 4980

user_ID 922

Add

Library Management System

Users | Users_Phone | Student | Faculty | Staff | Library_Staff | Other_Staff | Library_Systems | Books | Books_Purchase | Publishers | Publishers_Phone | Authors | Genres | Location | Transaction | Penalties | Purchase | Book_Issue | **User_Issue** | Strike | Book_Pub | Book_Auth | Book_Genre | Book_Location | System_Allocation | Library_Staff_Working_Hours

Show 10 entries

Search:

transaction_ID	user_ID	Delete
4238	101	X
4278	103	X
4898	200	X
4980	922	X

Showing 1 to 4 of 4 entries

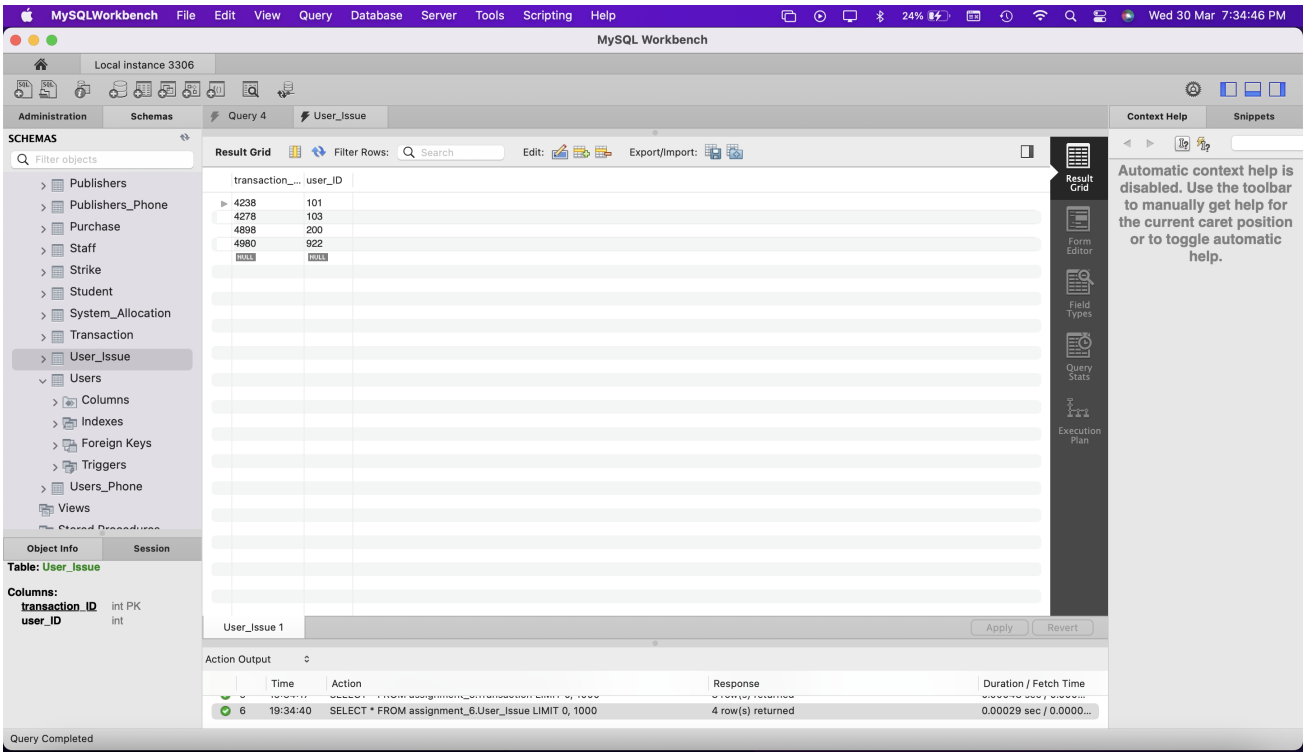
Previous 1 Next

Input Values to be Inserted

transaction_ID

user_ID

Add



Adding Entry in `Book_Issue` Relation

Library Management System

Users | Users_Phone | Student | Faculty | Staff | Library_Staff | Other_Staff | Library_Systems | Books | Books_Purchase | Publishers | Publishers_Phone | Authors | Genres | Location | Transaction | Penalties | Purchase | **Book_Issue** | User_Issue | Strike | Book_Pub | Book_Auth | Book_Genre | Book_Location | System_Allocation | Library_Staff_Working_Hours

Show 10 entries

Search:

transaction_ID	book_ID	Delete
4232	45678	X
4238	12345	X
4278	34567	X
4898	23456	X

Showing 1 to 4 of 4 entries

Previous 1 Next

Input Values to be Inserted

transaction_ID 4980

book_ID 67890

Add

Library Management System

Users | Users_Phone | Student | Faculty | Staff | Library_Staff | Other_Staff | Library_Systems | Books | Books_Purchase | Publishers | Publishers_Phone | Authors | Genres | Location | Transaction | Penalties | Purchase | **Book_Issue** | User_Issue | Strike | Book_Pub | Book_Auth | Book_Genre | Book_Location | System_Allocation | Library_Staff_Working_Hours

Show 10 entries

Search:

transaction_ID	book_ID	Delete
4232	45678	X
4238	12345	X
4278	34567	X
4898	23456	X
4980	67890	X

