

DATABASE FUNDAMENTALS

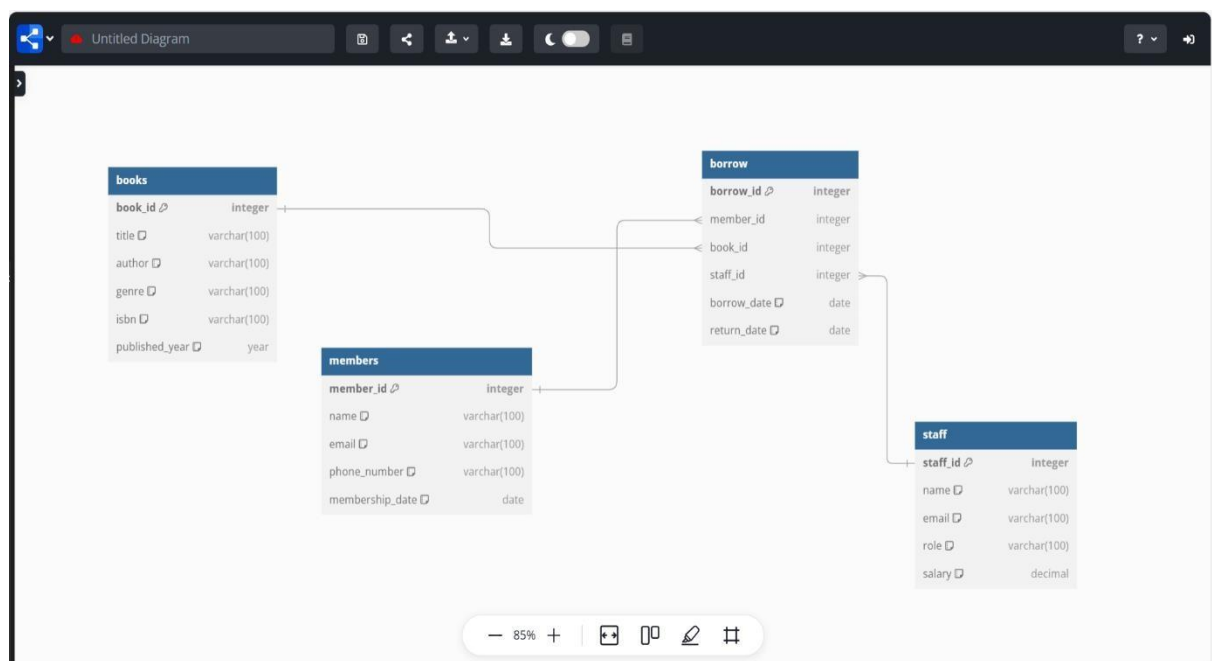
Database Fundamentals

- **Definition:** A database is an organized collection of data that can be easily accessed, managed, and updated. Databases are essential for storing large volumes of data in an efficient and structured manner.
- **Types of Databases:**
 - Relational (RDBMS)
 - NoSQL (e.g., MongoDB)
 - Hierarchical
 - Object-oriented
- **Database Management System (DBMS):** Software that manages databases. Examples include MySQL, PostgreSQL, Oracle DB, and MongoDB.

Database Concepts and Architecture

- **Three-Tier Architecture:**
 - **Physical Layer:** Storage of data on disks.
 - **Logical Layer:** Defines the structure of data (schemas, tables, relationships).
 - **View Layer:** How users interact with data (via queries or UI).
- **Schemas:**
 - **Physical Schema:** Defines physical storage.
 - **Logical Schema:** Defines the structure (tables, views).
 - **View Schema:** Subset of data accessible to users.
- **Client-Server Architecture:** Databases operate in a client-server model where a server hosts the database, and clients access it.

