Practical MySQL

Trainer Guide

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Edition 1 - 2022

PREFACE

MySQL is one of the most popular Database Management System that enables us to enter, organize, and select data from a database. MySQL is open source and available in free as well commercial editions. This book explains how to create and manage databases, tables, and database objects in MySQL. The book also describes queries, joins, functions, and stored procedures. New enhancements in MySQL 8.0 such as those made to server security, MySQL database maintenance, backup, replication, transaction management, performance optimization, and storage systems are also explored in this book. Features such as the new schemas, spatial data types, and so on are also discussed.

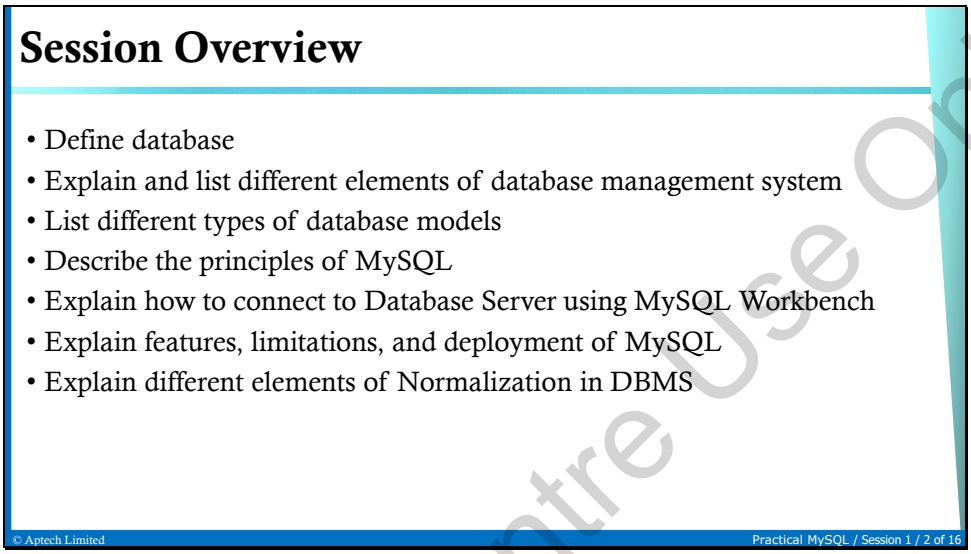
The faculty/trainer should teach the concepts in the theory class using the slides. This Trainer's Guide will provide guidance on the flow of the module and also provide tips and additional examples wherever necessary. The trainer can ask questions to make the session interactive and also to test the understanding of the students.

The knowledge and information in this book is the result of the concentrated effort of the Design Team, which is continuously striving to bring to you the latest, the best and the most relevant subject matter in Information Technology. As a part of Aptech's quality drive, this team does intensive research and curriculum enrichment to keep it in line with industry trends and learner requirements.

Contents

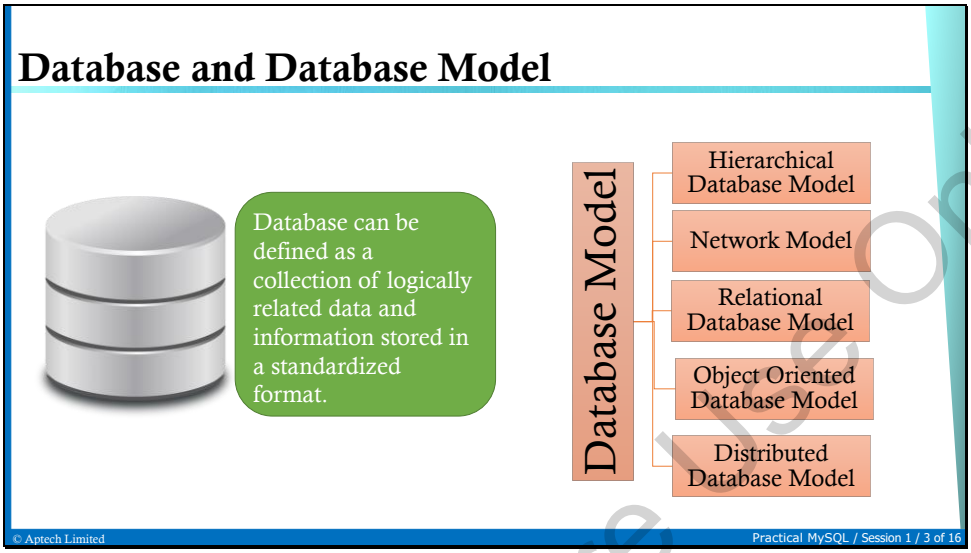
Session 1: Introduction to MySQL

Slide 2



Instruction(s) to the trainer:
Show slide 2 and give a brief overview on principles of MySQL. Explain features, limitations, and deployment of MySQL. Inform about the concepts of database and different elements of database management system. Finally, discuss with the students about different elements of Normalization of DBMS.

Slide 3



Instruction(s) to the Trainer:
Begin the session by asking the question:
Do you know what is a database?

Encourage participants to respond. Appreciate the responses.

- Then, show slide 3 and explain to students about Database and Database Model.
- Say that database is a collection of logically related data and information stored in a standardized format and database model is the logical structure of the database.
- Discuss about some of the common Database Models and their advantages and disadvantages.

1. Hierarchical Database Model
This model is like a tree structure where records form the nodes and fields form the branches. A record in a database can be defined as collection of fields with different data types. It is a natural method of implementing records and their relationship. However, it has limitations in representing the relationships. It does not adapt to the new format that occur in real world.

2. Network Model
In this, record type can have multiple owners and the data is represented as records using links. There are three components of the network model, namely - Network Schema, Sub-schema, and Data Management Language. It is useful when there is a requirement for showing a many-

to-many relationship. However, database structure will become very complex as pointers are used to maintain all records.

3. Relational Database Model
In this model, data is organized in the form of rows and columns similar to a table. There are certain terminologies used in this model, where tables are called as 'Relations' or 'instance' with rows and columns. This model is easy to use and helps in improve the performance. Drawback in this model is It requires skilled human resources to implement.

4. Object-Oriented Database Model
It supports Object-Oriented Programming features such as Object, class, Abstraction, Encapsulation, Inheritance, and Polymorphism that will make it easy to understand. It is used when there is a relationship among data elements that are more important than data items. One of the disadvantage of this model is its complexity and increases the cost.

5. **Distributed Database Model**
In this database model, the computers communicate and exchange data using data analytics, cloud computing, and other means of communication. This model is easier to expand. However, it creates a large overhead on entire system.

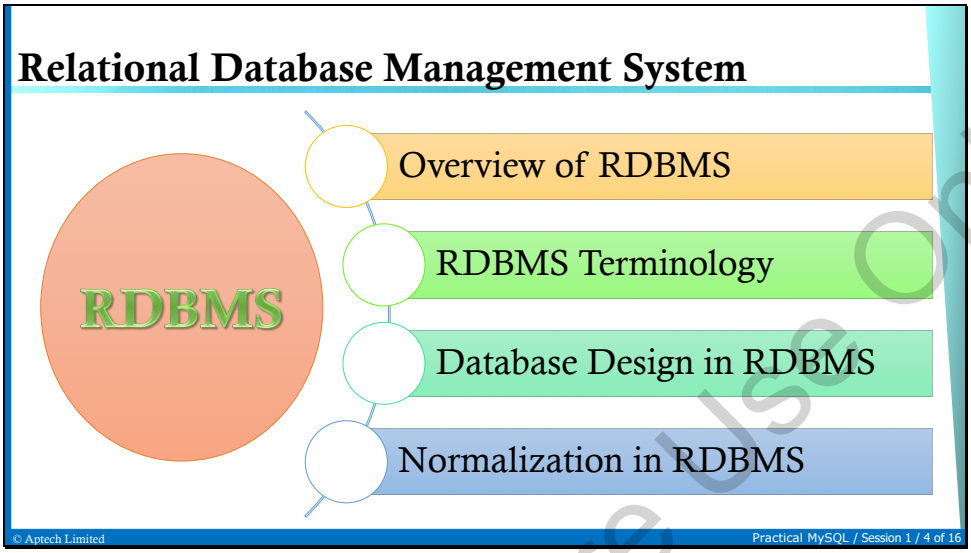
Additional Information:

Refer to following links for more information:
- https://www.javatpoint.com/mysql-create-database
- https://dev.mysql.com/doc/workbench/en/wb-database-synchronization.html

Ask students following question. Wait for a response before you answer.

In-Class Question: What is the full form of DBMS?
Answer: Database Management System

Slide 4



Instruction(s) to the Trainer:
Show slide 4 and explain Relational Database Management System (RDBMS) in detail. Tell students that RDBMS helps to maintains security, accuracy, consistency, and integrity for data. It is based on the principals of E.F. Codd. Examples of most popular RDBMS are MySQL, Oracle, IBM DB2, and SQL Server**.**

Discuss about the overview of RDBMS and its terminology. Inform students that RDBMS enable users to implement a database with tables and indexes. It also maintains the referential integrity between rows of various tables. Each table contains records. Each record defines a specific number of fields.

Discuss about the database design and normalization in RDBMS. Inform that database designing is a process of facilitating the designing, development, implementation, and maintenance of DBMS. Tell students that the database designer decides how the data elements correlate with each other and which data must be stored. It produces logical and physical design models of database.

Data Modelling can be defined as the process of analyzing data objects and their relation with other objects. Data can be modeled at different levels of abstraction. This process starts by collecting information from stakeholders and the end-users of the system about business requirements. It is important that the database should be designed accurately to maintain

information consistency, eliminate redundant data from the table, execute queries efficiently on the database, and also improve the database performance.

Tell students that normalization is a design technique that helps the user to efficiently organize data in a database and reduce data redundancy. It is important to improve usability of the dataset allowing databases to take less space.

Database Normalization is categorized into following types:
- 1NF (First Normal Form)
- 2NF (Second Normal Form)
- 3NF (Third Normal Form)
- BCNF (Boyce-Codd Normal Form)
- 4NF (Fourth Normal Form)
- 5NF (Fourth Normal Form)

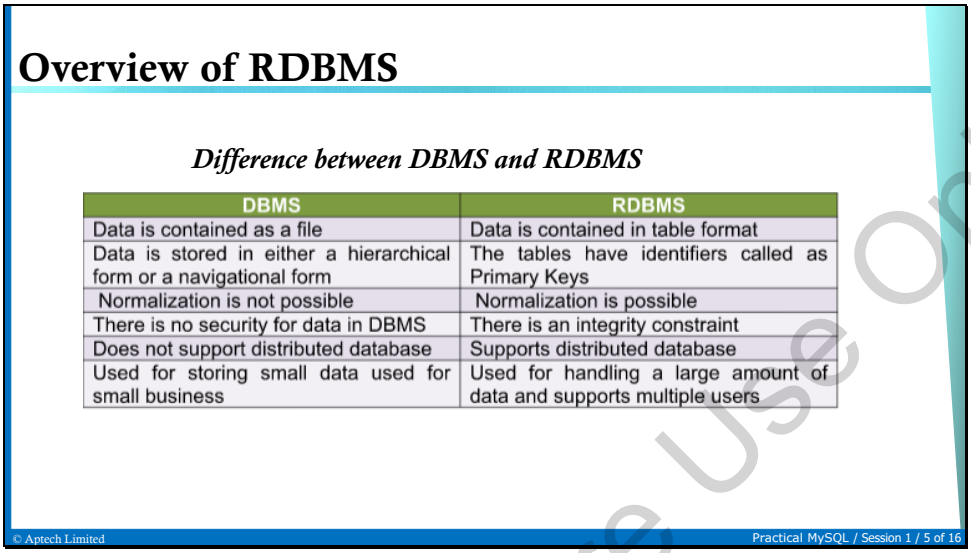
Normalization Definition: Normalization is the process of organizing the data in the database. It removes the redundancy from a relation or set of relations.

Additional Information:
Refer to following links for more information:
- https://www.javatpoint.com/mysql-create-database
- https://www.tutorialspoint.com/sql/sql-databases.htm

Ask students following question. Wait for a response before you answer.

In-Class Question: Mention the systems that use RDBMS.
Answer: A) IBM
B) Oracle
C) Microsoft SQL Server

Slide 5

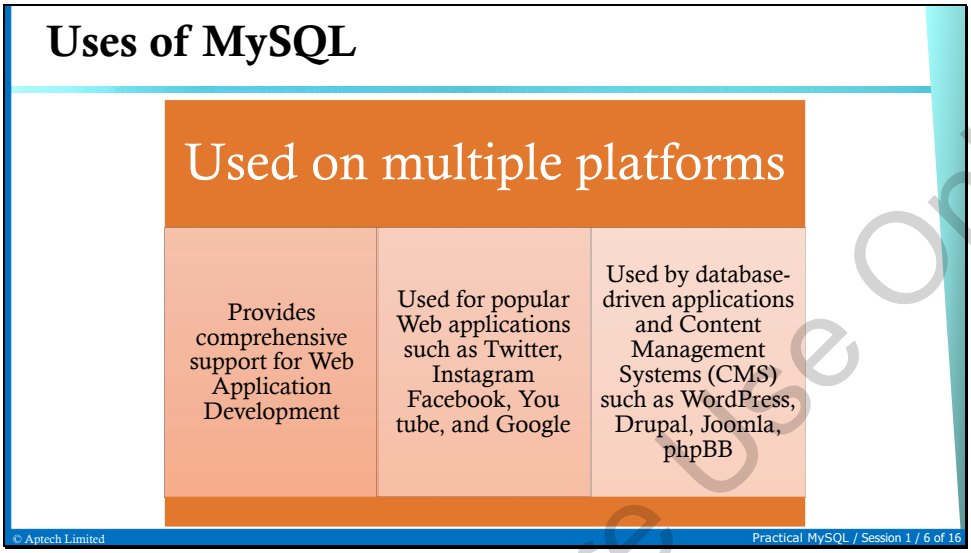


Instruction(s) to the Trainer:
Using slide 5, discuss the differences between DBMS and RDBMS.

Additional Information:
Refer to following links for more information:

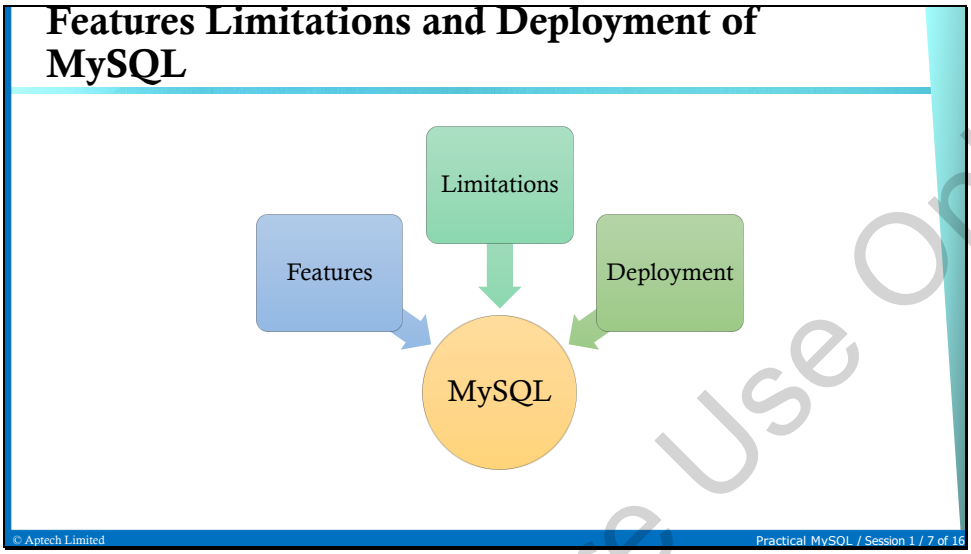
- https://www.javatpoint.com/difference-between-dbms-and-rdbms
- https://www.geeksforgeeks.org/difference-between-rdbms-and-dbms/

Slide 6



Instruction(s) to the Trainer:
Show slide 6 and explain the uses of MySQL. Say that MySQL can be used on multiple platforms (Operating Systems).

Slide 7

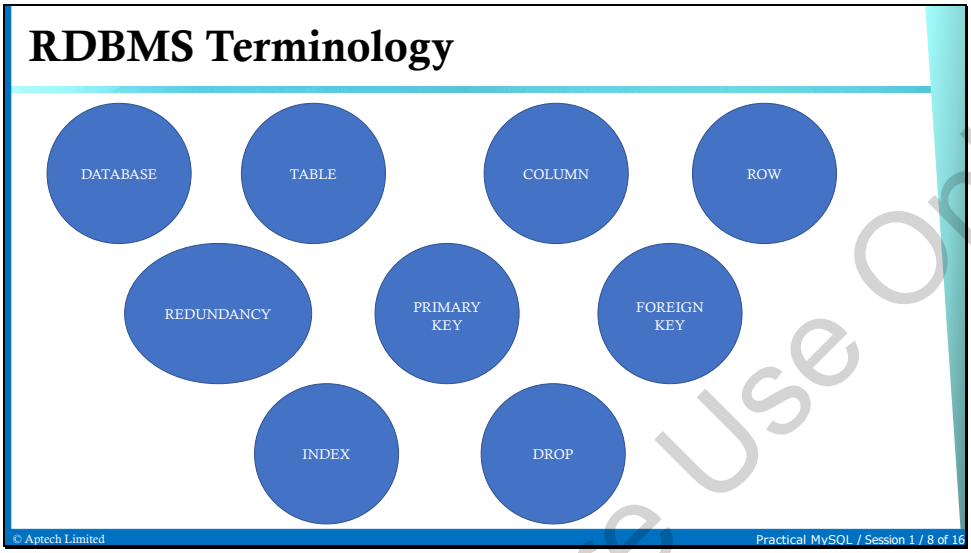


Instruction(s) to the Trainer:
Using slide 7, discuss about the features, limitations, and deployment of MySQL.
Say that MySQL is a widely used RDBMS that primarily works on relational database.
Inform students that it also has some limitations when it comes to big data analysis.

Additional Information:
Refer to following links for more information:
- https://www.javatpoint.com/mysql-create-database
- https://www.w3schools.com/mysql/mysql_rdbms.asp

Ask students following question. Wait for a response before you answer.
In-Class Question: What are the features of MySQL?
Answer: MySQL is widely used RDBMS that primarily works on relational database model. It is highly quick and reliable.

Slide 8



Instruction(s) to the Trainer:
Show slide 8, discuss about the common terminologies used in RDBMS in detail.

Database: In simple words, it is a collection of data and information stored in a standardized format.
Table: A table is used to store data of multiple data types in form of rows and columns. It can be sorted too.
Column: This refers to the series of cells that are aligned vertically in a table.
Row: This refers to a series of cells aligned horizontally in a table.
Redundancy: This refers to storing data twice or duplicating data.
Primary Key: A primary key is used to maintain uniqueness in the table and avoid duplicate data.
Foreign Key: A foreign key is used to relate one table with another. It can accept duplicate values.
Index: It retrieves data faster. It is similar to an index page on a book.
Drop: Drop is an operation to remove or delete a database or database object. For example, a database can be dropped.

Additional Information:
Refer to following links for more information:

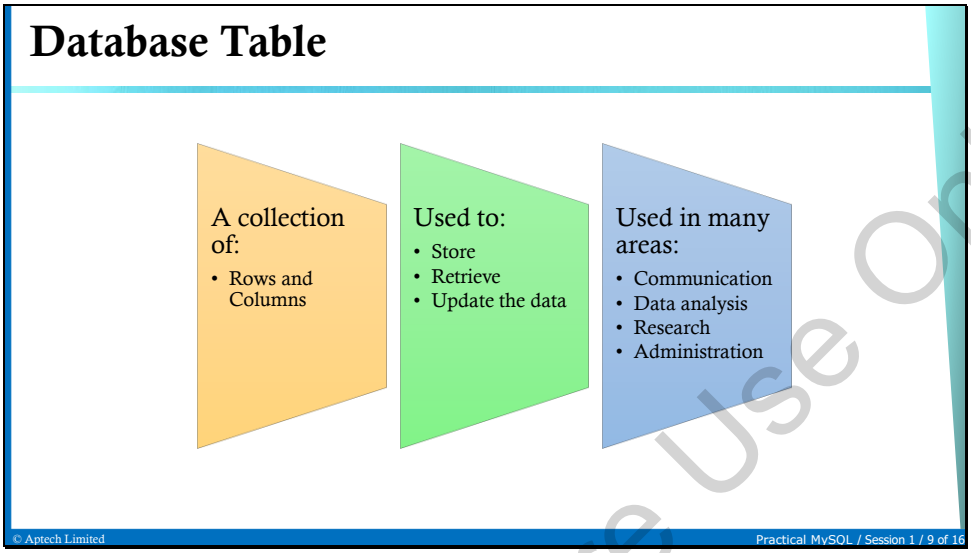
- https://www.javatpoint.com/mysql-create-database
- https://www3.ntu.edu.sg/home/ehchua/programming/sql/MySQL_Beginner.html

Ask the students following question. Wait for a response before you answer.

In-Class Question: What is the key to represent relationship between tables?

Answer: Foreign Key

Slide 9



Instruction(s) to the Trainer:

Show slide 9 and explain Database Table. Tables in database can be defined as a collection of rows and columns. The data is stored in tables and consists of related data entries in multiple columns and rows.

Discuss about its uses. It is used to store, retrieve, and update the data. Tables are widely used in many areas such as communication, data analysis, research, administration, and so on.

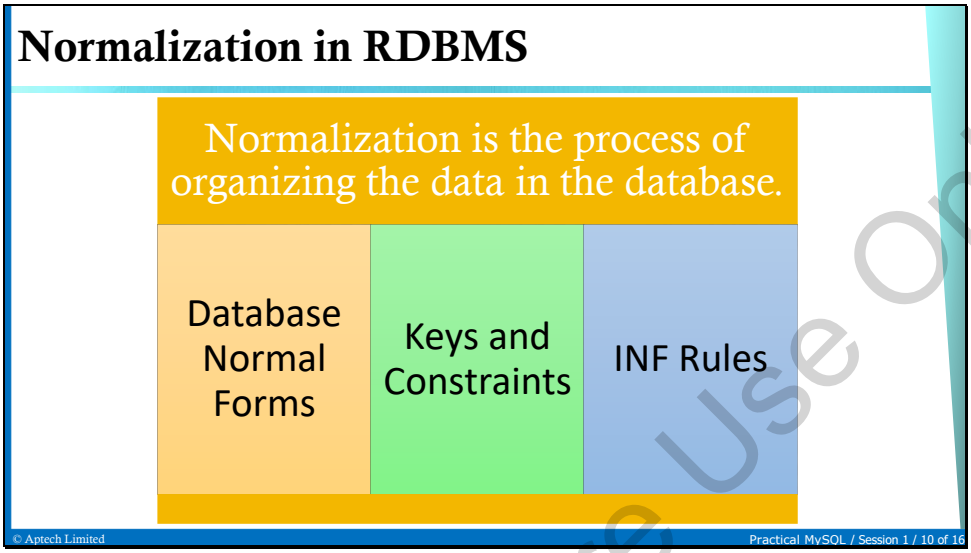
Tell students one can perform many operations on a table such as create, drop, delete, alter, and rename. A table should have name, rows, columns, and data types of the columns.

Additional Information:

Refer to following links for more information:

- https://www.tutorialspoint.com/sql/sql-rdbms-concepts.htm
- https://www.javatpoint.com/dbms-sql-table

Slide 10



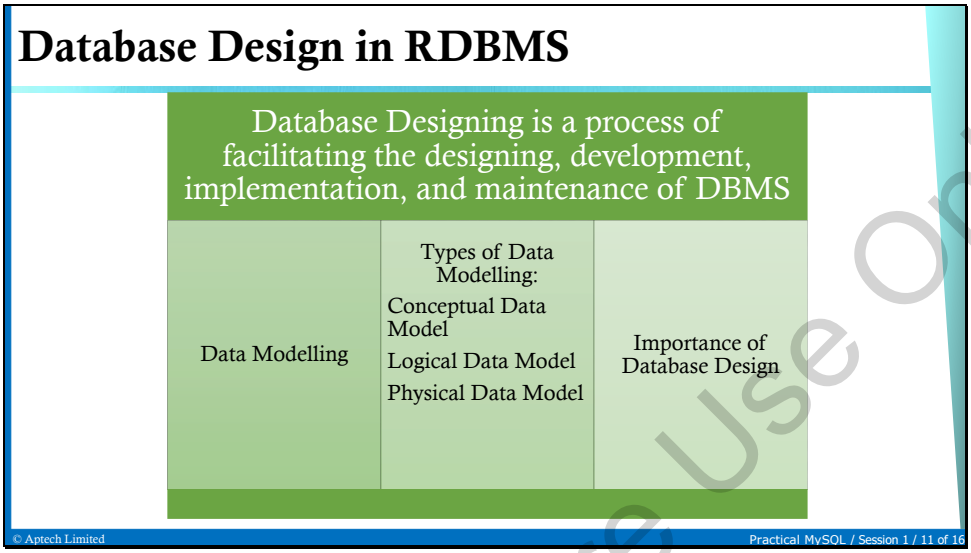
Instruction(s) to the Trainer:
Show slide 10 and explain the students about Normalization in RDBMS.
Discuss about the Database normal forms, keys and constraints and INF rules.

Additional Information:
Refer to following links for more information:
- https://www.javatpoint.com/dbms-normalization
- https://www.guru99.com/database-normalization.html

Ask students following question. Wait for a response before you answer.

In-Class Question: Why is Normalization required in RDBMS?
Answer: It is important that a database is normalized to minimize redundancy (duplicate data) and to ensure only related data is stored in each table.

Slide 11

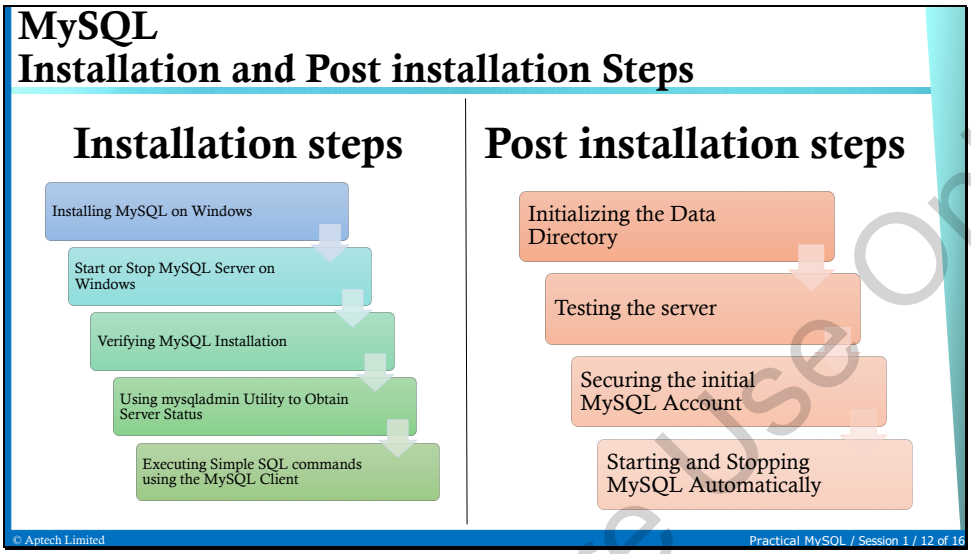


Instruction(s) to the Trainer:
Show slide 11 and discuss about the Database design in RDBMS.
Discuss about Data Modelling, types of Data Modelling, and then explain the importance of Database Design.

Additional Information:
Refer to following links for more information:
- https://www.javatpoint.com/database-design
- https://www.guru99.com/database-design.html

Ask students following question. Wait for a response before you answer.
In-Class Question: Define Data Modelling.
Answer: Data Modelling can be defined as a process of analyzing data objects and their relation with other objects.

Slide 12

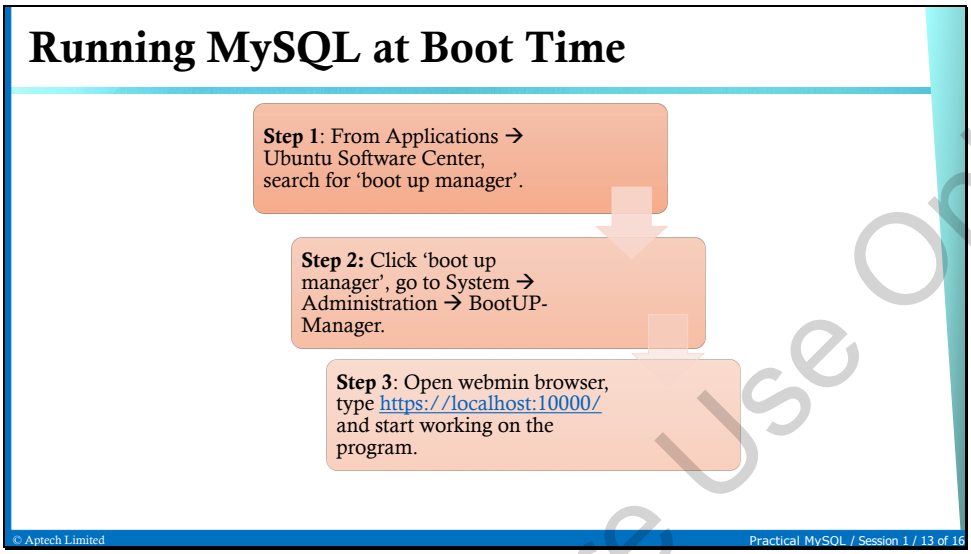


Instruction(s) to the Trainer:
Using slide 12, discuss various steps to be followed for MySQL Installation and post installation.

Additional Information:
Refer to following links for more information:

- https://www.javatpoint.com/how-to-install-mysql
- https://www.mysqltutorial.org/install-mysql/

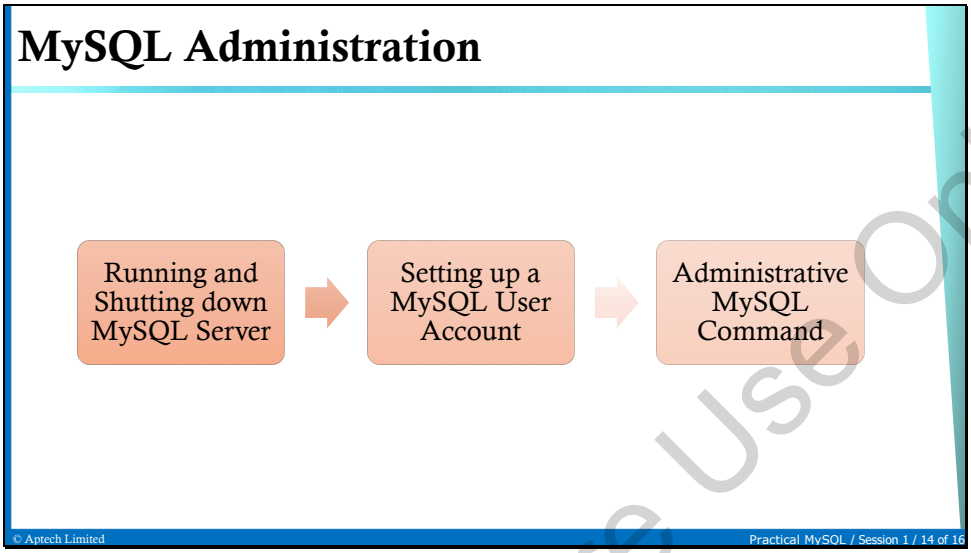
Slide 13



Instruction(s) to the Trainer:

Show slide 13 and explain the steps to be followed to run the MySQL at Boot time.

Slide 14



Instruction(s) to the Trainer:
Show slide 14 and discuss about MySQL Administration that enables the DBAs to perform a wide range of functions.
Say that the user will find information on server start-up and shutdown, setting up user account, and administrative commands.

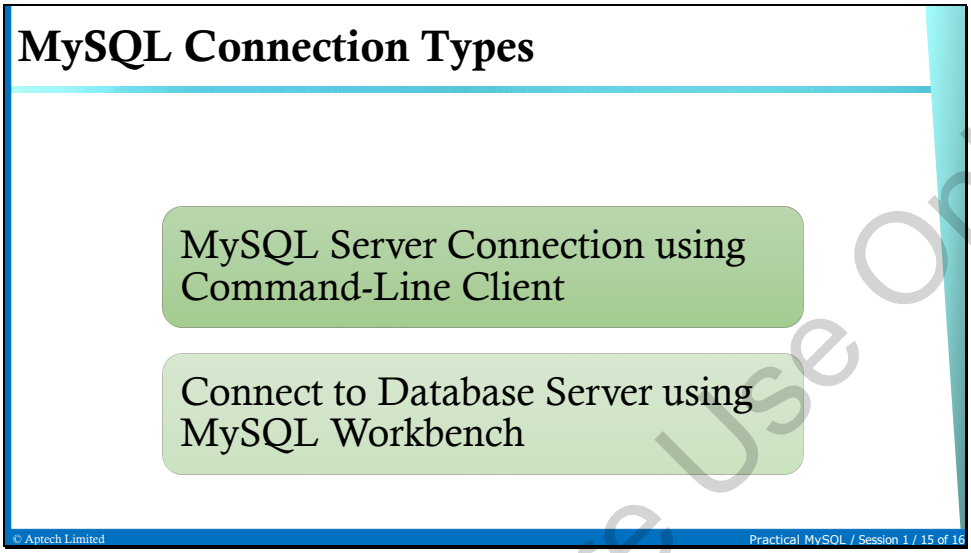
Following are the important MySQL Administrative commands, which can be used as per the user's requirement:

- **USE Databasename**: Select a database in the MySQL work area.
- **SHOW DATABASES**: It shows the lists of databases that are accessible.
- **SHOW TABLES**: It shows the list of tables in the database.
- **SHOW COLUMNS FROM tablename:** It shows the attributes, key information, types of attributes, and other information for a table.
- **SHOW INDEX FROM tablename**: It shows the details of all indexes on the table.
- **SHOW TABLE STATUS LIKE tablename\G**: It reports details of the MySQL DBMS performance and statistics.

Additional Information:
Refer to following links for more information:

- https://www.tutorialspoint.com/mysql/mysql-administration.htm
- https://www.mysqltutorial.org/mysql-administration

Slide 15



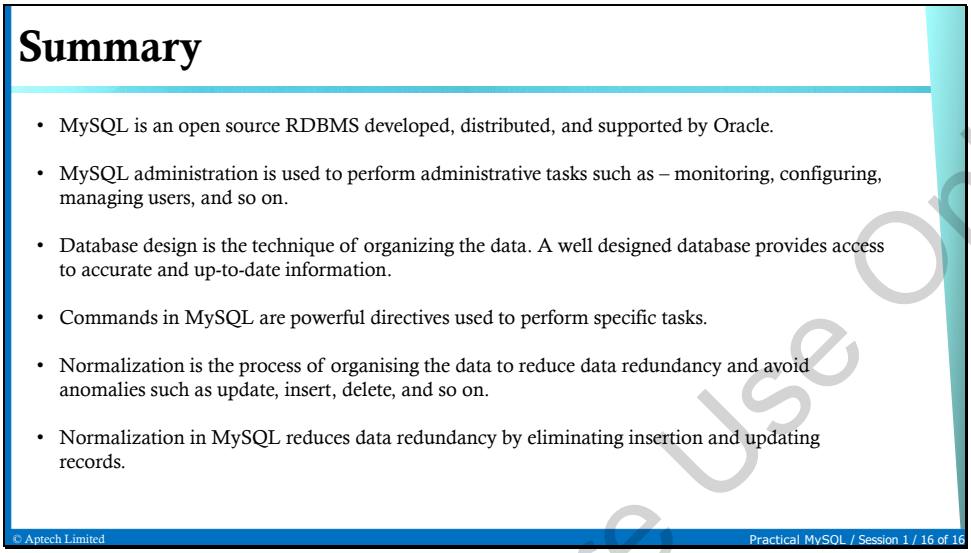
Instruction(s) to the Trainer:
Show slide 15 and explain MySQL Connection types in detail.
Inform students that user can connect with MySQL Database Server on the same machine or a remote machine using `mysql` binary at the command prompt. After connecting with the MySQL server, the user must connect to the database. Mention that there are multiple ways to connect with the database server. Once the MySQL server is installed, it can be connected using any of following client programs:

- MySQL Server Connection using Command-Line Client
- Connect to Database Server using MySQL Workbench

Additional Information:
Refer to following links for more information:

- https://www.javatpoint.com/mysql-create-database

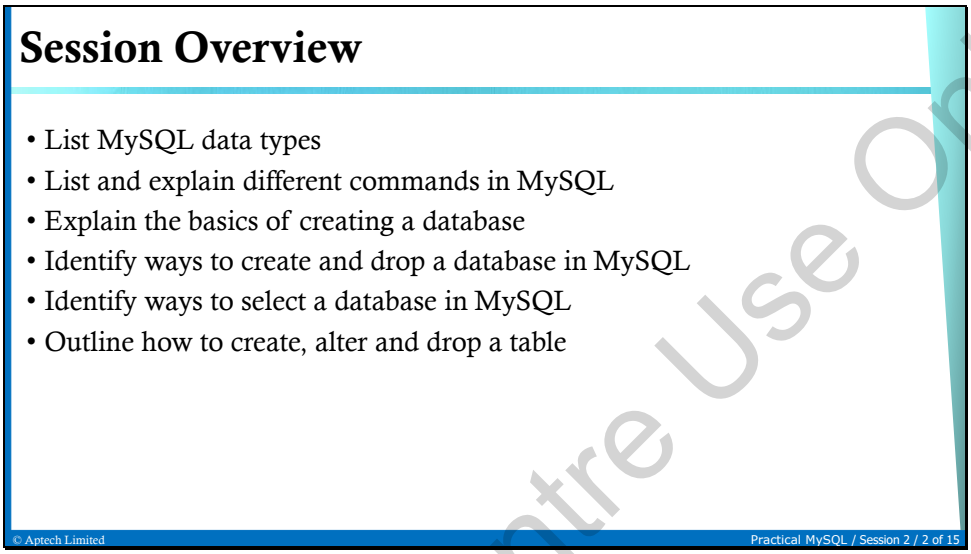
Slide 16



Use slide 16 to summarize the session. End the session, with a brief summary of what has been taught in the session. Tell the students pointers of the session. This will be a revision of the current session.

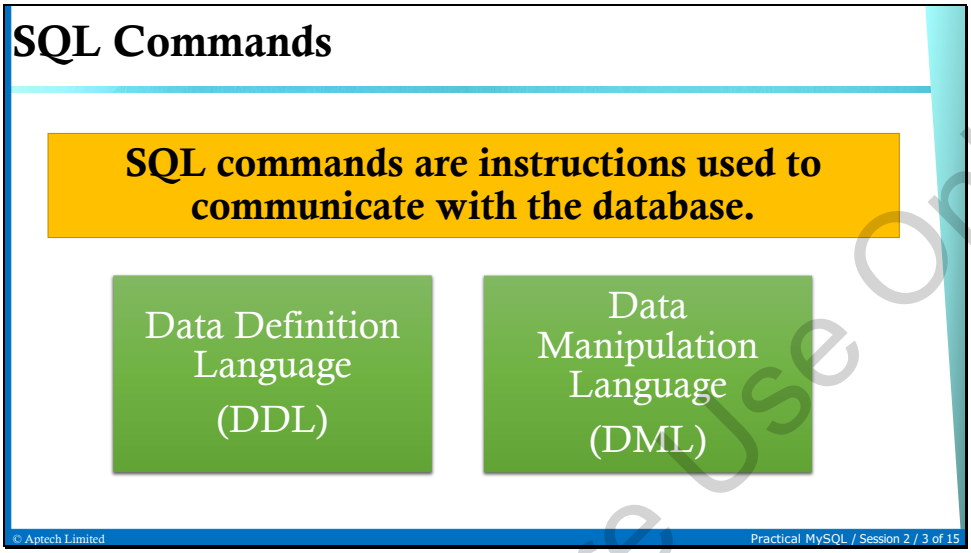
Session 2: Essentials of MySQL

Slide 2



Instruction(s) to the trainer:
Show slide 2 and give students a brief overview of the current session in the form of session objectives. Inform students that the session begins by introducing the list of MySQL data types. Next, it explains the different types of commands used in MySQL. The session further explains the basics of creating a database. It also discusses various ways of creating, dropping and selecting a database in MySQL. Finally, the session explains how to create, alter, and drop a table in MySQL.

Slide 3



In-Class Explanations

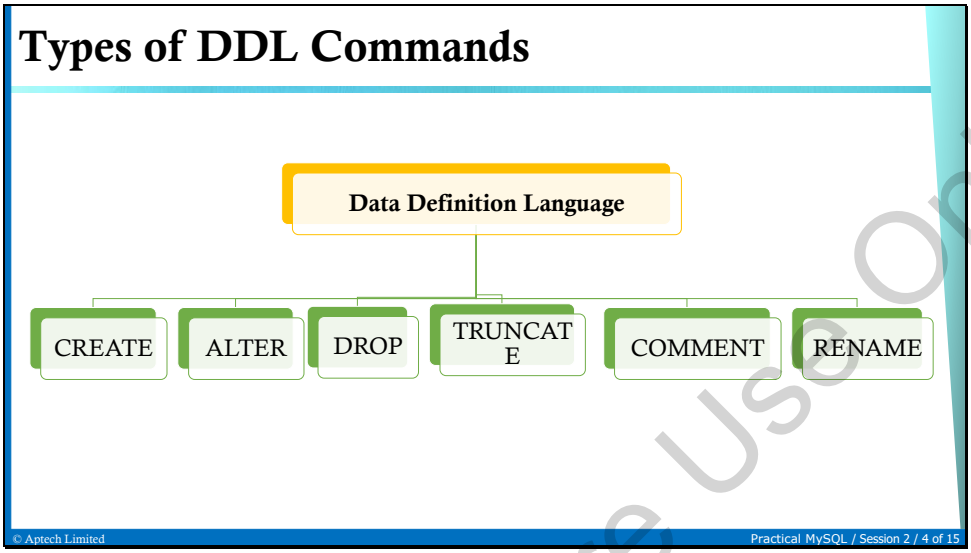
Instruction(s) to the trainer:
Use slide 3 to introduce students to SQL commands and the two basic types of SQL commands - DDL and DML. Tell them that SQL commands are instructions that are used to communicate with the database. Inform students that both these commands are not case-sensitive.