Showing 1 to 5 of 5 entries

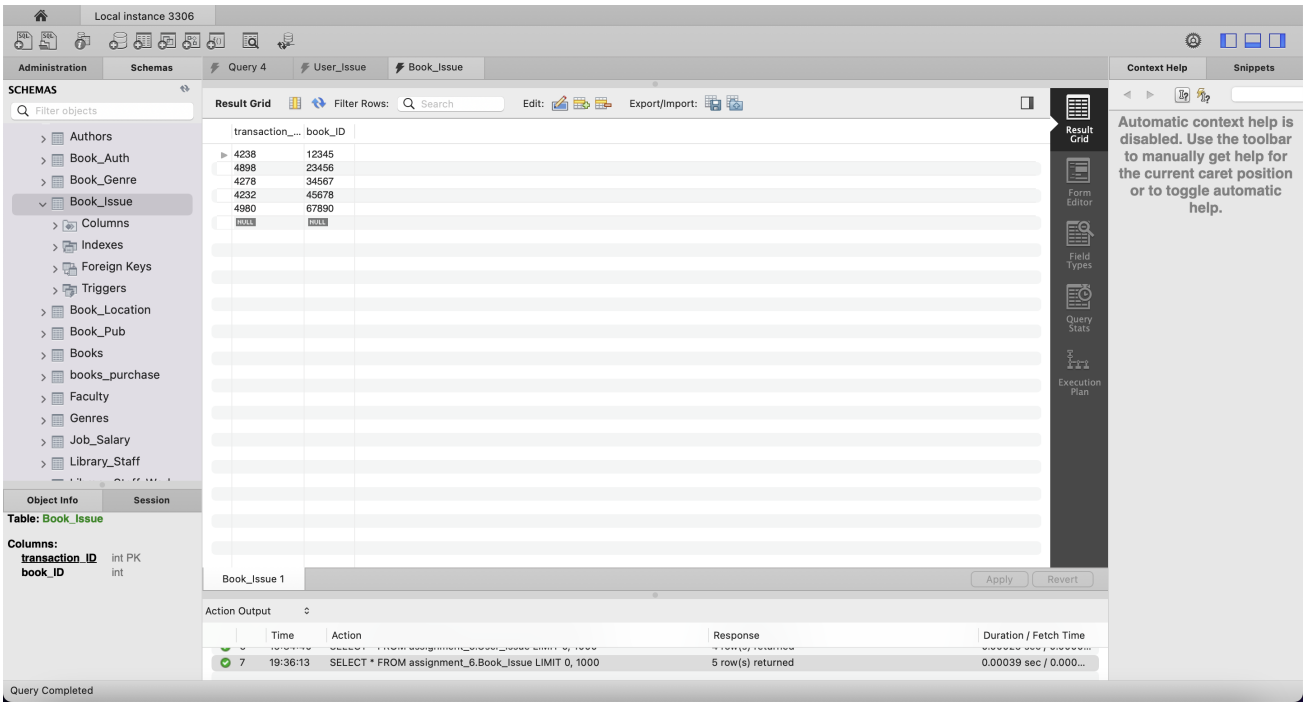
Previous 1 Next

Input Values to be Inserted

transaction_ID

book_ID

Add



Updating Entry in `Library_Systems` Relation

Library Management System

Users | Users_Phone | Student | Faculty | Staff | Library_Staff | Other_Staff | **Library_Systems** | Books | Books_Purchase | Publishers | Publishers_Phone | Authors | Genres | Location | Transaction | Penalties | Purchase | Book_Issue | User_Issue | Strike | Book_Pub | Book_Auth | Book_Genre | Book_Location | System_Allocation | Library_Staff_Working_Hours

Show 10 entries

Search:

system_ID	system_specs	Delete
1011	OS: Windows, NVIDIA GPU	X
102	update 'IDIA GPU 256 GB RAM	
102		
1035	OS: Windows, NVIDIA GPU	X

Showing 1 to 4 of 4 entries

Previous 1 Next

Input Values to be Inserted

system_ID

system_specs

Add

Library Management System

Users | Users_Phone | Student | Faculty | Staff | Library_Staff | Other_Staff | **Library_Systems** | Books | Books_Purchase | Publishers | Publishers_Phone | Authors | Genres | Location | Transaction | Penalties | Purchase | Book_Issue | User_Issue | Strike | Book_Pub | Book_Auth | Book_Genre | Book_Location | System_Allocation | Library_Staff_Working_Hours

Show 10 entries

Search:

system_ID	system_specs	Delete
1011	OS: Windows, NVIDIA GPU	X
1023	OS: Windows, NO GPU	X
1024	OS: MacOS, TPU	X
1035	OS: Windows, NVIDIA GPU 256 GB RAM	X

Showing 1 to 4 of 4 entries

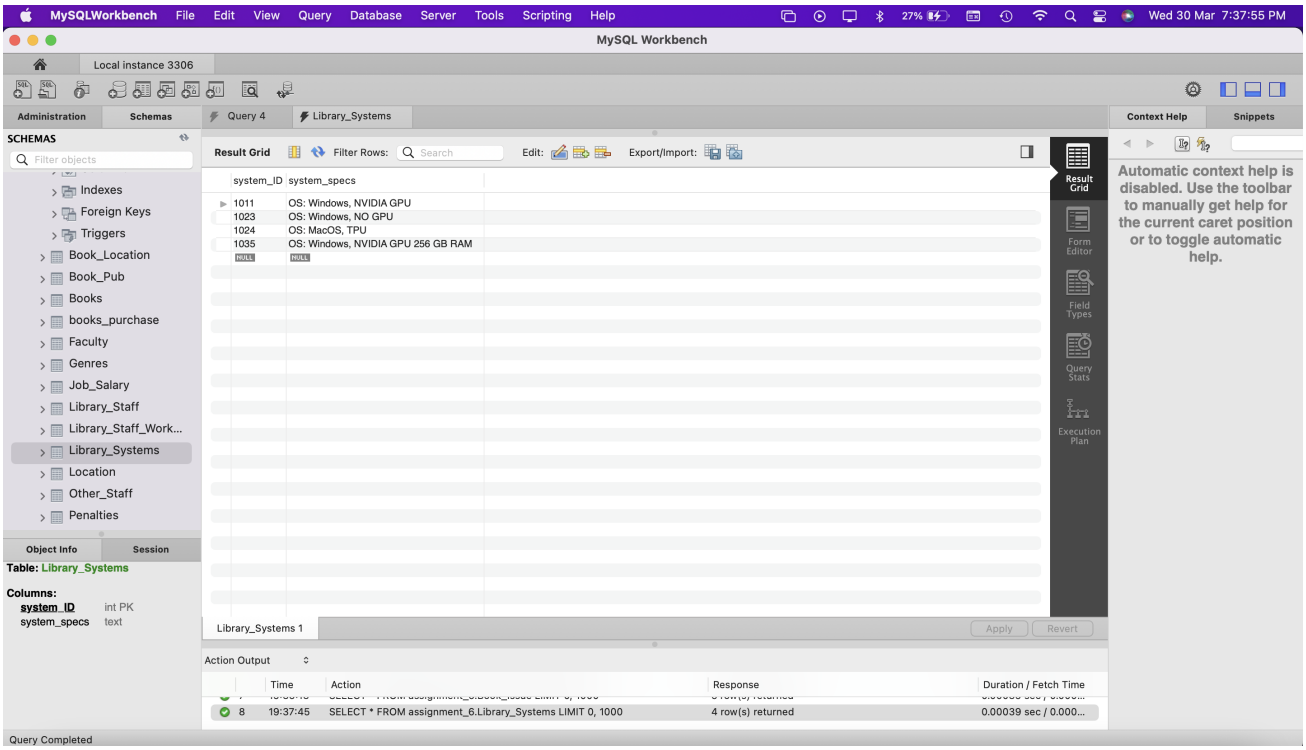
Previous 1 Next

Input Values to be Inserted

system_ID

system_specs

Add



Deleting Entry in `Library_Systems` Relation

Library Management System

Users | Users_Phone | Student | Faculty | Staff | Library_Staff | Other_Staff | Library_Systems | Books | Books_Purchase | Publishers | Publishers_Phone | Authors | Genres | Location | Transaction | Penalties | Purchase | Book_Issue | User_Issue | Strike | Book_Pub | Book_Auth | Book_Genre | Book_Location | **System_Allocation** | Library_Staff_Working_Hours

Show 10 entries

Search:

user_ID	system_ID	Delete
123	1035	X
561	1011	X
603	1023	X
604	1024	X

Showing 1 to 4 of 4 entries

Previous 1 Next

Input Values to be Inserted

user_ID
system_ID

Add

Library Management System

Users | Users_Phone | Student | Faculty | Staff | Library_Staff | Other_Staff | Library_Systems | Books | Books_Purchase | Publishers | Publishers_Phone | Authors | Genres | Location | Transaction | Penalties | Purchase | Book_Issue | User_Issue | Strike | Book_Pub | Book_Auth | Book_Genre | Book_Location | **System_Allocation** | Library_Staff_Working_Hours