Practical Task: Design a simple schema for a "Library Management System. book store"

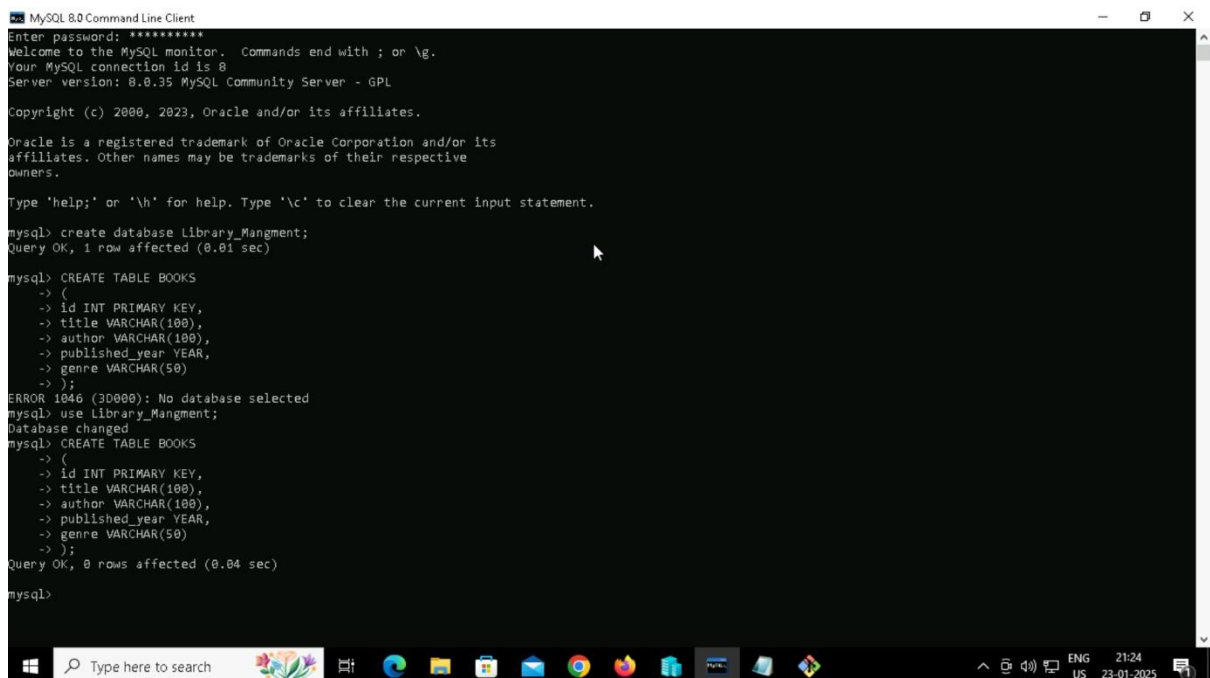


Relational Database Management Systems (RDBMS)

- **Definition:** A type of database that organizes data into tables (rows and columns) and uses relationships to connect them.
- **Key Features:**
 - Structured Data
 - Data Integrity
 - Use of SQL for operations
- **Examples:** MySQL, PostgreSQL, Oracle, Microsoft SQL Server.

Practical Task:

Create a table called books with columns: id, title, author, published_year, and genre.



```
MySQL 8.0 Command Line Client
Enter password: *****
Welcome to the MySQL monitor.  Commands end with ; or \g.
Your MySQL connection id is 8
Server version: 8.0.35 MySQL Community Server - GPL

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owners.

Type 'help;' or '\h' for help. Type '\c' to clear the current input statement.

mysql> create database Library_Managment;
Query OK, 1 row affected (0.01 sec)

mysql> CREATE TABLE BOOKS
-> (
-> id INT PRIMARY KEY,
-> title VARCHAR(100),
-> author VARCHAR(100),
-> published_year YEAR,
-> genre VARCHAR(50)
-> );
ERROR 1046 (3D000): No database selected
mysql> use Library_Managment;
Database changed
mysql> CREATE TABLE BOOKS
-> (
-> id INT PRIMARY KEY,
-> title VARCHAR(100),
-> author VARCHAR(100),
-> published_year YEAR,
-> genre VARCHAR(50)
-> );
Query OK, 0 rows affected (0.04 sec)

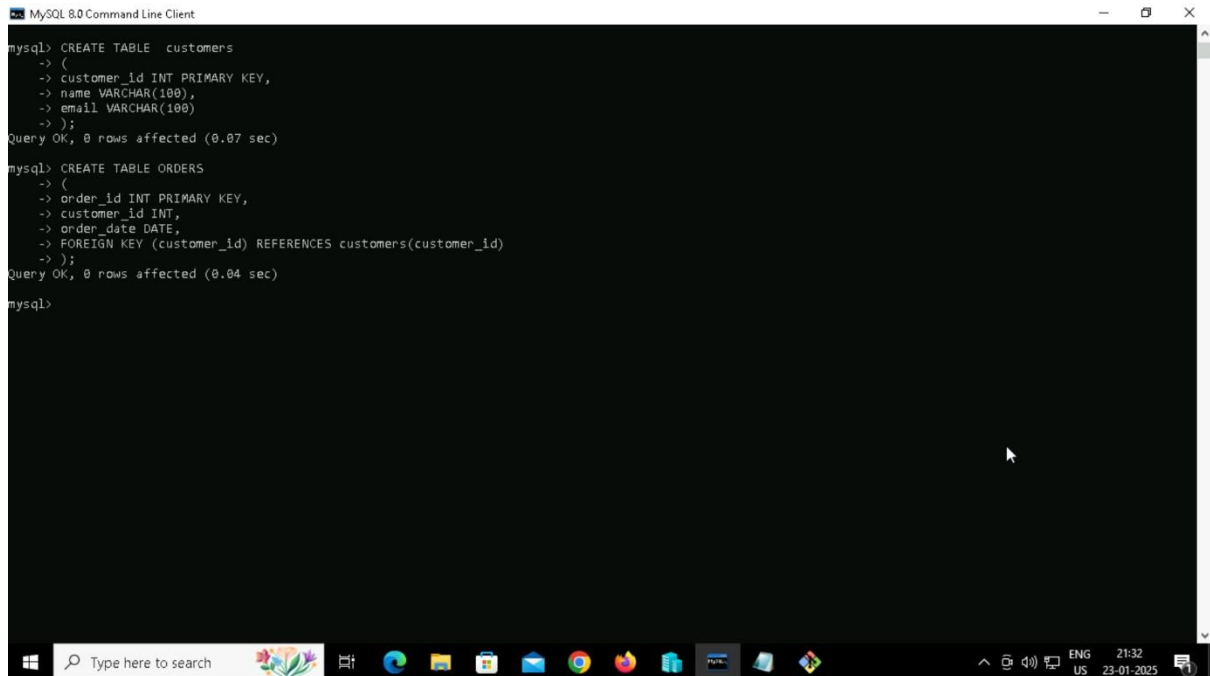
mysql>
```

Tables and Relationships

- **Table:** A collection of rows (records) and columns (fields). Each table represents an entity.
- **Relationships:**
 - **One-to-One:** Each row in Table A maps to one row in Table B.
 - **One-to-Many:** One row in Table A maps to multiple rows in Table B.
 - **Many-to-Many:** Multiple rows in Table A map to multiple rows in Table B via a junction table.

Practical Task:

Create two tables: customers and orders. Define a one-to-many relationship between them using foreign keys.



```
mysql> CREATE TABLE customers
-> (
-> customer_id INT PRIMARY KEY,
-> name VARCHAR(100),
-> email VARCHAR(100)
-> );
Query OK, 0 rows affected (0.07 sec)

mysql> CREATE TABLE orders
-> (
-> order_id INT PRIMARY KEY,
-> customer_id INT,
-> order_date DATE,
-> FOREIGN KEY (customer_id) REFERENCES customers(customer_id)
-> );
Query OK, 0 rows affected (0.04 sec)

mysql>
```

Primary Keys and Foreign Keys

- **Primary Key:**
 - Uniquely identifies each row in a table. ○ Cannot contain NULL values.
 - Example: id in a users table.
- **Foreign Key:**
 - Establishes a relationship between two tables.
 - Refers to the primary key in another table. ○ Example: user_id in an orders table references id in the users table.