Tell them that DDL commands are used to modify the structure of databases and database objects. These commands are auto-committed and database tables and objects will be permanently stored in the database.

DML commands are used to manipulate data in a database table. DML operations are performed by used SQL statements such as `SELECT`, `INSERT`, `DELETE`, and so on.

Additional Information:
Refer to following links for more information:
https://www.javatpoint.com/dbms-sql-command
https://www.edureka.co/blog/sql-commands

Slide 4



Instruction(s) to the trainer:
Use slide 4 to introduce students to different types of DDL commands and the purposes they are used for in MySQL queries.

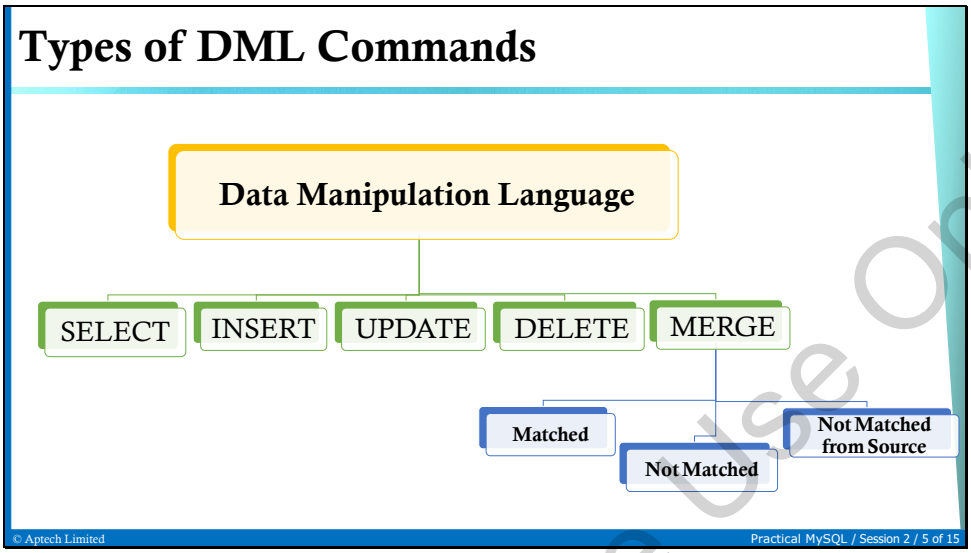
- `CREATE` command is used to create databases as well as objects in a database such as a table, view, index, and so on.
- `ALTER` command is used to restructure the database, table, and database objects.
- `DROP` command is used to delete databases as well as database objects from the database such as a table, view, index, and so on.
- `TRUNCATE` command is used to remove all rows from the table and at the time, keeping structure of the table the same.
- `COMMENT` command is used to specify some more information about the query. It will not be considered as a SQL query.
- `RENAME` command is used to change the name of the table.

Additional Information:

Refer to following links for more information:

https://www.edureka.co/blog/sql-commands
https://www.geeksforgeeks.org/sql-ddl-dql-dml-dcl-tcl-commands/

Slide 5



Instruction(s) to the trainer:

Use slide 5 to introduce students to different types of DML commands and the purposes they are used for in MySQL queries.

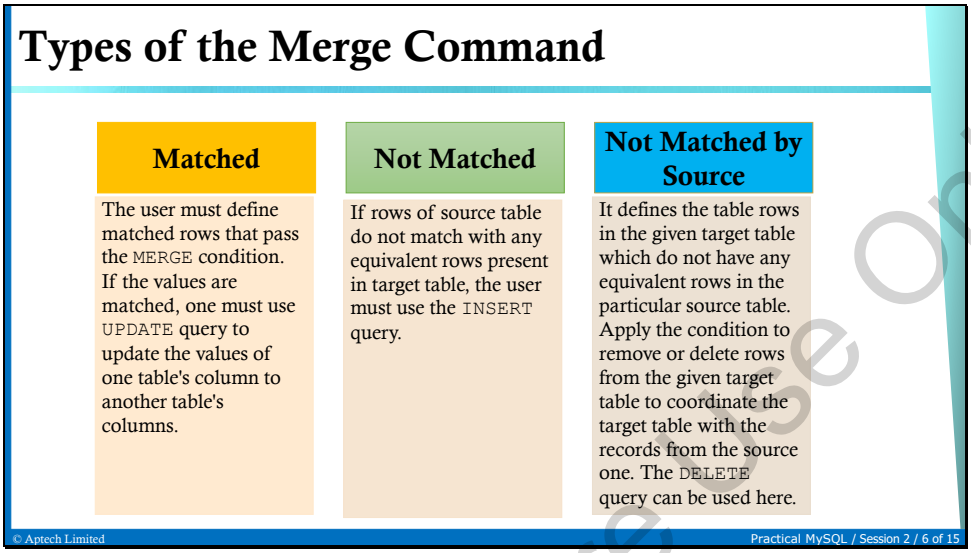
- `SELECT` command is used to fetch or retrieve records from tables.
- `INSERT` command is used to insert the records into the table.
- `UPDATE` command is used to modify data in a table. Tell students that if the WHERE clause is not specified, all records in the specified table will be modified.
- `DELETE` command is used to delete all records or specific records from a table.
- `MERGE` command is used to combine INSERT, UPDATE, and DELETE commands into a single SQL statement.
    - There are three types of Merge commands - Matched, Not Matched, and Not Matched with Source.

Ask students following question. Wait for a response before you answer.

In-Class Question: Which command should be used to combine `INSERT`, `UPDATE`, and `DELETE` commands into a single SQL Statement?
Answer: The `MERGE` command can be used to do this task.

Additional Information:
Refer to following links for more information:
https://www.edureka.co/blog/sql-commands
https://www.geeksforgeeks.org/sql-ddl-dql-dml-dcl-tcl-commands/

Slide 6



Instruction(s) to the trainer:

Show slide 6 and tell students about the three conditions of the `MERGE` command in MySQL. These three conditions are:

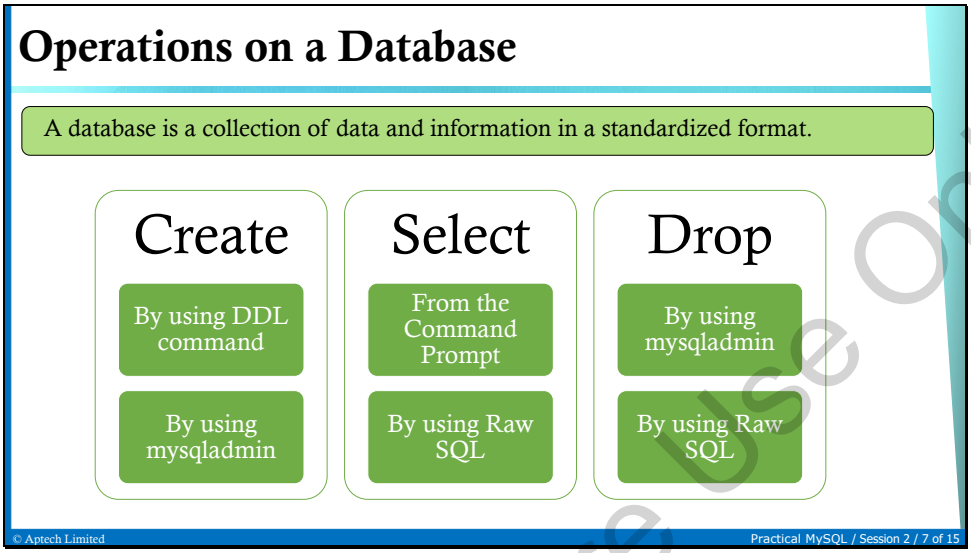
- **Matched:** In this case, the user should define matched rows that must pass the `MERGE` condition.
- **Not Matched:** The user must use the `INSERT` query in case the rows of source table do not match with any equivalent rows present in target table.
- **Not Matched by Source:** This condition should be applied to remove or delete rows from the given target table to coordinate the target table with the records from the source one.

Additional Information:

Refer to following links for more information:

https://www.edureka.co/blog/sql-commands
https://www.sqlshack.com/understanding-the-sql-merge-statement/
https://www.sqlservertutorial.net/sql-server-basics/sql-server-merge/

Slide 7



Instruction(s) to the trainer:

Use slide 7 to show how to perform some basic database operations in MySQL. A database in MySQL stores multiple tables and other related objects such as views, functions, and so on. Besides using the DDL command CREATE to create a database, one can also use `mysqladmin` to create databases.

The `mysqladmin` command is used to perform administrative operations. A database can also be created using `mysqladmin`.

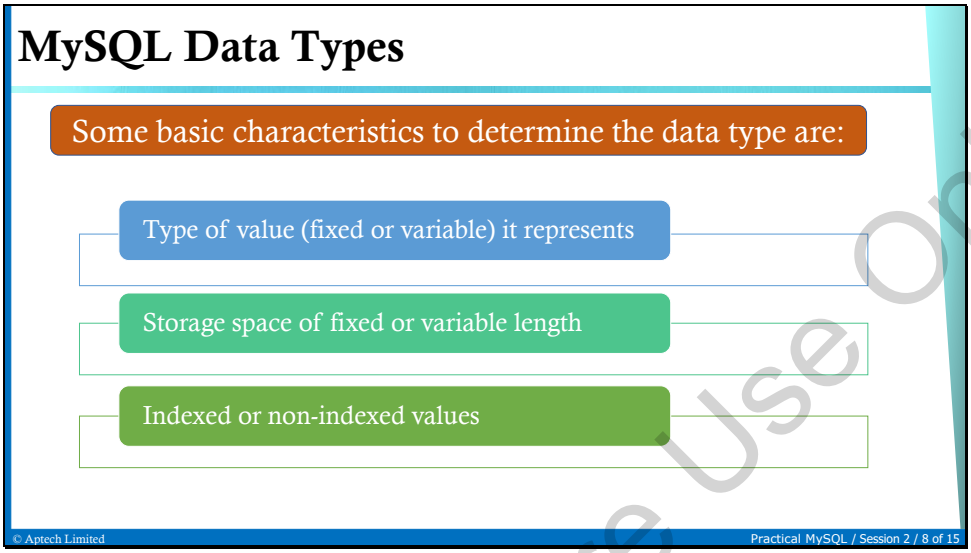
By dropping a database, we mean deleting the database from the server. A database can be dropped by using `mysqladmin` command as well as raw SQL command.

Tell students that they can select a database using raw SQL or from the command prompt.

Additional Information:

Refer to following links for more information:
https://www.w3schools.com/sql/sql_intro.asp
https://www.javatpoint.com/sql-tutorial

Slide 8



Instruction(s) to the trainer:

Show slide 8 and explain students about some basic characteristics to determine data type. Inform them that to identify a data type, they must know about:

- The type of value it represents
- The storage space or length of the variable
- Whether it contains indexed or non-indexed values

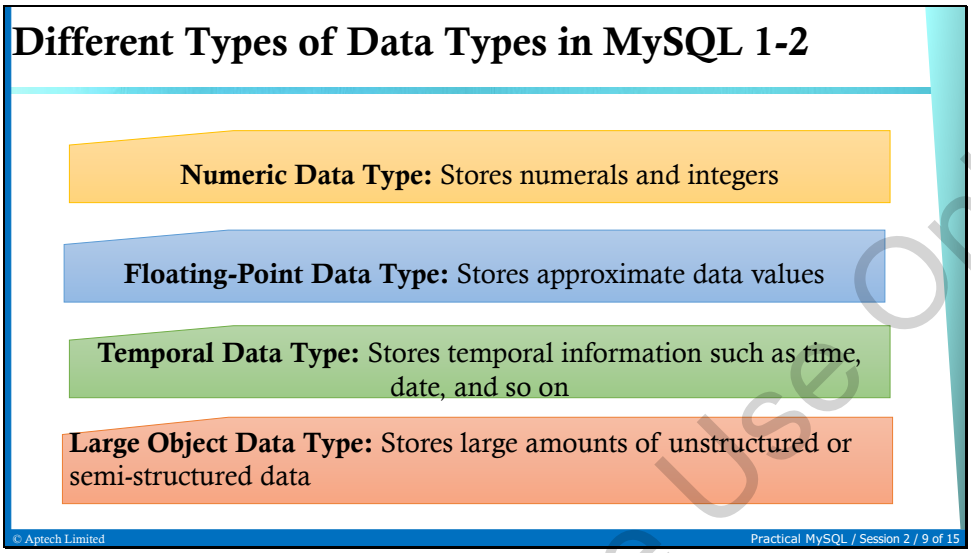
Some common data types in MySQL are categorized as Numeric, String, Date and Time, Spatial, and JSON. These are further subcategorized as floating-point, integer, boolean, character, and so on.

Additional Information:

Refer to following links for more information:

https://www.w3schools.com/sql/sql_datatypes.asp
https://www.tutorialspoint.com/sql/sql-data-types.htm
https://www.javatpoint.com/sql-data-types

Slide 9



Instruction(s) to the trainer:

Show slide 9 and list some of the most common types of data types in MySQL.

Tell students that Numeric data types represent whole numbers. For example, number of employees in an organization, number of people in a family, population of an entire country, and so on.

Inform students that floating-point data types can store a high range of decimal numbers for accuracy. These data types are mostly used in columns such as amount of a product, rate of an item, weights, measurements, and so on.

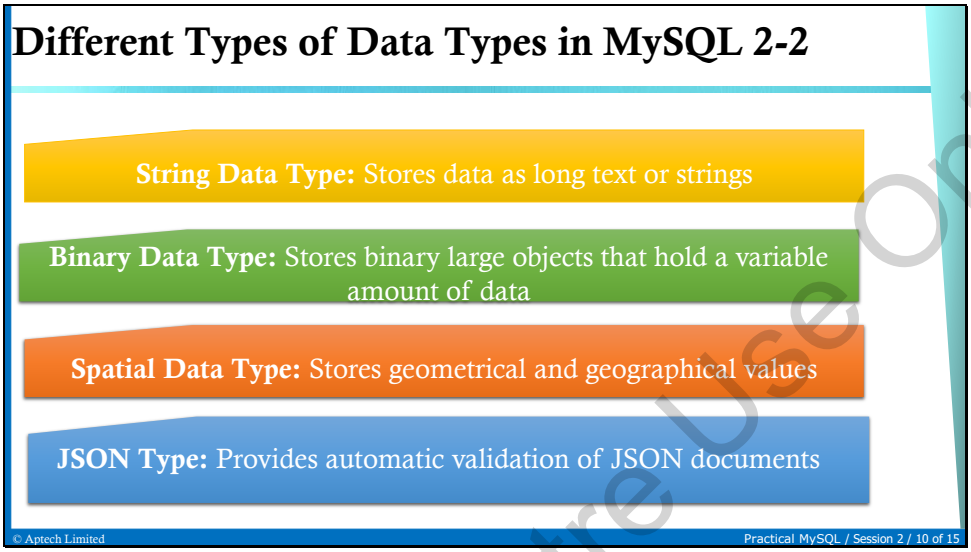
Temporal data types are used for storing information such as time, date, and so on. Every temporal data type has a valid range of values as well as zero.
A Large Object Data Type (LOB) is used for storing large amounts of unstructured or semi-structured data.

Additional Information:

Refer to following links for more information:

https://www.w3schools.com/sql/sql_datatypes.asp
https://www.tutorialspoint.com/sql/sql-data-types.htm
https://www.javatpoint.com/sql-data-types

Slide 10



Instruction(s) to the trainer:

Show slide 10 and explain that string data type can store either fixed or varied number of characters. Entity names such as Customer names, product names, cities, order status, and many other such textual data can be stored as strings.

Binary data type is used to maintain binary large objects that hold a variable amount of data. These differ only in terms of the maximum length of the values.

Spatial data is used to determine specific locations based on the coordinate data. Such data is typically stored in the spatial data types. Geometric data is highly used in Google Maps to display precise directions. Various important shapes such as rectangular tiles, pyramids, football pitches, and road designs require specific multi-polygonic data types to store values.

JSON data type provides automatic validation of JSON documents. It generates an error for invalid documents.

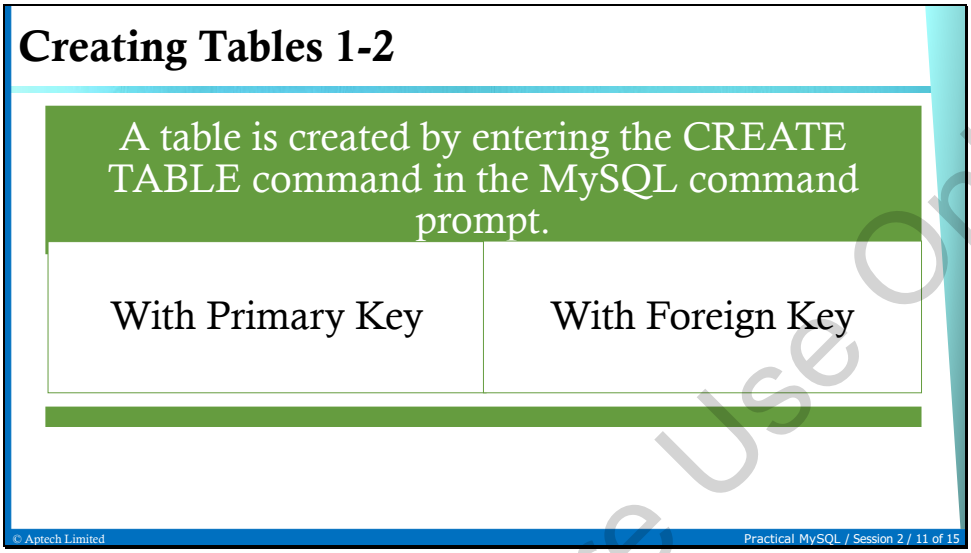
In-Class Question: Which data type is used to store geometrical and geographical values?
Answer: Spatial data type

Additional Information:

Refer to following links for more information:

https://www.w3schools.com/sql/sql_datatypes.asp
https://www.tutorialspoint.com/sql/sql-data-types.htm
https://www.javatpoint.com/sql-data-types

Slide 11



Instruction(s) to the trainer:

Show slide 11 and explain how tables can be created with primary key and foreign key respectively.

Primary keys can be used to relate one table to another. Adding primary key/s while creating a table maintains consistency, uniqueness, and avoids duplicate data. It must be noted that only one primary key is allowed in a table.

To establish a relationship with a child table or any other table, a foreign key must be added along with the column containing only the values as those of the parent table's primary key values.

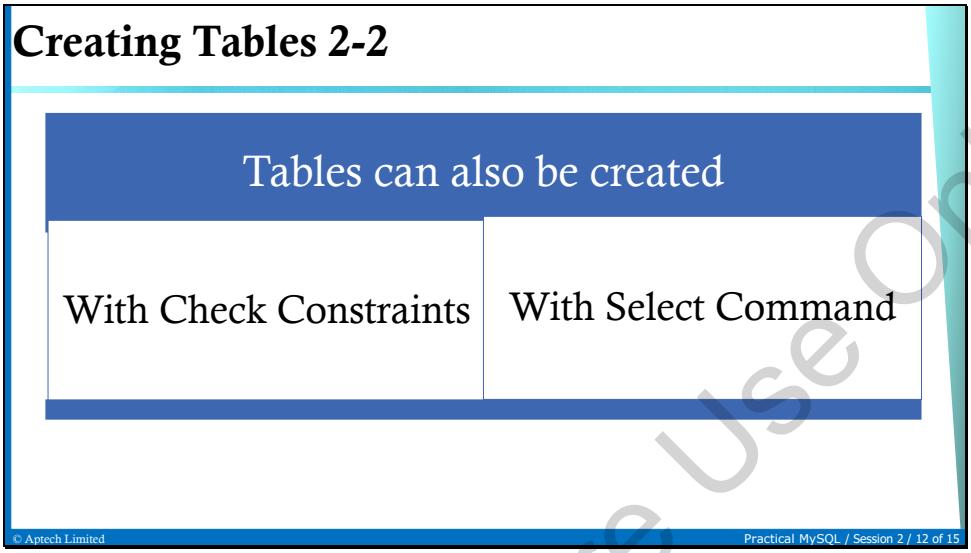
A foreign key is also known as referencing key and is used to link multiple tables. The foreign key field in a table refers to the primary key field of another table. The foreign keys can be defined in two ways using `CREATE TABLE` and `ALTER TABLE` statement.

Additional Information:

Refer to following links for more information:

https://www.w3schools.com/sql/sql_create_table.asp
https://www.javatpoint.com/sql-tutorial

Slide 12



Instruction(s) to the trainer:

Using slide 12, inform students on how to create a table with the `CHECK` constraint as well as the `SELECT` command. The `CHECK` constraint is used to check the value before inserting in the column. Query that contains `CHECK` constraint will return error if the value in a particular column does not match the conditions.

A new table can be created from an existing table as well using the `SELECT` command. Syntax is as follows:

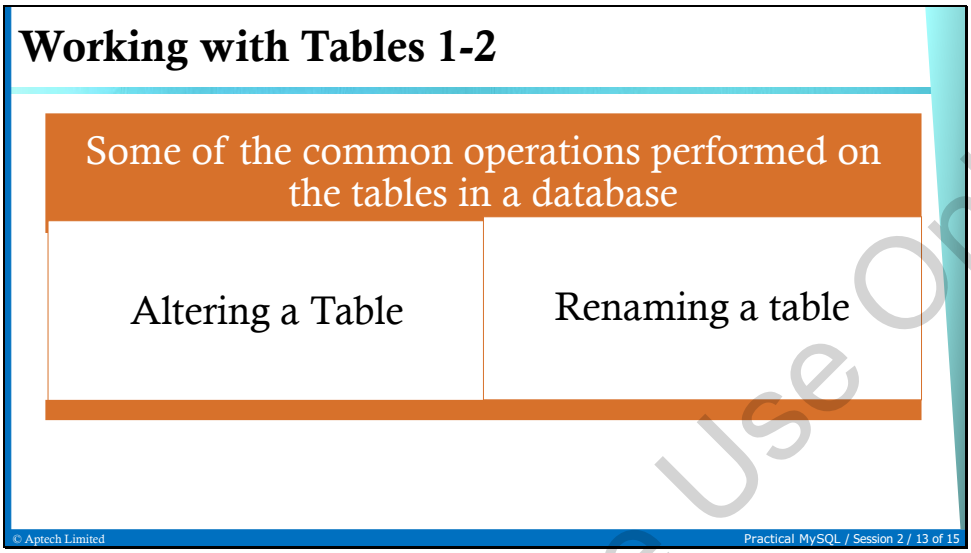
```
CREATE TABLE <TABLE_NAME> AS SELECT COLUMN_NAME,.... FROM
<TABLE_NAME>
```

Additional Information:

Refer to following links for more information:

https://www.w3schools.com/sql/sql_intro.asp
https://www.javatpoint.com/sql-tutorial
https://www.tutorialspoint.com/sql/sql-create-table.htm

Slide 13



Instruction(s) to the trainer:
Show slide 13 and tell students that the `ALTER` command is used to add and remove a column in an existing table. The data type of the column can also be modified using the `ALTER` command.

The user can change the size or field of any column, depending on the requirement. `ALTER COLUMN` keyword is used to increase or decrease the size of the column in MySQL.

A table in MySQL can be renamed by using following command:

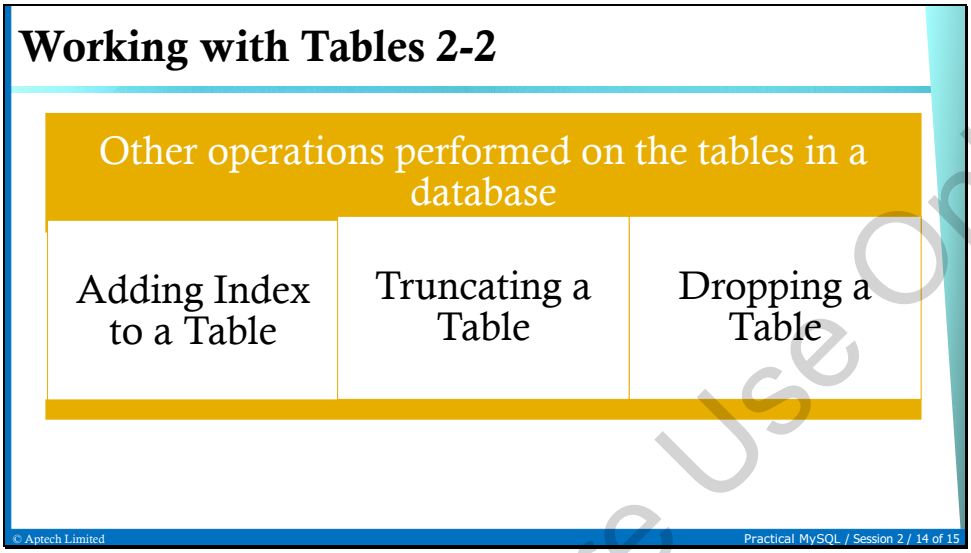
```
RENAME TABLE Customer TO New_Customer;
// Following command will also rename the table
ALTER TABLE Customer RENAME TO New_Customer;
```

Additional Information:

Refer to following links for more information:

https://www.w3schools.com/sql/sql_intro.asp
https://www.javatpoint.com/sql-tutorial

Slide 14



Instruction(s) to the trainer:

Use slide 14 to tell students about some other operations that can be performed on a table, such as adding and index, truncating or dropping a table.

Following is the syntax for `ALTER TABLE ADD INDEX`:

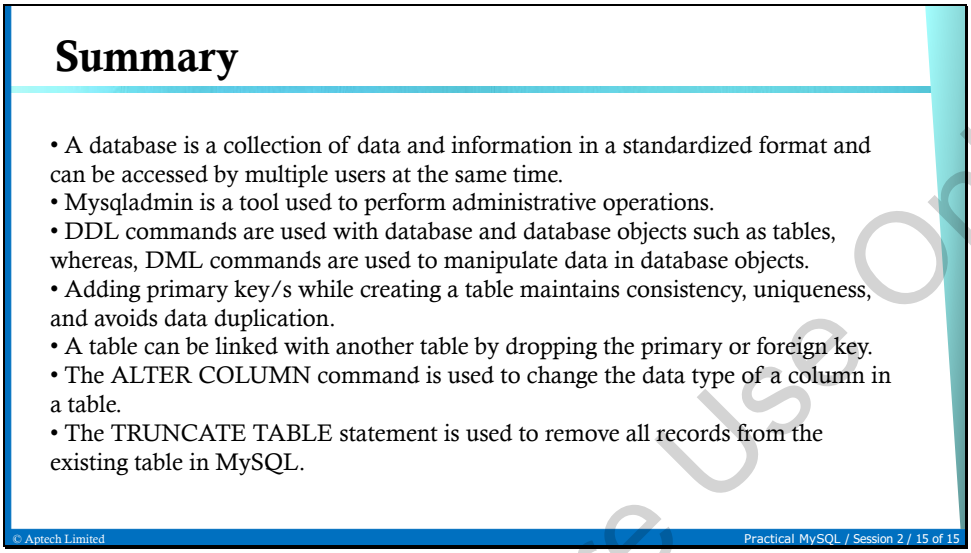
```
ALTER TABLE ADD INDEX `index_name` (`column_name`)
```

The `DROP TABLE` statement in MySQL is used to drop a table(s) from the database. It permanently erases all data from the table and removes the structure as well. The `TRUNCATE` command is used to remove all records from an existing table in MySQL. It performs the same function as a DELETE statement without using a WHERE clause. The structure of table remains intact even after executing the `TRUNCATE` command.

In-Class Question: What is the difference between the `DELETE` command and the `TRUNCATE` command?
Answer: `DELETE` is used to remove some or all of the records from the table, whereas `TRUNCATE` will delete entire rows from table.

Additional Information:
Refer to following links for more information:
https://www.w3schools.com/sql/sql_intro.asp
https://www.javatpoint.com/sql-tutorial

Slide 15

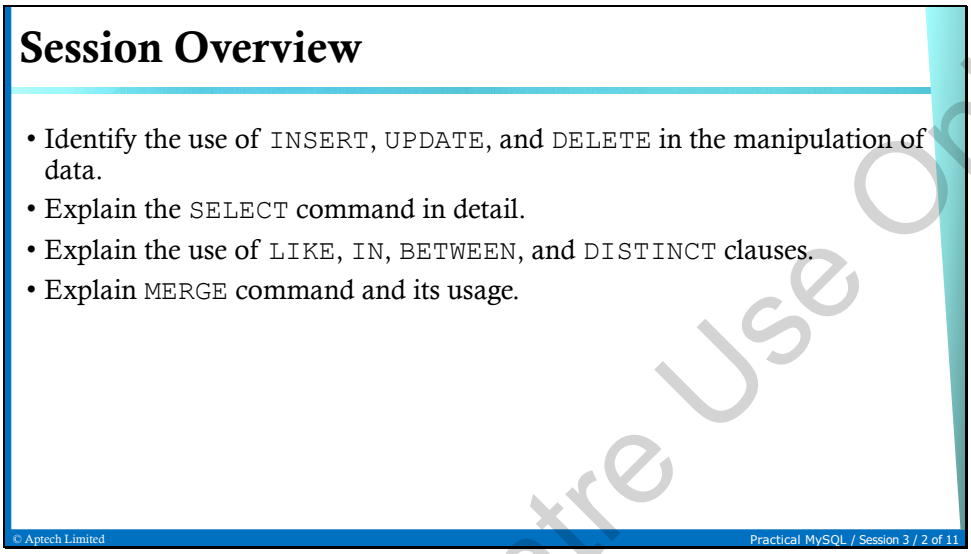


Instruction(s) to the trainer:

Use slide 15 to summarize the session. You will end the session with a summary of what has been taught in the session. Tell students the pointers of the session. This will be a revision of the current session.

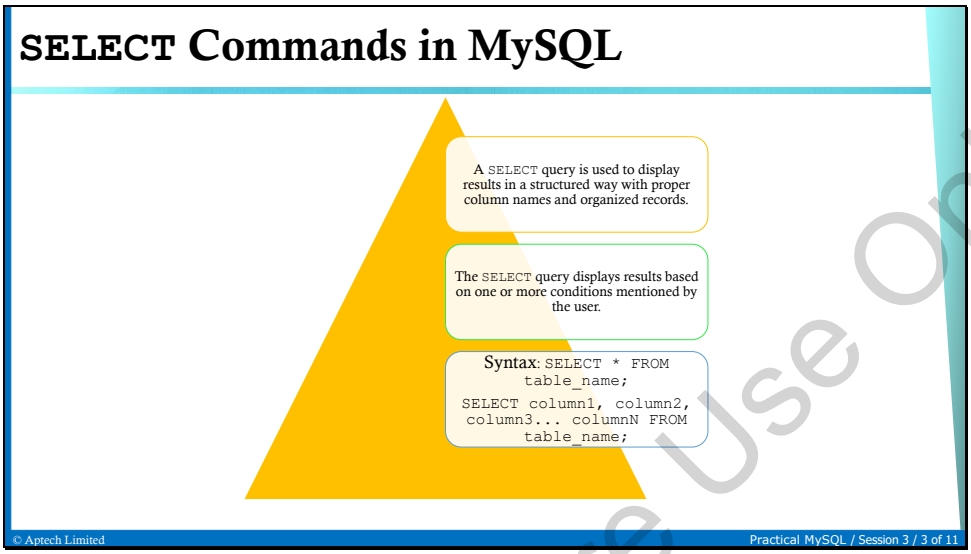
Session 3: Working with Data in MySQL

Slide 2



Instruction(s) to the trainer:
Show slide 2 and give the students a quick overview of the current session and its goals. Inform them that the session will explain the usage of `SELECT`, `INSERT`, `UPDATE`, and `DELETE` commands. They will also learn about some of the keywords and clauses. Finally, the `MERGE` command and its purpose will be discussed in detail.

Slide 3



Instruction(s) to the trainer:
Show slide 3 and explain the concept of `SELECT` commands in MySQL. Tell the students that the `SELECT` statement is used to pick data from a database. The data is saved in a result table known as the result-set.

Furthermore, describe the following syntax:

```
SELECT column1, column2, ...FROM table_name;
```

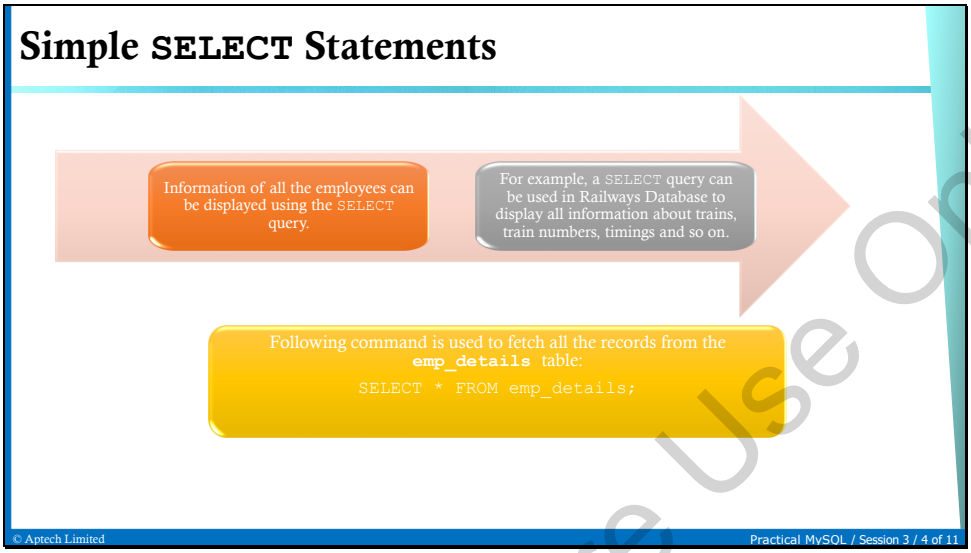
where, column1, column2 are the field names of the table from which a user wants to retrieve data.

Inform students that the following syntax is used to pick all of the fields accessible in the table:

```
SELECT * FROM table_name;
```

In-Class Question : What does select 0 mean in SQL?
Answer: A field name of 0 in the select statement means: **This field is not in the specified table**, so if you want to use the specified table in the subquery with this field, you add the field in this way and initialize the field with 0.

Slide 4



Instruction(s) to the trainer:
Show slide 4 and provide a brief overview on simple SELECT Statements.

Give the example of creating a table to explain the concept in a better way. By using queries:

```
CREATE TABLE emp_details (
EmployeeID INT,
Name VARCHAR(255),
Location VARCHAR(255),
Salary INT,
Dept VARCHAR(255),
PRIMARY KEY (EmployeeID)
);
```

Explain the following query to insert data into the **`emp_details`** table:

```
INSERT INTO `emp_details`(`EmployeeID`, `Name`, `Location`,
`Salary`, `Dept`) VALUES
(1001,'Daniel','Princeton', 10000,'Finance');
INSERT INTO `emp_details`(`EmployeeID`, `Name`, `Location`,
`Salary`, `Dept`) VALUES (1002,'Anna','Ohio', 15000,'Sales');
```

```
INSERT INTO `emp_details`(`EmployeeID`, `Name`, `Location`,
`Salary`, `Dept`) VALUES (1003,'Emma','New Jersey',
12500,'Marketing');
INSERT INTO `emp_details`(`EmployeeID`, `Name`, `Location`,
`Salary`, `Dept`) VALUES (1004,'Charles','Mexico',
20000,'Finance');
INSERT INTO `emp_details`(`EmployeeID`, `Name`, `Location`,
`Salary`, `Dept`) VALUES (1005,'Kipp','Florida', 25000,'Legal');
```

Tell students that the information of all employees can be displayed using the `SELECT` query. For example, a `SELECT` query can be used in company database to display all information about employees, employee id, name, and so on.

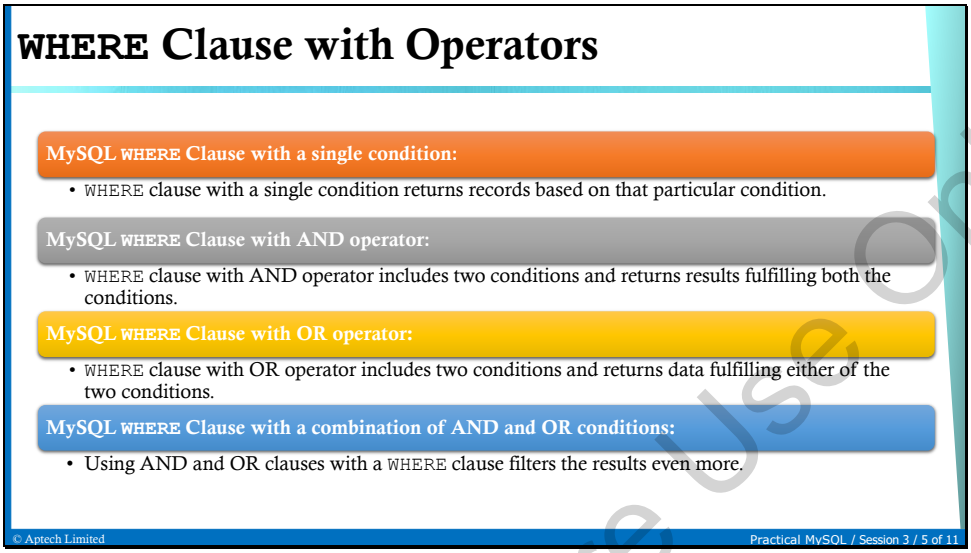
Following command is used to fetch all the records from the **`emp_details`** table:

Command: SELECT * FROM emp_details;
Output: The user will get all the details in a tabular form.

Discuss with students that only the distinctive (different) results are returned using the **`SELECT DISTINCT`** command.
A column in a table frequently has multiple duplicate values and a user may only wish to list the distinctive values.

Explain the following syntax:
`SELECT DISTINCT column1, column2, ...FROM table_name;`

Slide 5



Instruction(s) to the trainer:
Show slide 5 and describe the `WHERE` Clause used in MySQL. The `WHERE` clause is used to filter records. It is also used to retrieve only those records that meet a specific set of criteria.

Explain the following *Syntax*:

```
SELECT column1, column2, ...FROM table_name WHERE condition;
```

Note: Inform students that the `WHERE` clause is used not just in `SELECT` statements, but also in `UPDATE`, `DELETE`, and other statements.

Discuss the following pointers related to the MySQL AND, OR and NOT Operators:

- To filter records based on several conditions, the AND and OR operators are used.
- If all of the conditions separated by AND are TRUE, then the AND operator displays a record.
- If any of the conditions separated by OR is TRUE, then the OR operator displays a record.
- If the condition(s) are NOT TRUE, then the NOT operator displays a record.

Explain the following syntax to students:

- **AND:**
```
SELECT column1, column2, ...
FROM table_name
WHERE condition1 AND condition2 AND condition3 ...;
```

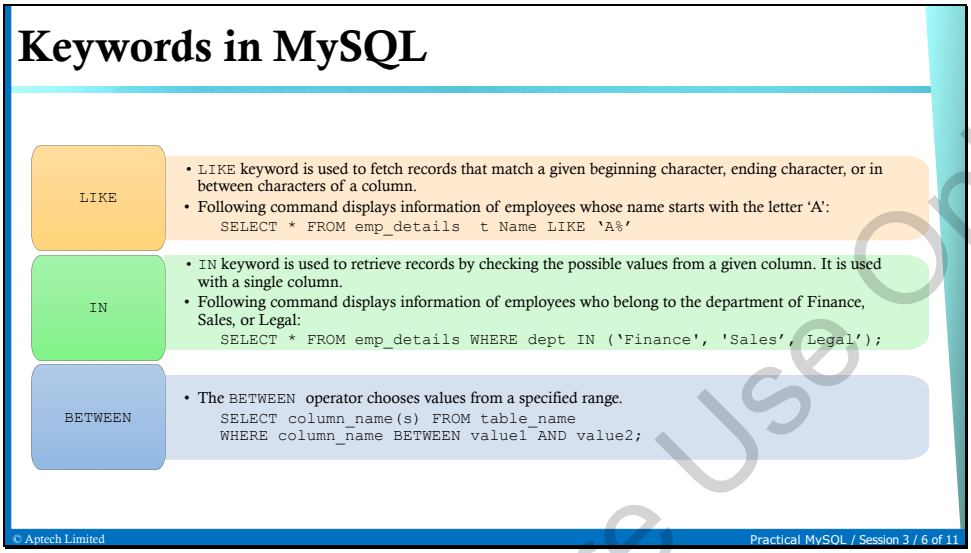
- **OR:** SELECT *column1*, *column2, ...*
  FROM *table_name*
  WHERE *condition1* OR *condition2* OR *condition3 ...;*
- **NOT:** SELECT *column1*, *column2, ...*
  FROM *table_name*
  WHERE NOT *condition*;

Additional Information:

Refer to following links for more information:

https://www.w3schools.com/sql/sql_where.asp
https://www.guru99.com/where-clause.html

Slide 6



Instruction(s) to the trainer:
Show slide 6 and discuss about the keywords in MySQL,

Tell the students that in a WHERE clause,

. **LIKE** keyword is used to look for a certain pattern in a column. There are two wildcards that are frequently used with the LIKE operator:

. The percent sign (%) denotes zero, one, or several characters.

. The underscore symbol (_) denotes a single character.

. The underscore and the percent sign can also be used together.

Further, define the appropriate syntax:
```
SELECT column1, column2, ...
    FROM table_name
    WHERE columnN LIKE pattern;
```

. **IN**: In a WHERE clause, the IN operator allows a user to define several values. Multiple OR conditions are represented by the IN operator.