Show 10 entries

Search:

user_ID	system_ID	Delete
123	1035	X
561	1011	X
604	1024	X

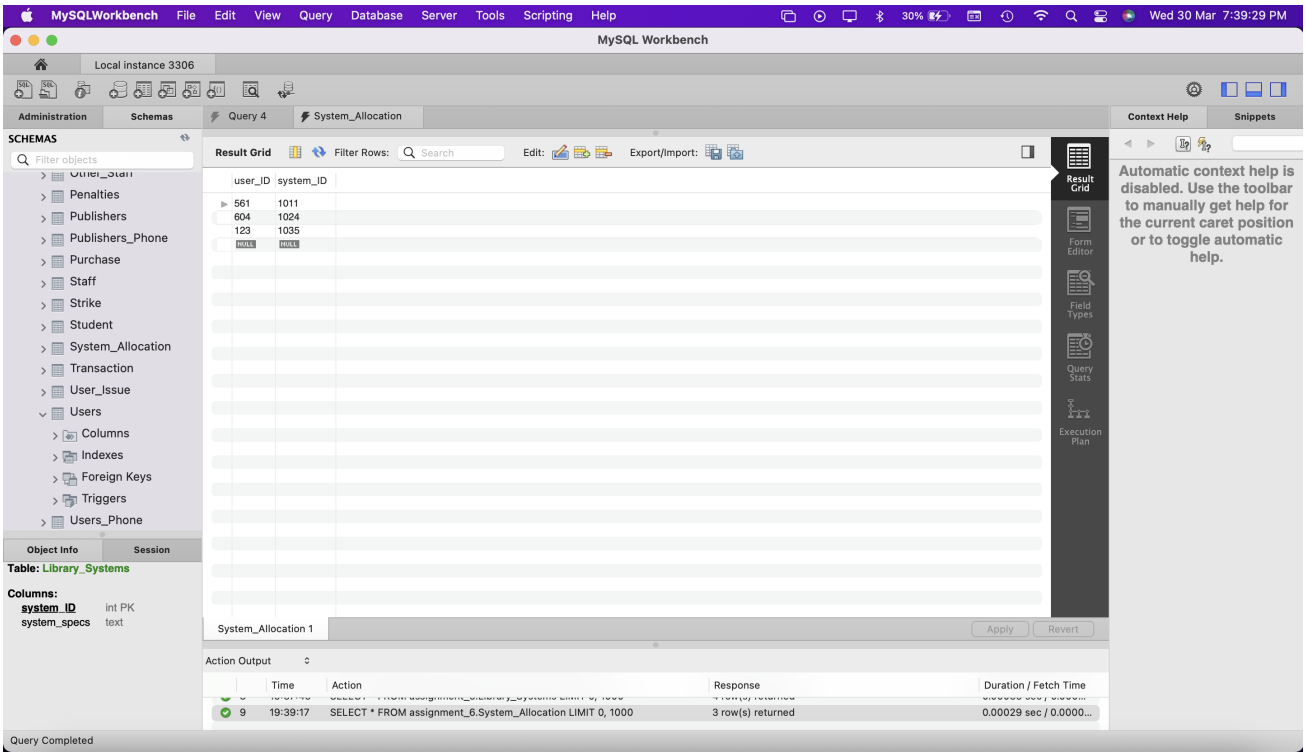
Showing 1 to 3 of 3 entries

Previous 1 Next

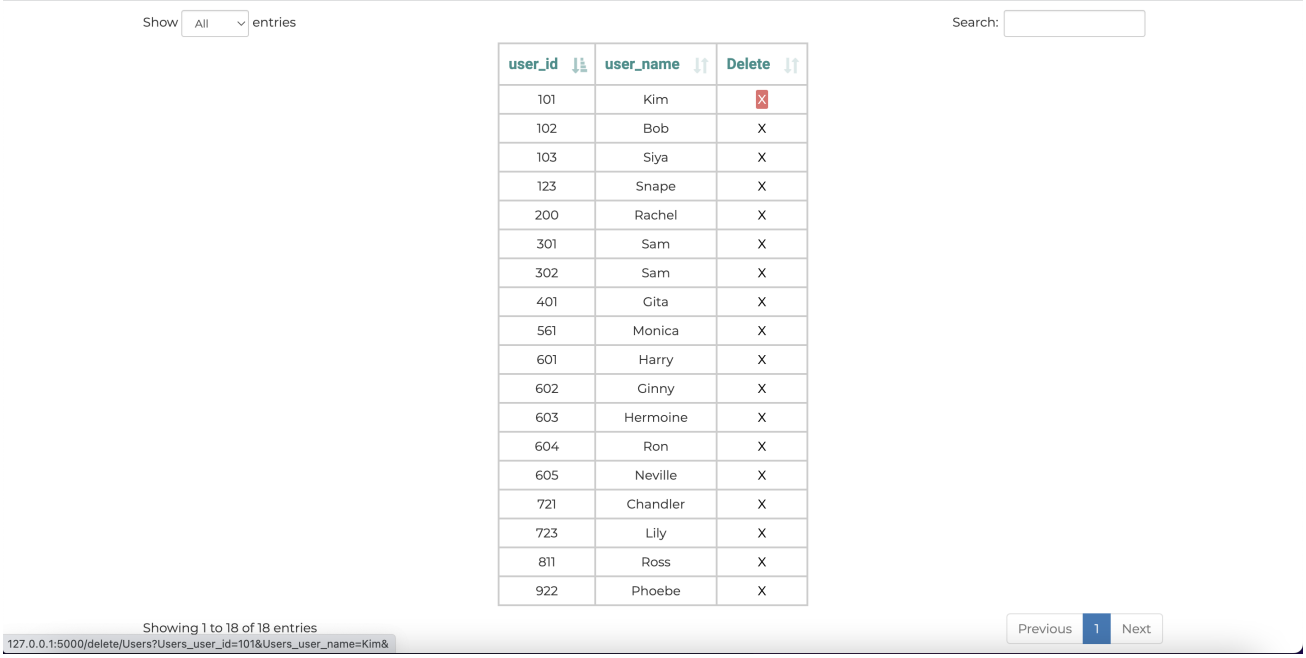
Input Values to be Inserted

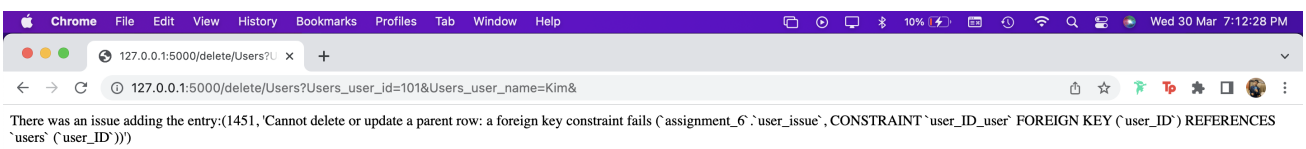
user_ID
system_ID

Add

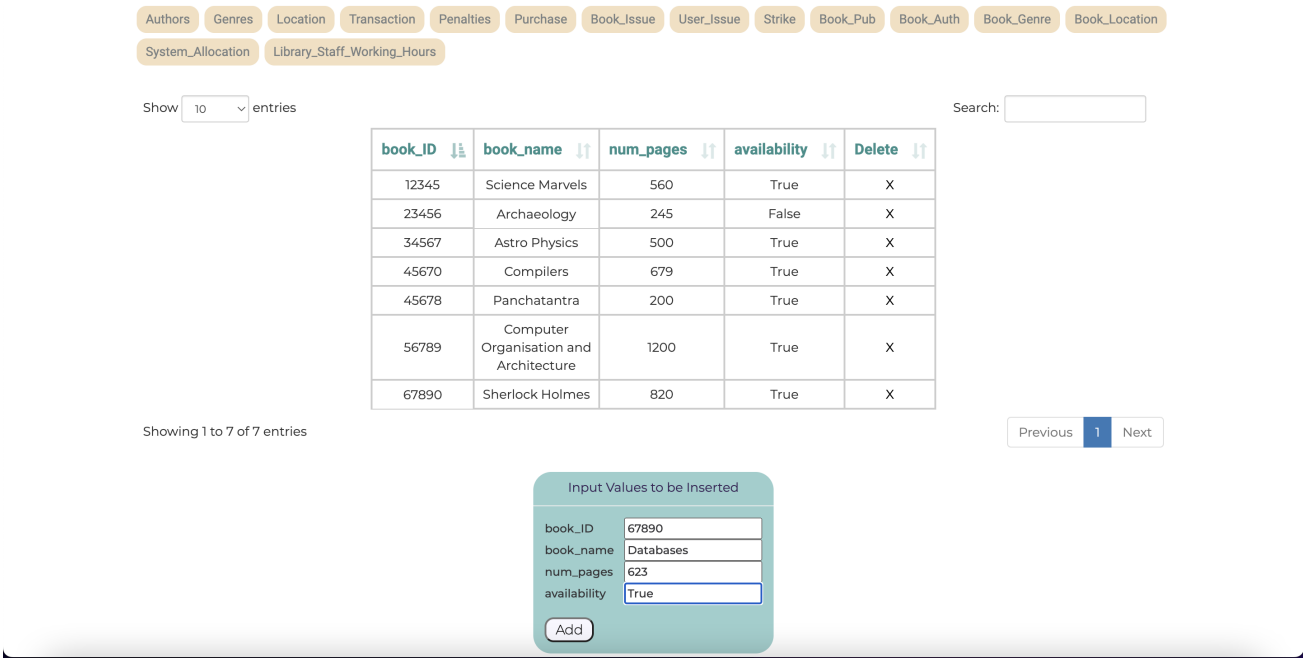


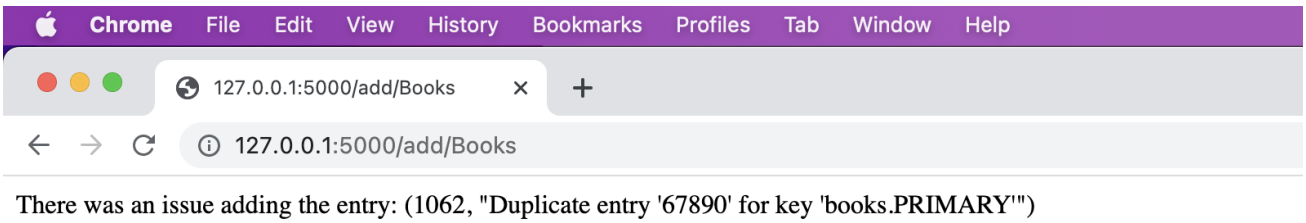
Error due to `Foreign Key` Constraint in `Users` Relation





Error due to `Duplicate Primary Key` in `Books` Relation





There was an issue adding the entry: (1062, "Duplicate entry '67890' for key 'books.PRIMARY'")

Tasks Assignment 8

Task 1

Query 1

`select * from publishers where publisher_name like 'Denise%' or street_name like '%Scott';`

Optimized query 1

```
select * from publishers where publisher_name like 'Denise%'
union all
select * from publishers where street_name like '%Scott';
```

```
mysql> set profiling = 1;
Query OK, 0 rows affected, 1 warning (0.00 sec)

mysql> select * from publishers where publisher_name like 'Denise%' or street_name like '%Scott';
+--------------+----------------+------------+--------------+------+-------+----------+---------+
| publisher_ID | publisher_name | street_num | street_name  | city | state | zip_code | email   |
+--------------+----------------+------------+--------------+------+-------+----------+---------+
|        10492 | Denise Hammond | 123        | Barbara Croft | abc  | abc   | 302363   | abc_612 |
|        10888 | William Fundora | 123       | Heather Scott | abc  | abc   | 935344   | abc_677 |
|        58182 | Denise Beaver  | 123        | Connie Downs | abc  | abc   | 404124   | abc_135 |
|        62834 | Allen Russell  | 123        | Janet Scott  | abc  | abc   | 171932   | abc_587 |
|        95239 | Sandra Nova    | 123        | Michael Scott | abc  | abc   | 788562   | abc_545 |
|        96184 | Pamela Bolton  | 123        | John Prescott | abc  | abc   | 810302   | abc_856 |
+--------------+----------------+------------+--------------+------+-------+----------+---------+
6 rows in set (0.08 sec)

mysql> set profiling = 0;
Query OK, 0 rows affected, 1 warning (0.00 sec)

mysql> explain select * from publishers where publisher_name like 'Denise%' or street_name like '%Scott';
+----+-------------+------------+------------+------+---------------+------+---------+------+------+----------+-------------+
| id | select_type | table      | partitions | type | possible_keys | key  | key_len | ref  | rows | filtered | Extra       |
+----+-------------+------------+------------+------+---------------+------+---------+------+------+----------+-------------+
|  1 | SIMPLE      | publishers | NULL       | ALL  | NULL          | NULL | NULL    | NULL | 1000 |    20.99 | Using where |
+----+-------------+------------+------------+------+---------------+------+---------+------+------+----------+-------------+
1 row in set, 1 warning (0.00 sec)

mysql> CREATE FULLTEXT INDEX pub_name_index ON publishers(publisher_name);
Query OK, 0 rows affected (0.75 sec)
Records: 0  Duplicates: 0  Warnings: 0

mysql> CREATE FULLTEXT INDEX street_name_index ON publishers(street_name);
Query OK, 0 rows affected (0.50 sec)
Records: 0  Duplicates: 0  Warnings: 0

mysql> set profiling = 1;
Query OK, 0 rows affected, 1 warning (0.00 sec)
```

```
MySQL 8.0 Command Line Client

mysql> select * from publishers where match(publisher_name) against ('Denise*' in boolean mode) union all select * from publishers where match(street_name) ag
ainst ('*Scott' in boolean mode);
+--------------+----------------+------------+--------------+------+-------+----------+---------+