Practical Task:

Create a table departments with a primary key, and another table employees with a foreign key referencing departments.

```
MySQL 8.0 Command Line Client
mysql> CREATE TABLE departments
-> (
-> dept_id INT PRIMARY KEY,
-> dept_name VARCHAR(100)
-> );
Query OK, 0 rows affected (0.03 sec)

mysql> CREATE TABLE employees
-> (
-> emp_id INT PRIMARY KEY,
-> name VARCHAR(100),
-> dept_id INT,
-> FOREIGN KEY (dept_id) REFERENCES departments(dept_id)
-> );
ERROR 1050 (42S01): Table 'employees' already exists

mysql> show tables;
+-----+
| Tables_in_library_mangement |
+-----+
| books                        |
| customers                   |
| department                  |
| departments                  |
| employees                    |
| orders                      |
+-----+
6 rows in set (0.00 sec)

mysql> drop table employees;
Query OK, 0 rows affected (0.02 sec)

mysql> CREATE TABLE employees
-> (
-> emp_id INT PRIMARY KEY,
-> name VARCHAR(100),
-> dept_id INT,
-> FOREIGN KEY (dept_id) REFERENCES departments(dept_id)
-> );
Query OK, 0 rows affected (0.05 sec)

mysql>
```

SQL Basics

- **SELECT:** Retrieve data from a table.
- **INSERT:** Add new data to a table.
- **UPDATE:** Modify existing data.
- **DELETE:** Remove data.

Practical Task:

- Perform CRUD operations on the books table

Inserting Data into books table

```
MySQL 8.0 Command Line Client
mysql> desc books;
+-----+
| Field      | Type          | Null | Key | Default | Extra |
+-----+
| id         | int           | NO   | PRI | NULL    |       |
| title      | varchar(100)  | YES  |     | NULL    |       |
| author     | varchar(100)  | YES  |     | NULL    |       |
| published_year | year         | YES  |     | NULL    |       |
| genre      | varchar(50)   | YES  |     | NULL    |       |
+-----+
5 rows in set (0.00 sec)

mysql> INSERT INTO books (id, title, author, published_year, genre) VALUES
-> (1, 'The Great Adventure', 'John Doe', 2015, 'Adventure'),
-> (2, 'Mystery at the Manor', 'Jane Smith', 2018, 'Mystery'),
-> (3, 'The Final Frontier', 'James Brown', 2020, 'Science Fiction'),
-> (4, 'Love in the Time of War', 'Emily White', 2017, 'Romance'),
-> (5, 'The Silent Witness', 'Michael Johnson', 2019, 'Thriller'),
-> (6, 'Journey Through Time', 'Anna Green', 2021, 'Historical Fiction'),
-> (7, 'Winds of Change', 'David Lee', 2016, 'Drama'),
-> (8, 'Echoes of the Past', 'Sarah Davis', 2022, 'Fantasy'),
-> (9, 'The Lost Kingdom', 'Robert King', 2014, 'Adventure'),
-> (10, 'Under the Moonlight', 'Lila Carter', 2023, 'Romance');
Query OK, 10 rows affected (0.01 sec)
Records: 10 Duplicates: 0 Warnings: 0

mysql>
```

SELECT Retrieve data from a table.

```
MySQL 8.0 Command Line Client
author      varchar(100) YES      NULL
published_year year      YES      NULL
genre       varchar(50)  YES      NULL
5 rows in set (0.00 sec)

mysql> INSERT INTO books (id, title, author, published_year, genre) VALUES
-> (1, 'The Great Adventure', 'John Doe', 2015, 'Adventure'),
-> (2, 'Mystery at the Manor', 'Jane Smith', 2018, 'Mystery'),
-> (3, 'The Final Frontier', 'James Brown', 2020, 'Science Fiction'),
-> (4, 'Love in the Time of War', 'Emily White', 2017, 'Romance'),
-> (5, 'The Silent Witness', 'Michael Johnson', 2019, 'Thriller'),
-> (6, 'Journey Through Time', 'Anna Green', 2021, 'Historical Fiction'),
-> (7, 'Winds of Change', 'David Lee', 2016, 'Drama'),
-> (8, 'Echoes of the Past', 'Sarah Davis', 2022, 'Fantasy'),
-> (9, 'The Lost Kingdom', 'Robert King', 2014, 'Adventure'),
-> (10, 'Under the Moonlight', 'Lisa Carter', 2023, 'Romance');
Query OK, 10 rows affected (0.01 sec)
Records: 10 Duplicates: 0 Warnings: 0

mysql> select * from books;
+----+-----+-----+-----+-----+
| id | title                | author      | published_year | genre      |
+----+-----+-----+-----+-----+
| 1  | The Great Adventure  | John Doe    | 2015           | Adventure  |
| 2  | Mystery at the Manor | Jane Smith  | 2018           | Mystery    |
| 3  | The Final Frontier   | James Brown | 2020           | Science Fiction |
| 4  | Love in the Time of War | Emily White | 2017           | Romance    |
| 5  | The Silent Witness    | Michael Johnson | 2019           | Thriller   |
| 6  | Journey Through Time | Anna Green  | 2021           | Historical Fiction |
| 7  | Winds of Change      | David Lee   | 2016           | Drama      |
| 8  | Echoes of the Past   | Sarah Davis | 2022           | Fantasy    |
| 9  | The Lost Kingdom     | Robert King | 2014           | Adventure  |
| 10 | Under the Moonlight  | Lisa Carter | 2023           | Romance    |
+----+-----+-----+-----+-----+
10 rows in set (0.00 sec)

mysql>
```