Describe the syntax:
```
SELECT column_name(s)
            FROM table_name
            WHERE column_name IN (value1, value2, ...);
```

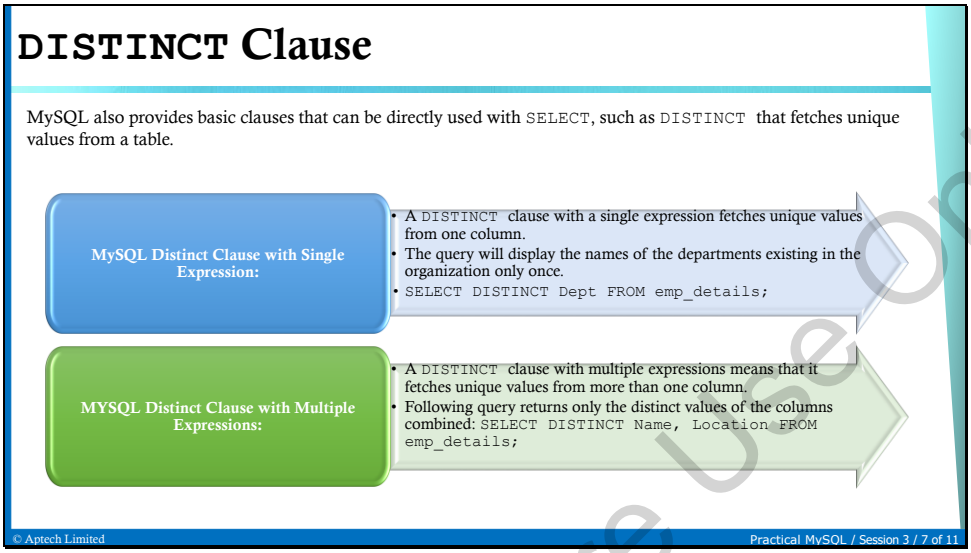
BETWEEN: The BETWEEN operator chooses values from a specified range. Numbers, text, and dates can all be used as values. The BETWEEN operator takes both the start and finish values into account.

Define the syntax to students:

```
SELECT column_name(s)
        FROM table_name
    WHERE column_name BETWEEN value1 AND value2;
```

In-Class Question: Is rank a keyword in MySQL?
Answer: The rank is a MySQL reserved word defined in MySQL version 8.0.

Slide 7



Instruction(s) to the trainer:
Show slide 7 and explain about the DISTINCT clause. Only distinctive (different) results are returned using the SELECT DISTINCT command.
A column in a table frequently has multiple duplicate values. Thus, a user might only want to list the distinctive values.

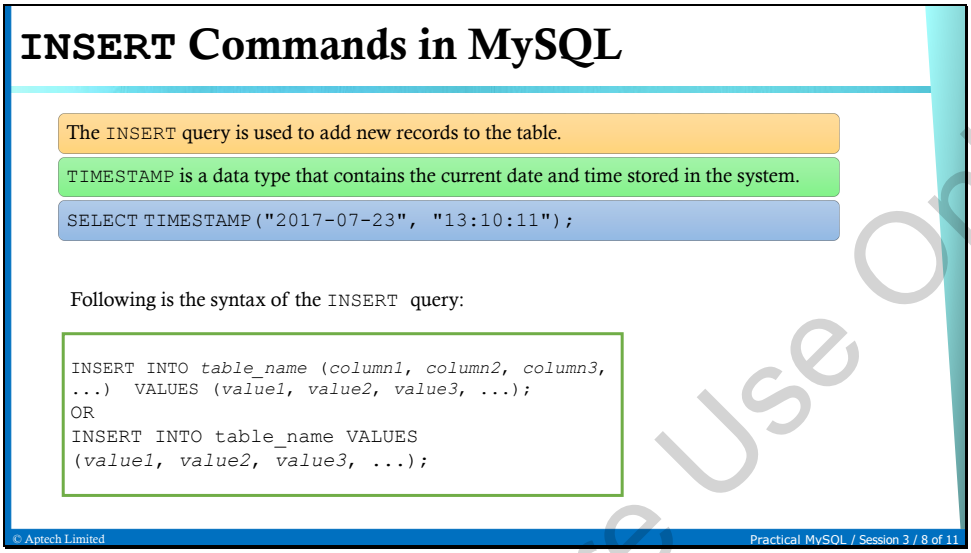
Explain the following syntax to students:
`SELECT DISTINCT column1, column2, ... FROM table_name;`

Additional Information:

Refer to following links for more information:

https://www.techonthenet.com/mysql/distinct.php#:~:text=Description,be%20used%20with%20SELECT%20statements.
https://www.javatpoint.com/mysql-distinct

Slide 8



Instruction(s) to the trainer:
Show slide 8 and give a brief outline on the INSERT Commands in MySQL. Tell students that the INSERT INTO statement is used to add new records to a table.

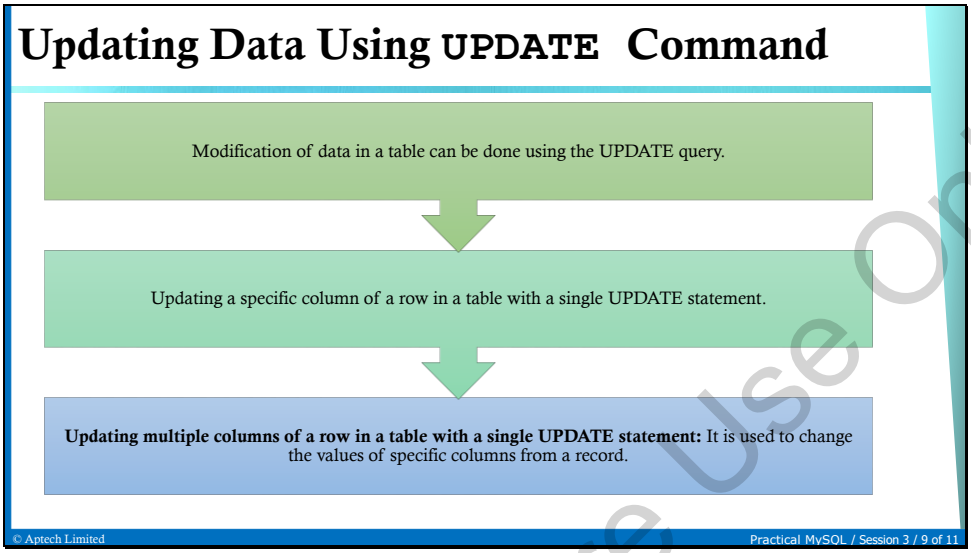
Inform them that there are two methods to write the INSERT INTO statement.
Both the column names and the values to be added must be specified.

Syntax: `INSERT INTO table_name (column1, column2, column3, ...) VALUES (value1, value2, value3, ...);`

2. A user does not have to include the column names in the SQL query if the values are being added to all of the table's columns. A programmer must ensure that the values are in the same order as the table's columns. The INSERT INTO *syntax* in this case would be as follows:

`INSERT INTO table_name VALUES (value1, value2, value3, ...)`

Slide 9



Instruction(s) to the trainer:
Show slide 9 and discuss how to update data in MySQL using UPDATE command, The UPDATE statement is used to change the contents of a table's existing records.

Following is the command to update a single column (Location) of the employees belonging to the Finance department:

```
UPDATE emp_details SET Location= 'Delaware‘ WHERE Dept = ‘Finance’;
```

Following is the command to update the salary and location of the employee having id 1002:

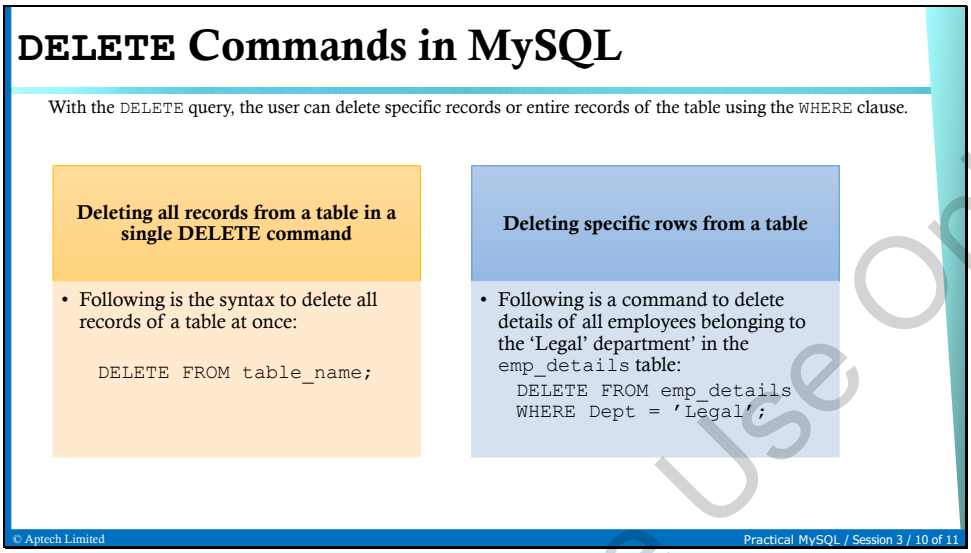
```
UPDATE emp_details SET Salary = 26000, Location= 'New York'
WHERE EmployeeId = 1002;
```

Introduce students to its syntax:

```
UPDATE table_name
SET column1 = value1, column2 = value2, ...
WHERE condition;
```

Note: A user must stay cautious while updating records in a table! In the UPDATE statement, one must take note of the WHERE clause. The WHERE clause determines which records should be updated. If the programmer does not utilize the WHERE clause, all of the table's records will be updated.

Slide 10



Instruction(s) to the trainer:
Show slide 10 and discuss how to DELETE data in MySQL using the DELETE command. The DELETE statement is used to erase existing records in a table.

Explain the following syntax:

```
DELETE FROM table_name WHERE condition;
```

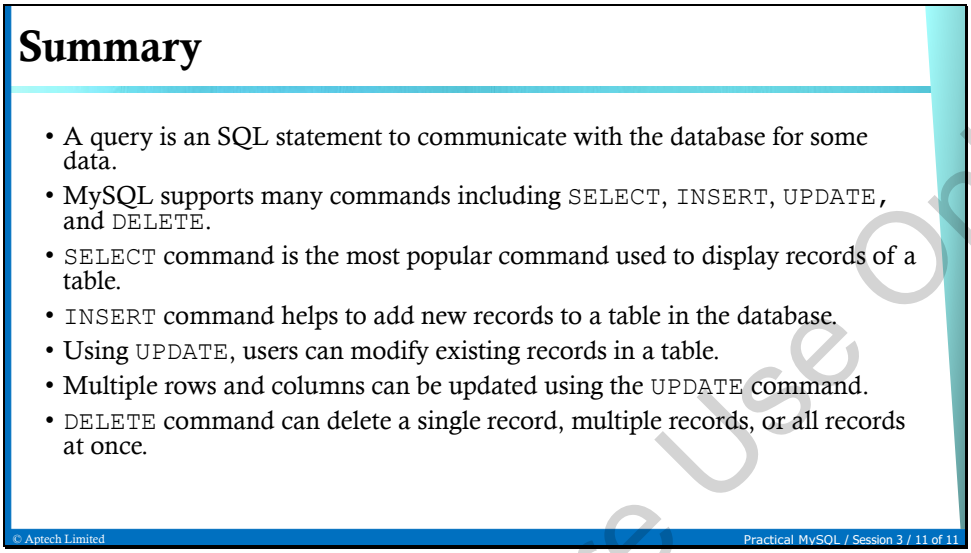
Note: One must stay alert while deleting records from a table. In the DELETE statement, a user must take note of the WHERE clause. The WHERE clause defines the records to be removed from the database. If a developer does not include the WHERE clause, the entire table will be destroyed.

To delete all the records, a user can delete all rows in a table without removing the table. Tell students that the table structure, characteristics, and indexes will all be preserved.

Describe the following syntax:

DELETE FROM *table_name*;

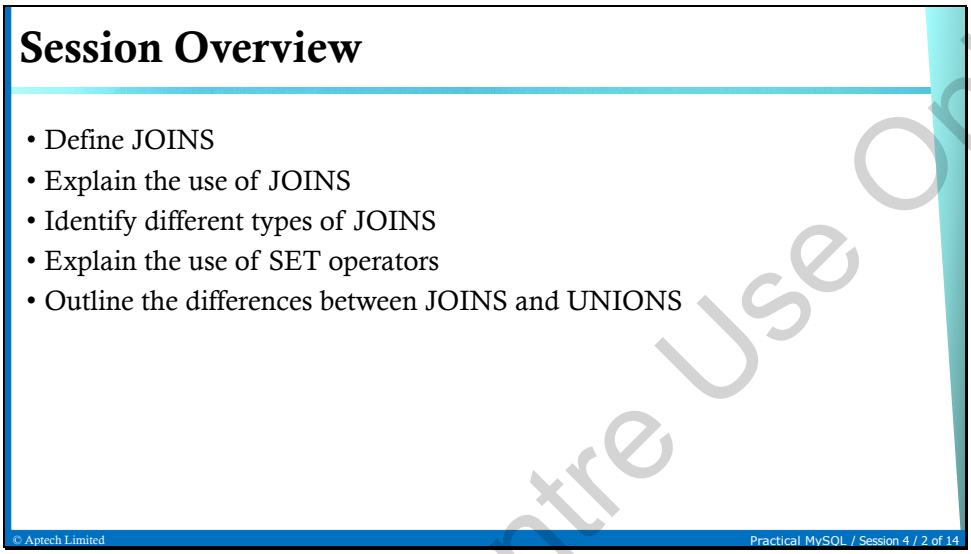
Slide 11



Instruction(s) to the trainer:
Use slide 11 to summarize the session. End the session, with a brief summary of what has been taught in the session. Tell the students pointers of the session. This will be a revision of the current session.

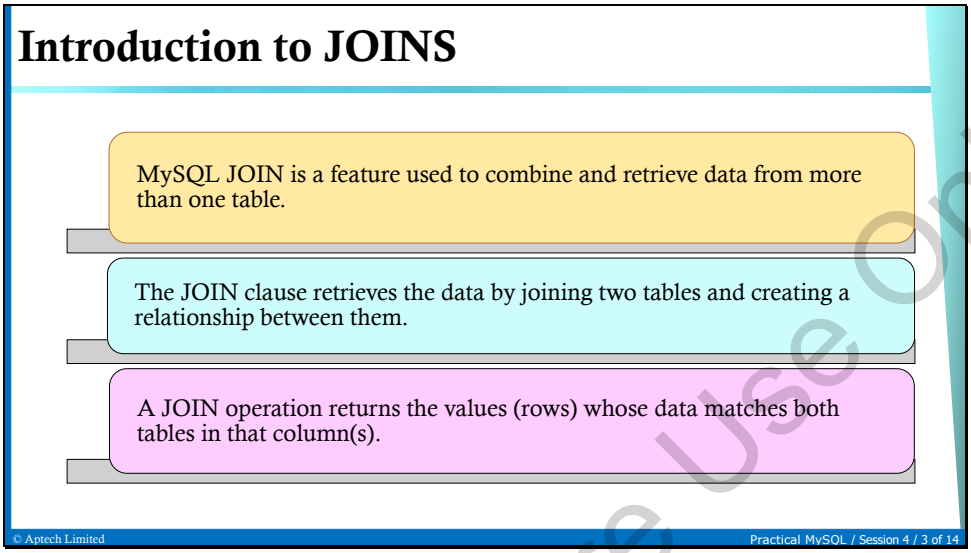
Session 4: Joins in MySQL

Slide 2



Instruction(s) to the trainer:
Show slide 2 and give students a brief overview of the current session in the form of session objectives. Inform students that the session discusses JOINS and SET operator in MySQL. The session begins with explaining the use of JOINS in MySQL with the help of various examples. Next, it lists different types of JOINS. Further, the session explains the use of SET operators. At the end, the session elaborate the differences between JOINS and UNIONS.

Slide 3



In-Class Explanations

Instruction(s) to the trainer:
Show slide 3 and inform students about the JOIN clause in MySQL. Explain to them that JOIN can be used to retrieve data from tables. It works by combining the data of multiple tables by forming a relationship between them.

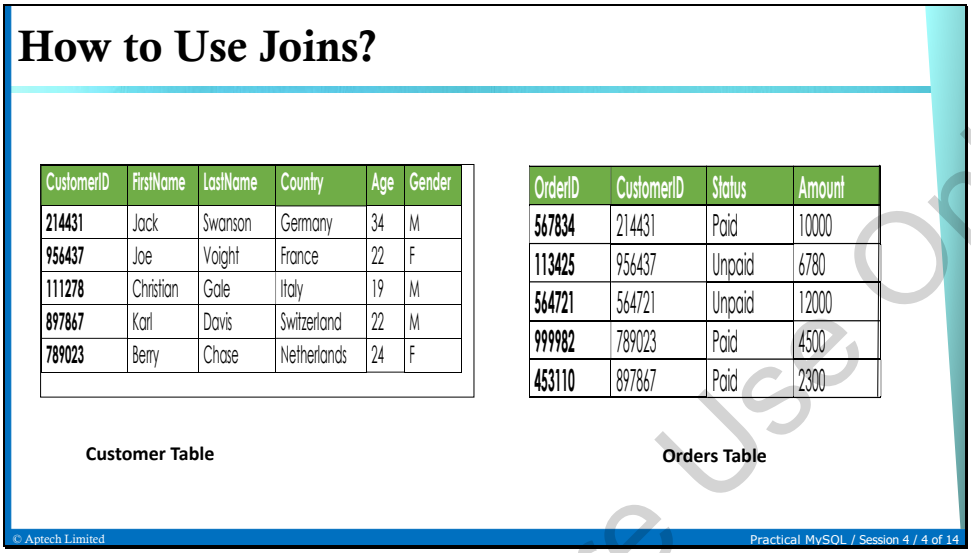
Tell students that to execute a JOIN clause, tables must have related columns. Join clauses reduce the number of queries, and thus also reduce the load on the server caused by the constant exchanging of data between the server and database.

Additional Information:

Refer to following links for more information:

https://www.sqlshack.com/sql-join-clause-introduction-and-overview/
https://www.mysqltutorial.org/mysql-join/?msclkid=57e7cd7eb0eb11eca0e7b2aa183b980a

Slide 4



Instruction(s) to the trainer:
Show slide 4 and explain the use of the JOIN clause by citing an example. Consider two tables Customer table and Orders table. The user must create following tables and insert the data into the tables.

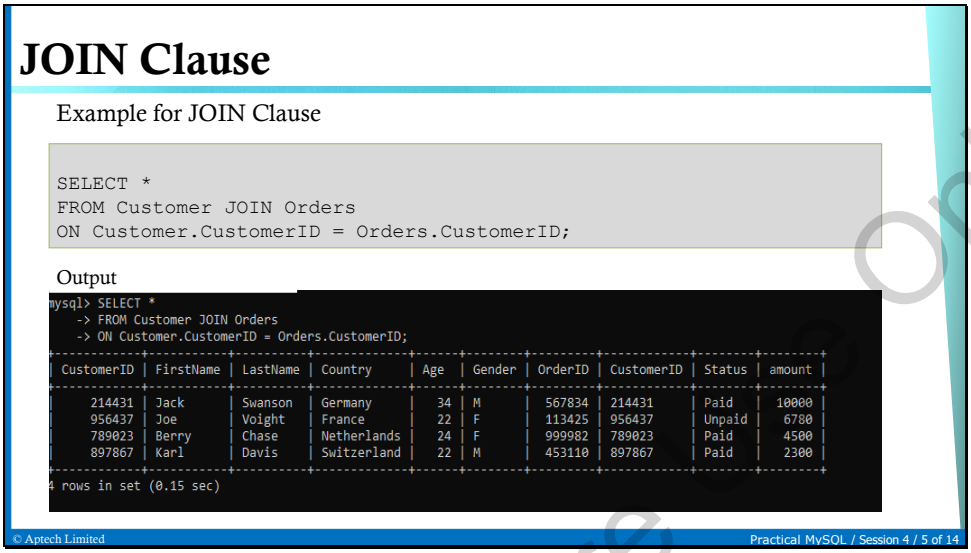
Tell students that here the common column is `CustomerID`, which is also a primary key in the Customer table. Also tell students that `CustomerID` is a foreign key in the `Orders` table.

Additional Information:

Refer to following links for more information:

https://www.w3schools.com/mysql/mysql_join.asp?msclkid=57e5fa47b0eb11ecb5259393749bc942
https://www.mysqltutorial.org/mysql-join/?msclkid=57e7cd7eb0eb11eca0e7b2aa183b980a

Slide 5



Instruction(s) to the trainer:
Show slide 5 and explain how the JOIN clause works with the example. You can see that the output is displaying the records of both the tables. This means that the JOIN clause has joined the records of both the tables. Also, point out that since there are no order details for `CustomerID` 111278 in the Orders table, the customer's details for that id are not displayed in the JOIN result.

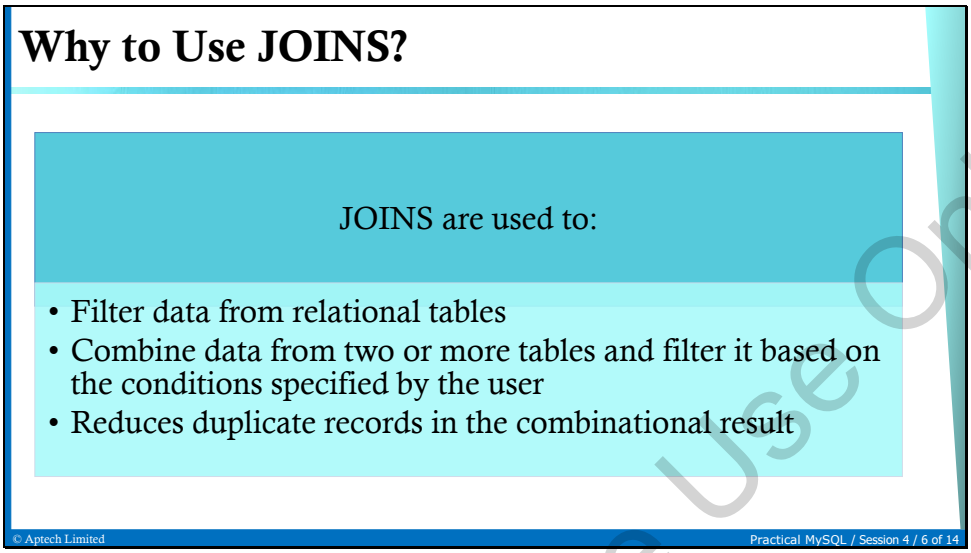
In-Class Question: Give two uses of the JOIN clause.
Answer: 1. It is used to filter data from relational tables.
2. It reduces duplicate records in the final output.

Additional Information:

Refer to following links for more information:

https://www.w3schools.com/mysql/mysql_join.asp?msclkid=57e5fa47b0eb11ecb5259393749bc942
https://www.mysqltutorial.org/mysql-join/?msclkid=57e7cd7eb0eb11eca0e7b2aa183b980a
https://www.guru99.com/joins.html?msclkid=57e80d51b0eb11ecbb3a719455fcf948

Slide 6



Instruction(s) to the trainer:
Show slide 6 and explain the use of JOIN clause. The JOIN clause not only combines the data of two tables but also filters data from relational tables on the basis of the given query.

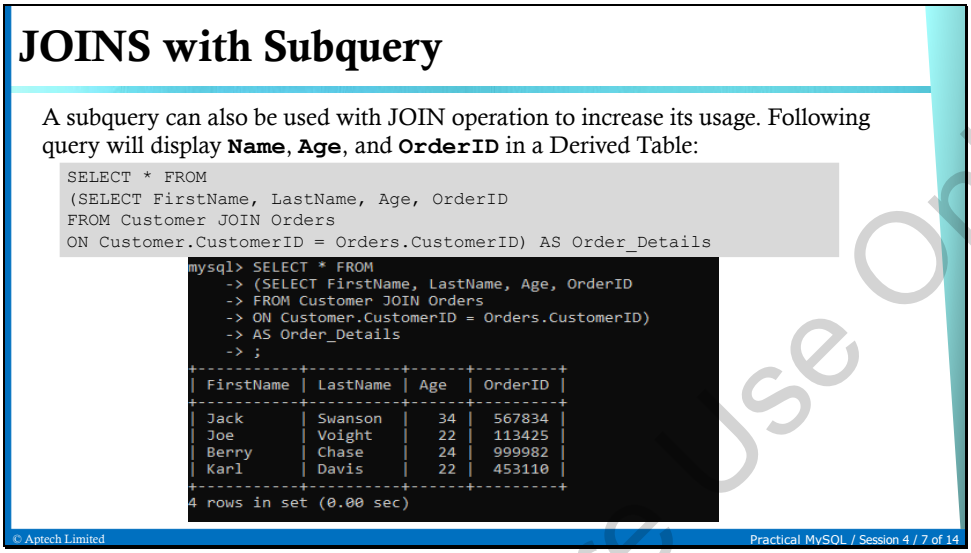
Thus, they help in retrieving data from two or more related database tables in a single query.
The JOIN clause reduces duplicate records in the final output. The reduced overhead makes query execution faster.

Additional Information:

Refer to following links for more information:

https://www.w3schools.com/mysql/mysql_join.asp?msclkid=57e5fa47b0eb11ecb5259393749bc942
https://www.mysqltutorial.org/mysql-join/?msclkid=57e7cd7eb0eb11eca0e7b2aa183b980a

Slide 7



Instruction(s) to the trainer:
Show slide 7 and tell students that the functionality of the JOIN clause can be increased by using subqueries with it. Inform them that when a JOIN clause is used with a subquery, the resulting output is known as a Derived table.

The output displays the columns **`FirstName`**, **`LastName`**, **`Age`**, and **`OrderID`** in a Derived table.

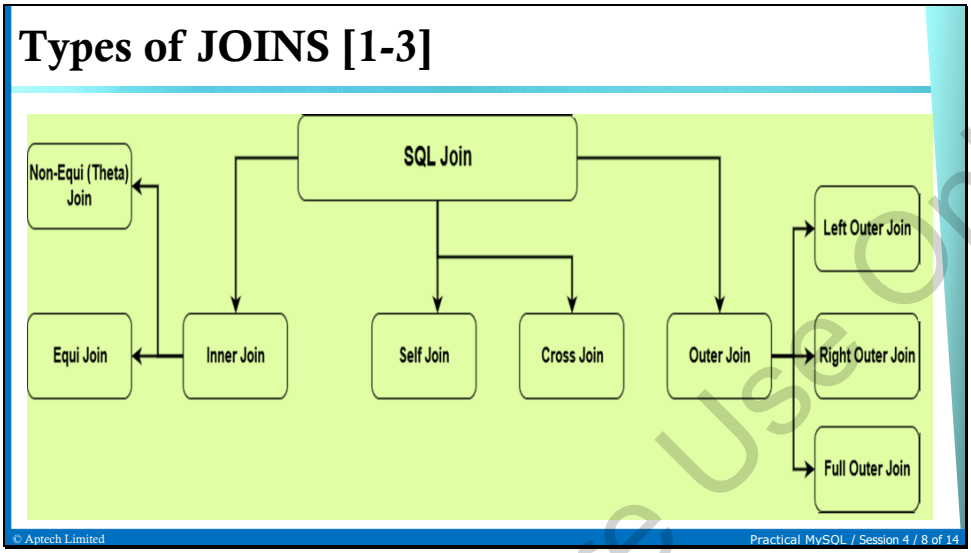
In-Class Question: Which clause should be used while creating a subquery with JOINS in MySQL?
Answer: When subqueries are used along with JOINS, the subquery is written using the FROM clause.

Additional Information:

Refer to following links for more information:

https://www.w3schools.com/mysql/mysql_join.asp?msclkid=57e5fa47b0eb11ecb5259393749bc942
https://stackoverflow.com/questions/26486512

Slide 8



Instruction(s) to the trainer:
Show slide 8 and explain different types of JOINS. MySQL supports different types of JOINS such as INNER JOIN, OUTER JOIN, SELF JOIN, and CROSS JOIN. Explain how they are connected to each other. Explain students that a JOIN clause links two tables based on a matching column and returns the desired result.

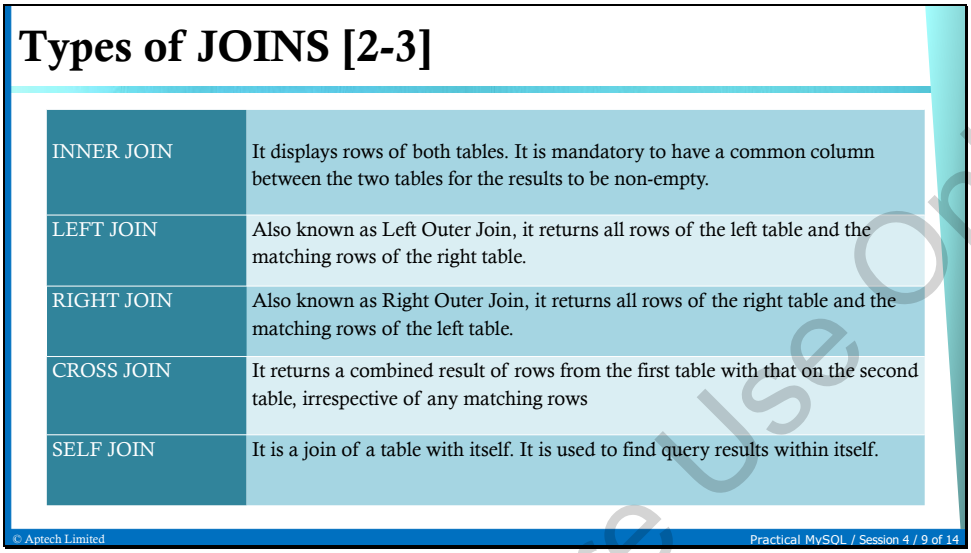
As seen on slide, INNER JOIN, OUTER JOIN, and SELF JOIN are three main types of SQL JOINS. CROSS JOIN can be used to display records of two tables that have no matching rows.

Additional Information:

Refer to following links for more information:

www.w3schools.com/sql/sql_join.asp
https://www.javatpoint.com/types-of-sql-join
https://www.educba.com/types-of-joins-in-sql

Slide 9



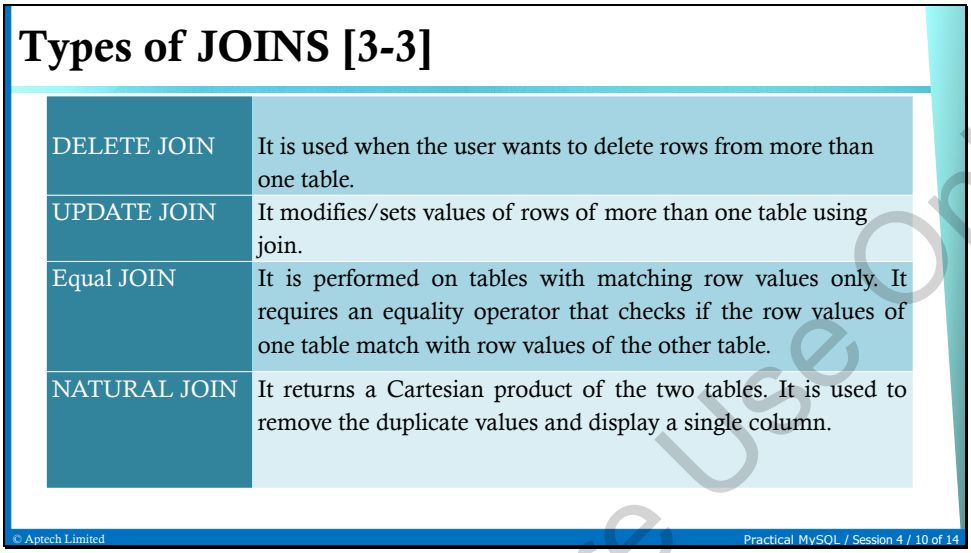
Instruction(s) to the trainer:

Using slides 9 and 10, explain the functionalities of different types of JOINS.

- INNER JOIN is the default JOIN clause that is used to display the rows of both tables.
- LEFT JOIN is used in cases where the records of the table mentioned on the left are to be displayed with the matching records of the table on the right. RIGHT JOIN is basically the inverse of LEFT JOIN.
- CROSS JOIN is used in cases where you need to display records of two tables that have no matching rows. CROSS JOIN returns the records in the form of a cartesian product of two tables.
- SELF JOIN is commonly used with tables having a column with data referring to one of the column of the table itself.

Additional Information:
Refer to following links for more information:
www.w3schools.com/sql/sql_join.asp
https://www.javatpoint.com/types-of-sql-join
https://www.educba.com/types-of-joins-in-sql

Slide 10



Instruction(s) to the trainer:

- DELETE JOIN is used to delete rows from more than one table. The `WHERE` condition can be used to limit the number of rows to be deleted.
- The JOIN statement returns a result containing rows of both tables and the `UPDATE` clause sets the row values accordingly.
- Equal JOIN requires an equality operator that checks if the row values of one table match with row values of the other table.
- NATURAL JOIN clause returns the result as a Cartesian product of two tables. It also removes duplicate values from the table.

In-Class Question: Explain the function of Equal JOIN in MySQL.
Answer: Equal JOIN in MySQL is used to check if row values of one table are matching with row values of the second table.

Additional Information:
Refer to following links for more information:
www.w3schools.com/sql/sql_join.asp
https://www.javatpoint.com/types-of-sql-join
https://www.educba.com/types-of-joins-in-sql

Slidea 11 and 12

Joining Three Tables [1-2]

StudentID	Student_Name
1001	Mary
1002	Jane

CourseID	Course_ Name	StudentID
5001	PHP	1004
5002	JAVA	1001

TeacherID	Teacher_N ame	CourseID
3001	Jill	5003
3002	Greul	5002

Syntax to join the three tables using INNER JOIN:

```
SELECT table1.column1_name, table1.column2_name,...,
table2.column1_name, table2.column2_name,...,
table3.column1_name, table3.column2_name,...,
FROM table1
INNER JOIN table2 ON table1.table1_id = table2.table1_id
INNER JOIN table3 ON table2.table2_id = table3.table2_id;
```


Joining Three Tables [2-2]

Following is the example to display all the rows of all three tables using INNER JOIN:

```
SELECT Student.Student_Name, Course.Course_Name,
Teacher.Teacher_Name
FROM Student
INNER JOIN Course ON Student.StudentID = Course.StudentID
INNER JOIN Teacher ON Course
```

```
mysql> SELECT Student.Student_Name, Course.Course_Name,
    -> Teacher.Teacher_Name
    -> FROM Student
    -> INNER JOIN Course ON Student.StudentID = Course.StudentID
    -> INNER JOIN Teacher ON Course.CourseID = Teacher.CourseID;
+--------------+-------------+--------------+
| Student_Name | Course_Name | Teacher_Name |
+--------------+-------------+--------------+
| Mary         | JAVA        | Greul        |
| Mary         | ASP.NET     | Jill         |
| Jane         | RUBY        | Polo         |
| Jack         | PHP         | Jemkins      |
+--------------+-------------+--------------+
4 rows in set (0.08 sec)
```


Instruction(s) to the trainer:

Using slides 11 and 12, explain students how to join three tables using the JOIN clause. Consider an example of three tables, Student, Course, and Teacher. Tell students that in the Course table, `StudentID` is the foreign key, which is the primary key in the Student table.
`CourseID` acts as the foreign key in the Teacher table and the primary key in the Course table.

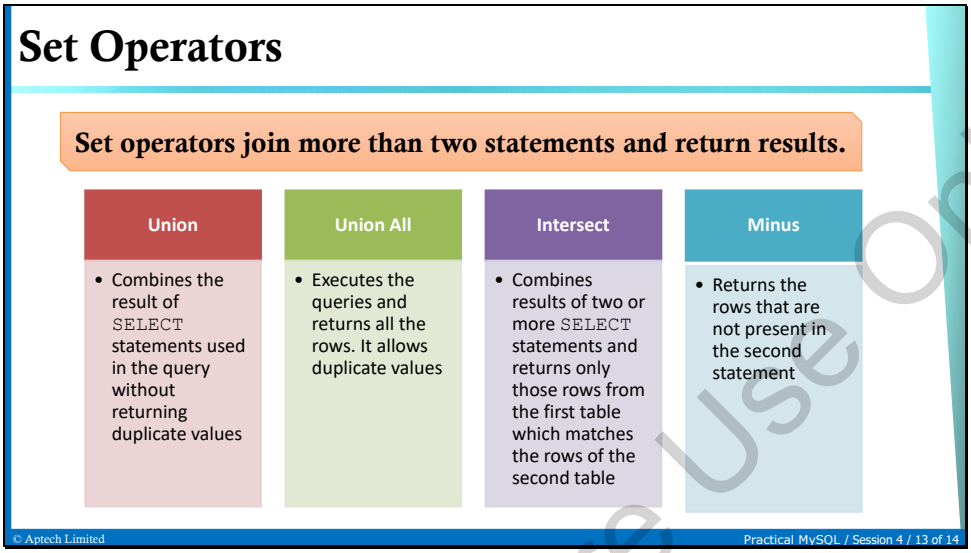
Using Slide 12 explain the example to display all the rows of all three tables - Student, Course, and Teacher using INNER JOIN.

Additional Information:

Refer to following links for more information:

http://codingstatus.com/sql-join-3-tables/
https://www.geeksforgeeks.org/join-multiple-tables-using-inner-join
https://stackoverflow.com/questions/10195451

Slide 13



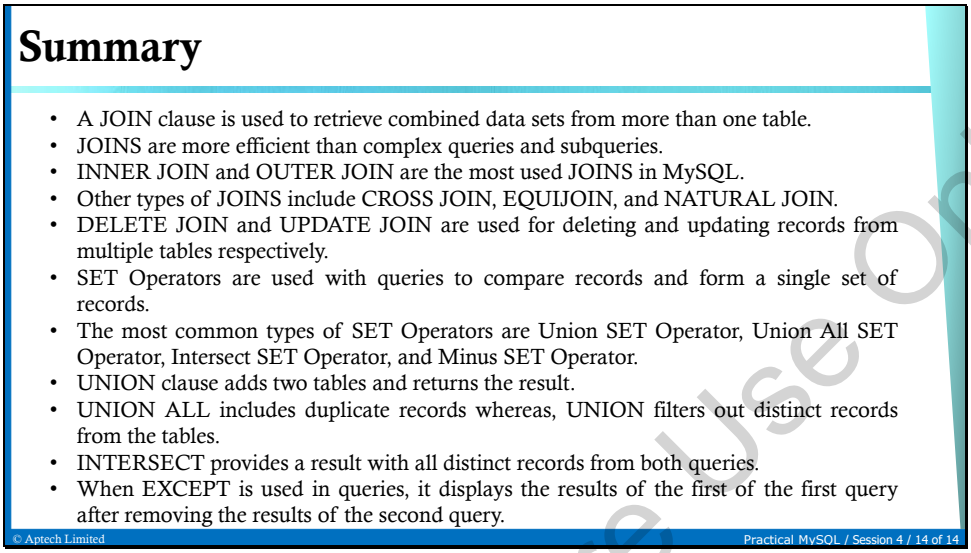
Instruction(s) to the trainer:
Using slide 13, explain different types of Set operators.

- The Union operator is used to combine distinct results of two or more `SELECT` statements. UNION is useful when normalized tables are combined to find out results. The `WHERE` clause is used with UNION to filter specific rows in a query.
- The Union All operator is used to combine all the results of two or more `SELECT` statements, including duplicates. UNION ALL executes the queries and returns all the rows (allows duplicate values).
- The Intersect operator returns only the common records obtained from two or more `SELECT` statements.
- The Except operator is also known as the Minus operator, It returns only those records which are exclusive to the first table.

In-Class Question: Why is the `WHERE` clause used with UNION?
Answer: The `WHERE` clause is used with UNION to filter specific rows in a query.
.
Additional Information:

Refer to following links for more information:
https://www.w3schools.com/sql/sql_union.asp
https://www.databasestar.com/sql-set-operators/
https://www.tutorialsteacher.com/sql/sql-union-operator
https://www.techonthenet.com/sql/union.ph

Slide 14

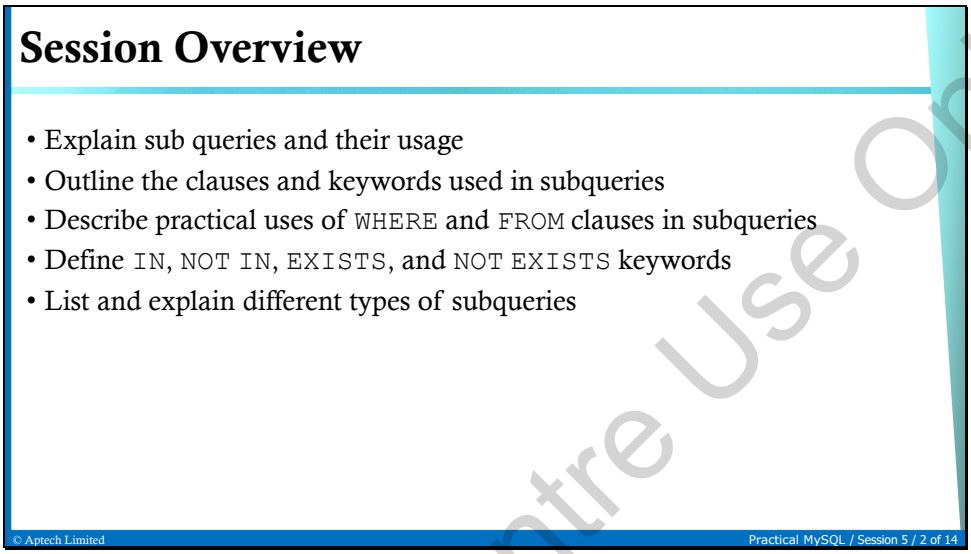


Instruction(s) to the trainer:

Use slide 14 to summarize the session. You will end the session with a summary of what has been taught in the session. Tell students the pointers of the session. This will be a revision of the current session.