| publisher_ID | publisher_name | street_num | street_name  | city | state | zip_code | email   |
+--------------+----------------+------------+--------------+------+-------+----------+---------+
|        10492 | Denise Hammond | 123        | Barbara Croft | abc  | abc   | 302363   | abc_612 |
|        58182 | Denise Beaver  | 123        | Connie Downs | abc  | abc   | 404124   | abc_135 |
|        10888 | William Fundora | 123       | Heather Scott | abc  | abc   | 935344   | abc_677 |
|        62834 | Allen Russell  | 123        | Janet Scott  | abc  | abc   | 171932   | abc_587 |
|        81960 | Maria Torres   | 123        | Scott Robledo | abc  | abc   | 929974   | abc_726 |
|        95239 | Sandra Nova    | 123        | Michael Scott | abc  | abc   | 788562   | abc_545 |
+--------------+----------------+------------+--------------+------+-------+----------+---------+
6 rows in set (0.01 sec)

mysql> set profiling = 0;
Query OK, 0 rows affected, 1 warning (0.00 sec)

mysql> explain select * from publishers where match(publisher_name) against ('Denise*' in boolean mode) union all select * from publishers where match(street_
name) against ('*Scott' in boolean mode);
+----+-------------+------------+------------+----------+------------------+------------------+---------+-------+------+----------+-----------------------
----------+
| id | select_type | table      | partitions | type     | possible_keys    | key              | key_len | ref   | rows | filtered | Extra
         |
+----+-------------+------------+------------+----------+------------------+------------------+---------+-------+------+----------+-----------------------
----------+
|  1 | PRIMARY     | publishers | NULL       | fulltext | pub_name_index   | pub_name_index   | 0       | const |    1 |   100.00 | Using where; Ft_hints: n
o_ranking |
|  2 | UNION       | publishers | NULL       | fulltext | street_name_index | street_name_index | 0       | const |    1 |   100.00 | Using where; Ft_hints: n
o_ranking |
+----+-------------+------------+------------+----------+------------------+------------------+---------+-------+------+----------+-----------------------
----------+
2 rows in set, 1 warning (0.00 sec)
```

```
mysql> show profiles;
+----------+------------+-------------------------------------------------------------------------------------------------------------------------------------------------------------
-------------------------------------------------+
| Query_ID | Duration   | Query
                                                                                                                                                                |
+----------+------------+-------------------------------------------------------------------------------------------------------------------------------------------------------------
-------------------------------------------------+
|        1 | 0.08033325 | select * from publishers where publisher_name like 'Denise%' or street_name like '%Scott'
                                                                                                                                                                |
|        2 | 0.00825325 | select * from publishers where match(publisher_name) against ('Denise*' in boolean mode) union all select * from publishers where m
atch(street_name) against ('*Scott' in boolean mode) |
+----------+------------+-------------------------------------------------------------------------------------------------------------------------------------------------------------
-------------------------------------------------+
2 rows in set, 1 warning (0.00 sec)

mysql>
```