UPDATE: Modify existing data.

```
MySQL 8.0 Command Line Client

mysql> select * from books;
+----+-----+-----+-----+-----+
| id | title                | author      | published_year | genre      |
+----+-----+-----+-----+-----+
| 1  | The Great Adventure  | John Doe    | 2015           | Adventure  |
| 2  | Mystery at the Manor | Jane Smith  | 2018           | Mystery    |
| 3  | The Final Frontier   | James Brown | 2020           | Science Fiction |
| 4  | Love in the Time of War | Emily White | 2017           | Romance    |
| 5  | The Silent Witness    | Michael Johnson | 2019           | Thriller   |
| 6  | Journey Through Time | Anna Green  | 2021           | Historical Fiction |
| 7  | Winds of Change      | David Lee   | 2016           | Drama      |
| 8  | Echoes of the Past   | Sarah Davis | 2022           | Fantasy    |
| 9  | The Lost Kingdom     | Robert King | 2014           | Adventure  |
| 10 | Under the Moonlight  | Lisa Carter | 2023           | Romance    |
+----+-----+-----+-----+-----+
10 rows in set (0.00 sec)

mysql> UPDATE books
-> SET genre = 'Fantasy'
-> WHERE id = 3;
Query OK, 1 row affected (0.01 sec)
Rows matched: 1 Changed: 1 Warnings: 0

mysql> select * from books;
+----+-----+-----+-----+-----+
| id | title                | author      | published_year | genre      |
+----+-----+-----+-----+-----+
| 1  | The Great Adventure  | John Doe    | 2015           | Adventure  |
| 2  | Mystery at the Manor | Jane Smith  | 2018           | Mystery    |
| 3  | The Final Frontier   | James Brown | 2020           | Fantasy    |
| 4  | Love in the Time of War | Emily White | 2017           | Romance    |
| 5  | The Silent Witness    | Michael Johnson | 2019           | Thriller   |
| 6  | Journey Through Time | Anna Green  | 2021           | Historical Fiction |
| 7  | Winds of Change      | David Lee   | 2016           | Drama      |
| 8  | Echoes of the Past   | Sarah Davis | 2022           | Fantasy    |
| 9  | The Lost Kingdom     | Robert King | 2014           | Adventure  |
| 10 | Under the Moonlight  | Lisa Carter | 2023           | Romance    |
+----+-----+-----+-----+-----+
10 rows in set (0.00 sec)

mysql>
```