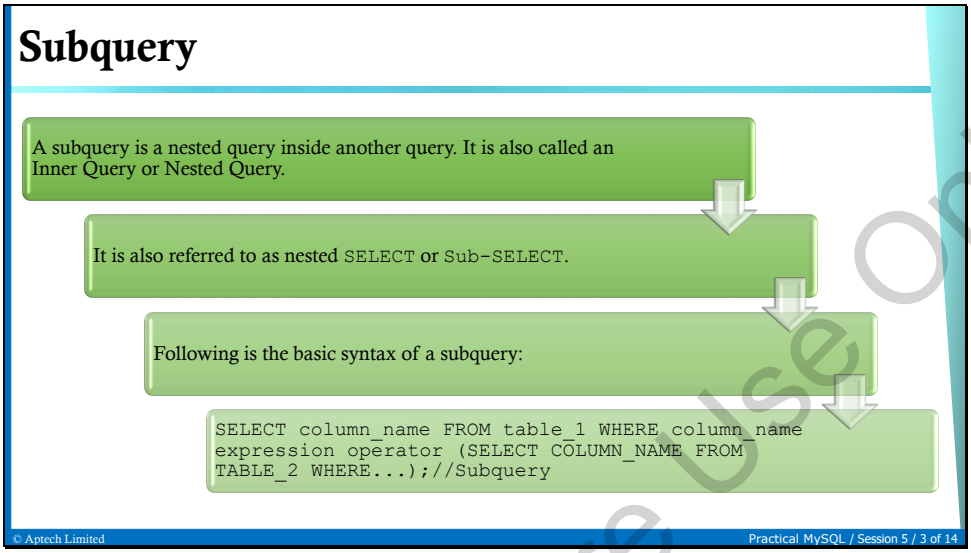
Session 5: Subqueries

Slide 2



Instruction(s) to the trainer:
Show slide 2 and give students a brief overview of the current session and the session objectives. Inform students that this session explains the concept subqueries, clauses, and keywords in subqueries. It also describes the practical approach of using different clauses like WHERE and FROM in sub-queries. Finally, the session explains the various keywords and types of subqueries present in MySQL.

Slide 3



nstruction(s) to the trainer:
Show slide 3 and introduce students to the concept of Subquery in MySQL. Explain that a MySQL subquery is a query nested inside another query like SELECT, INSERT, UPDATE, or DELETE. A subquery can also be nested inside of another subquery.
An inner query in MySQL is a subquery, whereas an outer query contains the subquery. A subquery must be enclosed in parentheses and can be used anytime that expression is used.

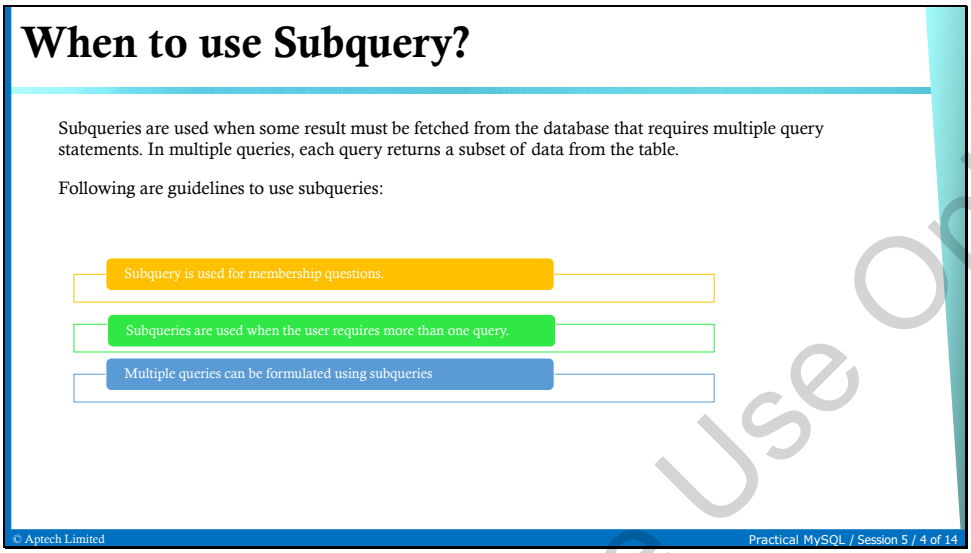
Elaborate on the concept through an example. The following query uses a subquery to return employees who work in offices in the United States.

```
SELECT lastName, firstName FROM employees WHERE officeCode IN
(SELECT officeCode FROM offices WHERE country = 'USA');
```

Discuss the following pointers related to this example:
.The subquery retrieves all the office codes for offices in the USA.
.The outer query chooses the last name and first name of employees who work in offices with office codes that appear in the subquery's result set.

In-Class Question: Why do we use subquery in SQL?
Answer: A Subquery or Inner query or a Nested query is a query within another SQL query and embedded within the WHERE clause. A subquery is used **to return data that will be used in the main query as a condition to further restrict the data to be retrieved**.

Slide 4



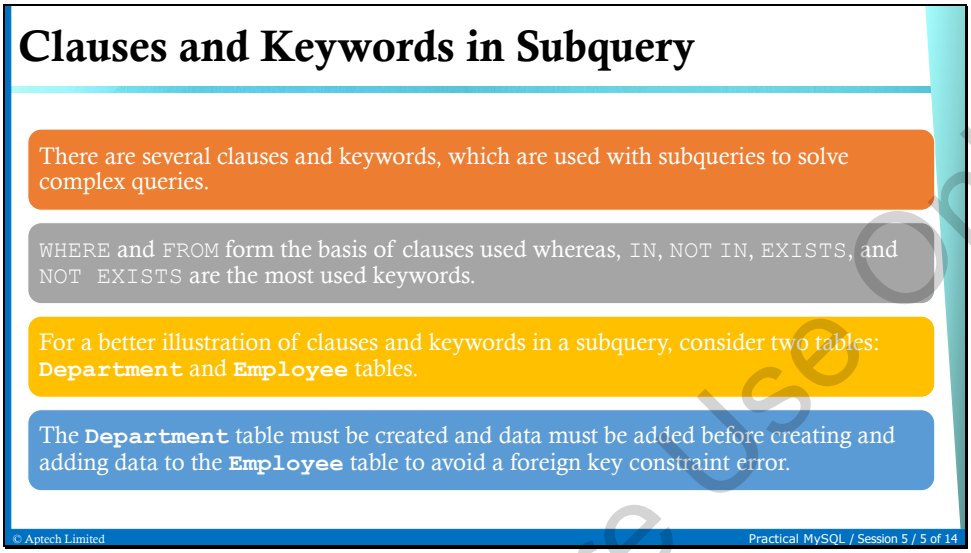
Instruction(s) to the trainer:
Show slide 4 and give students information about when to use a Subquery. An inner query is a subquery, while the outer query is the query that contains the subquery. The result of the inner query is passed to the outer query first, and then the main/outer query is executed. Subqueries can be used anywhere in MySQL. However, they must be enclosed in parentheses. MySQL will handle all subquery forms and actions that are supported by the SQL standard.

Describe following rules for using sub-queries with the students:

- Subqueries must be enclosed in parenthesis.
- If the primary query does not have multiple columns for subqueries, then the SELECT command for a subquery can only have one column.
- With a subquery, we can utilise comparison operators like >, =, IN, ANY, SOME, and ALL.
- When a subquery returns more than one row, a multiple-row operator comes in handy.
- The ORDER BY clause cannot be used in a subquery, although it can be used within the main query.
- A subquery cannot be immediately included in a set function.

Additional Links:
Refer to following links for more information:
https://www.mysqltutorial.org/mysql-subquery/#:~:text=A%20MySQL%20subquery%20is%20called,offices%20located%20in%20the%20USA.
https://www.w3resource.com/mysql/subqueries/index.php

Slide 5



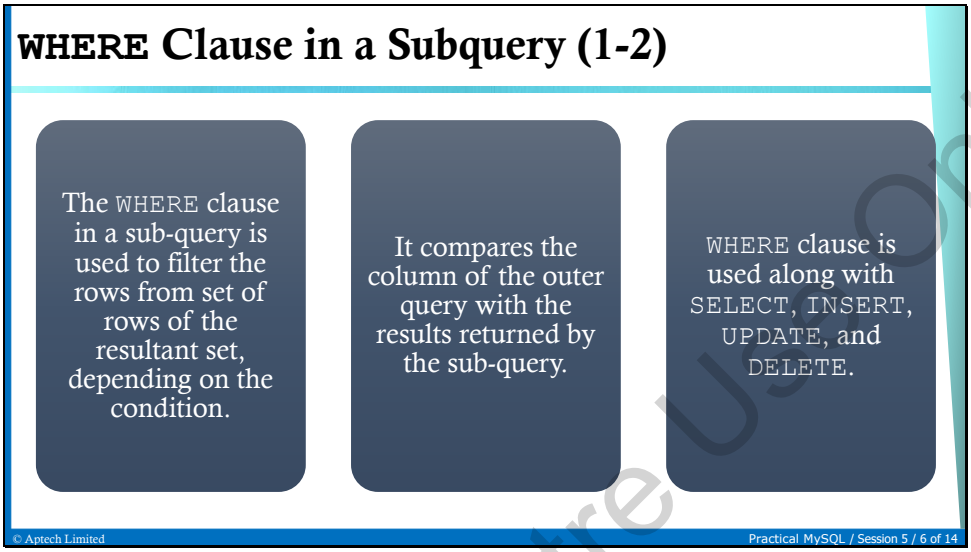
Instruction(s) to the trainer:
Show slide 5 explain the topic of clauses and keywords in subquery,
To compare a single value provided by the subquery with the expression in the WHERE clause, a user must use comparison operators like =, >, etc. The following query, for example, returns the client with the highest payment.

```
SELECT
customerNumber,
checkNumber,
amount
FROM
payments
WHERE
amount = (SELECT MAX(amount) FROM payments);
```

Inform students that a user can also utilize comparison operators like greater than (>), greater than or equal to (>=), less than(), and less than or equal to (=) in addition to the = operator.

Keywords:
ADD: To add a column to an existing table, use the ADD command.
ALL: If all of the subquery values fulfil the requirement, the ALL command returns true.
AND: The AND command is used in conjunction with WHERE to only include rows that satisfy both conditions.
ASC: The ASC command sorts the returned data in ascending order.

Slide 6



Instruction(s) to the trainer:
Show slide 6 and tell students that the WHERE clause is used to filter records. It can be utilized to retrieve only those records that meet a specific set of criteria.

Further, explain the syntax with the help of the following example.

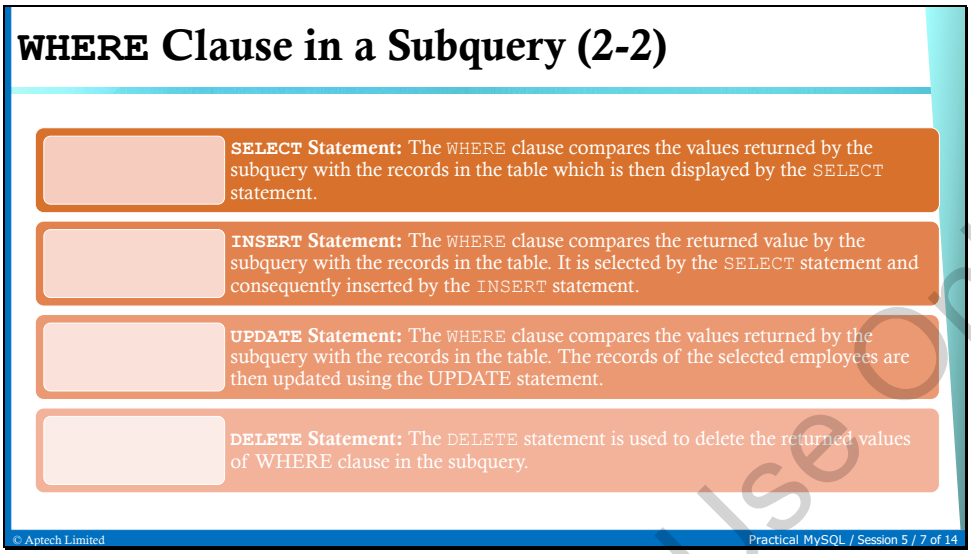
The given subquery returns the department numbers for departments on the third floor. The outer query retrieves the names of employees who work on the third floor.

SELECT NAME FROM employee WHERE dept IN(SELECT DID FROM dept WHERE floor = 3);

Although aggregate functions cannot be directly used in a WHERE clause, they can be used in the SELECT or HAVING clause of a WHERE clause subquery.

In-Class Question: Can we use SELECT in WHERE clause?
Answer: To filter records and conduct various operations on the data, the WHERE clause can be used with SQL statements like INSERT, UPDATE, SELECT, and DELETE.

Slide 7



Instruction(s) to the trainer:
Show slide 7 and elaborate on WHERE Clause with different statements such as SELECT, INSERT, UPDATE, and DELETE.

Using Subqueries in SELECT Statements: Subqueries are most commonly used in SELECT statements. Further, these are mostly used in the WHERE clause of SELECT statements. Still, they can also be used in other clauses such as WHERE, FROM, and HAVING.

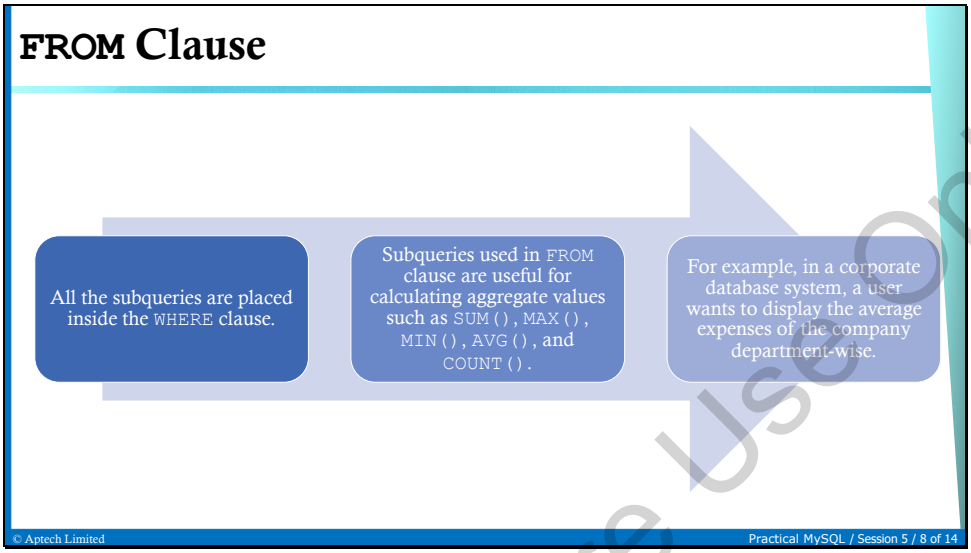
Explain the syntax:
SELECT name FROM students WHERE name NOT IN (SELECT student_name FROM college)

Using Subqueries in INSERT Statements: In an INSERT statement, using a subquery is a common practice. In such cases, the entire result set from a subquery or SELECT statement is inserted into a table.

Using Subqueries in UPDATE Statements: The UPDATE statement can have a subquery in several places or clauses (similar to a SELECT query). The most frequent clauses are SET and WHERE in which subqueries are utilized in an UPDATE.
The new value for the column being edited by the UPDATE is defined in the SET clause. A user can get this new value using a subquery, which can come from any table or any legitimate subquery. This can happen as long as a user only gets one record with one column for each record being modified. The data type of the column returned by the subquery must match the data type of the changed column.

Using Subqueries in DELETE Statements: Subqueries can only be used inside a WHERE clause with the DELETE statement.

Slide 8



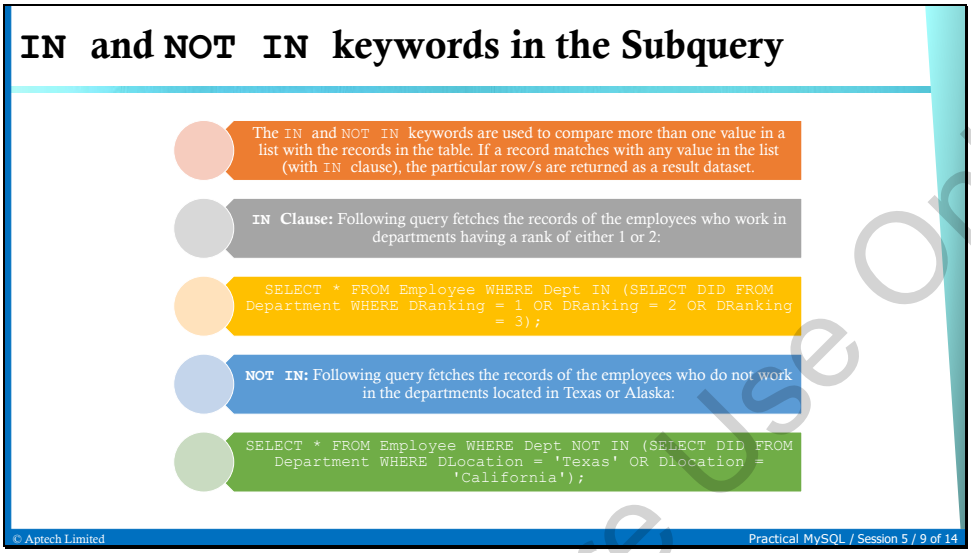
Instruction(s) to the trainer:
Show slide 8 and inform students that the result set returned from a subquery is used as a temporary table when a subquery is utilized in the FROM clause. This table is known as a materialised subquery or derived table.
Provide an example of a subquery that finds the maximum, lowest, and average number of items in sale orders:

```
SELECT
MAX(items),
MIN(items),
FLOOR(AVG(items))
FROM
(SELECT orderNumber, COUNT(orderNumber) AS items FROM orderdetails GROUP BY orderNumber) AS lineitems;
```

It is worth noting that the FLOOR() function is used to remove decimal places from item average values.

Additional Links:
Refer to following links for more information:
https://www.javatpoint.com/mysql-from
https://www.w3schools.com/mysql/mysql_where.asp

Slide 9



Instruction(s) to the trainer:
Show slide 9 and define the IN and NOT IN keywords in subqueries. Tell the students that if a subquery returns several values, a user can use different operators in the WHERE clause, such as IN or NOT IN.

Moreover, explain that subqueries are SQL queries that contain one or more SELECT statements nested within the WHERE clause of another SELECT statement. The outer query is the first statement in this form of query, whereas the inner query is the second statement. When such queries are run, the inner query is assessed first, and the outer query is given the result of the inner query.

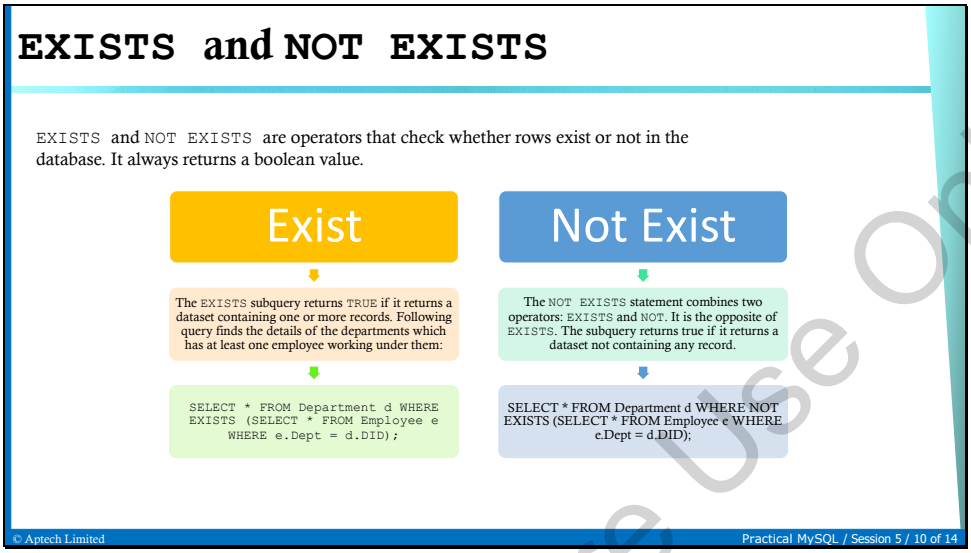
Now, give an example where a user will make a schema for our database. Then, the developer will construct a table called geeks data and utilise the IN operator with a sub-query.

IN:
```
SELECT first_name, last_name FROM employee_data WHERE dept IN (SELECT dept_name FROM computer_dept WHERE id = 1);
```

For example, a user can utilize a subquery with NOT IN operator to find the customers who have not placed any orders as follows:

```
SELECT customerName FROM customers WHERE customerNumber NOT IN (SELECT DISTINCT customerNumber FROM orders);
```

Slide 10



Instruction(s) to the trainer:
Show slide 10 and explain the keywords EXISTS and NOT EXISTS. In SQL, the EXISTS condition is used to determine whether the result of a correlated nested query is empty (i.e., includes no tuples) or not. EXISTS returns a boolean value of True or False. It can be used in a SELECT, UPDATE, INSERT, or DELETE statement.

Explain the following syntax:

```
SELECT column_name(s) FROM table_name WHERE EXISTS (SELECT
column_name(s) FROM table_name WHERE condition);
```

Using EXISTS condition with SELECT statement
To fetch the first and last name of the customers who placed at least one order:

```
SELECT fname, lname FROM Customers WHERE EXISTS (SELECT * FROM
Orders WHERE Customers.customer_id = Orders.c_id);
```

Using NOT with EXISTS
To fetch the last and first name of the customers who has not placed any order:

```
SELECT lname, fname FROM Customer WHERE NOT EXISTS (SELECT *
FROM Orders WHERE Customers.customer_id = Orders.c_id);
```

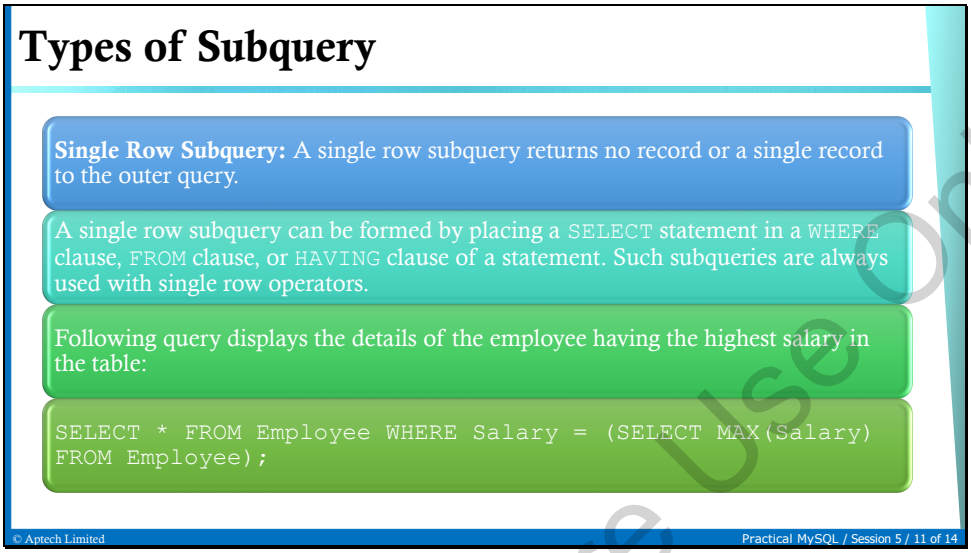
Using EXISTS condition with DELETE statement
To delete the record of all the customers from Order Table whose last name is 'Milton':

```
DELETE FROM Orders WHERE EXISTS (SELECT * FROM customers WHERE
Customers.customer_id = Orders.cid AND Customers.lname =
'Milton');
```

NOT EXISTS:
Tell students to suppose that a user wishes to choose all pupils with a grade of 9 or higher. He/She may do this by using NOT EXISTS, which contradicts the logic of the EXISTS operator. As a result, if the underlying subquery returns no results, the NOT EXISTS operation returns true. If the inner subquery matches a single record, the NOT EXISTS operator returns false, and the subquery execution can be halted. The user may use the following SQL query to find all student records that have no related student grade with a value less than 9:

```
SELECT
    id, first_name, last_name
FROM
    student
WHERE NOT EXISTS (
    SELECT 1
    FROM
        student_grade
    WHERE
        student_grade.student_id = student.id AND
        student_grade.grade < 9
)
ORDER BY id
```

Slide 11



Instruction(s) to the trainer:
Show slide 11 and discuss the different types of subqueries present in MySQL.

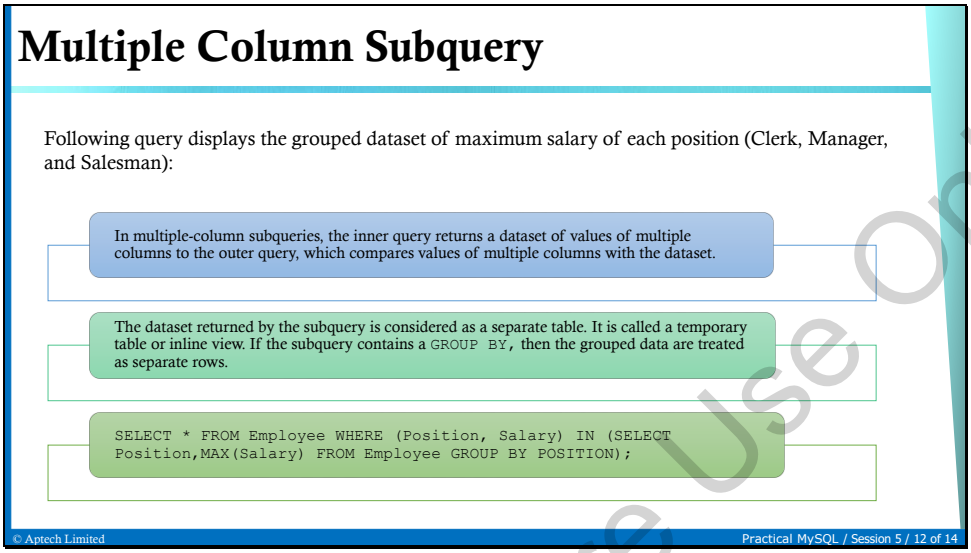
- Single Row Subquery: In the results, zero or one row is returned.
- Multiple Row Subquery: One or more rows of results are returned.
- Multiple Column Subqueries: Subqueries with several columns.
- Correlated Subqueries: A linked subquery returns one or more columns in accordance with the primary or outer query.
- Nested Subqueries: There are queries within inquiries (inner and outer query).

Additional Links:

Refer to following links for more information:

https://data-flair.training/blogs/sql-subquery/
https://www.w3resource.com/mysql/subqueries/index.php

Slide 12



Instruction(s) to the trainer:
Show slide 12 explain the concept of Multiple Column Subquery in MySQL. The duplicate WHERE criteria can be combined into a single WHERE clause using multiple-column subqueries. A pair-wise or non-pairwise comparison can be made between columns in a multiple-column subquery.

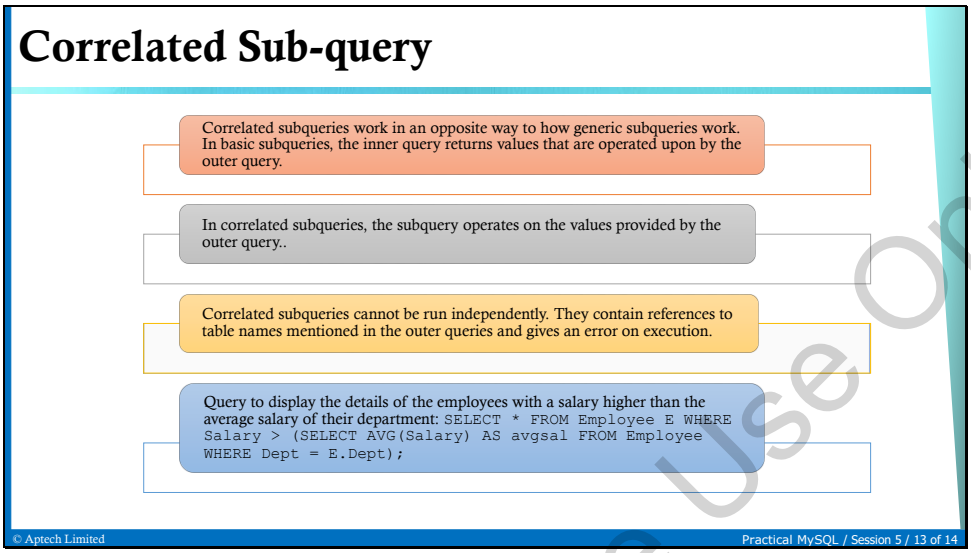
Elaborate on the topic with the help of the following example:

Display the order number, product number, and quantity of any item in which the product number and quantity match both the product number and quantity of an item in ordid 364.

```
SELECT  ordid, prodid, qty FROM item WHERE  (prodid,   qty)    IN (SELECT prodid, qty
FROM item WHERE ordid = 364)
AND  ordid   =  364 ;
```

Output: ORDID PRODID QTY
364 84 22

Slide 13



Instruction(s) to the trainer:
Show slide 13 and describe the concept of correlated subquery. Discuss the following pointers in detail:
•A correlated subquery refers to a column of a table that is not in the FROM clause of the query. The column can appear in both the Projection and the WHERE clauses. Correlated subqueries, in general, degrade performance.
•For each row processed by the parent statement, a connected subquery is examined once.
•A SELECT, UPDATE, or DELETE statement can be the parent statement.

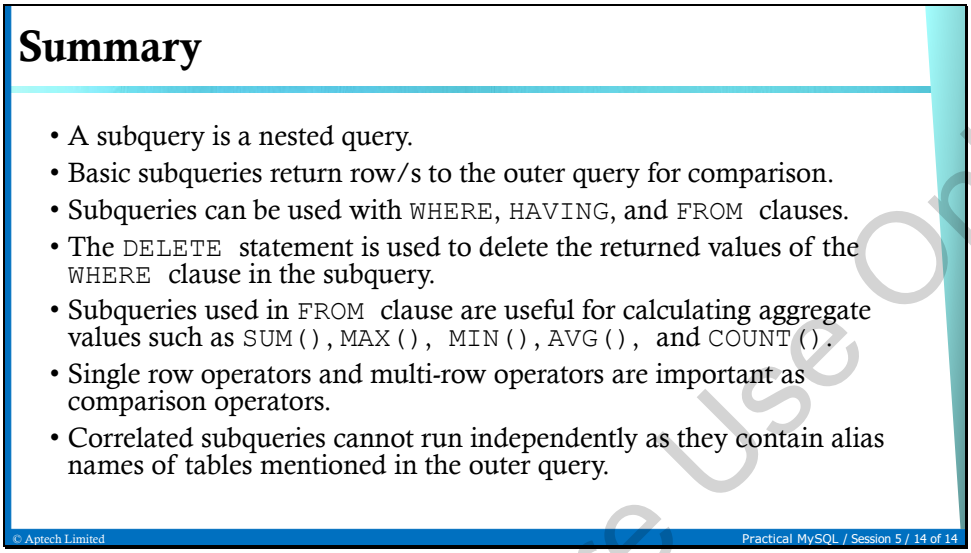
Describe the working of following query:
SELECT column1, column2, ... FROM table1 outer WHERE column1 operator (SELECT column1, column2 FROM table2 WHERE expr1 = outer.expr2);

A correlated subquery is a method of reading each row of a table and comparing the values in each row to related data. It is utilized when a subquery has to deliver a different result or collection of results for each candidate row that the main query considers.
Simply put, a correlated subquery can be used to answer a multipart question whose response is dependent on the value in each row processed by the parent statement.

Additional Links:
Refer to following links for more information:

https://www.javatpoint.com/mysql-subquery#:~:text=A%20correlated%20subquery%20in%20MySQL,row%20in%20the%20outer%20query.
https://dev.mysql.com/doc/refman/8.0/en/correlated-subqueries.html

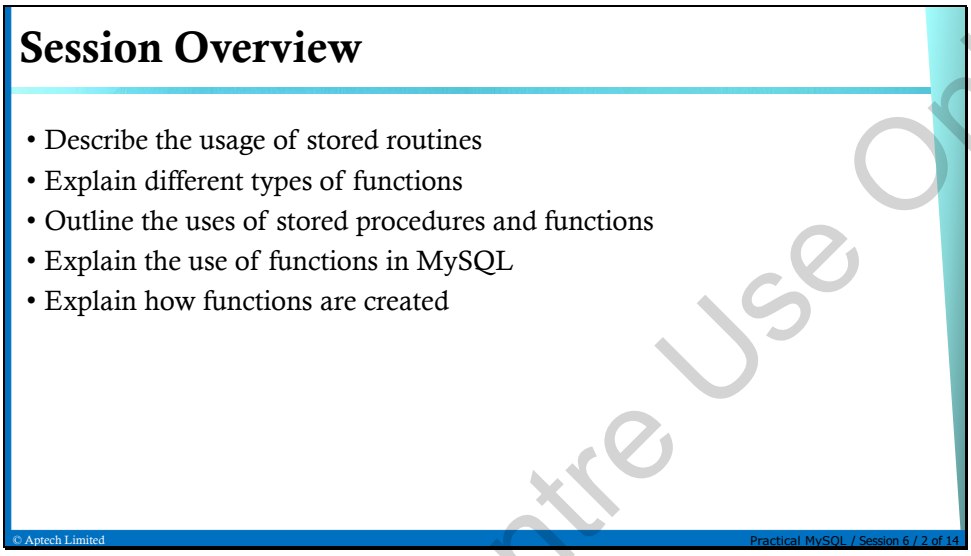
Slide 14



Instruction(s) to the trainer:
Use slide 14 to summarize the session. End the session, with a brief summary of what has been taught in the session. Tell the students pointers of the session. This will be a revision of the current session.

Session 6: Functions and Stored Procedures

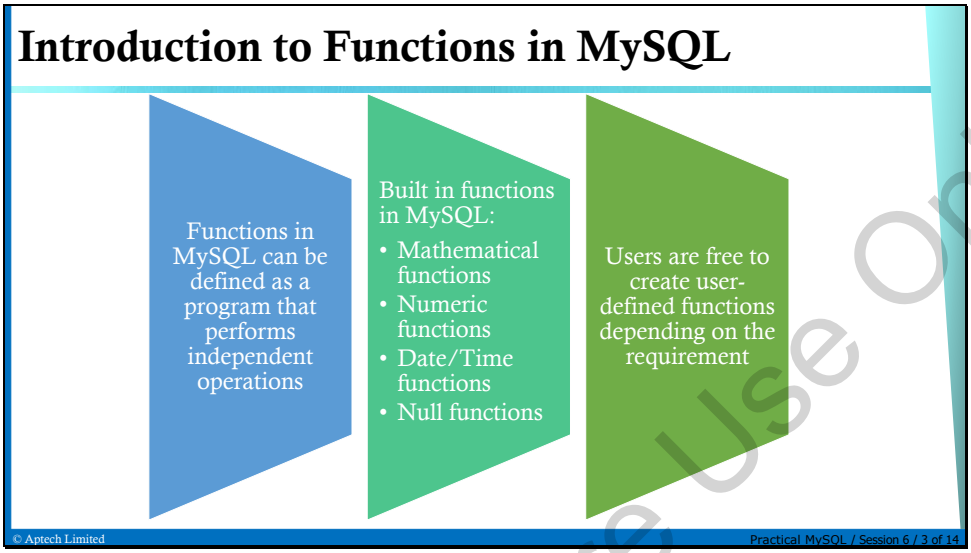
Slide 2



Instruction(s) to the trainer:

- Give brief overview of the objective of the session. Say that students will understand about the use of functions in MySQL and explain how the functions are created. Also, they will be able to explain different types of functions and describe usage of stored routines. Functions and stored procedures explained in this session will help students to write codes faster.

Slide 3



Instruction(s) to the trainer:

- Using slide 3, explain to students about functions in MySQL.
- Say that there are many built-in functions in MySQL and users are free to create user-defined functions.
- There are many built-in functions in MySQL such as Numeric functions, Mathematical functions, Date/Time functions, NULL functions, and so on. Users are free to create user-defined functions depending on the requirement.

Additional Information:

Refer to following links for more information:

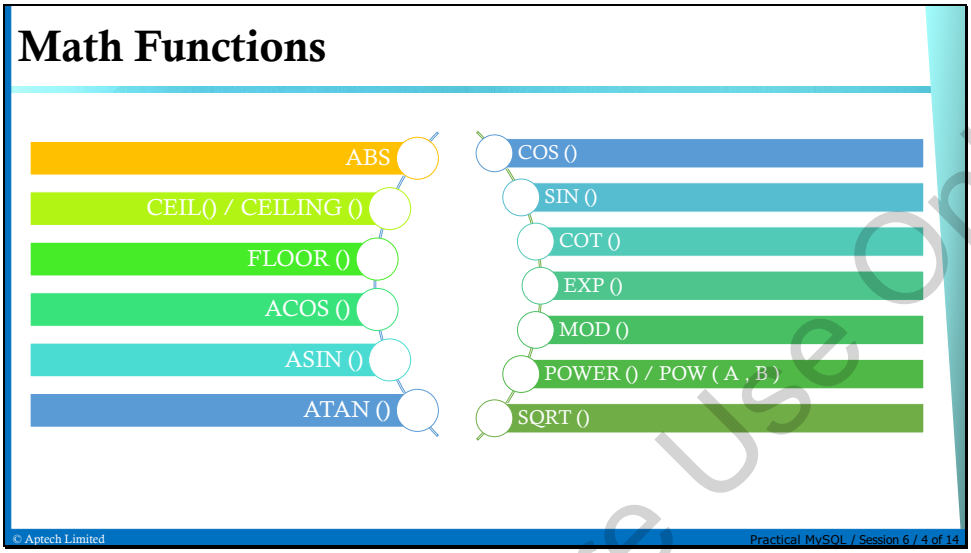
- https://www.javatpoint.com/mysql-functions
- https://www.guru99.com/functions.html

Ask students following question. Wait for a response before you answer.

In-Class Question: Define functions in MySQL?

Answer: It can be defined as a program that performs independent operations.

Slide 4



Instruction(s) to the trainer:

- Show slide 4 and say that mathematical functions in SQL are numeric functions used to perform calculations by taking input values as arguments.
- Explain the Math functions.
- Discuss about some important Math functions in MySQL such as ABS(), CEIL()/CEILING(), FLOOR(), and so on.

Additional Information:

Refer to following links for more information.

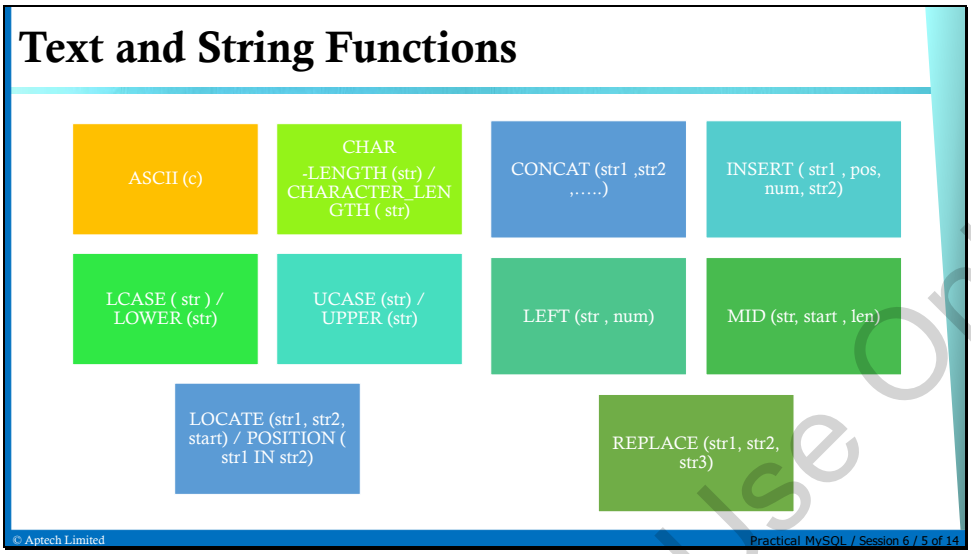
- https://www.javatpoint.com/mysql-functions
- https://www.guru99.com/functions.html

Ask students following question. Wait for a response before you answer.

In-Class Question: List the function of COS() and MOD().

Answer: COS () – Returns the cosine of the input value. The input must be in radians.
MOD () – Returns the value of the remainder when A is divided by B.

Slide 5



Instruction(s) to the trainer:

- Show slide 5 and say that the string functions perform significant operations on string-type input values. It returns either a string or a numeric value.
- Then, discuss text and string functions.
- Finally, explain some important string functions in MySQL such as ASCII(c), CHAR_LENGTH(str)/CHARACTER_LENGTH(str), CONCAT(str1,str2,..), INSERT(str1, pos, num, str2), LCASE(str)/LOWER(str), and so on.

Additional Information:

Refer to following links for more information:

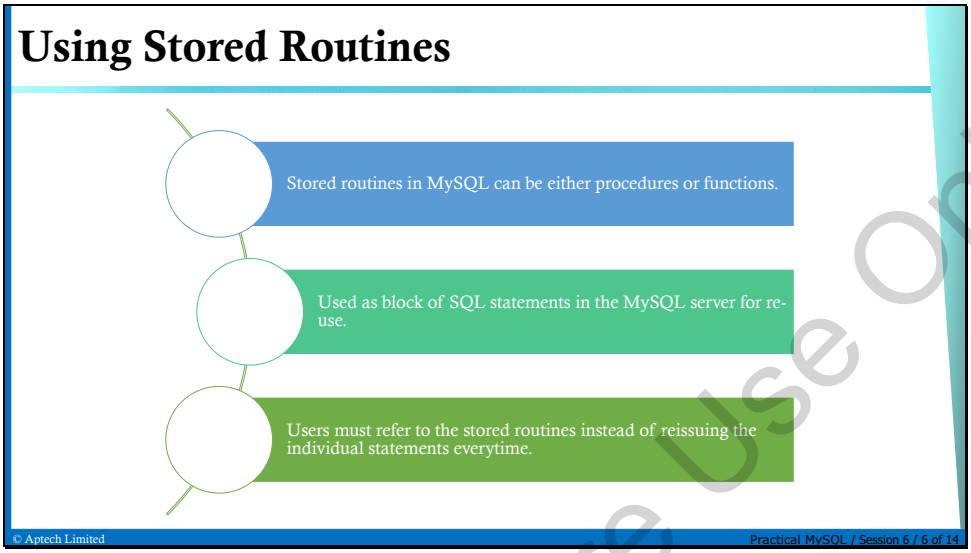
- https://www.javatpoint.com/mysql-functions
- https://www.guru99.com/functions.html

Ask the students following question. Wait for a response before you answer.

In-Class Question: Which function is used to perform specific words/phrases in search engines?

Answer: The LOCATE() function is used by search engines when specific words/phrases are typed in the search box. The search results are based on the phrases entered in the Google search box.