Query 1

Rows: `1000`

Duration: `0.08033325 s`

Optimized query 1
Rows: `2` (reduced)
Duration: `0.00825325 s` (reduced)

If we run queries using the comparison operator 'or' on different columns in the where clause, there are chances that the MySQL optimizer may incorrectly choose a full table scan to retrieve a record. However, having different indices to optimize two separate queries on the two different attributes and taking the union of those results can make the query run faster. The query 1 above can run far much slower compared to optimized query 1 which uses a union operator to merge the results of 2 separate fast queries that take advantage of the indexes.

Task 2

Query: `SELECT * FROM users WHERE user_name LIKE "m%";`
[pattern selected: x% , where x is any character from english alphabet]

Number of rows hit: `2000`

Execution time: `0.00189500 sec`

In the query mentioned above, we are querying a name that starts with the English alphabet 'm'. The query is expected to return the rows from the `users` table having the value of attribute user_name as a string starting with 'm'. Clearly, this can be modeled as a prefix selection problem. In our query, the prefix required is 'm'. Therefore, we can create a prefix index on the attribute user_name using:

```
CREATE INDEX user_name_ind ON users(user_name(1));
```

Now, we run the query again for the same pattern. To force the use of index, we run the optimized query as:

```
SELECT * FROM users USE INDEX(user_name_ind) WHERE user_name LIKE "m%";
```

Number of rows hit: `221`

Execution time: `0.00142900 sec`

Results:

```
mysql> EXPLAIN SELECT * from users where user_name LIKE "m%";
+----+-------------+-------+------------+------+---------------+------+---------+------+------+----------+-------------+
| id | select_type | table | partitions | type | possible_keys | key  | key_len | ref  | rows | filtered | Extra       |
+----+-------------+-------+------------+------+---------------+------+---------+------+------+----------+-------------+
|  1 | SIMPLE      | users | NULL       | ALL  | NULL          | NULL | NULL    | NULL | 2000 |    11.11 | Using where |
+----+-------------+-------+------------+------+---------------+------+---------+------+------+----------+-------------+
1 row in set, 1 warning (0.01 sec)
```

```
mysql> CREATE INDEX user_name_ind ON users(user_name(1));
Query OK, 0 rows affected (0.08 sec)
Records: 0  Duplicates: 0  Warnings: 0
```

```
+----+-------------+-------+------------+-------+---------------+---------------+---------+------+------+----------+-------------+
| id | select_type | table | partitions | type  | possible_keys | key           | key_len | ref  | rows | filtered | Extra       |
+----+-------------+-------+------------+-------+---------------+---------------+---------+------+------+----------+-------------+
|  1 | SIMPLE      | users | NULL       | range | user_name_ind | user_name_ind | 6       | NULL |  221 |   100.00 | Using where |
+----+-------------+-------+------------+-------+---------------+---------------+---------+------+------+----------+-------------+
```

```
mysql> show profiles;
+----------+------------+-----------------------------------------------------------------------------+
| Query_ID | Duration   | Query                                                                       |
+----------+------------+-----------------------------------------------------------------------------+
|        1 | 0.00189500 | SELECT * FROM users WHERE user_name LIKE 'm%'                               |
|        2 | 0.03234700 | CREATE INDEX user_name_ind ON users(user_name(1))                           |
|        3 | 0.00142900 | SELECT * FROM users USE INDEX(user_name_ind) WHERE user_name LIKE 'm%'      |
+----------+------------+-----------------------------------------------------------------------------+
```

Task 3

Table: **Publishers**
Column:

- **zip_code**: Change to BIGINT
  The longest postal code used around the world is 10 digits long. So, space required to store zip_code will be 8 bytes. INT type comparisons are faster than VARCHAR as the former takes up less space than varchars. If we store zip_code as varchar(10) space required will be 11 bytes per entry.