DELETE: Remove data.

```

MySQL 8.0 Command Line Client
Query OK, 1 row affected (0.01 sec)
Rows matched: 1 Changed: 1 Warnings: 0

mysql> select * from books;
+----+-----+-----+-----+-----+
| id | title           | author      | published_year | genre      |
+----+-----+-----+-----+-----+
| 1  | The Great Adventure | John Doe    | 2015           | Adventure  |
| 2  | Mystery at the Manor | Jane Smith  | 2018           | Mystery    |
| 3  | The Final Frontier  | James Brown | 2020           | Fantasy    |
| 4  | Love in the Time of War | Emily White | 2017           | Romance    |
| 5  | The Silent Witness  | Michael Johnson | 2019           | Thriller   |
| 6  | Journey Through Time | Anna Green  | 2021           | Historical Fiction |
| 7  | Winds of Change     | David Lee   | 2016           | Drama      |
| 8  | Echoes of the Past  | Sarah Davis | 2022           | Fantasy    |
| 9  | The Lost Kingdom    | Robert King | 2014           | Adventure  |
| 10 | Under the Moonlight  | Lisa Carter | 2023           | Romance    |
+----+-----+-----+-----+-----+
10 rows in set (0.00 sec)

mysql> DELETE FROM books
-> WHERE id = 5;
Query OK, 1 row affected (0.01 sec)

mysql> select * from books;
+----+-----+-----+-----+-----+
| id | title           | author      | published_year | genre      |
+----+-----+-----+-----+-----+
| 1  | The Great Adventure | John Doe    | 2015           | Adventure  |
| 2  | Mystery at the Manor | Jane Smith  | 2018           | Mystery    |
| 3  | The Final Frontier  | James Brown | 2020           | Fantasy    |
| 4  | Love in the Time of War | Emily White | 2017           | Romance    |
| 6  | Journey Through Time | Anna Green  | 2021           | Historical Fiction |
| 7  | Winds of Change     | David Lee   | 2016           | Drama      |
| 8  | Echoes of the Past  | Sarah Davis | 2022           | Fantasy    |
| 9  | The Lost Kingdom    | Robert King | 2014           | Adventure  |
| 10 | Under the Moonlight  | Lisa Carter | 2023           | Romance    |
+----+-----+-----+-----+-----+
9 rows in set (0.00 sec)

mysql>

```

Normalization

- **Definition:** Process of organizing data to reduce redundancy and improve efficiency.
- **Forms of Normalization:**
 - **1NF (First Normal Form):** Ensure atomic values and unique rows.
 - **2NF (Second Normal Form):** Eliminate partial dependencies.
 - **3NF (Third Normal Form):** Remove transitive dependencies.
 - **BCNF (Boyce-Codd Normal Form):** Handle more complex dependencies.

Transactions and ACID Properties

- **Transaction:** A sequence of database operations treated as a single logical unit.
- **ACID Properties:**
 - **Atomicity:** Transactions are all-or-nothing.
 - **Consistency:** Transactions bring the database from one valid state to another.
 - **Isolation:** Transactions do not interfere with each other.
 - **Durability:** Once committed, data remains saved even in case of a failure.

Practical Task:

- Perform a transaction with multiple SQL operations and test rollback.

```
MySQL 8.0 Command Line Client
mysql> START TRANSACTION;
Query OK, 0 rows affected (0.00 sec)

mysql> DESC CUSTOMERS;
+-----+-----+-----+-----+-----+-----+
| Field | Type | Null | Key | Default | Extra |
+-----+-----+-----+-----+-----+-----+
| customer_id | int | NO | PRI | NULL | |
| name | varchar(100) | YES | | NULL | |
| email | varchar(100) | YES | | NULL | |
+-----+-----+-----+-----+-----+-----+
3 rows in set (0.00 sec)

mysql> INSERT INTO customers(customer_id, name, email)
-> values(1, 'John Doe', 'john@email.com');
Query OK, 1 row affected (0.00 sec)

mysql> INSERT INTO orders (order_id, customer_id, order_date)
-> values (1,1, '2025-01-01');
Query OK, 1 row affected (0.00 sec)

mysql> ROLLBACK;
Query OK, 0 rows affected (0.00 sec)

mysql> COMMIT;
Query OK, 0 rows affected (0.00 sec)

mysql> _
```

Indexes

- **Definition:** A database optimization technique to speed up data retrieval.
- **Types:**
 - **Primary Index:** Automatically created for the primary key.
 - **Secondary Index:** Manually created on other columns for faster lookups.
- **Trade-offs:**
 - Improves SELECT queries.
 - Slows down INSERT/UPDATE/DELETE due to index maintenance.