Slide 6



Instruction(s) to the trainer:

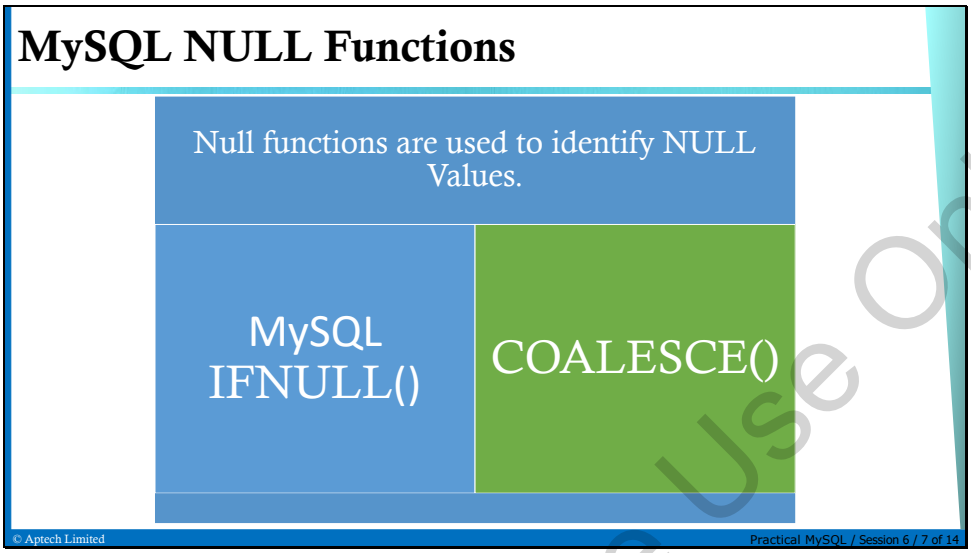
- Show slide 6 and say that the stored routines in MySQL can be either procedures or functions. They are used as a block of SQL statements in the MySQL server for re-use. Users must refer to stored routines instead of reissuing the individual statements every time.
- Discuss the following:
    - How to create a stored routine?
    - How to drop a procedure?
    - How to drop a function?
- Then, list the important points to remember about stored procedures and routines.

Additional Information:

Refer to following links for more information:

- https://www.guru99.com/functions.html
- https://www.mysqltutorial.org/mysql-stored-function
- https://www.guru99.com/functions.html

Slide 7



Instruction(s) to the trainer:

- Show slide 7 and explain about MySQL Null Functions.
- Say that NULL functions are used to identify NULL values. NULL values have no value, no data type, and can be fit into any column anytime. They are placeholders for values that are not available in the table.
- Discuss about few null functions defined in MySQL.

Additional Information:

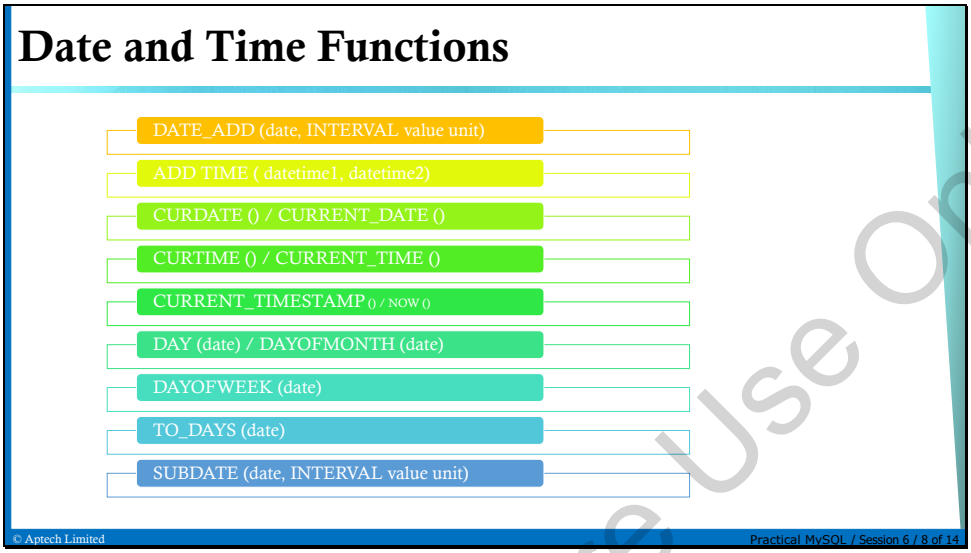
Refer to following links for more information:

- https://www.javatpoint.com/mysql-functions
- https://www.guru99.com/functions.html

Ask students the following question. Wait for a response before you answer.

In-Class Questions: Which function returns NULL if expr1= expr2?
Answer: NULLIF()

Slide 8



Instruction(s) to the trainer:

- Say that DATE and TIME functions are commonly used in applications involving daily operations of organizations. They are used internally with bulky codes of applications.
- Using slide 8, discuss the date/time functions available in MySQL.

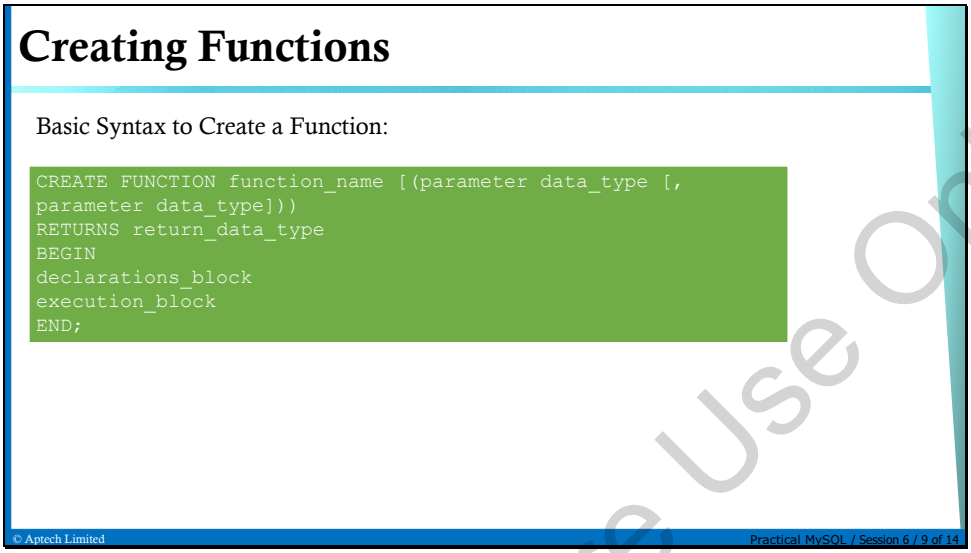
Additional Information:

Refer to following links for more information:

https://www.guru99.com/functions.html
https://www.javatpoint.com/mysql-functions

Ask the students the following question. Wait for a response before you answer.
In-Class Question: What is the function of TO_DAYS (date)?
Answer: It returns the total number of days from year 0 to input date.

Slide 9



Instruction(s) to the trainer:

- Say that functions in MySQL allows you to provide multiple parameters, but returns a single value.
- Show slide 9, and explain the syntax for creating functions.

Additional Information:

Refer to following links for more information:

- https://www.javatpoint.com/mysql-regexp-replace-function
- https://www.techonthenet.com/mysql/functions

Slide 10

Instruction(s) to the trainer:

- Say that the drop function command is used to remove a function (if it exists) from database.
- Using slide 10, explain the syntax for creating drop function with example.
- Say that dropping the database would eventually drop all the routines within it. Also, a user may alter the procedure/function using the ALTER command.
- Mention that the stored procedures and routines correspond to only one database.

Additional Information:

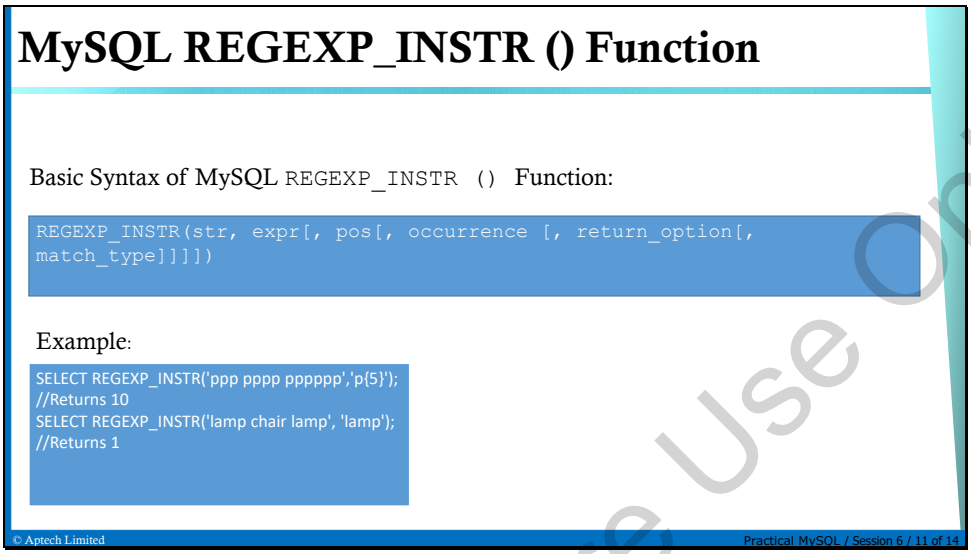
Refer to following links for more information:

- https://www.javatpoint.com/mysql-regexp-replace-function
- https://www.techonthenet.com/mysql/functions.php
- https://www.tutorialspoint.com/mysql/mysql_drop_function.htm

Ask students the following question. Wait for a response before you answer.

- **In-Class Question:** What is the syntax of the drop function? Give an example.
- **Answer**: The syntax for the drop function is
- DROP FUNCTION function_name;
- Example: DROP FUNCTION getEmployeeSalary();

Slide 11



Instruction(s) to the trainer:

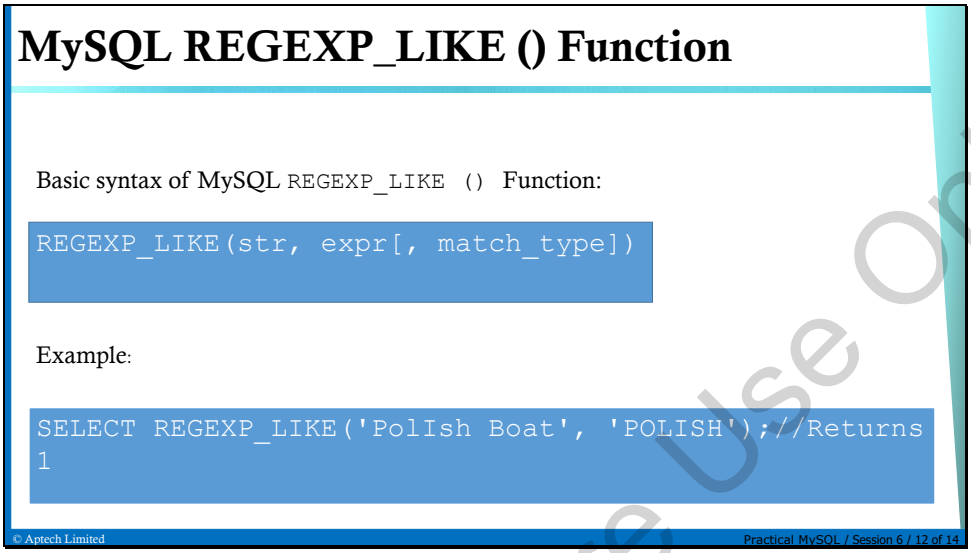
- Say that regular expression is a method of specifying a patter to perform a complex search.
- Using slide 11, explain the syntax for REGEXP_INSTR () Function with example.

Additional Information:

Refer to following links for more information:

- https://www.javatpoint.com/mysql-regexp-replace-function
- https://www.geeksforgeeks.org/mysql-regular-expressions-regexp
- https://www.tutorialspoint.com/mysql/mysql-regexps.htm

Slide 12



Instruction(s) to the trainer:

- Using slide 12, explain the syntax for REGEXP_LIKE () Function.
- Say that the REGEXP_LIKE function returns 1 if the string str matches with the regular input expression expr and returns NULL if str or expr is NULL. The REGEXP_LIKE() returns a Boolean value as a result.

Additional Information:

Refer to following links for more information:

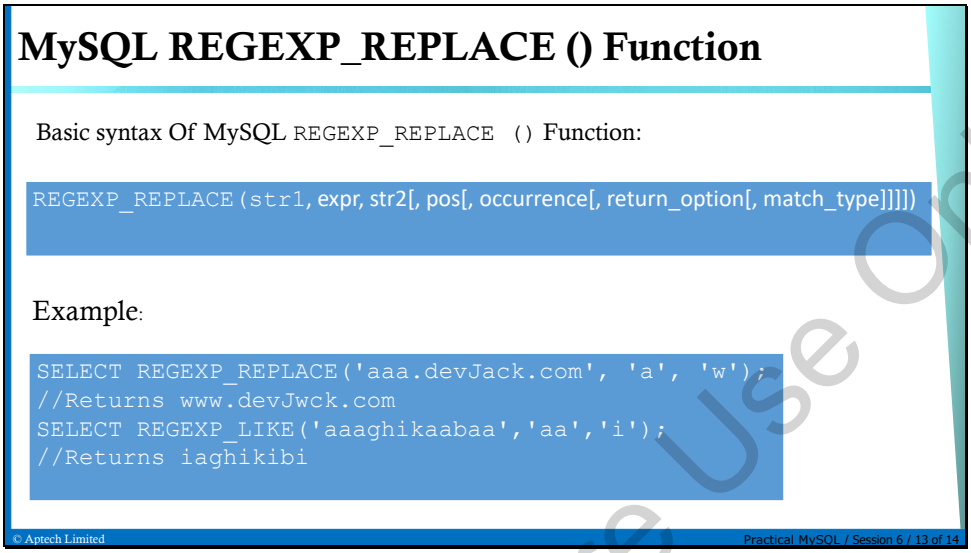
- https://www.javatpoint.com/mysql-regexp-replace-function
- https://www.geeksforgeeks.org/mysql-regular-expressions-regexp
- https://www.tutorialspoint.com/mysql/mysql-regexps.htm

Ask students the following question. Wait for a response before you answer.

In-Class Question: What is the difference between the REGEXP_LIKE() and REGEXP_INSTR() function?

Answer: The difference is that REGEXP_LIKE() returns a boolean value as a result whereas, REGEXP_INSTR() returns an integer value.

Slide 13



Instruction(s) to the trainer:

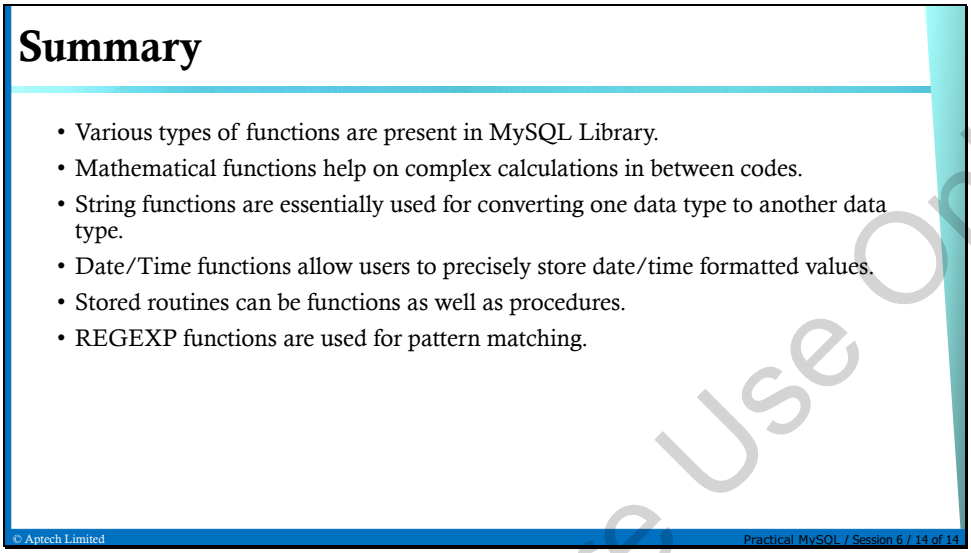
- Ask: Can anyone of you state the functionality of the REPLACE() function?
- Encourage the students to respond and appreciate them for the participation.
- Say that that REGEXP_REPLACE function extends the functionality of the REPLACE function. It allows the users to search a string for a regular expression pattern.
- Then, using slide 13, explain the syntax for REGEXP_REPLACE () function with example.

Additional Information:

Refer to following links for more information:

- https://www.javatpoint.com/mysql-regexp-replace-function
- https://www.geeksforgeeks.org/mysql-regular-expressions-regexp
- https://www.tutorialspoint.com/mysql/mysql-regexps.htm

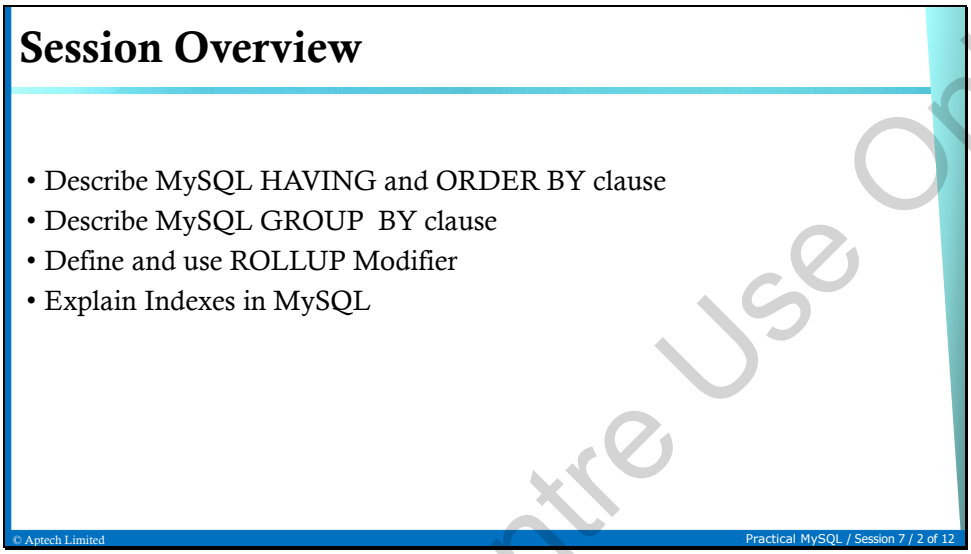
Slide 14



Use slide 14 to summarize the session. End the session, with a brief summary of what has been taught in the session. Tell the students pointers of the session. This will be a revision of the current session.

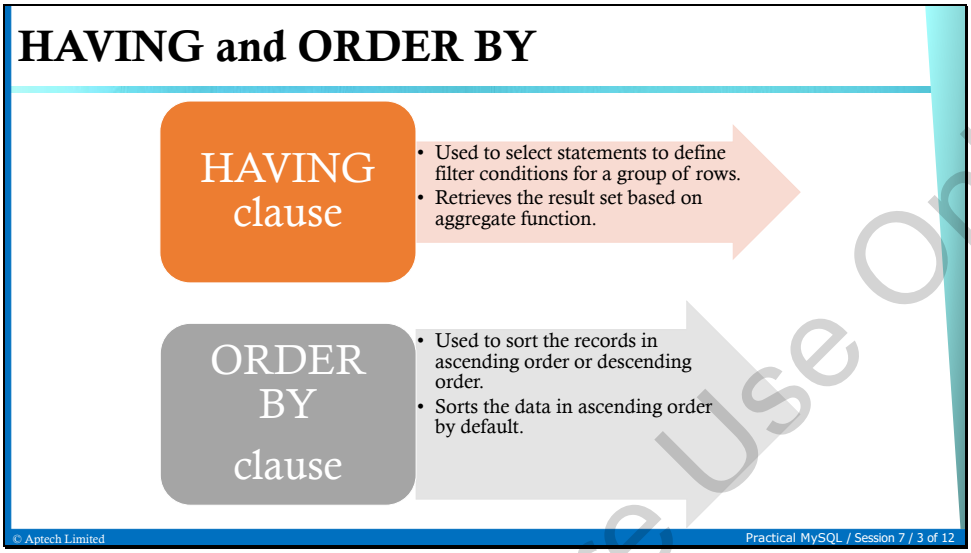
Session 7: MySQL Clauses and Indexes

Slide 2



Instruction(s) to the trainer:
Show slide 2 and inform the students that in this session they will get a brief overview on MySQL clauses and understand the Use Roll Up modifier. They will also understand the indexes in MySQL. Indexes help users to find rows, eliminate rows, and retrieve rows from other tables, and so on.

Slide 3



Instruction(s) to the trainer:

- Say that WHERE keyword cannot be used in aggregate functions, hence, HAVING clause is used in SELECT statements to define filter conditions for a group of rows.
- Using slide 3, discuss the MySQL Having and Order by clauses.

Following is the syntax for ORDER BY clause:

```
SELECT column1, column2,... FROM table_name ORDER BY column1, column2, ... ASC | desc;
```

Inform students that ASC attribute is used to sort data in the ascending order in ORDER BY clause. The desc attribute is utilized to sort and print data in decreasing or descending flow. However, the MySQL ORDER BY clause can be used without any attribute as well.

Additional Information:

Refer to following links for more information:

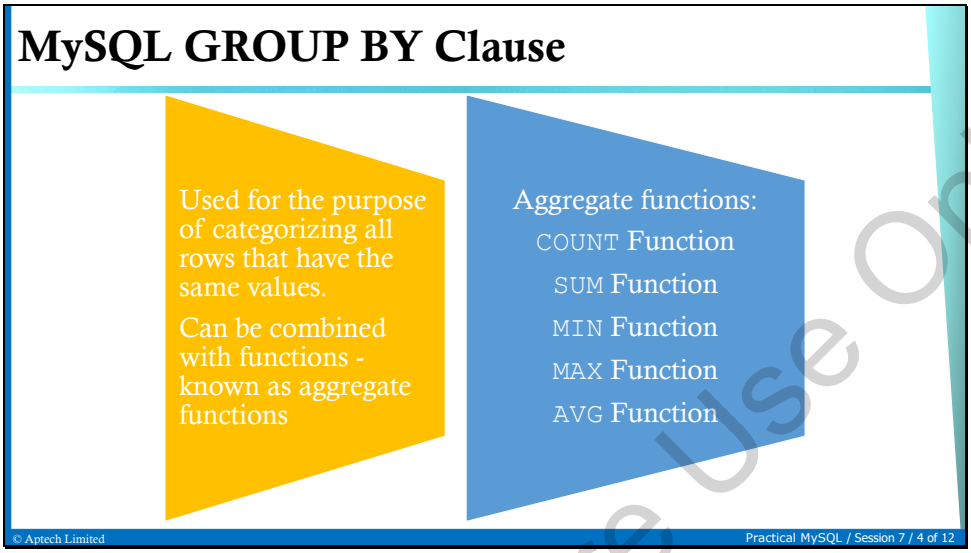
- https://www.mysqltutorial.org/mysql-having.aspx
- https://www.guru99.com/group-by.html
- https://www.techonthenet.com/mysql/having.php

Ask the students the following question. Wait for a response before you answer.

In-Class Question: What is the use of ORDER BY clause in MySQL and how does it sort by default?

Answer: The ORDER BY clause is used to sort the result set in ascending or descending order. ORDER BY clause sorts the data in ascending order by default.

Slide 4



Instruction(s) to the trainer:

- Say that the GROUP BY clause is used for the purpose of categorizing all rows that have the same values.
- Using slide 4, explain the MySQL Group By Clause and then, discuss the functions used with the clause.

Following is the syntax for GROUP BY clause:

```
SELECT column_name(s)
FROM table_name
WHERE condition
GROUP BY column_name(s);
```

The GROUP BY clause with the COUNT function is used to show the grouping of rows based on the column values and the aggregate function COUNT.

Explain in detail the aggregate functions of GROUP BY with examples to students.

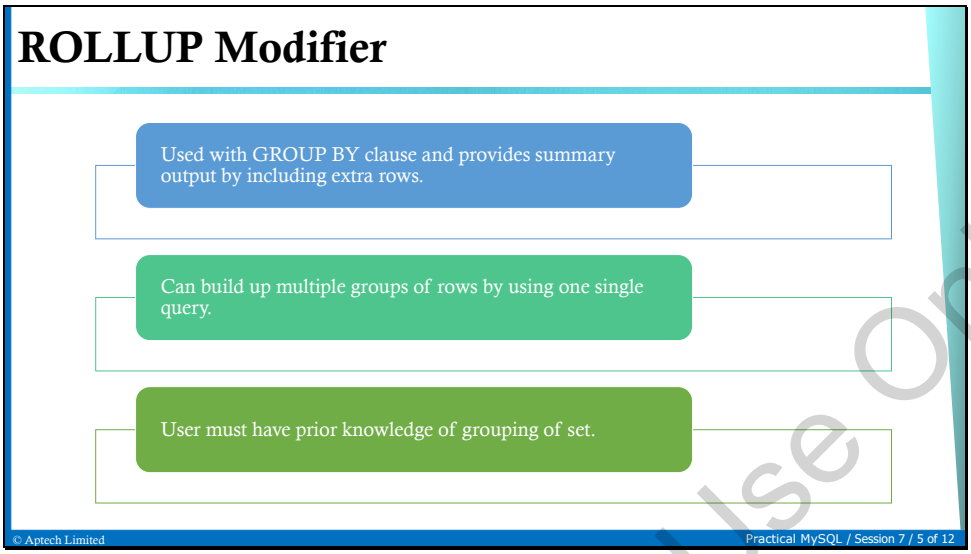
- The GROUP BY clause with the SUM function is used to show the total number of orders received grouped datewise.
- The MIN function is another aggregate function used alongside the GROUP BY clause. It is utilized to retrieve minimum value of a column over each group against a condition.

- Equivalent to the MIN function, the MAX is another function that can be utilized alongside the GROUP BY clause. It is utilized to retrieve maximum value of a column over each group against a condition.
- The AVG is another function that can be utilized with GROUP BY clause. The average can be calculated using this function.

Additional Information:
Refer to following links for more information:
- https://www.javatpoint.com/mysql-group-by
- https://www.mysqltutorial.org/mysql-group-by.aspx
- https://www.techonthenet.com/mysql/group_by.php

Ask students following question. Wait for a response before you answer.
In-Class Question: What is a Group By clause?
Answer: Group By clause groups the selected rows based on identical values in a column or expression.

Slide 5



Instruction(s) to the trainer:

- Say that the ROLLUP in MySQL is a modifier used to spawn the summary output with extra rows. It helps to construct the sub totals and grand totals for the resultant
- Using slide 5, explain Rollup Modifier in MySQL and say that it is used to spawn the summary output with extra rows.
- Explain the syntax of Rollup Modifier and the method to use it.

Following is the syntax of ROLLUP Modifier:

```
SELECT
    column1, column2, column3, ...
FROM
    table_name
GROUP BY
    column1, column2,... WITH ROLLUP;
```

Additional Information:

Refer to the following links for more information:

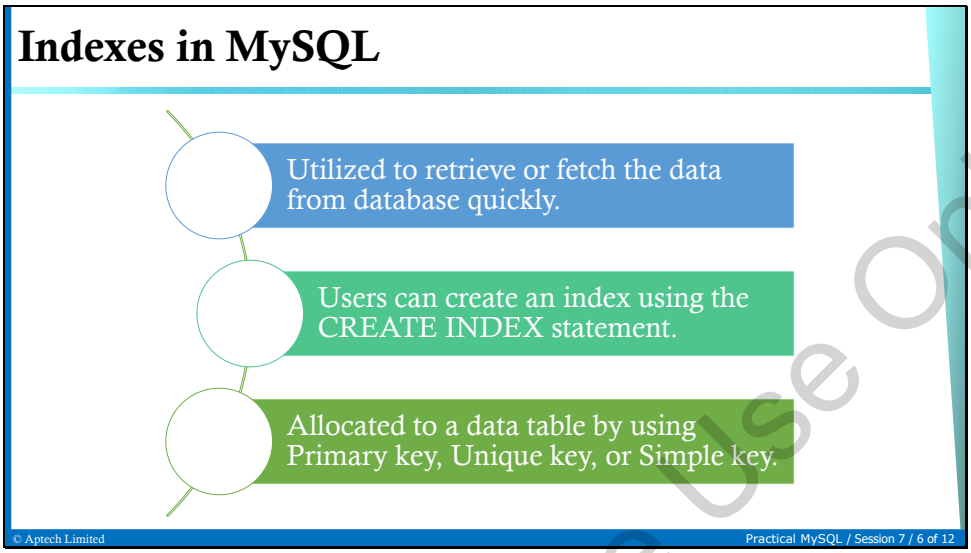
- https://www.tutorialspoint.com
- https://www.javatpoint.com/mysql-rollup
- https://www.mysqltutorial.org/mysql-rollup

Ask students the following question. Wait for a response before you answer.

In-Class Question: Why do we use Rollup modifier in SQL?

Answer: Rollup enables a select statement to calculate multiple levels of subtotals across a specified group of dimensions.

Slide 6



Instruction(s) to the trainer:

- Using slide 6, explain indexes in MySQL.
- Say that it is utilized to retrieve or fetch the data from database quickly.

Additional Information:

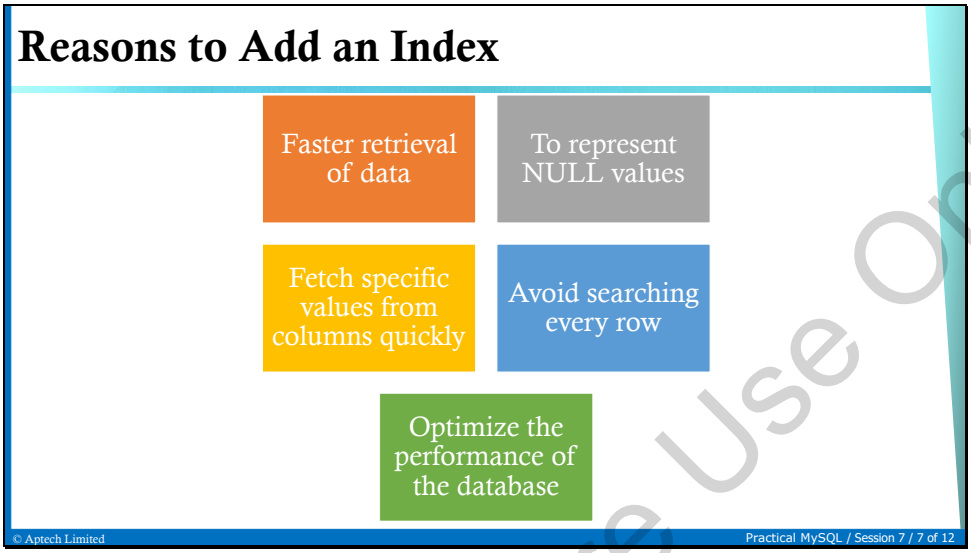
Refer to following links for more information:

- https://www.tutorialspoint.com/mysql/mysql-indexes.
- https://dev.mysql.com/doc/refman/8.0/en/mysql-indexes.html
- https://www.mysqltutorial.org/mysql-index

Ask the students following question. Wait for a response before you answer.

- **In-Class Question:** What are the types of index in MySQL?
- **Answer:** MySQL has three types of indexes: Primary key, Unique key, and simple key.

Slide 7



Instruction(s) to the trainer:
Using slide 7, discuss with the students about reasons to add an index to a table.

Additional Information:
Refer to following links for more information:

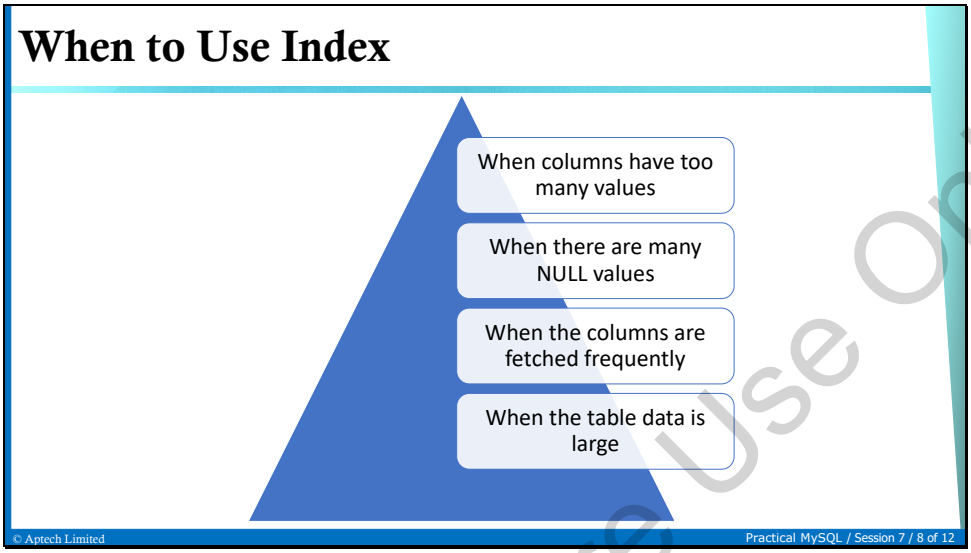
- https://www.tutorialspoint.com/mysql/mysql-indexes.
- https://www.javatpoint.com/how-to-create-index-in-mysql
- https://www.mysqltutorial.org/mysql-index

Ask students following question. Wait for a response before you answer.

In-Class Question: Why do we need index in MySQL?

Answer: 1) Faster retrieval of data.
2) Fetch specific values from columns quickly.
3) To represent NULL values

Slide 8



Instruction(s) to the trainer:

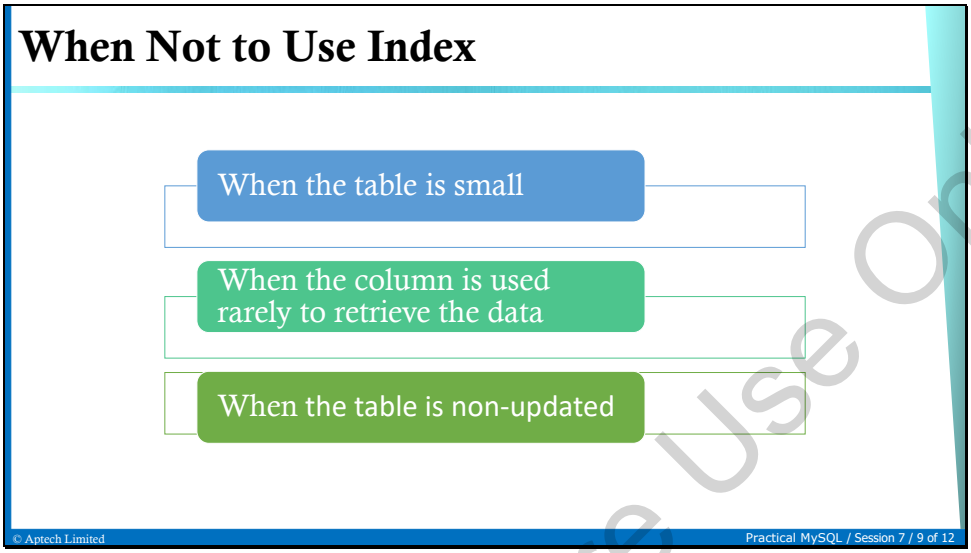
- Using slide 8, discuss the situations in which indexes can be used.

Additional Information:

Refer to following links for more information:

- https://www.tutorialspoint.com/mysql/mysql-indexes.htm
- https://www.mysqltutorial.org/mysql-index/mysql-use-index
- https://linuxhint.com/create-index-mysql

Slide 9

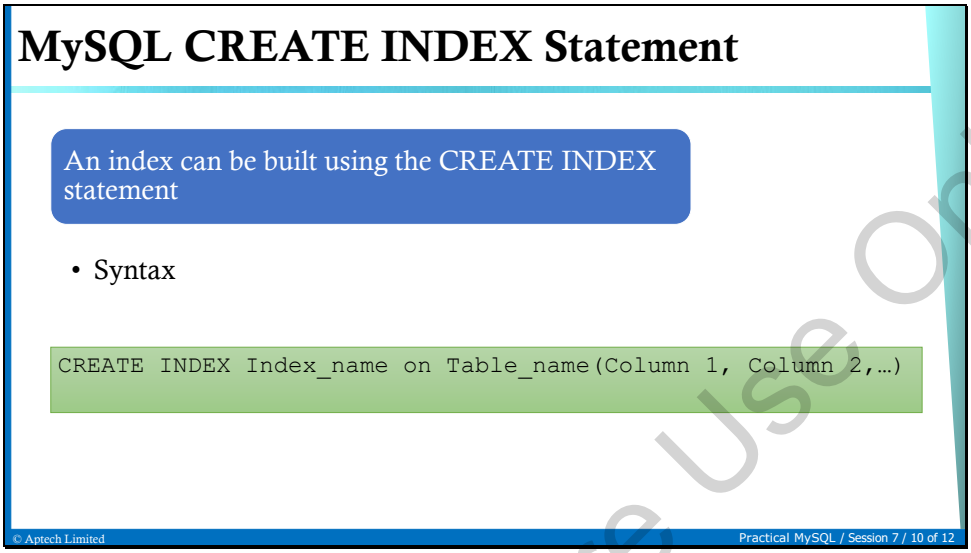


Instruction(s) to the trainer:
Using slide 9, discuss the situations in which indexes are not recommended for use.

Additional Information:
Refer to following links for more information:

- https://dev.mysql.com/doc/refman/8.0/en/mysql-indexes.html
- https://www.howtoforge.com/when-to-use-indexes-in-mysql-databases

Slide 10



Instruction(s) to the trainer:

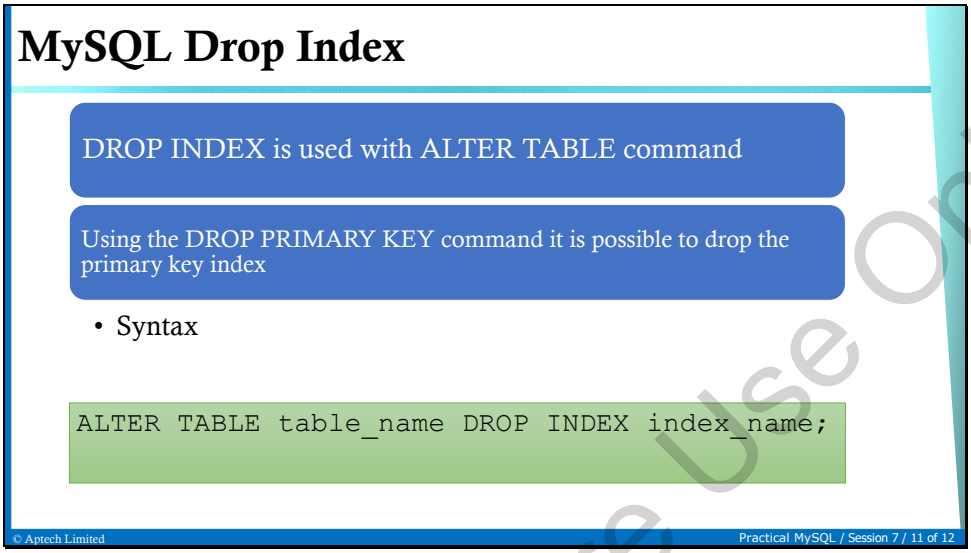
- Using slide 10, explain about an index in MySQL.
- Say that indexes helps to retrieve data from the database quickly.
- Say that it can be built by using CREATE INDEX statement.

Additional Information:

Refer to following links for more information:

- https://www.w3schools.com/sql/sql_create_index.asp
- https://www.mysqltutorial.org/mysql-index/mysql-create-index
- https://www.javatpoint.com/how-to-create-index-in-mysql

Slide 11



Instructions to the trainer:

- Using slide 11, discuss about Drop Index in MySQL.
- Say that if an index is not required anymore, the particular index can be dropped.
- Say that the syntax requires the table name to be specified because MySQL allows index names to be reused on multiple tables.

Additional Information:

Refer to following links for more information:

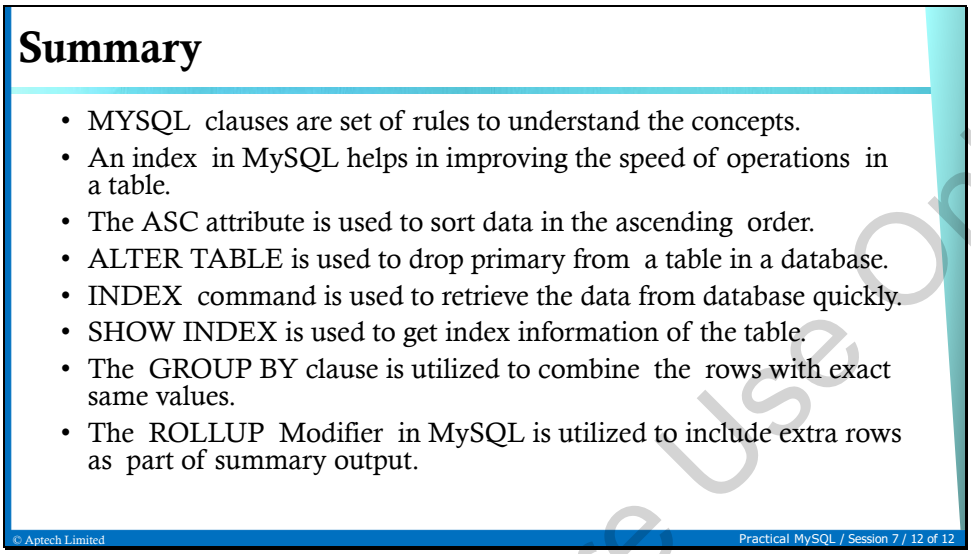
- https://www.mysqltutorial.org/mysql-index/mysql-drop-index
- https://www.javatpoint.com/mysql-drop-index
- https://www.techonthenet.com/mysql/indexes.php

Ask the students following question. Wait for the response before you answer.

In-Class Question: What is a Drop Index?

Answer: DROP INDEX is used with ALTER TABLE command. When an index is not required anymore, the particular index can be dropped from the database.