Results:

```
mysql> describe publishers;
+----------------+-------------+------+-----+---------+-------+
| Field          | Type        | Null | Key | Default | Extra |
+----------------+-------------+------+-----+---------+-------+
| publisher_ID   | int         | NO   | PRI | NULL    |       |
| publisher_name | varchar(225) | NO   |     | NULL    |       |
| street_num     | varchar(45) | YES  |     | NULL    |       |
| street_name    | varchar(45) | YES  |     | NULL    |       |
| city           | varchar(45) | YES  |     | NULL    |       |
| state          | varchar(45) | YES  |     | NULL    |       |
| zip_code       | varchar(10) | YES  |     | NULL    |       |
| email          | varchar(45) | YES  | UNI | NULL    |       |
+----------------+-------------+------+-----+---------+-------+
8 rows in set (0.00 sec)

mysql> set profiling = 1;
Query OK, 0 rows affected, 1 warning (0.00 sec)

mysql> select count(*) from publishers where zip_code > 980000;
+----------+
| count(*) |
+----------+
|       22 |
+----------+
1 row in set (0.01 sec)

mysql> set profiling = 0;
Query OK, 0 rows affected, 1 warning (0.00 sec)
```

```
mysql> alter table publishers modify column zip_code bigint;
Query OK, 1000 rows affected (0.03 sec)
Records: 1000  Duplicates: 0  Warnings: 0

mysql> describe publishers;
+----------------+-------------+------+-----+---------+-------+
| Field          | Type        | Null | Key | Default | Extra |
+----------------+-------------+------+-----+---------+-------+
| publisher_ID   | int         | NO   | PRI | NULL    |       |
| publisher_name | varchar(225) | NO   |     | NULL    |       |
| street_num     | varchar(45) | YES  |     | NULL    |       |
| street_name    | varchar(45) | YES  |     | NULL    |       |
| city           | varchar(45) | YES  |     | NULL    |       |
| state          | varchar(45) | YES  |     | NULL    |       |
| zip_code       | bigint      | YES  |     | NULL    |       |
| email          | varchar(45) | YES  | UNI | NULL    |       |
+----------------+-------------+------+-----+---------+-------+
8 rows in set (0.01 sec)

mysql> set profiling = 1;
Query OK, 0 rows affected, 1 warning (0.00 sec)

mysql> select count(*) from publishers where zip_code > 980000;
+----------+
| count(*) |
+----------+
|       22 |
+----------+
1 row in set (0.01 sec)

mysql> set profiling = 0;
Query OK, 0 rows affected, 1 warning (0.00 sec)
```

```
mysql> SHOW PROFILES;
+----------+------------+-----------------------------------------------------------+
| Query_ID | Duration   | Query                                                     |
+----------+------------+-----------------------------------------------------------+
|        1 | 0.00160600 | select count(*) from publishers where zip_code > 980000 |
|        2 | 0.00149400 | select count(*) from publishers where zip_code > 980000 |
+----------+------------+-----------------------------------------------------------+
2 rows in set, 1 warning (0.00 sec)
```

Similarly, we can only change the following column types:

Table: **Publishers_Phone**
Column:

- **phone_number**: Change to BIGINT
  Phone numbers are 10 digits long. So, space required to store phone_numbers will be 8 bytes using BIGINT. INT type comparisons are faster than VARCHAR as the former takes up less space than varchars. If we store phone_number as varchar(10) space required will be 11 bytes per entry.

Table: **Faculty**
Column:

- **salary**: No salary will be greater than 1,67,77,215. So we can keep the salary field as MEDIUMINT.

Table: **Book_Location**
Column:

- **shelf_ID**: Change to TINYINT
  At most there will be 100 shelves in the library.

Task 4

Query 1: `SELECT * FROM transaction WHERE issue_date = "2022-09-07"`

This task was implemented on the Transaction table. Initially, the issue_date column had the data type as `VARCHAR(20)`.
The time taken by the query as given by the profiling functionality in MySQL is:
`0.00618500`

```
mysql> DESCRIBE transaction;
+----------------------+-------------+------+-----+---------+-------+
| Field                | Type        | Null | Key | Default | Extra |
+----------------------+-------------+------+-----+---------+-------+
| transaction_ID       | int         | NO   | PRI | NULL    |       |
| issue_date           | varchar(20) | NO   |     | NULL    |       |
| expected_return_date | varchar(20) | NO   |     | NULL    |       |
| actual_return_date   | varchar(20) | YES  |     | NULL    |       |
+----------------------+-------------+------+-----+---------+-------+
4 rows in set (0.00 sec)
```

```
mysql> SELECT * FROM transaction WHERE issue_date = "2022-09-07";
+----------------+------------+----------------------+--------------------+
| transaction_ID | issue_date | expected_return_date | actual_return_date |
+----------------+------------+----------------------+--------------------+
|           1021 | 2022-09-07 | 2022-09-14           | 2022-09-09         |
|           2575 | 2022-09-07 | 2022-09-14           | 2022-09-12         |
|           2599 | 2022-09-07 | 2022-09-14           | 2022-09-15         |
|           2698 | 2022-09-07 | 2022-09-14           | 2022-09-15         |
|           3064 | 2022-09-07 | 2022-09-14           | 2022-09-15         |
|           3274 | 2022-09-07 | 2022-09-14           | 2022-09-16         |
|           3280 | 2022-09-07 | 2022-09-14           | 2022-09-09         |
|           3304 | 2022-09-07 | 2022-09-14           | 2022-09-14         |
|           3397 | 2022-09-07 | 2022-09-14           | 2022-09-09         |
|           3739 | 2022-09-07 | 2022-09-14           | 2022-09-14         |
|           3913 | 2022-09-07 | 2022-09-14           | 2022-09-11         |
+----------------+------------+----------------------+--------------------+
11 rows in set (0.01 sec)

mysql> show profiles;
+----------+------------+-----------------------------------------------------------------+
| Query_ID | Duration   | Query                                                           |
+----------+------------+-----------------------------------------------------------------+
|        1 | 0.00072700 | set profiling = 1                                               |
|        2 | 0.00618500 | SELECT * FROM transaction WHERE issue_date = "2022-09-07"       |
+----------+------------+-----------------------------------------------------------------+
2 rows in set, 1 warning (0.00 sec)

mysql> ALTER TABLE `assignment_6`.`Transaction`
    -> CHANGE COLUMN `issue_date` `issue_date` DATE NOT NULL ,
    -> CHANGE COLUMN `expected_return_date` `expected_return_date` DATE NOT NULL ,
    -> CHANGE COLUMN `actual_return_date` `actual_return_date` DATE NULL DEFAULT NULL ;
Query OK, 1000 rows affected (0.04 sec)
Records: 1000  Duplicates: 0  Warnings: 0
```

The data type was then changed to DATE for the attribute issue_date.

```
mysql> DESCRIBE transaction;
+----------------------+------+------+-----+---------+-------+
| Field                | Type | Null | Key | Default | Extra |
+----------------------+------+------+-----+---------+-------+
| transaction_ID       | int  | NO   | PRI | NULL    |       |
| issue_date           | date | NO   |     | NULL    |       |
| expected_return_date | date | NO   |     | NULL    |       |
| actual_return_date   | date | YES  |     | NULL    |       |
+----------------------+------+------+-----+---------+-------+
4 rows in set (0.00 sec)
```