Practical Task:

- Create an index on the title column of the books table.

```
MySQL 8.0 Command Line Client
Query OK, 0 rows affected (0.00 sec)

mysql> CREATE INDEX idx_books_title ON books(title);
ERROR 1072 (42000): Key column 'title' doesn't exist in table
mysql> CREATE INDEX idx_books_title ON books(title);
Query OK, 0 rows affected (0.04 sec)
Records: 0 Duplicates: 0 Warnings: 0

mysql> Explain select * from books;
+----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| id | select_type | table | partitions | type | possible_keys | key | key_len | ref | rows | filtered | Extra |
+----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| 1 | SIMPLE | books | NULL | ALL | NULL | NULL | NULL | NULL | 9 | 100.00 | NULL |
+----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
1 row in set, 1 warning (0.00 sec)

mysql> select * from books;
+----+-----+-----+-----+-----+
| id | title | author | published_year | genre |
+----+-----+-----+-----+-----+
| 1 | The Great Adventure | John Doe | 2015 | Adventure |
| 2 | Mystery at the Manor | Jane Smith | 2018 | Mystery |
| 3 | The Final Frontier | James Brown | 2020 | Fantasy |
| 4 | Love in the Time of War | Emily White | 2017 | Romance |
| 6 | Journey Through Time | Anna Green | 2021 | Historical Fiction |
| 7 | Winds of Change | David Lee | 2016 | Drama |
| 8 | Echoes of the Past | Sarah Davis | 2022 | Fantasy |
| 9 | The Lost Kingdom | Robert King | 2014 | Adventure |
| 10 | Under the Moonlight | Lisa Carter | 2023 | Romance |
+----+-----+-----+-----+-----+
9 rows in set (0.00 sec)

mysql> Explain select * from books;
+----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| id | select_type | table | partitions | type | possible_keys | key | key_len | ref | rows | filtered | Extra |
+----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| 1 | SIMPLE | books | NULL | ALL | NULL | NULL | NULL | NULL | 9 | 100.00 | NULL |
+----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
1 row in set, 1 warning (0.00 sec)

mysql>
```

Database Design

- **Steps:**
 - **Requirement Analysis:** Understand data needs.
 - **Conceptual Design:** Create Entity-Relationship (ER) diagrams.
 - **Logical Design:** Define tables, relationships, and keys.
 - **Physical Design:** Optimize storage and indexing.
- **Best Practices:**
 - Use normalization.
 - Avoid redundancy.
 - Optimize queries for performance.

Practical Task:

- Design a database for an "Online Store" using:
 - Entities: Products, Categories, Orders, Customers.
 - Relationships: Define primary keys and foreign keys.


```
MySQL 8.0 Command Line Client
mysql> CREATE DATABASE OnlineStore;
Query OK, 1 row affected (0.01 sec)

mysql> CREATE TABLE products
-> (
-> product_id INT PRIMARY KEY,
-> name VARCHAR(100),
-> price DECIMAL(10,2),
-> category_id INT,
-> DELETE FROM books
-> WHERE id = 5;
ERROR 1064 (42000): You have an error in your SQL syntax; check the manual that corresponds to your MySQL server version for the right syntax to use near 'DE
LETE FROM books
WHERE id = 5' at line 7
mysql> CREATE TABLE categories
-> (
-> category_id INT PRIMARY KEY,
-> name VARCHAR(100)
-> );
Query OK, 0 rows affected (0.03 sec)

mysql> CREATE TABLE products
-> (
-> product_id INT PRIMARY KEY,
-> name VARCHAR(100),
-> price DECIMAL(10,2),
-> category_id INT,
-> FOREIGN KEY (category_id) REFERENCES categories(category_id)
-> );
Query OK, 0 rows affected (0.05 sec)

mysql>
```

Backup and Recovery

- **Backup:**
 - Regularly save copies of database data.
 - Types: Full, Incremental, Differential.
- **Recovery:** ◦ Process of restoring data after a failure.
 - **Point-in-Time Recovery:** Restore database to a specific moment.
- **Tools:**
 - MySQL Backup Tools, pg_dump (PostgreSQL), RMAN (Oracle).

Practical Task:

- Perform a full backup of your database:
`mysqldump -u root -p my_database > my_database_backup.sql`
- Simulate a data loss scenario by dropping a table, then restore it:
`DROP TABLE books;`

`-- Restore using the backup`
`SOURCE my_database_backup.sql;`