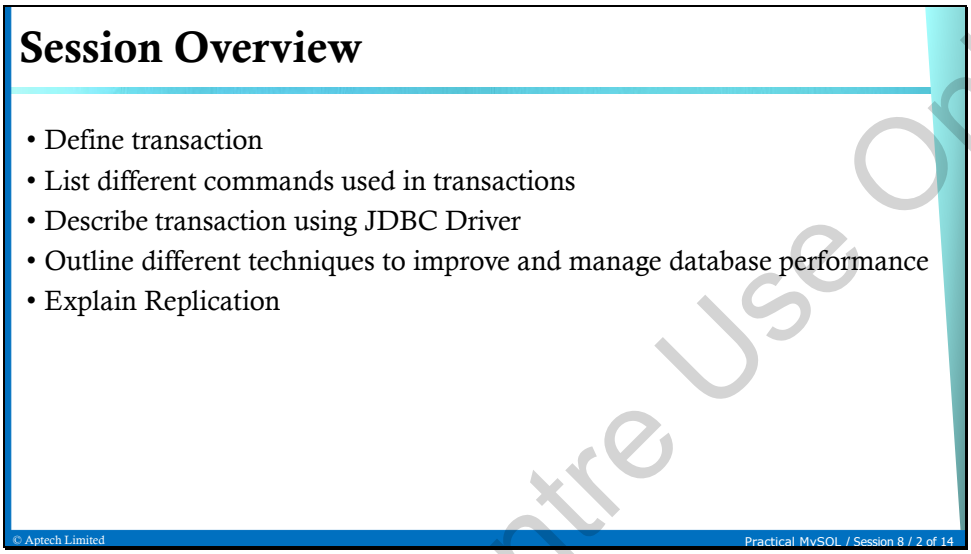
Slide 12



Use slide 12 to summarize the session. End the session, with a brief summary of what has been taught in the session. Tell the students pointers of the session. This will be a revision of the current session.

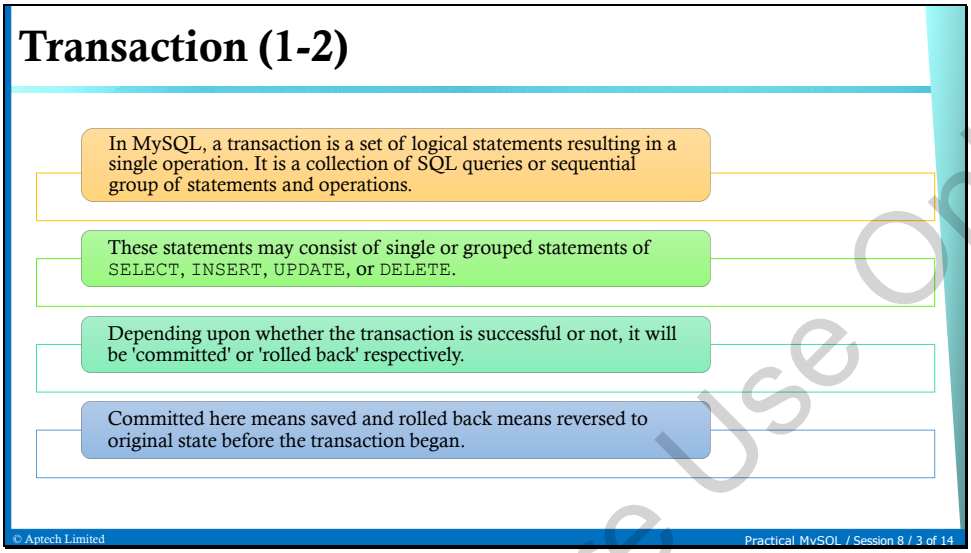
Session 8: Transactions, Performance Management, and Backup

Slide 2



Instruction(s) to the trainer:
Show slide 2 and give students a brief outline of what they will learn in this session. Tell them that the session covers the concepts including transactions, various commands used in transactions, and transactions using the JDBC driver. The session will also acquaint them with the different techniques to enhance and manage database performance. Finally, they will understand the basics of Replication.

Slide 3



Instruction(s) to the trainer:
Show slide 3 and explain the concept of a transaction in MySQL.

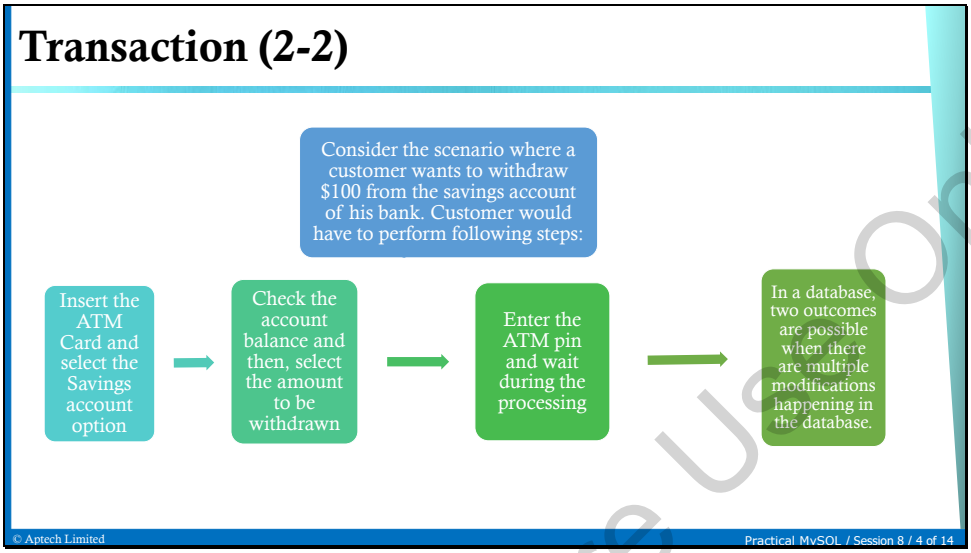
- In MySQL, a transaction is a set of statements, queries, or operations, such as `SELECT`, `INSERT`, `UPDATE`, or `DELETE`, that are executed sequentially as a single work unit and can be committed or rolled back.
- When a transaction makes many database modifications, two things can happen either the transaction is committed or all modifications are successful.
- When a transaction is rolled back, all changes are undone. In other words, a transaction cannot be successful unless all of the operations in the set are completed. It means that if any statement fails, the transaction activity will fail.
- In MySQL, a transaction begins with the first SQL statement that may be executed. It then ends when it finds a commit or is rolled back, either expressly or implicitly.

Additional Information:

Refer to following links for more information:

https://dev.mysql.com/doc/refman/8.0/en/commit.html
https://www.mysqltutorial.org/mysql-transaction.aspx

Slide 4

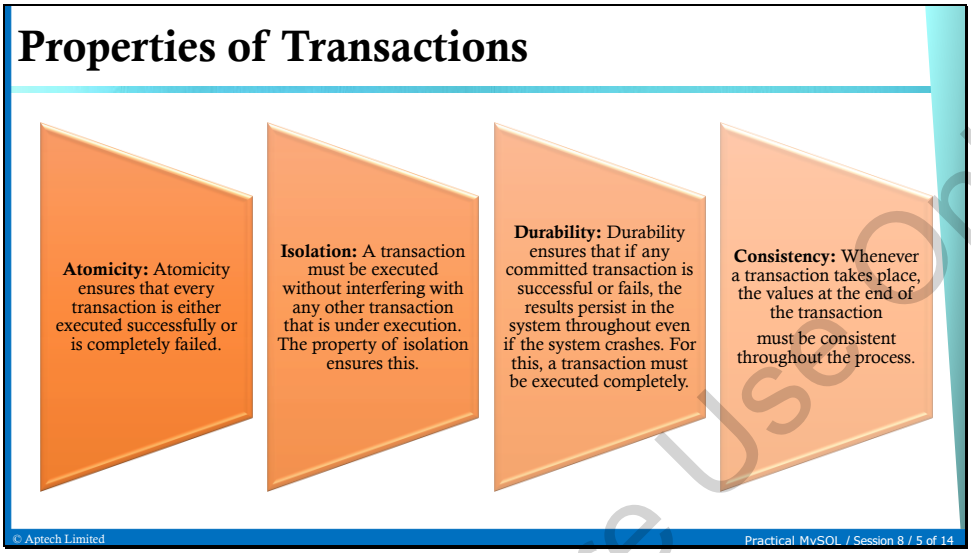


Instruction(s) to the trainer:
Show slide 4 and elaborate on transactions with the help of an example.

Ask students to consider a banking database for understanding the concept of a transaction in MySQL. Suppose a bank customer wants to transfer funds from one account to another. This can be accomplished through SQL statements. Now, explain following steps in the class:

- The first step is to verify that the requested amount is available in the first account.
- Deduct the money from the first account if it is available. Then, make a change to the first account.
- Finally, make a deposit into the second account. Then, to finalize the transaction, update the second account.
- The transaction will be rolled back to its former state if any of the foregoing processes fail.

Slide 5



Instruction(s) to the trainer:
Show slide 5 and discuss the properties of a transaction in MySQL.
The transaction primarily consists of four attributes, referred to as the ACID property. The acronym for the ACID property is Atomicity, Consistency, Isolation, and Durability.

. **Atomicity:** This feature guarantees that all the statements or actions within a transaction unit must succeed. Otherwise, if any operation fails, the transaction will be terminated and the data will get rolled back to its previous state. Inform students about its features:

- `COMMIT` statement
- `ROLLBACK` statement
- Auto-commit setting
- Operational data from the INFORMATION_SCHEMA tables

• **Consistency:** This feature ensures that the database only changes state when a transaction is successfully committed. It is also in charge of keeping data safe from crashes. It has the following features:

- InnoDB doublewrite buffer
- InnoDB crash recovery

• **Isolation**: This feature ensures that each transaction unit operation gets performed individually. It also makes sure that the statements are mutually transparent. It has the following features:

- SET ISOLATION LEVEL statement
- Auto-commit setting
- The low-level details of InnoDB locking

• **Durability**: This attribute ensures that the outcome of committed transactions is preserved even if the system fails or crashes. It has the following features:

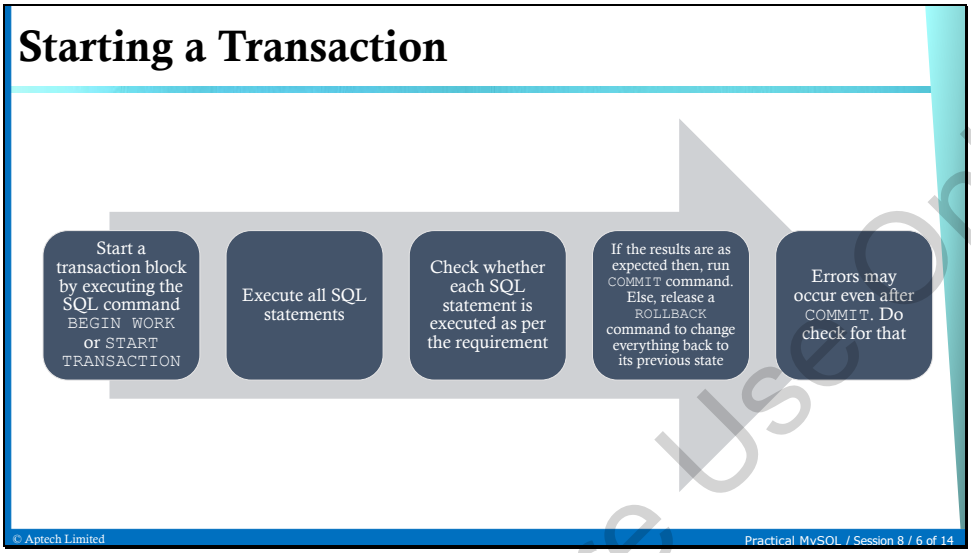
- Write buffer in a storage device
- Battery-backed cache in a storage device
- Configuration option innodb_file_per_table
- Configuration option innodb_flush_log_at_trx_commit
- Configuration option sync_binlog

Additional Information:

Refer to following links for more information:

https://www.javatpoint.com/mysql-transaction
https://www.tutorialspoint.com/mysql/mysql-transactions.htm

Slide 6

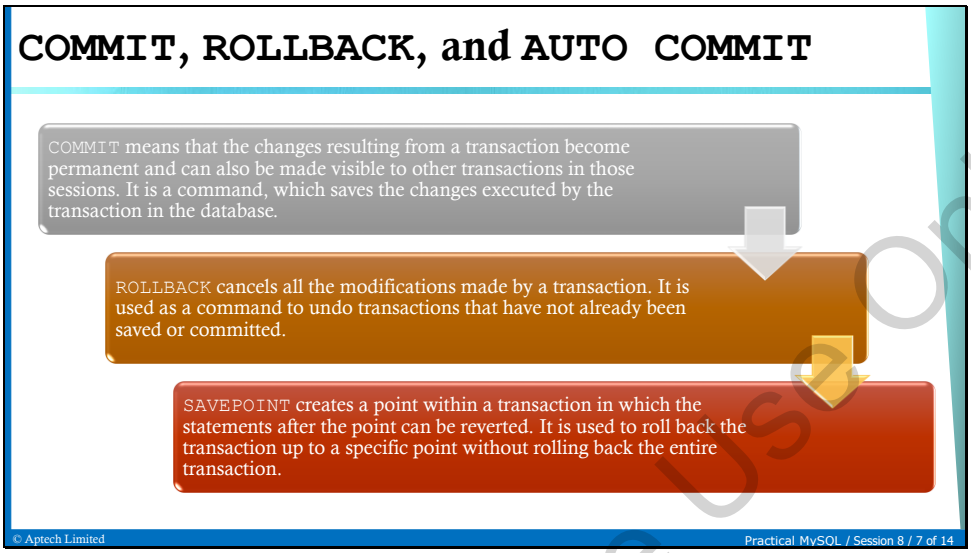


Instruction(s) to the trainer:
Show slide 6 and explain the process of starting a transaction in MySQL. Describe following step-wise procedure in detail:

- The `START TRANSACTION` command is used to start the transaction in MySQL. It also has an alias for the `START TRANSACTION` called '`BEGIN`' and '`BEGIN WORK`'.
- To commit the current transaction, a user can utilize the `COMMIT` command. It enables the database to make lasting modifications.
- To undo the current transaction, one can use the `ROLLBACK` statement. It enables the database to undo all modifications and return to its original state.
- To disable/enable the auto-commit mode for the current transaction, a programmer can use the `SET` auto-commit command.
- The `COMMIT` statement is executed automatically by default. However, if a user does not want modifications to be committed automatically, he/she can use following statement:

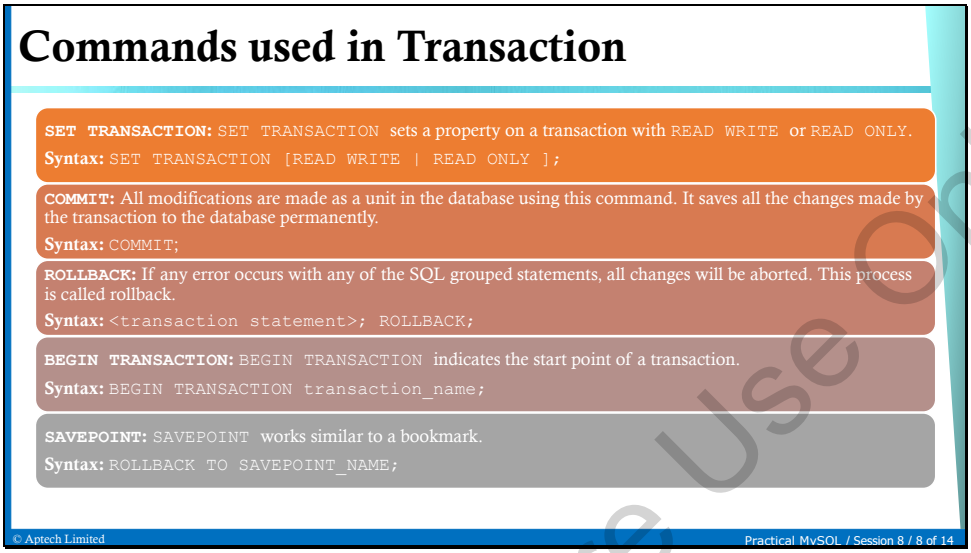
```
SET autocommit = 0;
OR,
SET autocommit = OFF:
```

Slide 7



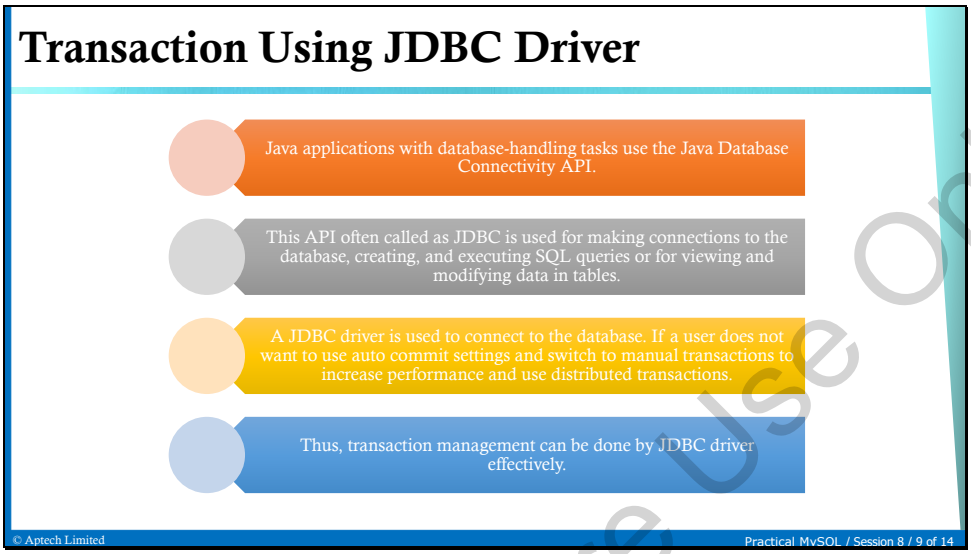
Instruction(s) to the trainer:
Show slide 7 and explain the concepts of `Commit`, `Rollback`, and `Auto Commit` in MYSQL. All user activity in InnoDB happens within a transaction. If autocommit mode is enabled, each SQL statement is treated as a separate transaction. MySQL starts each new connection's session with autocommit enabled, which means MySQL commits after each SQL statement if the statement does not return an error. If a statement fails, the commit or rollback behavior is determined by the error.
When autocommit is enabled, a session can initiate a multiple-statement transaction with an explicit `START TRANSACTION` or `BEGIN` statement and end it with a `COMMIT` or `ROLLBACK` statement.
A `COMMIT` indicates that the current transaction's changes are made permanent and visible to other sessions. A `ROLLBACK` statement, on the other hand, undoes all of the current transaction's changes. All InnoDB locks that were set during the current transaction are released with both `COMMIT` and `ROLLBACK`.

Slide 8



Instruction(s) to the trainer:
Show slide 8 and elaborate on the commands used in transactions.

Slide 9



Instruction(s) to the trainer:
Show slide 9 and describe the concept of a transaction using the JDBC driver. Use following example to deepen students' understanding:

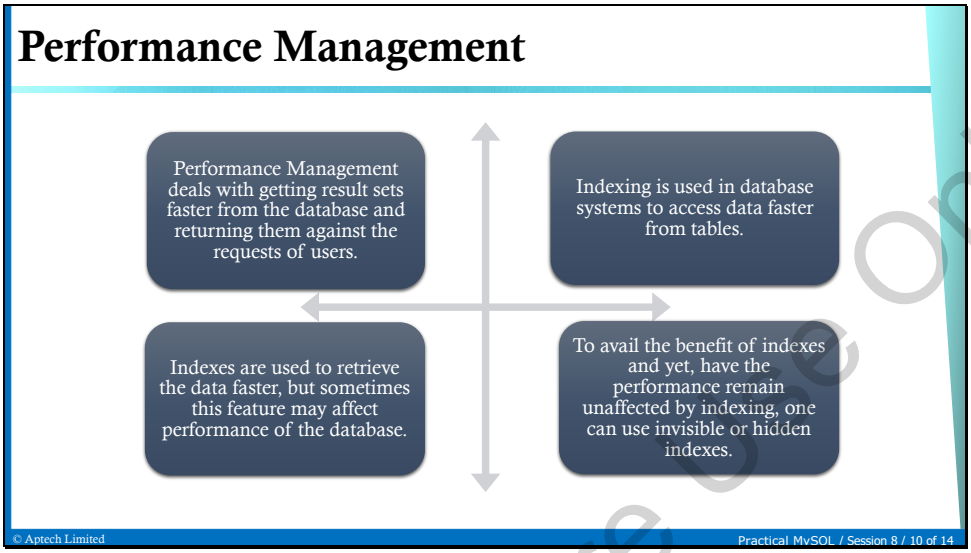
- First, the user creates a new record into the candidates' database and assigns some skills to the newly inserted applicant as an example.
- Within a single transaction, the user will insert an applicant and assign skills.
- Following measure must be taken to get the inserted ID back after inserting a record into the candidate's table.
- In the candidate skills table, a user will enter a set of candidate IDs and Skill IDs.
- Finally, Commit the transaction if all of the foregoing operations were successful; otherwise, roll it back.

Additional Information:

Refer to following links for more information:

https://www.mysqltutorial.org/mysql-jdbc-transaction/
https://riptutorial.com/mysql/example/20923/transaction-using-jdbc-driver

Slide 10



Instruction(s) to the trainer:
Show slide 10 and tell students about performance management in MySQL.
Inform students that there may be a million rows in the tables directly affecting an app's performance. Discuss the different techniques to deal with such performance issues.

Using Indexes: The most simple solution to the majority of slow query concerns is using indexes. A user must try this method before moving on to further techniques.

Introduce students to the types of indexes available in MySQL:

- Primary index: It is a one-of-a-kind index in which no value can be null. It is commonly used for the identification column and cannot be modified.
- Unique index: All column values must be unique in a unique index.
- Normal index: It can be on one or more columns and is mostly used to find items more quickly.
- Descending index (MySQL 8+): It is a standard index stored in reverse order. It comes in handy if the user requires to show the most recently inserted data.
- Full-text index: It is used for text indexing.

- **Using Cache:** It is a useful way to solve performance problems. It can be used at the program level with Memcached services such as Redis or the database level with SQL. On the SQL level,

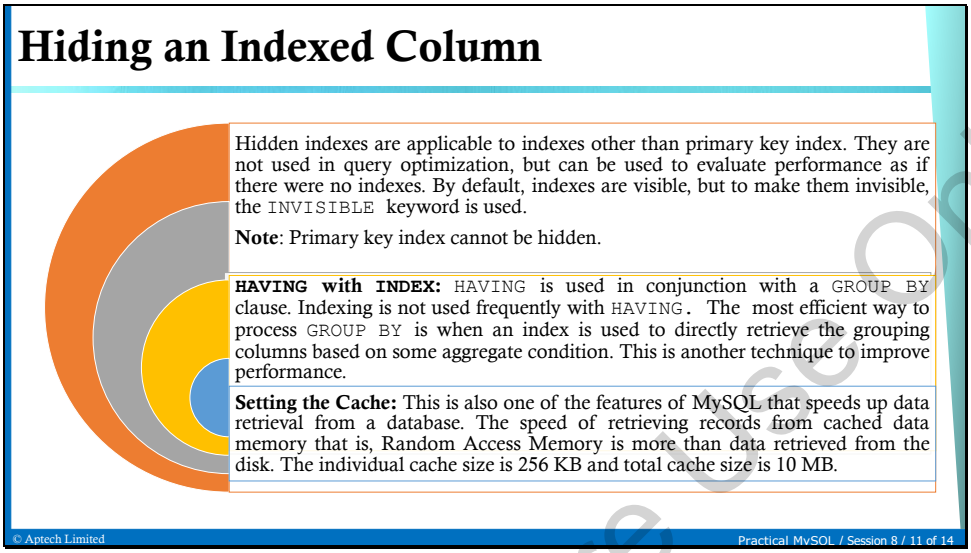
one should be aware that it has been deprecated. Moreover, it has already been removed in version 8 and beyond.

- If a user decides to use a program-level cache, the most difficult part is figuring out how to keep the cache and database consistent. Caching can be used as a bridge between the code and the database or it can be employed in certain situations. It can also be used to store data after it has been manipulated rather than as raw queries.

In-Class Question: What is the performance schema in MySQL?

Answer: MySQL Performance Schema is a feature that allows you to keep track of how the MySQL Server is performing at a low level. The Performance Schema allows you to inspect the server's internal execution while it is running.

Slide 11



Instruction(s) to the trainer:
Show slide 11 and tell students about hiding an indexed column in MySQL.

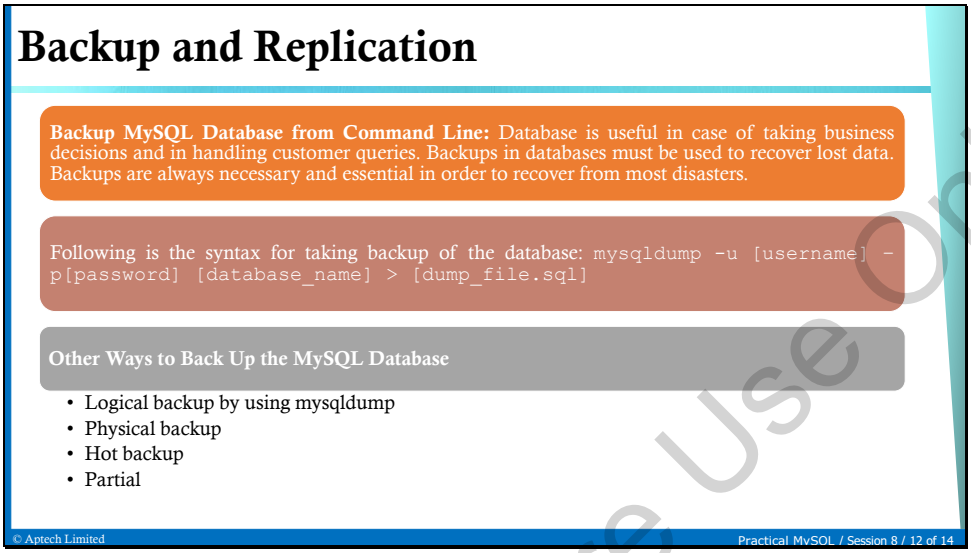
Hidden indexes can be used on indexes other than the main key indexes. They are not used in query optimization, but they can be used to assess performance as if no indexes were present.

Indexes are visible by default. However, the `INVISIBLE` keyword can be used to make them invisible. It is worth noting that the primary key index can not be disguised.

`HAVING` is used when combined with a `GROUP BY` clause. `HAVING` does not use indexing very much.
The most efficient way to perform `GROUP BY` is using an index to directly get the grouping columns based on some aggregate condition. This is another method for enhancing performance.

Additional Information:
Refer to following links for more information:
https://dev.mysql.com/doc/refman/8.0/en/invisible-columns.html
https://blogs.oracle.com/mysql/post/how-to-use-invisible-indexes-in-mysql-80

Slide 12



Instruction(s) to the trainer:
Show slide 12 and explain backup and replication in MySQL.

- **Back Up from the Command-Line with `mysqldump`:** The client utility `mysqldump` can dump a database, including SQL statements needed to recreate it. The SQL commands to restore the tables and data are included in the dump file by default.

Following is the usual syntax for backing up your MySQL database:

```
sudo mysqldump -u [user] -p [database_name] > [filename].sql
```

Replace [**user**] with your username and password (if needed).
The [**database_name**] is the path and filename of the database.
The **>** command specifies the output.
[**filename**] is the path and filename a user wants to save the dump file as.

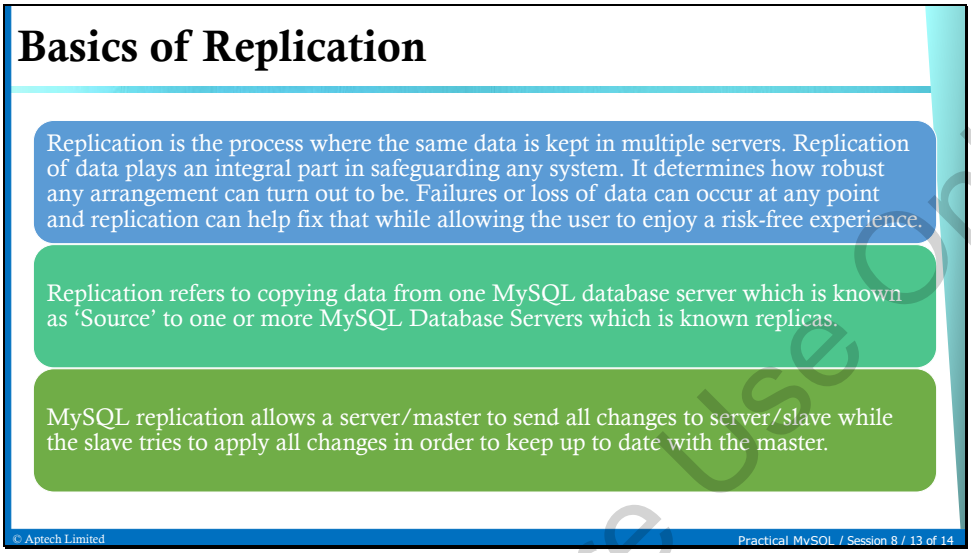
- **Logical backup:** This backup is saved as a `.sql` file. This type does not involve or require any third-party dependencies. The `mysqldump` command can be used to create a backup.

- **Physical backup:** It is made by duplicating database files. Physical backups take substantially longer to make and restore than logical backups. Large databases should be backed up with it.

- **Hot backup:** If MySQL Server is operating on the InnoDB subsystem, users can create transactional consistent backups without interrupting or restarting the server.

- **Partial:** Partial backups are not utilized to create backups for a database's whole storage. It is used to backup individual tables or databases.

Slide 13



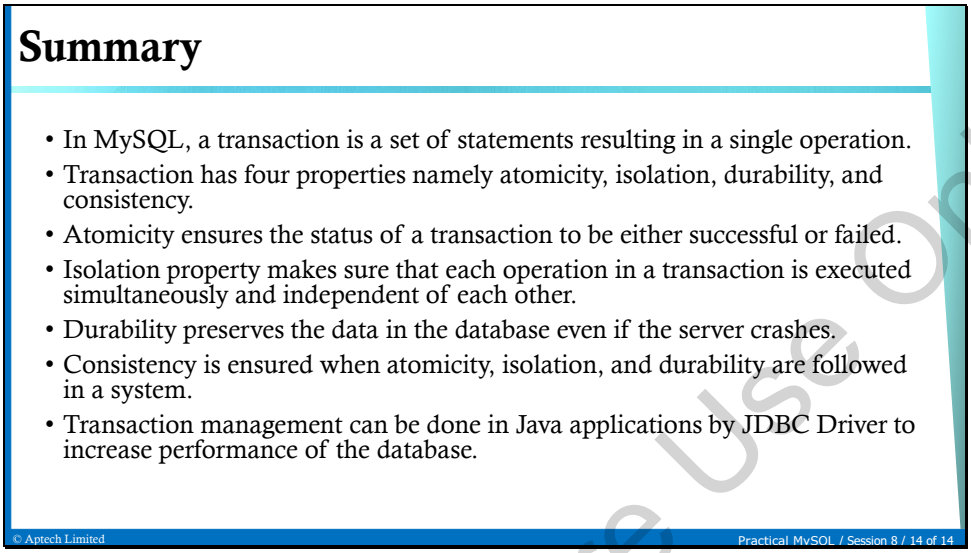
Instruction(s) to the trainer:
Show slide 13 and discuss the basics of replication. MySQL replication is a technique for keeping data in one or more MySQL database servers, known as slaves, in sync with one master MySQL database server. Replication is useful because it provides for scalability by distributing read access over different servers, helps data backup, and allows data analysis on the slave without requiring access to the master.

Additional Information:

Refer to following links for more information:

https://www.digitalocean.com/community/tutorials/how-to-set-up-replication-in-mysql
https://www.educative.io/edpresso/what-is-mysql-replication

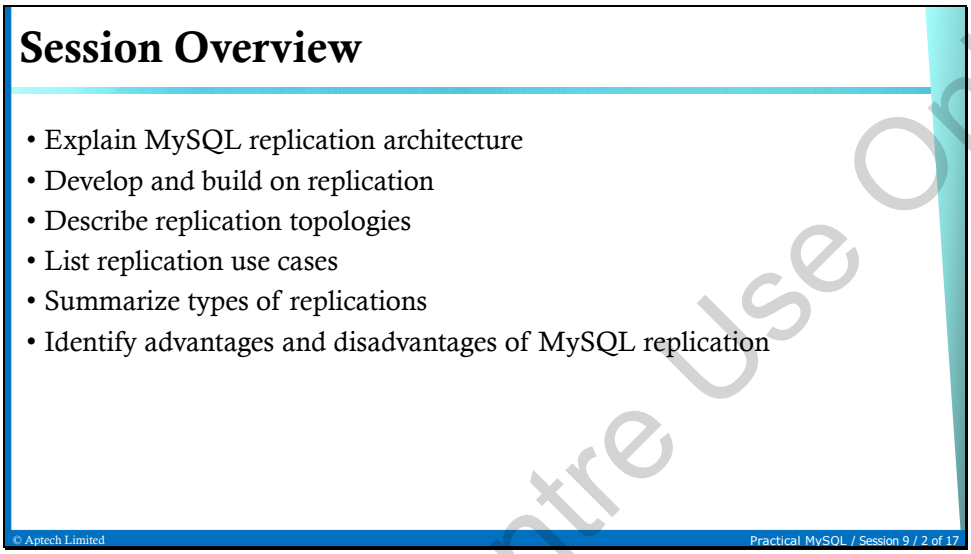
Slide 14



Instruction(s) to the trainer:
Show slide 14 and provide students with a quick summary of all the topics taught in the session. Discuss the important pointers as this will serve as a revision of the current session.

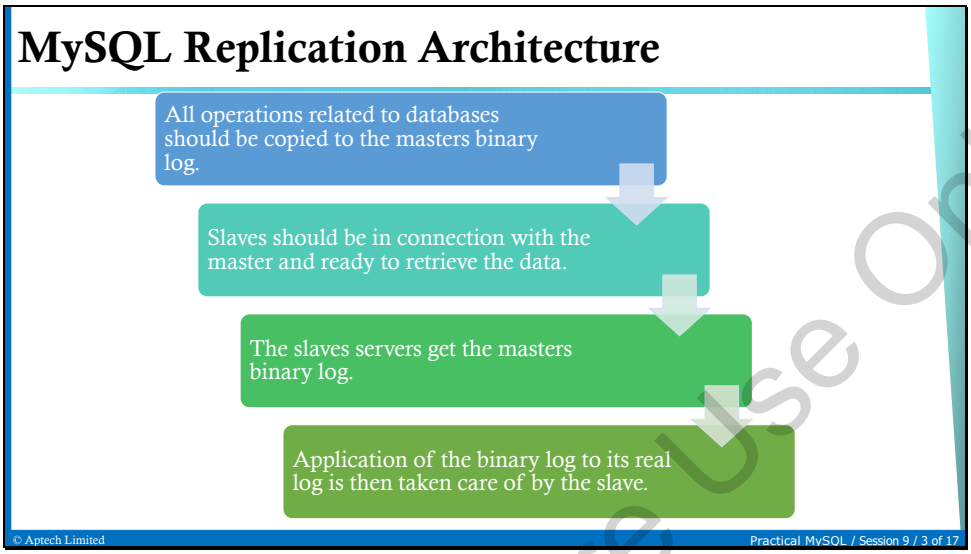
Session 9: Replication and Scalability

Slide 2



Instruction(s) to the trainer:
Using slide 2, give brief overview on MySQL replication architecture. Discuss the advantages and disadvantages of MySQL replication. Describe replication topologies. Explain how to develop and build on replication. List replication use cases.

Slide 3



Instruction(s) to the trainer:
Show slide 3 and discuss with students about the stages involved in MySQL replication process. Say that each directory server picks a replication server and connects to that replication server. All changes processed by the directory server are then sent to the replication server and all changes from other servers are received through the replication server.

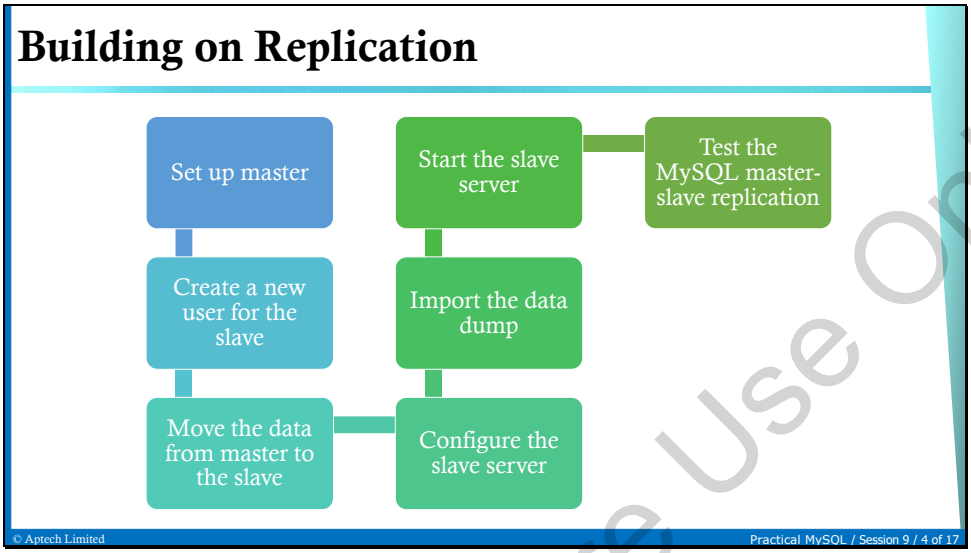
Additional Information:

Refer to following links for more information:

- https://dev.mysql.com/doc/internals/en/replication.html
- https://severalnines.com/resources/database-management-tutorials/mysql

In-Class Question: What is MySQL replication architecture?
Answer: MySQL replication is a process that enables data from one MySQL database server (the master) to be copied automatically to one or more MySQL database servers (the slaves).

Slide 4



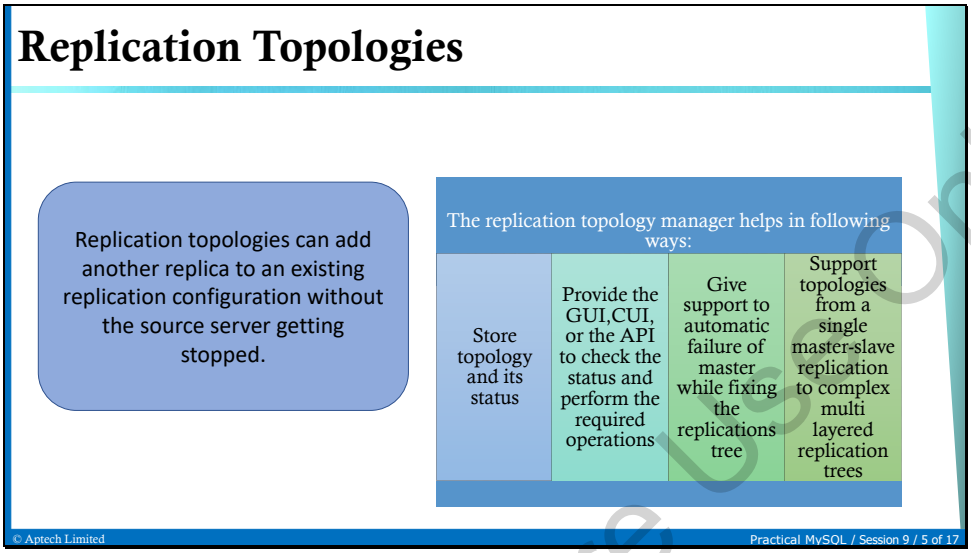
Instructions to the trainer:
Using slide 4, inform students that the procedure of building on replication involves increasing the availability of data. The primary reason for the replication is recovering data. Explain the procedure to adhere to while building a master-slave replication.

Additional Information:

Refer to following links for more information:

- https://dev.mysql.com/doc/mysql-replication
- https://www.toptal.com/mysql/mysql-master-slave-replication-tutorial

Slide 5



Instruction(s) to the trainer:
Show slide 5 and explain replication topologies. Say that the replication topologies can add another replica to an existing replication configuration without the source server getting stopped. To administer the effects of different topologies, the 'Orchestrator' can be utilized. Discuss the advantages of replication topology manager.

Different topologies for MySQL replication are:

- Master with Slaves (Single Replication)
- Master with Relay Slaves (Chan Replication)
- Master with Active Master (Curricular Replication)
- Master with Backup Master (Multiple Replication)
- Multiple Masters to Single Slave (Multi-Source Replication)
- Galera with Replication Slave (Hybrid Replication)
- MySQL Group Replication

Additional Information:

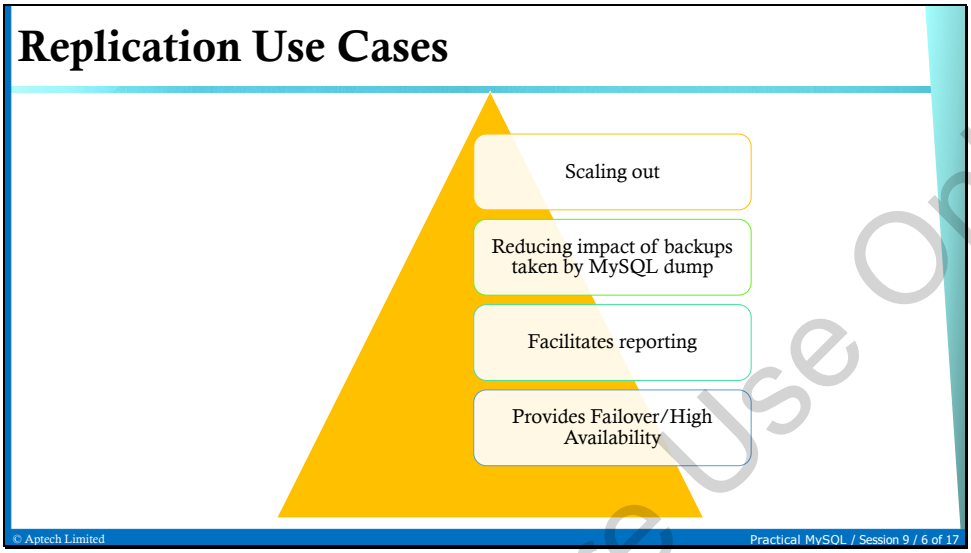
Refer to following links for more information:

- https://dev.mysql.com/doc/mysql-replication

- https://www.slideshare.net/isotopp/mysql-replication-topologies-and-architectures

In-Class Question: What is Replication Topologies?
Answer: Replication topologies can add another replica to an existing replication configuration without the source server getting stopped.