Time taken for the same query now reduces to 0.00364000, which is almost half of the earlier execution time.

```
mysql> show profiles;
+----------+------------+------------------------------------------------------------------------------------------------------------------------
--------------------------------------------------------------------------+
| Query_ID | Duration   | Query
                                                                          |
+----------+------------+------------------------------------------------------------------------------------------------------------------------
--------------------------------------------------------------------------+
|        1 | 0.00072700 | set profiling = 1
                                                                          |
|        2 | 0.00618500 | SELECT * FROM transaction WHERE issue_date = "2022-09-07"
                                                                          |
|        3 | 0.03670500 | ALTER TABLE `assignment_6`.`Transaction`
CHANGE COLUMN `issue_date` `issue_date` DATE NOT NULL ,
CHANGE COLUMN `expected_return_date` `expected_return_date` DATE NOT NULL ,
CHANGE COLUMN `actual_return_date` `actual_return_date` DATE NULL DEFAULT NULL |
|        4 | 0.00364000 | SELECT * FROM transaction WHERE issue_date = "2022-09-07"
                                                                          |
+----------+------------+------------------------------------------------------------------------------------------------------------------------
--------------------------------------------------------------------------+
4 rows in set, 1 warning (0.00 sec)
```

Task 5

Initially the description of all the fee receipts in the penalties column is NULL. Therefore counting over that column returns 0. However, when a NOT NULL description is added, count over description = 1 (i.e. the NOT NULL description is counted). Similarly, when more NOT NULL description values are added to the table, count(description) returns the count of the total NOT NULL description rows from the table.

```
mysql> select * from penalties;
+----------------+-------------+
| fee_receipt_ID | description |
+----------------+-------------+
|         368882 | NULL        |
|         768131 | NULL        |
|         888284 | NULL        |
|         930558 | NULL        |
|         955515 | NULL        |
+----------------+-------------+
5 rows in set (0.00 sec)

mysql> select count(description) from penalties;
+--------------------+
| count(description) |
+--------------------+
|                  0 |
+--------------------+
1 row in set (0.00 sec)
```

```
mysql> insert into penalties values(455525, "Returned Late");
Query OK, 1 row affected (0.00 sec)
```

```
mysql> select * from penalties;
+----------------+---------------+
| fee_receipt_ID | description   |
+----------------+---------------+
|         368882 | NULL          |
|         455525 | Returned Late |
|         768131 | NULL          |
|         888284 | NULL          |
|         930558 | NULL          |
|         955515 | NULL          |
+----------------+---------------+
6 rows in set (0.00 sec)
```

```
mysql> select count(description) from penalties;
+--------------------+
| count(description) |
+--------------------+
|                  1 |
+--------------------+
1 row in set (0.01 sec)
```

```
mysql> insert into penalties values(455526, "Returned Late");
Query OK, 1 row affected (0.00 sec)

mysql> select count(description) from penalties;
+--------------------+
| count(description) |
+--------------------+
|                  2 |
+--------------------+
1 row in set (0.00 sec)
```

Task 6

`System not compatible to cache queries`

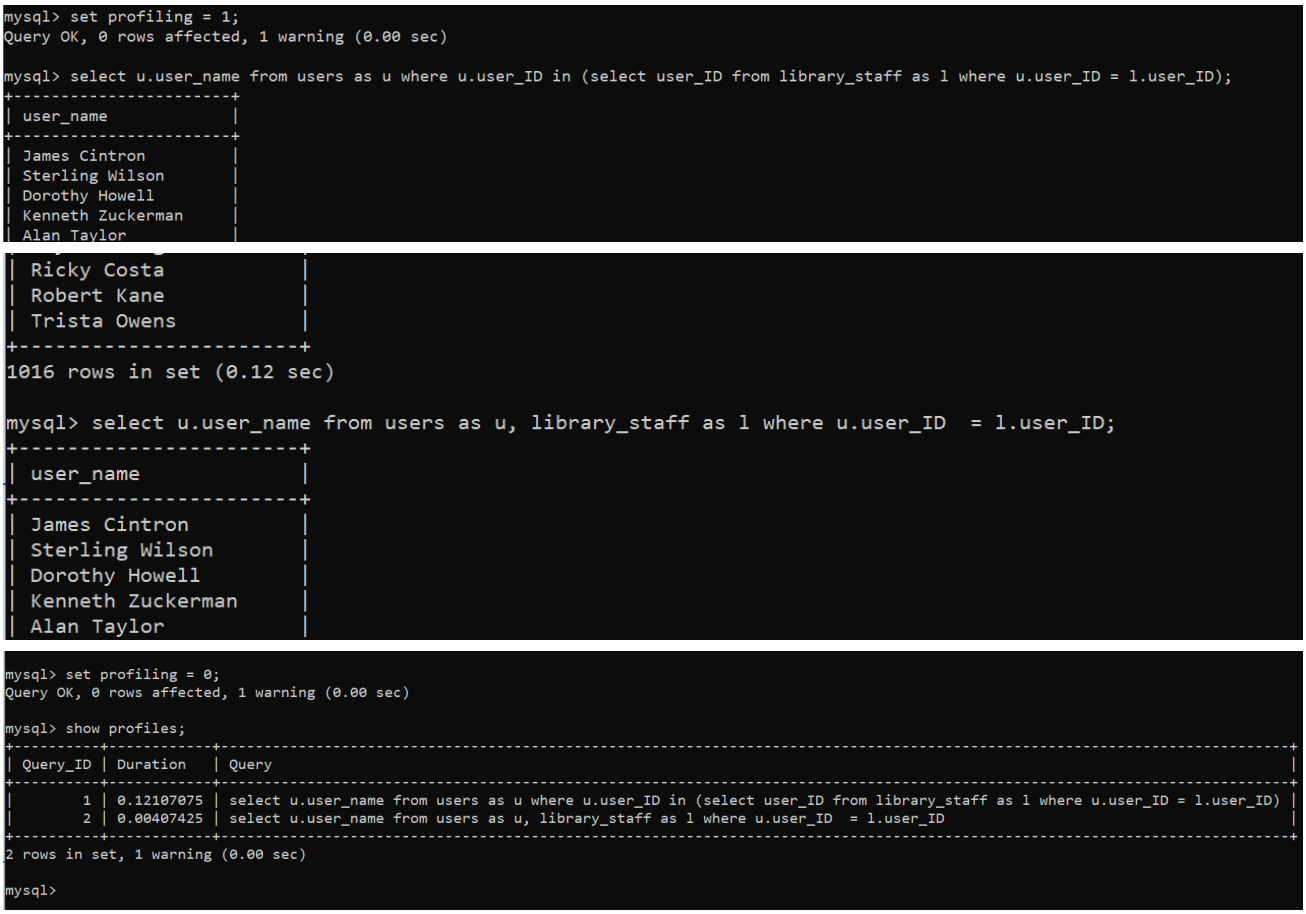
Task 7

Query: To find the names of all users working in the library.

```
select u.user_name
from users as u
where u.user_ID in
(select user_ID
from library_staff as l
where u.user_ID = l.user_ID);
```