Slide 6



Instruction(s) to the trainer:
Say that a database replication tool allows one to move or consolidate data from one particular database server to a newer version of that database. Show slide 6 and list the general MySQL replication use cases. Say that replication use cases can differ based on type of replication. Redundancy and replication can help save from ransomware attacks. Finally, describe the use cases for group replication.

Following are the use cases for group replication:

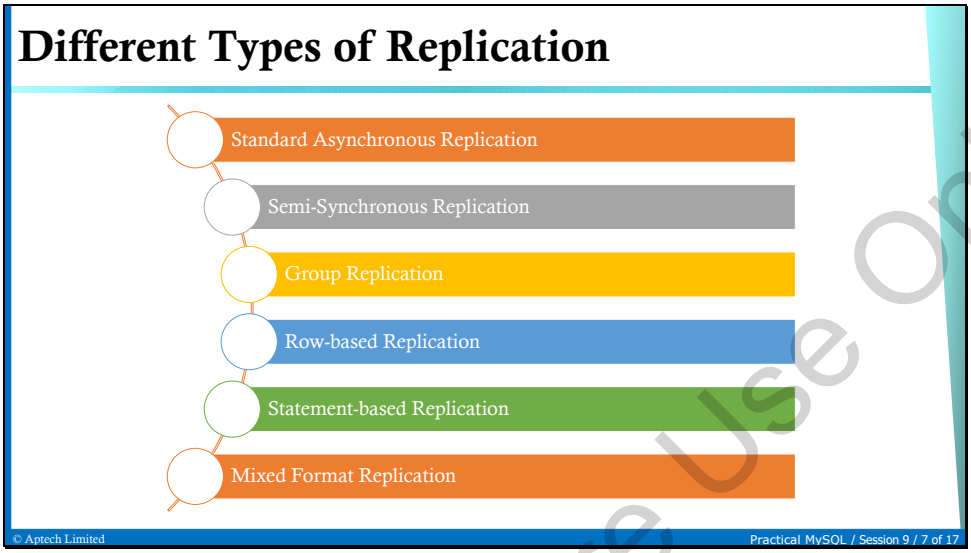
Elastic Replication: It is used in places where fluid replication infrastructure is present. In this replication, the number of servers can grow and shrink dynamically, but side effects are minimal.
Highly Available Shards: It is one of the most famous approaches to achieving write scale-out. Here, each shard maps to a replication group.
Alternative to Source-Replica Replication: In a few circumstances, replication is a single point of contention when utilizing a single source server.
Autonomic Systems: Deployment of MySQL group replication can be done purely for automation. The replication protocols have this built into them.

Additional Information:

Refer to following links for more information:

- https://www.oracle.com/technetwork/community/developer-day/msql
- https://dev.mysql.com/doc/refman/8.0/en/replication.html

Slide 7



Instruction(s) to the trainer:
Using slide 7, discuss different types of replication. Tell that replications format mainly has two core types. One is statement based and the other one is row based.
There is also a third type called mixed based replication. Explain different types of replication in detail to students.

- Standard asynchronous replication ensures that the local environment transaction is completed and is not influenced by replication slaves.
- Semi-synchronous replication ensures that proper transfer of database transactions occur.
- Group replication is a process by which a pool of servers is established so that they can be used to copy data correctly.
- Row-based replication or RBR is a type of replication in which the binary log stores record level changes which takes place on database tables to the master server.
- Statement-based replication is a type of replication where SQL statements are stowed in binary log in order to change databases on the master server.
- Mixed format replication involves a server which can dynamically choose Statement Based Replication (SBR) or Row Based Replication (RBR) as per the condition.

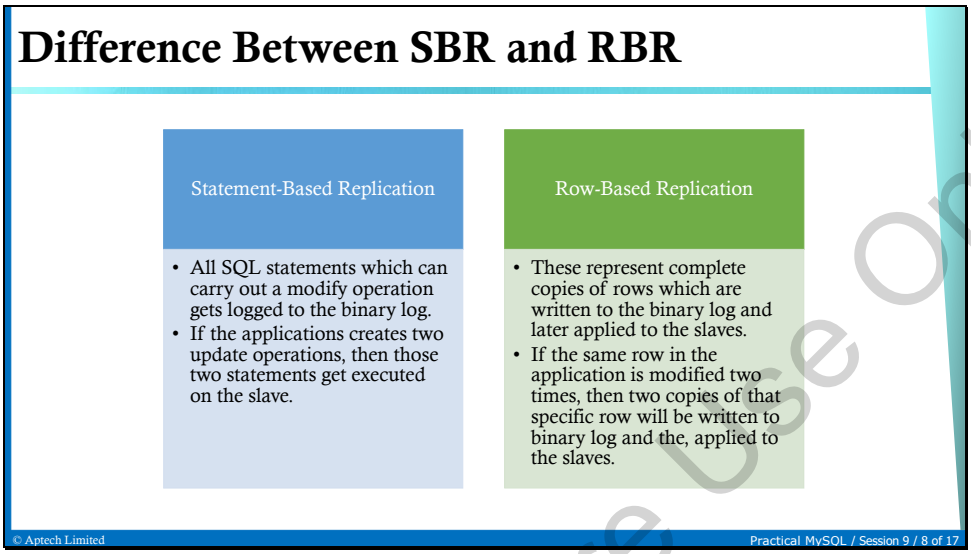
Additional Information:

Refer to following links for more information:

- https://www.oracle.com/technetwork/community/developer-day/mysql
- https://severalnines.com/resources/database-management-tutorials/mysql-replication-high-availability-tutorial

In-Class Question: What is Group Replication?
Answer: Group replication is a process by which a pool of servers is established so that they can be used to copy data correctly.

Slide 8



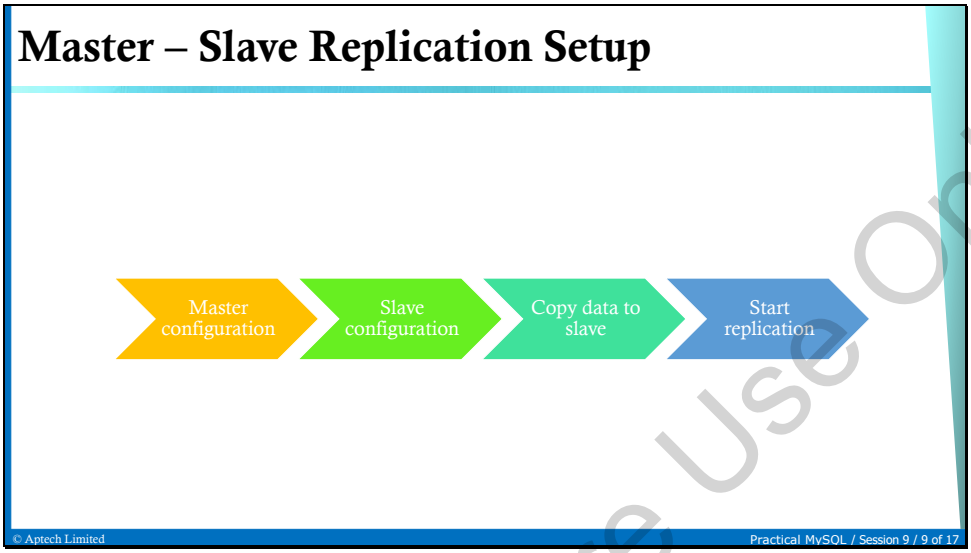
Instruction(s) to the trainer:
Using slide 8, explain statement-based replication and row-based replication.
Then, discuss the differences between statement-based replication and row-based replication.

Additional Information:

Refer to following links for more information:

- https://www.databasejournal.com/mysql/comparing-mysql-statement-based-and-row-based-replication
- https://www.linuxtopia.org/online_books/database_guides/mysql_5.1_database_reference_guide/replication-sbr-rbr.html

Slide 9



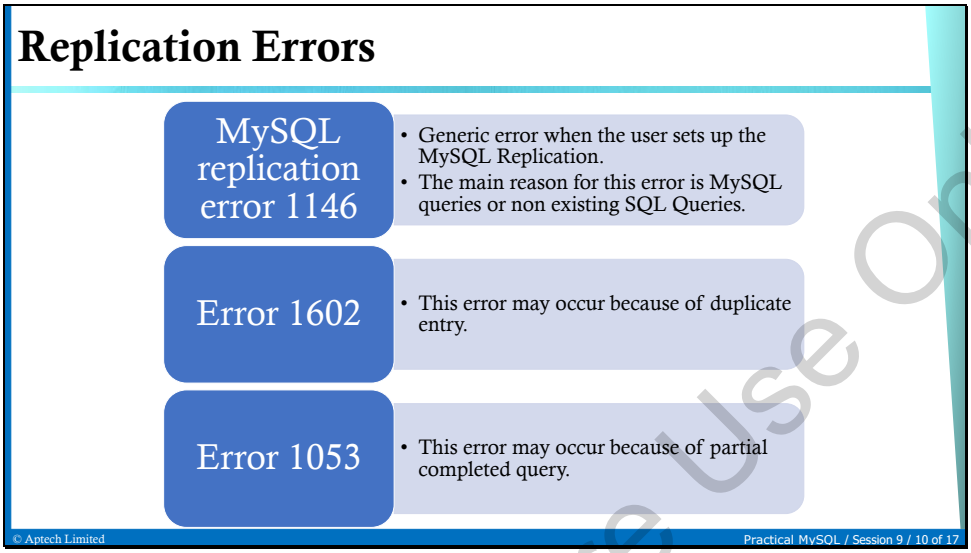
Instruction(s) to the trainer:
Using slide 9, explain the process of master-slave replication.
Say that it enables database administrator to replicate or copy the data on more than one server simultaneously.

Additional Information:

Refer to following links for more information:

- https://www.toptal.com/mysql/mysql-master-slave-replication-tutorial
- https://dev.mysql.com/doc/refman/5.6/en/replication-howto.html

Slide 10



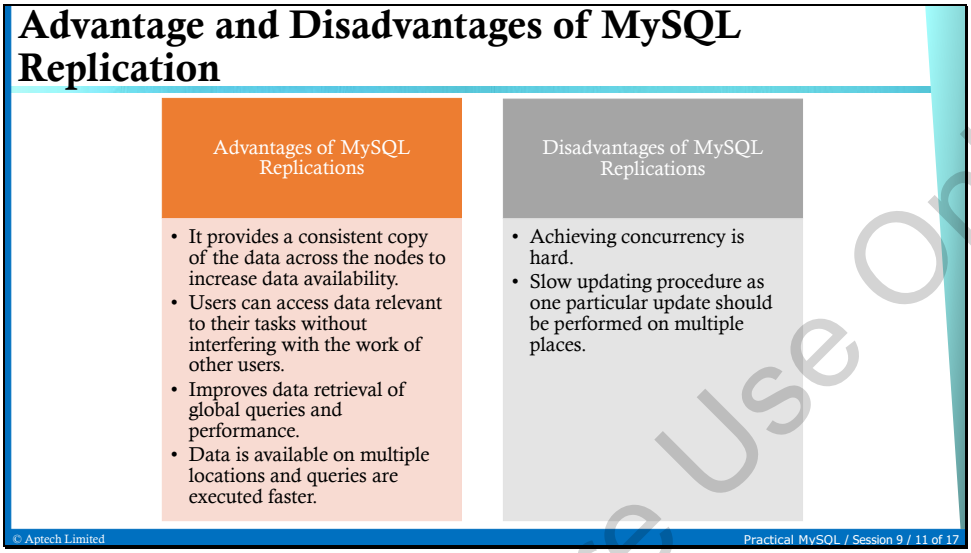
Instruction(s) for the trainer:
Using slide 10, explain that while doing master-slave replication there are possibilities of getting errors.
Discuss about the replication errors.

Additional Information:

Refer to following links for more information:

- https://dev.mysql.com/doc/mysql-replication-excerpt/5.7/en/replication-features-slaveerrors.html
- https://riptutorial.com/mysql/example/24095/replication-errors

Slide 11



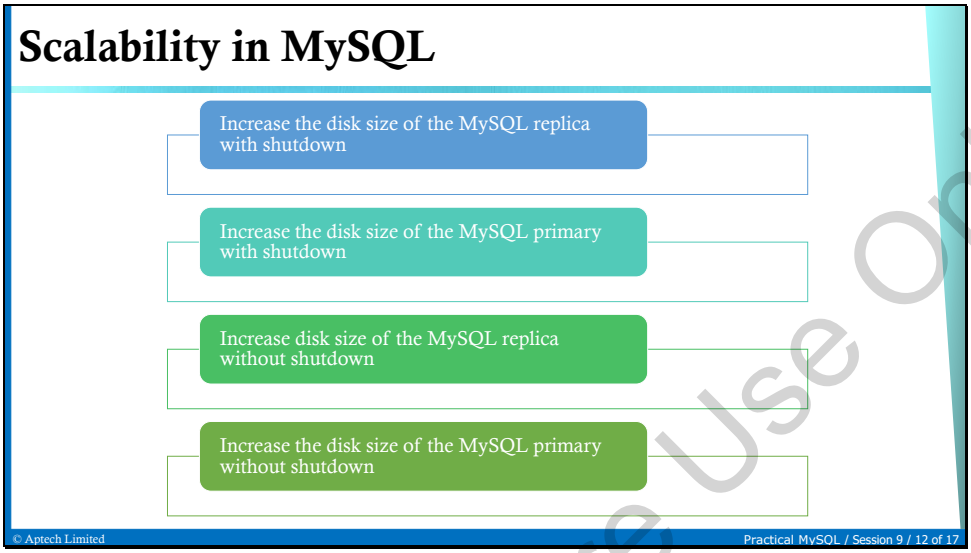
Instructions to the trainer:
Using slide 11, explain the multiple advantages of MySQL replication. Then, list few disadvantages.

Additional Information:

Refer to following links for more information:

- https://www.oracle.com/technetwork/community/developer-day/mysql-replication
- https://severalnines.com/resources/database-management-tutorials/mysql-replication-high-availability-tutorial

Slide 12



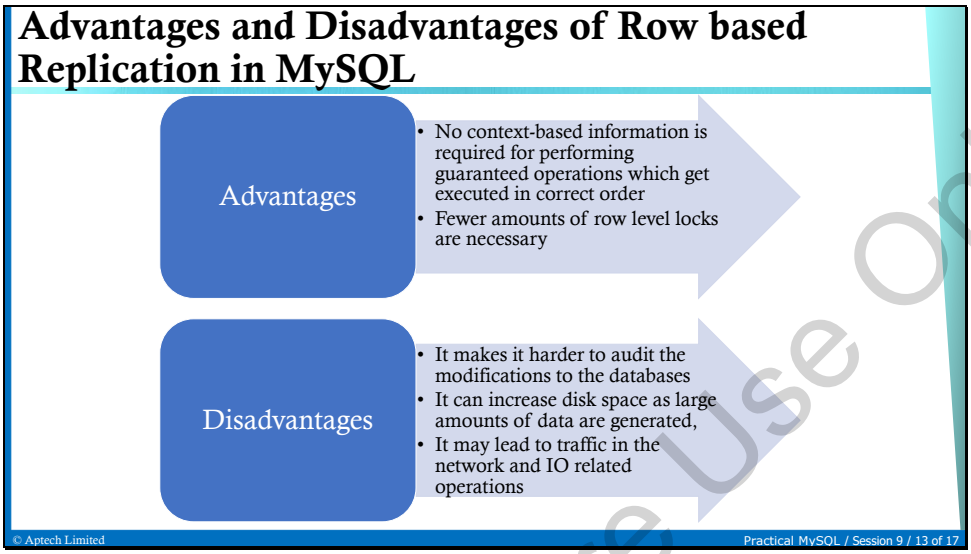
Instruction(s) of the trainer:
Using slide 12, explain the different ways to scale MySQL database.

Additional Information:

Refer to following link for more information:

- https://www.oracle.com/technetwork/community/developer-day/mysql-replication-scalability-403030.pdf

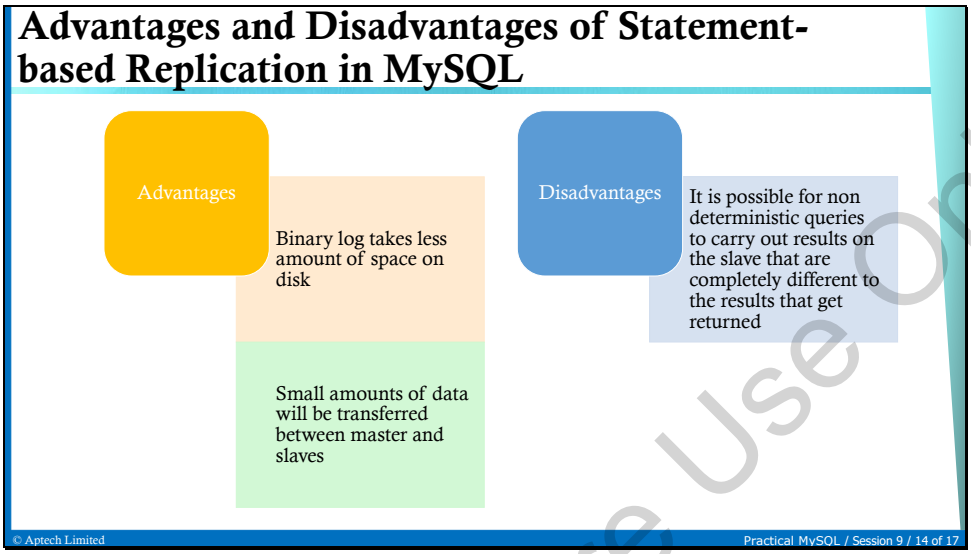
Slide 13



Instructions to the trainer:
Using slide 13, explain row based replication.
Discuss the advantages and disadvantages of row based replication in MySQL.

In-Class Question: What are the advantages of row based replication?
Answer: 1) All changes can be replicated.
2) Fewer amount of row level locks are necessary.

Slide 14



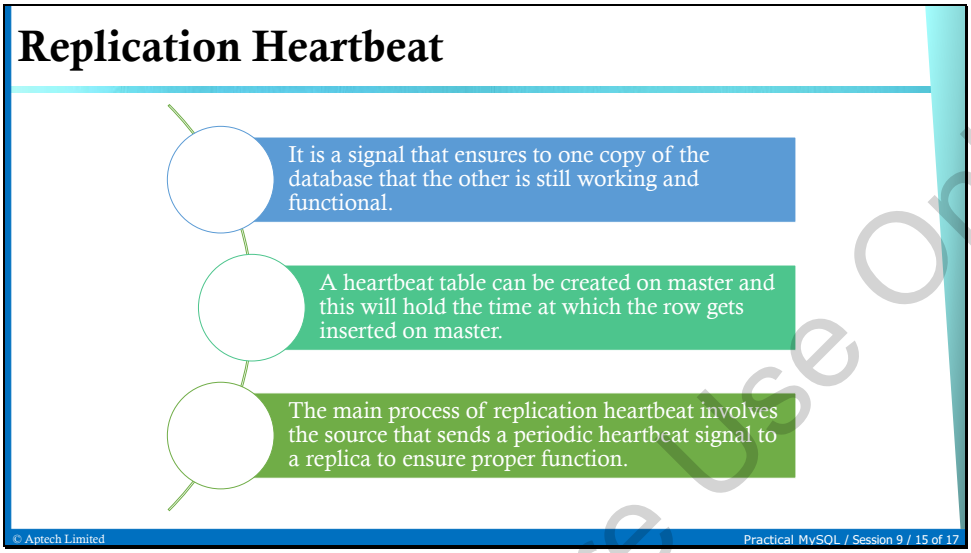
Instruction(s) to the trainer:
Using slide 14, explain statement-based replication.
Discuss the advantages and disadvantages of statement-based replication in MySQL.

Additional Information:

Refer to following links for more information:

- https://dev.mysql.com/doc/mysql-replication
- https://www.exploredatabase.com/2014/08/advantages-and-disadvantages-of-data-replication-in-distributed-databases.html

Slide 15



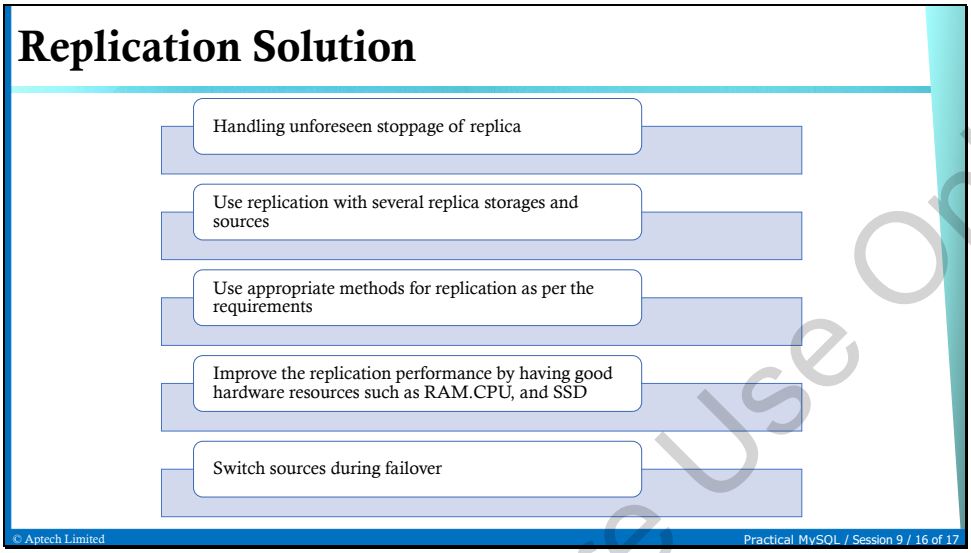
Instruction(s) to the trainer:
Using slide 15, explain the replication heartbeat.
Say that the main process of replication heartbeat involves the source that sends a periodic heartbeat signal to replica to ensure proper function.

Additional Information:

Refer to following links for more information:

- https://dev.mysql.com/doc/mysql-replication-excerpt/5.7/en/replication-administration-status.html
- https://docs.oracle.com/cd/E19623-01/820-6169/changing-heartbeat-interval.html

Slide 16



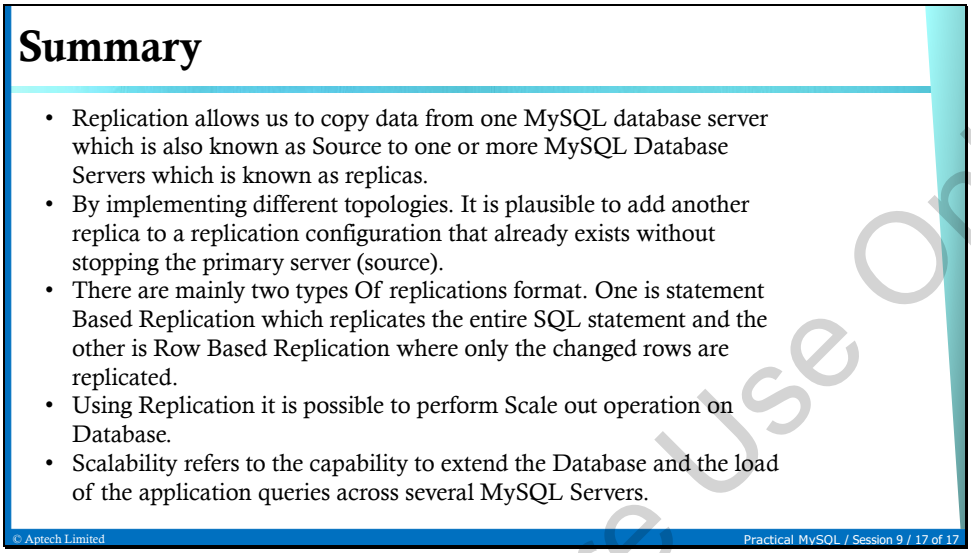
Instruction(s) to the trainer:
Using slide 16, discuss the solutions that can be used while performing replication.
Say that it is important to note that while performing scale-out solutions, there might be requirements to make some changes in logic and operations of application.

Additional Information:

Refer to following links for more information:

- https://dev.mysql.com/doc/mysql-replication-excerpt/5.7/en/replication-solutions.html
- https://www.ibm.com/analytics/data-replication

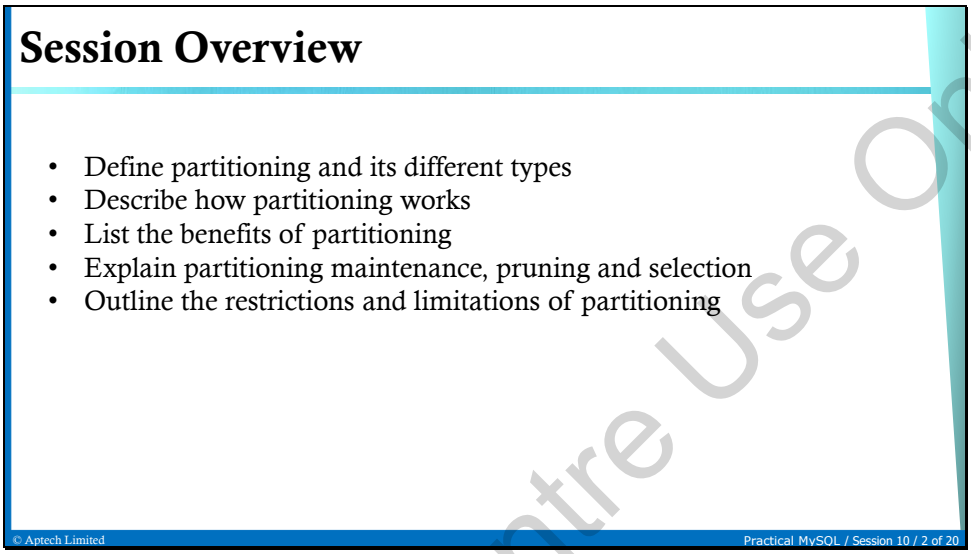
Slide 17



Use slide 17 to summarize the session. Tell the students pointers of the session. This will be a revision of the current session.

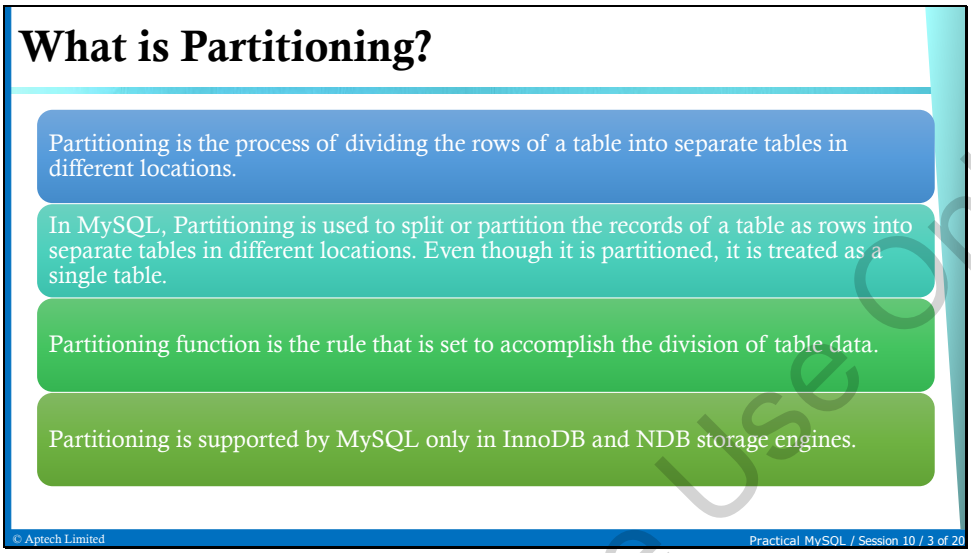
Session 10: Partitioning

Slide 2



Instruction(s) to the trainer:
Show slide 2 to the students and give them a quick overview of the current session and its goals. Inform students that the session will explain about partitioning and its different types. They will also learn the benefits and working of partitioning. The session also introduces them to partitioning maintenance, pruning, and selection along with its restrictions and limitations.

Slide 3



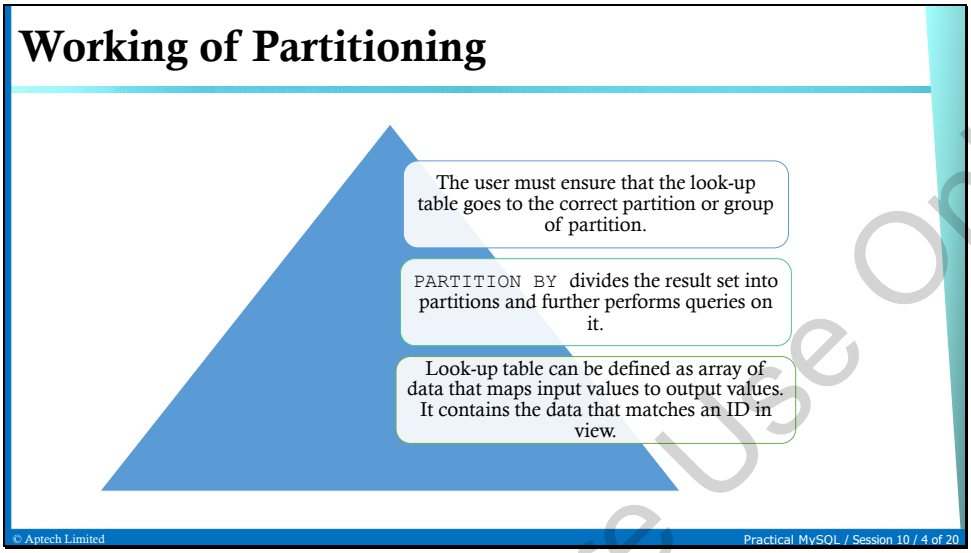
Instruction(s) to the trainer:

Show slide 3 to the students and explain partitioning. In MySQL, partitioning is used to divide or partition a table's rows into separate tables in different places, but the table is still viewed as a single table. It distributes chunks of the table's data over a file system according to the rules defined by the user. A partitioning function is a rule that we used to divide the table data. The chosen function is based on the user-defined partitioning type and takes as an argument as user-supplied phrase. Depending on the type of partitioning employed, the user expression can be a column value or a function acting on column values.

In-Class Question: What is the difference between partition and index?

Answer: Indexes are used to speed the search of data within tables. Partitions provide segregation of the data at the HDFS level, creating sub-directories for each partition. Partitioning allows the number of files read and the amount of data searched in a query to be limited.

Slide 4

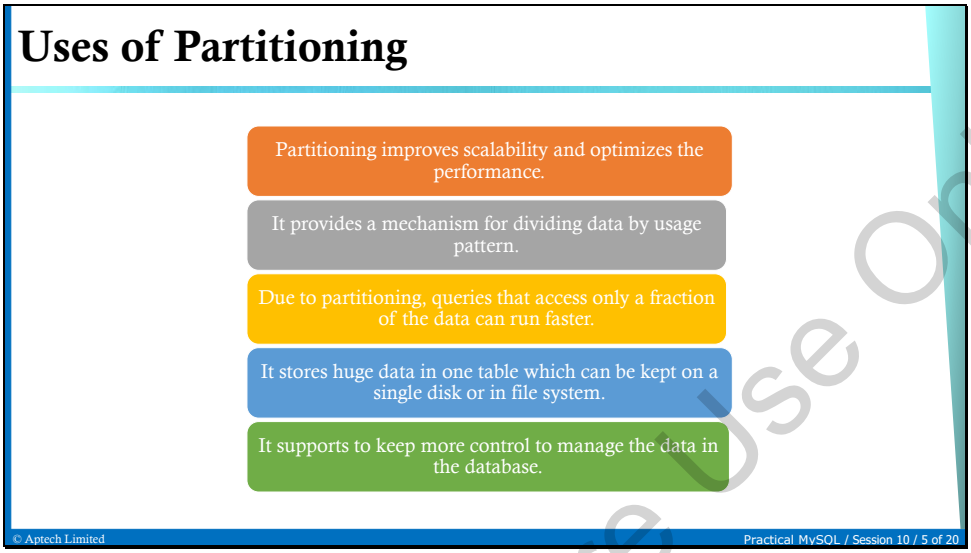


Instruction(s) to the trainer:

Show slide 4 and explain the working of partitioning with an example. The construct `TABLE` or `ALTER TABLE` statements in MySQL can be used to create a partition. The syntax for generating partitions using the `CREATE TABLE` command is as follows:

```
CREATE TABLE [IF NOT EXISTS] table_name
(column_definitions)
[table_options]
[partition_options]
```

Slide 5

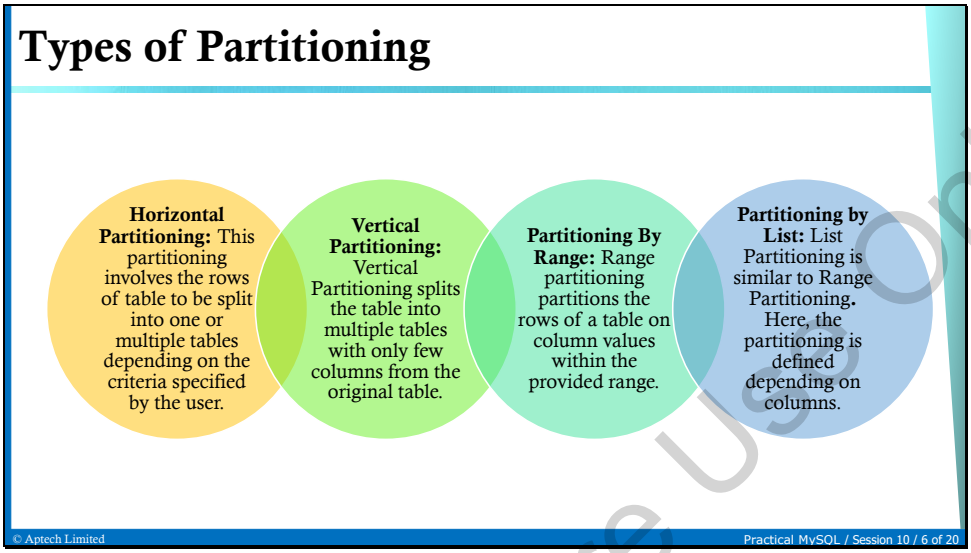


Instruction(s) to the trainer:
Show slide 5 and discuss the uses of partitioning in MySQL.

Tell them that,

- It improves query performance. When a user runs a query on the table, it only looks at the parts of the table that would fulfil the given statement.
- Large amounts of data can be stored in a single table that can be stored on a single disc or file system partition.
- It gives you more control over your database's data.
- Partitioning gives a database administrator additional flexibility over how data is handled within the database.
- A DBA can simplify the way certain data operations are conducted by intelligently designing partitions. A DBA can, for example, drop selected partitions in a partitioned table while leaving the others alone.

Slide 6



Instruction(s) to the trainer:

Show slide 6 and explain the types of partitioning in MySQL.

- **Horizontal Partitioning:** Based on rationale, this partitioning splits a table's rows into numerous tables. Each table in horizontal partitioning has the same number of columns, but there is no need to preserve the same number of rows. It separates the table physically, yet it is logically viewed as a whole. MySQL is the only database that currently supports partitioning. For example: A table containing ten years' worth of historical invoice data might be partitioned into ten unique partitions, each containing a single year's worth of data, as an example of horizontal partitioning.

- **Vertical Partitioning:** The table is partitioned into numerous tables, each with fewer columns than the original table. The remaining columns are stored in a separate table. Currently, MySQL does not support partitioning in this way. For Example**:** A table with a number of very wide text or BLOB columns that are not frequently addressed could be split into two tables, with the most frequently referenced columns in one table and the rarely referenced text or BLOB data in the other.

- **MySQL RANGE Partitioning:** This partitioning technique allows to divide a table's rows into groups based on column values that fall within a certain range. The specified range is always

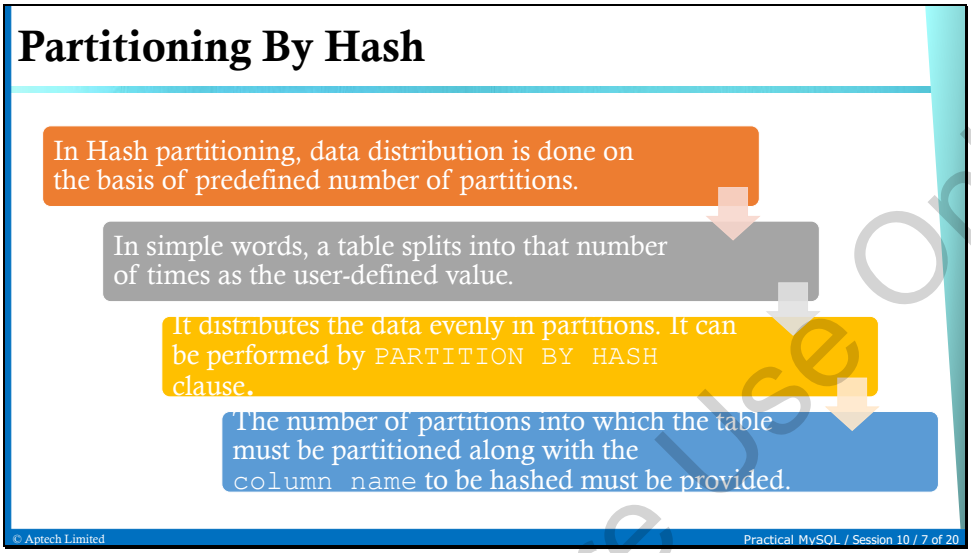
continuous, but should not overlap, and the ranges are defined using the `VALUES LESS THAN` operator. For Example: A DBA might build a partitioned table with three partitions, each containing data from the 1980s, 1990s, and anything after the year 2000.

- **MySQL LIST Partitioning:** In this partitioning, instead of a collection of contiguous values, the division is defined and selected, based on columns matching one of a set of discrete value lists. The `PARTITION BY LIST`(exp) clause is responsible for this. The exp is a column value or expression that returns an integer value. Each partition will be defined using the `VALUES IN`(value lists) statement. For Example**:** A DBA might build a partitioned table with three partitions based on the years 2004, 2005, and 2006.

In-Class Question: What is partitioning strategy?

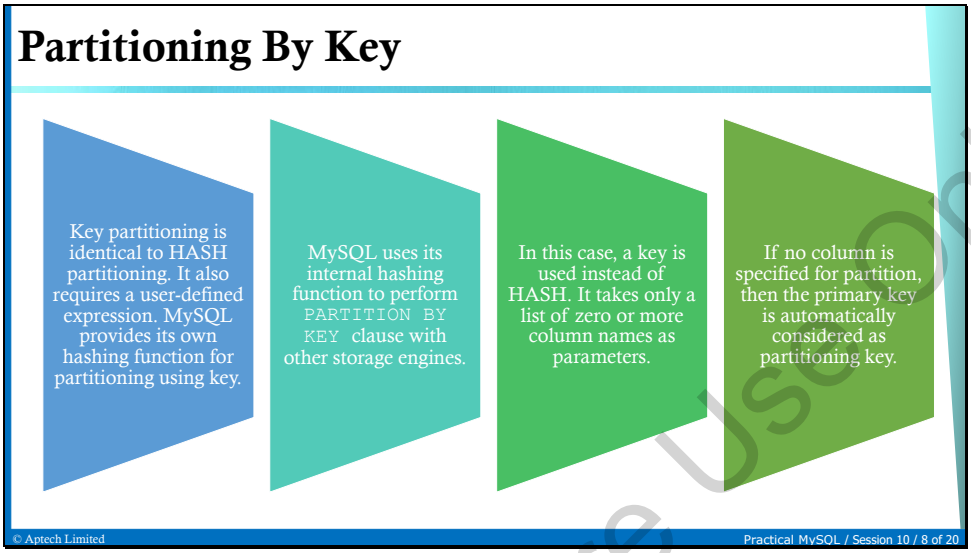
Answer: The partitioning approach is a way of breaking down huge additions into smaller, easier-to-do additions. Partitioning includes dividing integers into hundreds, tens, and units before adding them together. Separately, the hundreds, tens, and units are added.

Slide 7



Instruction(s) to the trainer:
Show slide 7 and explain about Hash partitioning. Tell them that Hash partitioning is generally used to ensure an even distribution of data across a set number of partitions.

Slide 8



Instruction(s) to the trainer:

Show slide 8 and explain them about the partitioning done by the Key. It is similar to Hash partitioning, in which the user-specified expression is used and the MySQL server provides the hashing function for the key. While using different storage engines, the MySQL server uses its own internal hashing function, which is done with the `PARTITION BY KEY` clause. User will utilize KEY instead of `HASH`, which can only accept a list of zero or more column names. If the table has a PRIMARY KEY and no partitioning column is given, the primary key is utilized as the Partitioning key.