Optimized query using joins-

```
select u.user_name
from users as u, library_staff as l
where u.user_ID  = l.user_ID;
```



```
mysql> set profiling = 1;
Query OK, 0 rows affected, 1 warning (0.00 sec)

mysql> select u.user_name from users as u where u.user_ID in (select user_ID from library_staff as l where u.user_ID = l.user_ID);
+----------------------+
| user_name            |
+----------------------+
| James Cintron        |
| Sterling Wilson      |
| Dorothy Howell       |
| Kenneth Zuckerman    |
| Alan Taylor          |
| Ricky Costa          |
| Robert Kane          |
| Trista Owens         |
+----------------------+
1016 rows in set (0.12 sec)

mysql> select u.user_name from users as u, library_staff as l where u.user_ID  = l.user_ID;
+----------------------+
| user_name            |
+----------------------+
| James Cintron        |
| Sterling Wilson      |
| Dorothy Howell       |
| Kenneth Zuckerman    |
| Alan Taylor          |

mysql> set profiling = 0;
Query OK, 0 rows affected, 1 warning (0.00 sec)

mysql> show profiles;
+----------+------------+-----------------------------------------------------------------------------------------------------------------------------------------------+
| Query_ID | Duration   | Query                                                                                                                                         |
+----------+------------+-----------------------------------------------------------------------------------------------------------------------------------------------+
|        1 | 0.12107075 | select u.user_name from users as u where u.user_ID in (select user_ID from library_staff as l where u.user_ID = l.user_ID)                   |
|        2 | 0.00407425 | select u.user_name from users as u, library_staff as l where u.user_ID  = l.user_ID                                                           |
+----------+------------+-----------------------------------------------------------------------------------------------------------------------------------------------+
2 rows in set, 1 warning (0.00 sec)

mysql>
```

We can observe that the first query takes `0.12s` however, the optimized query using the join gives the correct output in `0.004s` which is very less compared to the first query.

The reason is because in the first query, for every row of the users table, the complete library_staff table is checked for a matching ID. This is a slow process as for each row the entire library_stafff table has to be fetched from the disc into memory for comparison. However, in the optimized query, first a temporary table is formed by joining the two tables, resulting in their cartesian product and just the two ID columns of both the tables are compared.

Drawbacks of multiple joins:-

As the number of tables increases, the cost of optimizing such complex queries increases. This is because for n joins, there are n! Possible orderings. A 2 table join can be performed in 2 ways (A join B or B join A), However, for a three table join, there are 6 possible orders and for a 10 table join there are 3,628,800 unique join orders. Thus the time required to inspect all possible query plans is much longer however the difference in actually executing those different join orders is not much. Also, more space is needed to store the intermediate results in temporary tables.

Task 8

Query: To find all the user_names who are part of the staff and working in the job_profile with highest salary

Nested Query:

```
select user_name
from users
where user_id in
(select user_id
from staff
where job_profile in
(select job_profile
from job_salary
where salary =
(select max(salary) from job_salary)));
```

Optimized Query:

```
select distinct(user_name)
from (select job_profile
from job_salary
order by salary desc limit 1) as a
natural join staff
natural join users
```

```
mysql> explain select user_name from users where user_id in (select user_id from staff where job_profile in (select job_profile from job_salary where salary = (select max(salary) from job_salary)));
+----+-------------+------------+------------+--------+---------------+---------+---------+---------------------------+------+----------+--------------------------------------------+
| id | select_type | table      | partitions | type   | possible_keys | key     | key_len | ref                       | rows | filtered | Extra                                      |
+----+-------------+------------+------------+--------+---------------+---------+---------+---------------------------+------+----------+--------------------------------------------+
|  1 | PRIMARY     | job_salary | NULL       | ALL    | PRIMARY       | NULL    | NULL    | NULL                      |   16 |    10.00 | Using where                                |
|  1 | PRIMARY     | staff      | NULL       | ALL    | PRIMARY       | NULL    | NULL    | NULL                      | 1000 |    10.00 | Using where; Using join buffer (hash join) |
|  1 | PRIMARY     | users      | NULL       | eq_ref | PRIMARY       | PRIMARY | 4       | assignment8.staff.user_ID |    1 |   100.00 | NULL                                       |
|  4 | SUBQUERY    | job_salary | NULL       | ALL    | NULL          | NULL    | NULL    | NULL                      |   16 |   100.00 | NULL                                       |
+----+-------------+------------+------------+--------+---------------+---------+---------+---------------------------+------+----------+--------------------------------------------+
4 rows in set, 1 warning (0.00 sec)

mysql> explain select distinct(user_name) from (select job_profile from job_salary order by salary desc limit 1) as a natural join staff natural join users;
+----+-------------+------------+------------+--------+---------------+---------+---------+---------------------------+------+----------+-----------------+
| id | select_type | table      | partitions | type   | possible_keys | key     | key_len | ref                       | rows | filtered | Extra           |
+----+-------------+------------+------------+--------+---------------+---------+---------+---------------------------+------+----------+-----------------+
|  1 | PRIMARY     | <derived2> | NULL       | system | NULL          | NULL    | NULL    | NULL                      |    1 |   100.00 | Using temporary |
|  1 | PRIMARY     | staff      | NULL       | ALL    | PRIMARY       | NULL    | NULL    | NULL                      | 1000 |    10.00 | Using where     |
|  1 | PRIMARY     | users      | NULL       | eq_ref | PRIMARY       | PRIMARY | 4       | assignment8.staff.user_ID |    1 |   100.00 | NULL            |
|  2 | DERIVED     | job_salary | NULL       | ALL    | NULL          | NULL    | NULL    | NULL                      |   16 |   100.00 | Using filesort  |
+----+-------------+------------+------------+--------+---------------+---------+---------+---------------------------+------+----------+-----------------+
4 rows in set, 1 warning (0.00 sec)
```

```
mysql> show profiles;
+----------+------------+---------------------------------------------------------------------------------------------------------------------------------------------------------------+
| Query_ID | Duration   | Query                                                                                                                                                         |
+----------+------------+---------------------------------------------------------------------------------------------------------------------------------------------------------------+
|        1 | 0.00087000 | select user_name from users where user_id in (select user_id from staff where job_profile in (select job_profile from job_salary where salary = (select max(salary) from job_salary))) |
|        2 | 0.00085250 | select distinct(user_name) from (select job_profile from job_salary order by salary desc limit 1) as a natural join staff natural join users |
+----------+------------+---------------------------------------------------------------------------------------------------------------------------------------------------------------+
2 rows in set, 1 warning (0.00 sec)
```

We can observe that the original nested query takes `0.00087000 sec`., however the optimized query which is written using join operations and order by, limit clauses takes `0.00085250 sec`. which is less than the execution time for original nested query.

The reason is clear from the number of scan rows shown in the above image. The max clause in the nested query scans all the 16 rows of job_salary, however the order by and limit clause effectively scans 1 row from the derived table which makes the query faster.

Additional features in the website

For `Task 1`, we have added a search functionality that takes substrings of the publisher name and the street name and returns results about all the publishers whose attributes contain those substrings.

For `Task 2`, we have added a search functionality that takes a string and returns the details of all users whose user_name starts with the input string (i.e. searching from the prefix).

For `Task 4`, we added a feature where the user can enter a date, and he will be shown all the transactions where the issue date was the date that he entered.

For `Task 7`, we have implemented a join functionality where the user can find the names of all users working in the library in a faster manner due to our optimized query using join.

References

https://www.bridge-global.com/blog/tips-to-improve-mysql-query-performance/