Following example explains more clearly:

```
CREATE TABLE AgentDetail (
  agent_id INT NOT NULL PRIMARY KEY,
  agent_name VARCHAR(40)
)
PARTITION BY KEY()
PARTITIONS 2;
```

If the table has unique key, but do not contain the primary key, then a `UNIQUE_KEY` is used as a partition key.

```
CREATE TABLE AgentDetail (
  agent_id INT NOT NULL UNIQUE KEY,
```

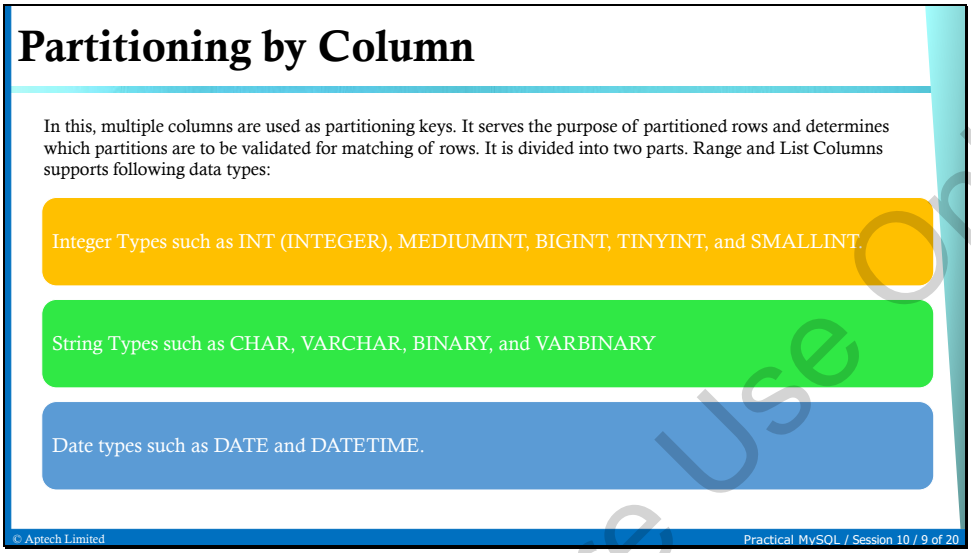
```
  agent_name VARCHAR(40)
)
PARTITION BY KEY()
PARTITIONS 2;
```

Additional Information:

Refer to following links for more information:

https://dev.mysql.com/doc/refman/5.7/en/partitioning-key.html
https://blog.toadworld.com/2017/07/06/table-partitioning-in-mysql

Slide 9



Instruction(s) to the trainer:
Show slide 9 and explain about partitioning by column. User can use many columns in partitioning keys using this partitioning.
These columns are used to separate the rows and determine which partition will be validated for matching rows. It is mostly separated into two categories:

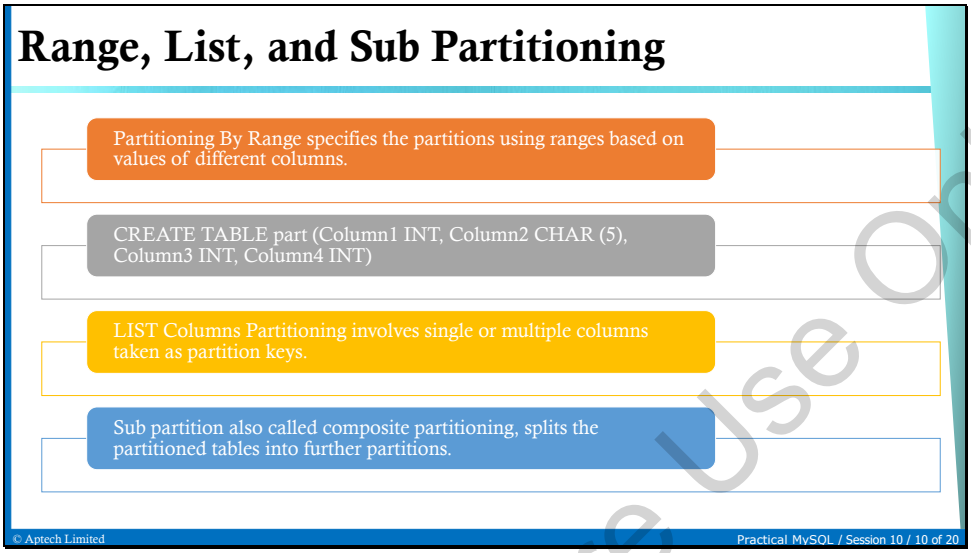
- RANGE Columns Partitioning
- LIST Columns Partitioning

They allow for the definition of ranges or value lists using non-integer columns.

Following data types are supported:

- **All Integer Types:** TINYINT, SMALLINT, MEDIUMINT, INT (INTEGER), and BIGINT.
- **String Types:** CHAR, VARCHAR, BINARY, and VARBINARY.
- DATE and DATETIME data types.

Slide 10



Instruction(s) to the trainer:
Show slide 10 and describe Range, List, and Sub Partitioning to students.

- **Range Partitioning:** Range partitioning is a sort of relational database partitioning in which the division is based on a preset range for a certain data column, such as IDs, dates, or basic values like currency. A partitioning key column is given a range, and when a data input falls within that range, it is assigned to that partition; otherwise, it is moved to another partition.

Range partitioning characteristics include:

- Each partition has an upper bound that is specific to it.
- Except for the first partition, each partition has a non-inclusive lower bound.

Following example demonstrate how to set up and use RANGE partitioning for MySQL performance:

```
CREATE TABLE customer_contract( cust_id INT NOT NULL, cust_fname
VARCHAR(30), cust_lname VARCHAR(30), st_dt DATE NOT NULL DEFAULT
'1970-01-01', end_dt DATE NOT NULL DEFAULT '9999-12-31',
contract_code INT NOT NULL, contract_id INT NOT NULL ) PARTITION
BY RANGE (contract_id) ( PARTITION p0 VALUES LESS THAN (50),
```

```
PARTITION p1 VALUES LESS THAN (100), PARTITION p2 VALUES LESS THAN
(150), PARTITION p3 VALUES LESS THAN (200) );
```

- **LIST Partitioning:** The distinction between RANGE and LIST partitioning is that in LIST partitioning, each partition is based on a certain column's specified list of values. User can do it with `PARTITION BY LIST` (EXPR), where EXPR is the specified column for list partitioning. Following is an example of LIST partitioning:

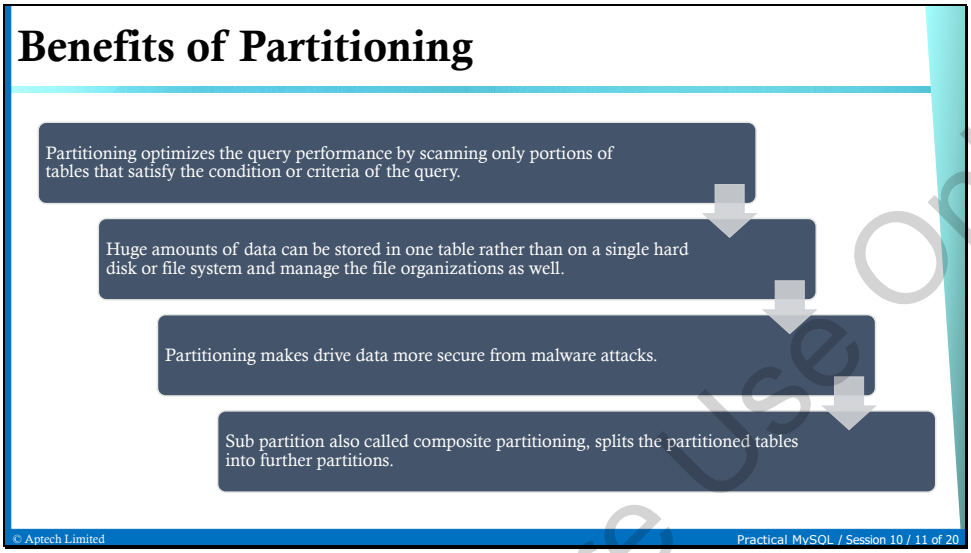
```
CREATE TABLE students ( student_id INT NOT NULL, student_fname
VARCHAR(30), student_lname VARCHAR(30), student_joined DATE NOT
NULL DEFAULT '1970-01-01', student_separated DATE NOT NULL DEFAULT
'9999-12-31', student_house INT, student_grade_id INT ) PARTITION
BY LIST(student_grade_id) ( PARTITION P1 VALUES IN (1,2,3,4),
PARTITION P2 VALUES IN (5,6,7), PARTITION P3 VALUES IN (8,9,10),
PARTITION P4 VALUES IN (11,12) );
```

- **SUB Partitioning:** SUB Partitioning, also known as composite partitioning, is a method of partitioning a table by combining RANGE and HASH for better results.

Following example explains SUB Partitioning:

```
CREATE TABLE purchase (id INT, item VARCHAR(30), purchase_date
DATE) PARTITION BY RANGE( YEAR(purchase_date) ) SUBPARTITION BY
HASH( TO_DAYS(purchase_date) ) SUBPARTITIONS 2 ( PARTITION p0
VALUES LESS THAN (2000), PARTITION p1 VALUES LESS THAN (2010),
PARTITION p2 VALUES LESS THAN MAXVALUE );
```

Slide 11

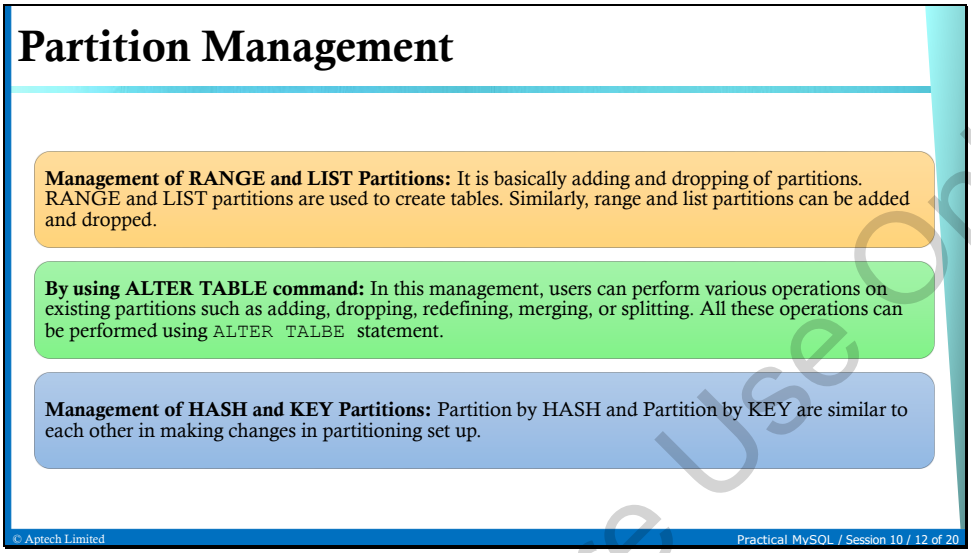


Instruction(s) to the trainer:
Show slide 11 and list and explain all the benefits of partitioning.

Following are some of the benefits of using partitions:

- More data can be stored in a single table than stored on a single disc or file system partition.
- Deletion: Dropping a useless partition takes seconds, whereas running a traditional `DELETE` query in a huge table can take minutes.
- Partition Pruning: This feature allows you to exclude non-matching partitions and their data from a search, which speeds up queries.

Slide 12



Instruction(s) to the trainer:
Show slide 12 and brief about partition management in MYSQL. Tell students that this is the process of partitioning the data in different ways such as RANGE and LISTS
Partitions, HASH and KEY partitions, sub-portioning, and so on.

In Management of RANGE and LIST Partitions, adding and dropping of partitions are handled. RANGE and LIST partitions are used to create tables. Similarly, range and list partitions can be added and dropped. Inform students that in this management, users can perform various operations on existing partitions such as adding, dropping, redefining, merging, or splitting. All these operations can be performed using `ALTER TALBE` statement.

The `ALTER TABLE` command with the DROP PARTITION option can be used to drop a partition from a table that is partitioned by either RANGE or LIST.

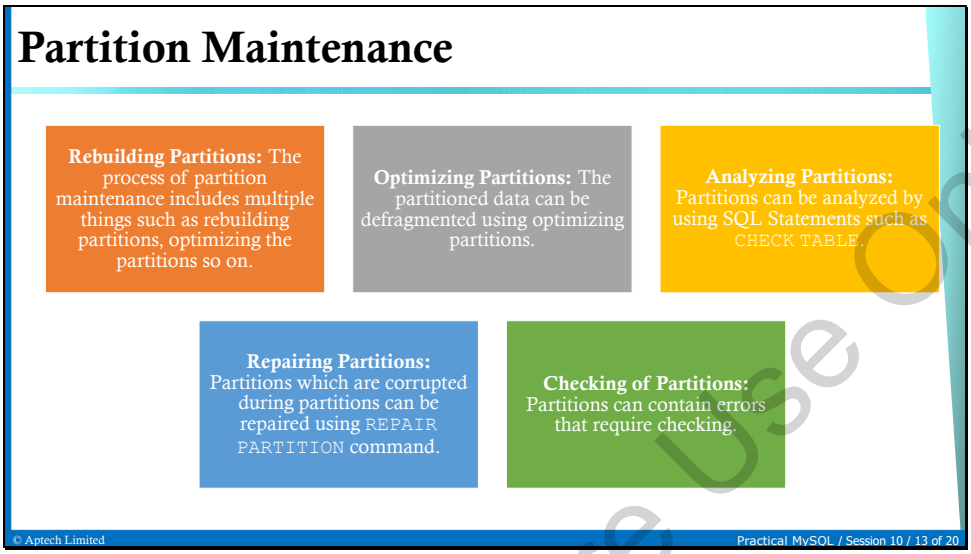
Inform students that partition by HASH and partition by KEY are similar to each other in making changes in partitioning set up. `ALTER TABLE` statement is used for Management of Hash and Key partitions.

Additional Information:

Refer to following links for more information:

https://dev.mysql.com/doc/refman/8.0/en/partitioning-management.html
https://dev.mysql.com/doc/refman/5.7/en/partitioning-management.html

Slide 13



Instruction(s) to the trainer:
Using slide 13, brief about partition maintenance in MYSQL. SQL statements designed for this purpose can be used to perform a variety of table and partition maintenance operations on partitioned tables.

The statements `CHECK TABLE`, `OPTIMIZE TABLE`, `ANALYZE TABLE`, and `REPAIR TABLE`, which are supported for partitioned tables, can be used to maintain partitioned tables.

User can utilize a number of `ALTER TABLE` extensions to perform operations of this type directly on one or more partitions, as specified in the following list:

- **Rebuilding partitions**: Rebuilds the partition; this has the same effect as deleting and then re-inserting all of the partition's entries. This can be beneficial in terms of defragmentation.
  Syntax: `ALTER TABLE t1 REBUILD PARTITION p0, p1;`

- **Optimizing Partitions:** User can use `ALTER TABLE... OPTIMIZE PARTITION` to reclaim any unused space and defragment a partitioned table with variable-length rows (that is, having VARCHAR, BLOB, or TEXT columns) if you have deleted a large number of rows from a partition or if you have made many changes to a partitioned table with variable-length rows.
  Syntax: `ALTER TABLE t1 OPTIMIZE PARTITION p0, p1;`

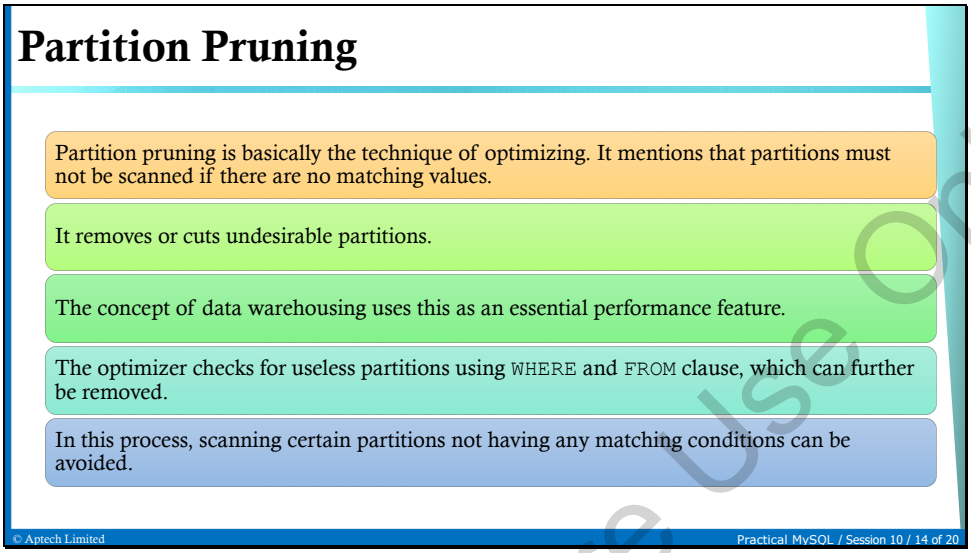
- **Analyzing partitions:** This reads and stores the key distributions for partitions. For partitioned tables, `ANALYZE TABLE` is supported, and `ALTER TABLE`... To examine one or more partitions, use the `ANALYZE PARTITION` command.
  Syntax: `ALTER TABLE t1 ANALYZE PARTITION p3;`

- **Repairing partitions:** This restores partitions that have been corrupted.
  Syntax: `ALTER TABLE t1 REPAIR PARTITION p0,p1;`

- **Checking partitions**: The user can use `CHECK TABLE` to check partitions for problems in the same manner that you can with non-partitioned tables.
  Syntax: `ALTER TABLE trb3 CHECK PARTITION p1;`

In-Class Question: Does DB partitioning improve performance?
Answer: Partitioning can make managing huge tables easier while also improving scalability and availability. Improved query performance might also be a side effect of partitioning.

Slide 14



Instruction(s) to the trainer:
Show slide 14 and explain about partition pruning. The partition pruning optimization is based on a relatively simple notion that can be summarized as 'Do not scan partitions when no matching values are possible.'

Assume following line creates a partitioned table t1:

```
CREATE TABLE t1 ( fname VARCHAR(50) NOT NULL, lname VARCHAR(50)
  NOT NULL, region_code TINYINT UNSIGNED NOT NULL, dob DATE NOT
  NULL ) PARTITION BY RANGE( region_code ) ( PARTITION p0 VALUES
  LESS THAN (64), PARTITION p1 VALUES LESS THAN (128), PARTITION
  p2 VALUES LESS THAN (192), PARTITION p3 VALUES LESS THAN MAXVALUE
  );
```

Assume that following statement is used to get results from a `SELECT` statement:d

```
SELECT fname, lname, region_code, dob FROM t1 WHERE region_code >
  125 AND region_code < 130;
```

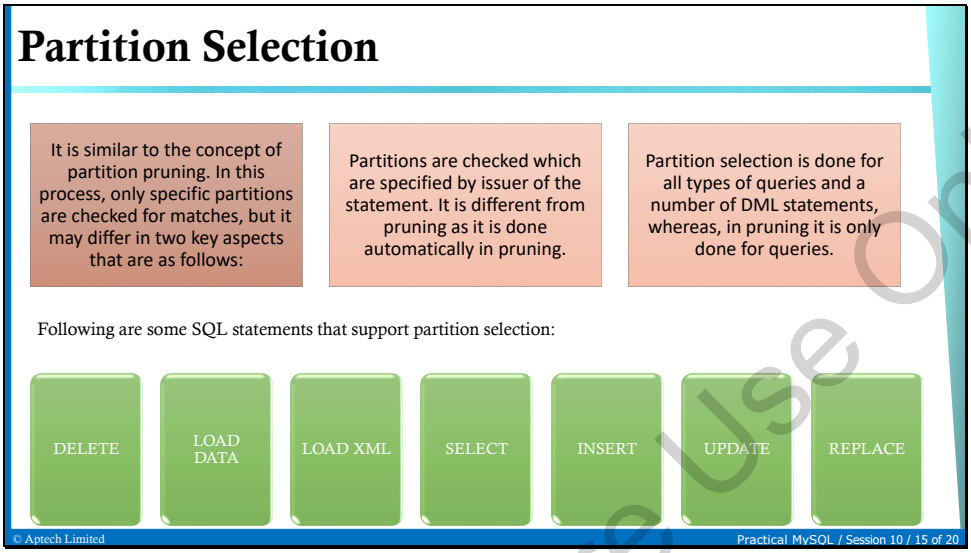
It is clear that none of the rows that should be returned are in partitions p0 or p3; therefore, user only need to look in partitions p1 and p2 to discover matching rows. It is feasible to locate matched rows in considerably less time and effort by narrowing the search rather than scanning

all partitions in the table. Pruning is the process of 'cutting away' superfluous partitions. When the optimizer can use partition pruning to execute this query, it can be an order of magnitude faster than executing the same query against a non-partitioned table with identical column definitions and data.

```
partition_column = constant
partition_column IN (constant1, constant2, ..., constantN)
```

The optimizer simply evaluates the partitioning equation for the given value, identifies which partition holds that value, and scans only that partition in the first case. In many circumstances, the equal sign can be replaced with another arithmetic comparison, such as, >,=, >=, and>. Partition pruning can be used in some queries that employ `BETWEEN` in the `WHERE` clause.

Slide 15



Instruction(s) to the trainer:
Show slide 15 and explain them about partition selection. SQL statements supporting explicit partition selection are listed here:

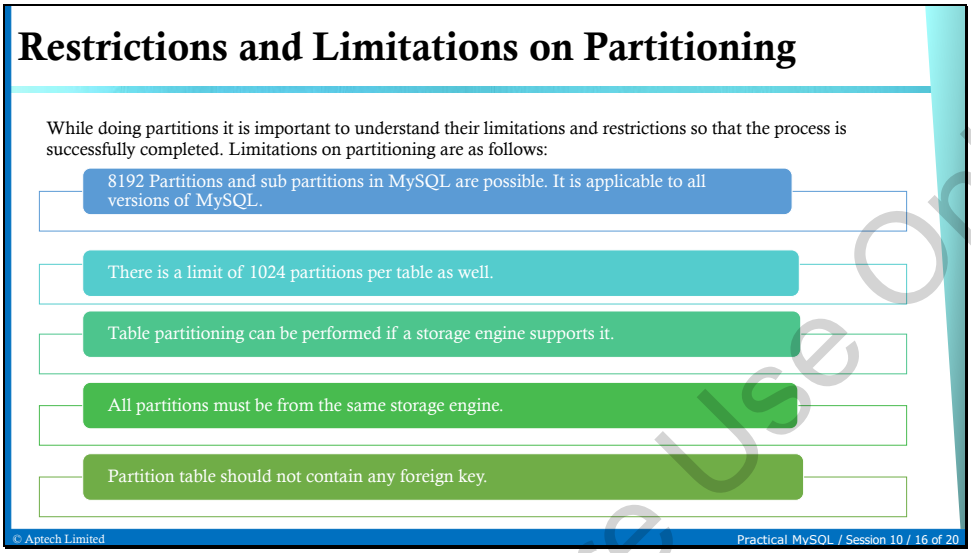
- SELECT
- DELETE
- LOAD DATA
- LOAD XML
- INSERT
- UPDATE
- REPLACE

A partition option is used to implement explicit partition selection. This option uses following syntax for all supported statements:

```
PARTITION (partition_names) partition_names: partition_name, ...
```

The name of the table to which the partition or partitions belong is always followed by this option. Partition name is a list of partitions or sub-partitions to utilize, are separated by commas. Each name in this list must be the name of an existing partition or sub-partition of the provided table; if any of the partitions or sub-partitions are not discovered, the statement fails. Partitions and sub-partitions named in partition names can be listed in whatever order they want, and they can overlap.

Slide 16

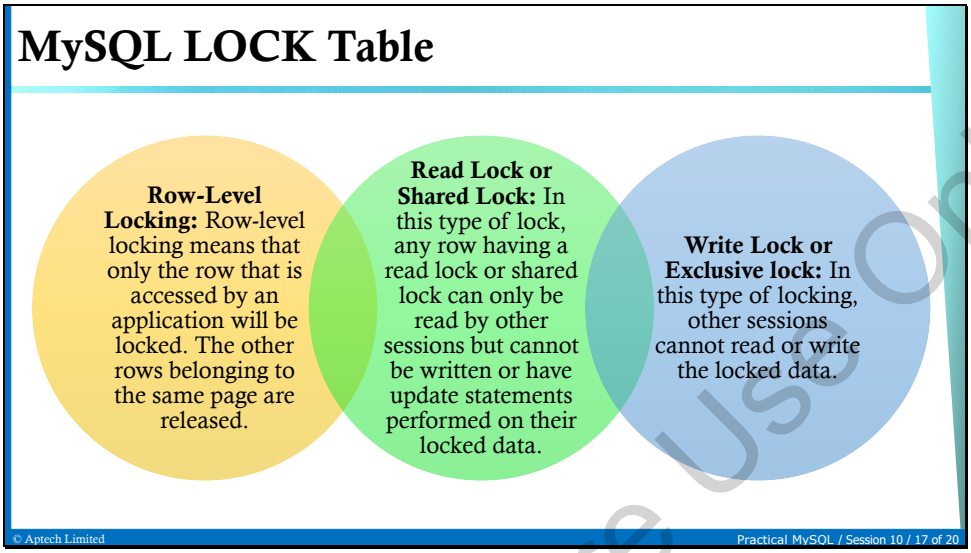


Instruction(s) to the trainer:
Show slide 16 and discuss about restrictions and limitations while using partitioning. List the limitations given on slide and explain each of them in detail.

List the following restrictions and inform that these restrictions are important to analyze so that the process is successfully completed:

- Stored routines or plugins are not allowed in partitioning expression.
- Variables that have been declared or variables that have been entered by the user.
- Operators for arithmetic and logic. In partitioning expressions, the arithmetic operators +, -, and * are allowed. However, except in the case of [LINEAR] KEY partitioning, the result must be an integer value or NULL.
- The bit operators |, &, <<,>>are not permitted in partitioning expressions.
- Tables with user-defined partitioning do not keep the SQL mode that was in effect when they were created. The outcomes of several MySQL functions and operators can vary depending on the server SQL mode.

Slide 17



Instruction(s) to the trainer:
Show slide 17 and explain MySQL LOCK Table. Inform that,

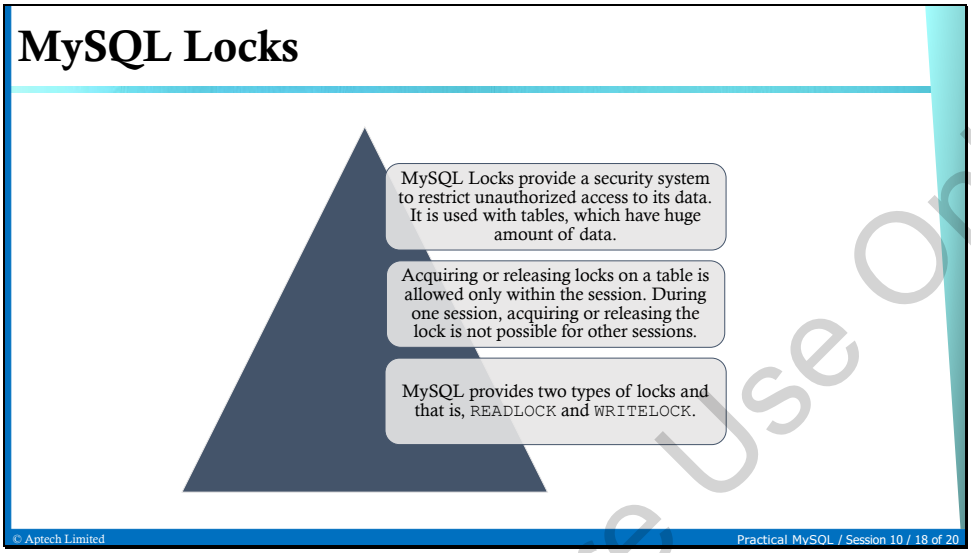
- Client sessions can deliberately acquire table locks to cooperate with other sessions for table access or to prohibit other sessions from altering tables during periods when a session requires exclusive access to them.
- Only a single session can acquire or release locks.
- A session cannot get locks for another session or release locks that another session has.
- Locks can be used to simulate transactions or to improve the speed with which tables are updated.
- LOCK TABLES obtains table locks for the current client session explicitly.
- For base tables and views, table locks can be obtained.
- For each object to be locked, you must have the LOCK TABLES and SELECT privileges.
- LOCK TABLES adds all base tables used in the view to the set of tables to be locked and locks them automatically when the view is locked.
- LOCK TABLES verifies that the view definer (for SQL SECURITY DEFINER views) or invoker (for all views) has the appropriate privileges on the tables underlying any locked view.
- If user use LOCK TABLES to lock a table explicitly, any trigger tables are likewise locked implicitly, as discussed in LOCK TABLES and Triggers.

Additional Information:

Refer to following links for more information:

https://dev.mysql.com/doc/refman/8.0/en/lock-tables.html#:~:text=MySQL%20enables%20client%20sessions%20to,release%20locks%20only%20for%20itself.
https://dev.mysql.com/doc/refman/8.0/en/table-locking.html

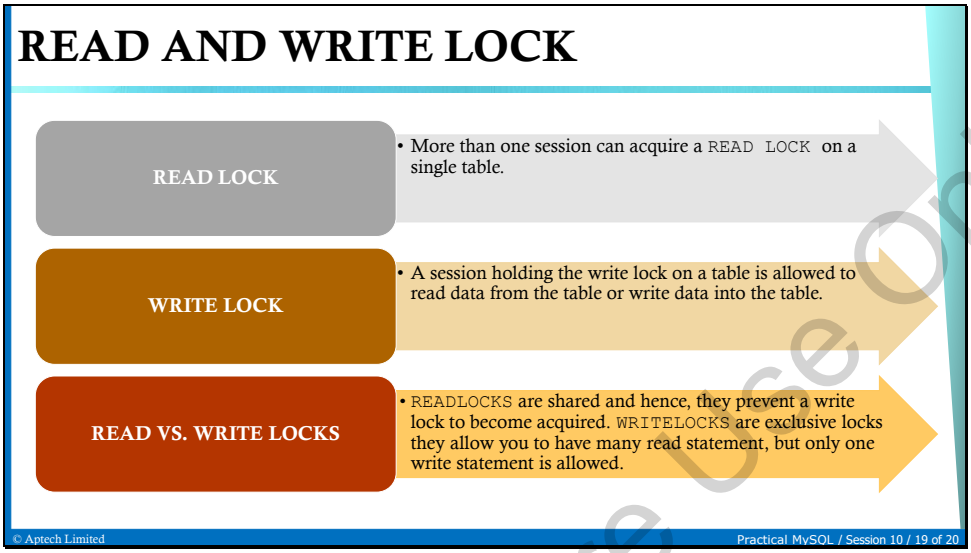
Slide 18



Instruction(s) to the trainer:
Show slide 18 and explain them about MySQL Locks. A table lock is a mechanism that prevents unauthorized access to the data stored in the table. MySQL allows a client session to acquire a table lock in order to share the table's contents with other sessions. MySQL also supports table locking, which prevents unauthorized changes to the same table within a specified time period. In MySQL, a session can only acquire or release locks on the table for itself. As a result, one session will not be able to acquire or release table locks for other sessions. It is worth noting that table locking requires `TABLE LOCK` and `SELECT` rights. In MySQL, table locking is primarily used to tackle concurrency issues. It will be utilized to complete a transaction.

In-Class Question: Does MySQL lock on select?
Answer: On InnoDB tables, `SELECT`s do not generally perform any locking that you worry about. Selects do not lock things when the transaction isolation level is set to the default.

Slide 19



Instruction(s) to the trainer:
Show slide 19 and tell students that there are two types of table locks provided by MySQL.

READ LOCK: If a table has a READ LOCK by some session, then other sessions cannot perform write operations in that table. Write operation cannot be performed on a table by sessions not acquiring a READ LOCK. To perform a write operation, the READ LOCK must be released. If a session is terminated by any user or abnormally terminated, MySQL releases all types of locks. The table can be locked for read operations by executing following command:

```
LOCK TABLE Customer READ;
```

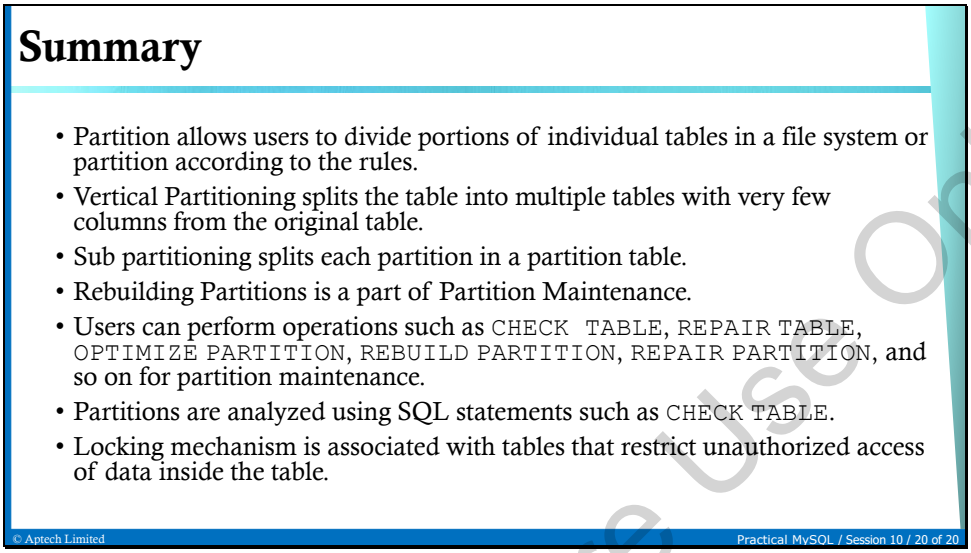
WRITE LOCK: This lock allows a user to read and write into a table at the same time. It is worth noting that MySQL's default storage engine is InnoDB. Because MySQL uses row-level locking for InnoDB tables, the InnoDB storage engine does not require explicit table locking. As a result, several read and write operations can be done on the same table at the same time without having to wait for each other. Table locking is used by all other storage engines except MySQL.

Additional Information:

Refer to following links for more information:

https://www.geeksforgeeks.org/readwritelock-interface-in-java/
https://jenkov.com/tutorials/java-concurrency/read-write-locks.html

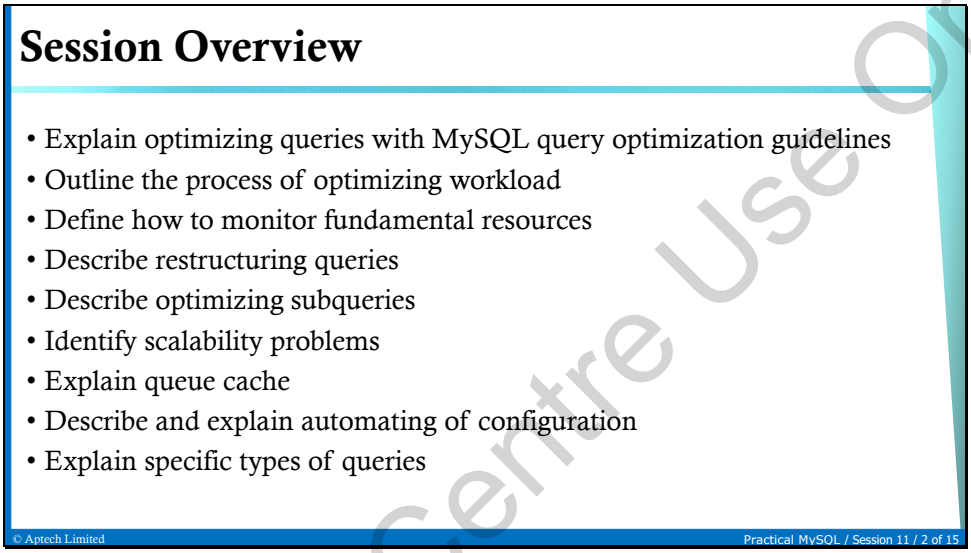
Slide 20



Use slide 20 to summarize the session. End the session, with a brief summary of what has been taught in the session. Tell the students pointers of the session. This will be a revision of the current session.

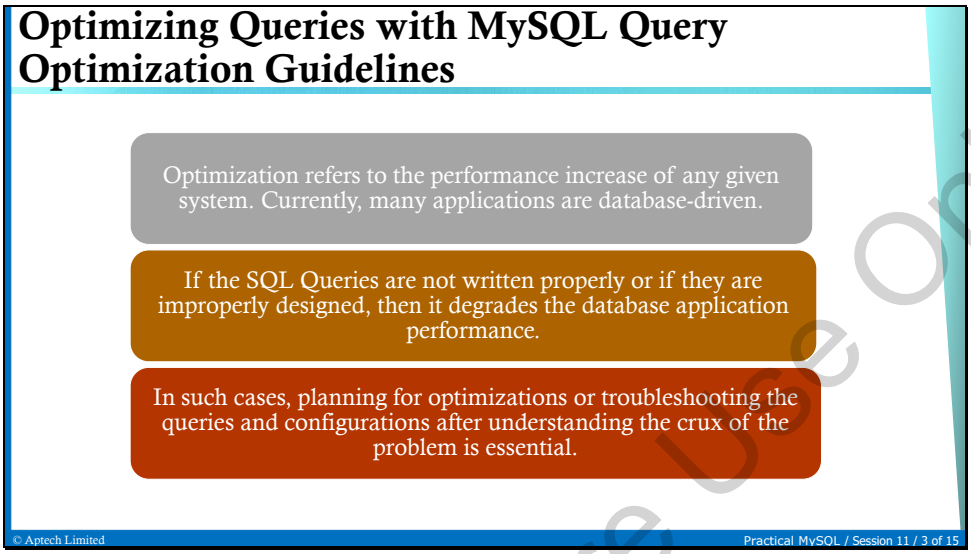
Session 11: Performance Optimization in MySQL

Slide 2



Instruction(s) to the trainer:
Show slide 2 and give students a brief overview of the current session and the session objectives. Inform students that this session explains the concept of Performance Optimization in MySQL, describe how to restructure queries, optimizing subqueries, and how to identify scalability problems in MySQL. Inform that they will learn about Queue cache, automating of configuration, and specific type of queries.

Slide 3



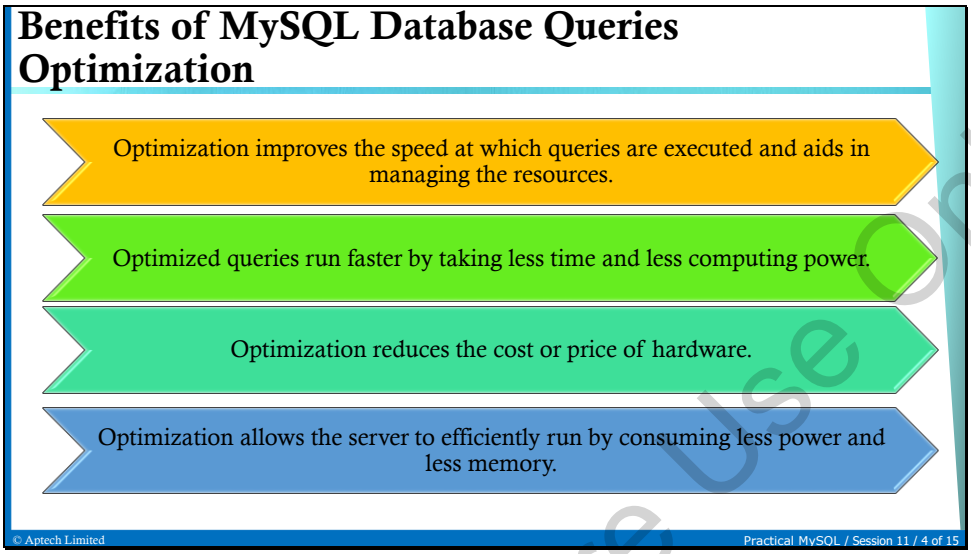
Instruction(s) to the trainer:
Show slide 3 and give students an explanation on Optimizing Query practices with MySQL Query.

Tell students that, for optimizing query they should begin by double-checking all WHERE, JOIN, ORDER BY, and GROUP BY clause predicates are indexable. WebSphere Commerce prioritizes indexing predicates to increase SQL performance. As poor indexing of SQL queries can lead to table scans, which can cause locking and other issues.

As a result, indexing all predicate columns for MySQL query optimization can benefit the database. Functions should not be included in predicates. The database does not use an index if a column has a function predefined in it.

In-Class Question: Why is query optimization needed?
Answer: Query optimization allows more efficient query processing. It has a low cost per query. The database is less stressed as a result. It ensures the system's high performance.

Slide 4

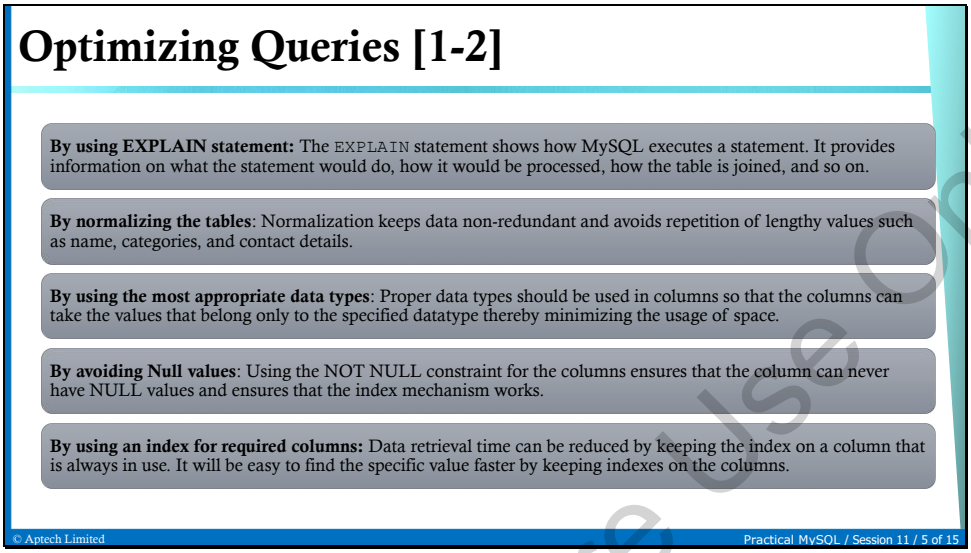


Instruction(s) to the trainer:
Show slide 4 and explain the benefits of using MySQL database queries in Optimization process.

- User prioritizes speed and efficiency. Queries that have been optimized can run faster and use less computational power.
- For starters, it gives the faster results, making the application appear to be more fast.
- As each request takes less time than un-optimized queries, the system can handle more enquiries in the same amount of time.
- Query optimization decreases the amount of impairment on the server's hardware (for example, disc drives) and allows it to run more efficiently (for example, lower power consumption and less memory usage).

In-Class Question: What affects SQL query performance?
Answer: Data volume and transaction concurrency have an impact on query performance. Executing the same query on a table with millions of records takes longer than doing the same operation on a table with just a few thousand records. SQL Server performance can be harmed by a large number of concurrent transactions.

Slide 5



Instruction(s) to the trainer:
Show slide 5 and explain students about Optimizing Queries, Index Columns used in the `WHERE`, `ORDER BY`, and `GROUP BY` clauses.

Consider following SQL query, which is being executed from a database with 500 rows and no index:

```
<mysql> select customer_id, customer_name from customers where
   customer_id='665247';
```

Here, the query will cause MySQL to perform a full table scan (from beginning to end) to retrieve the record user is looking for.

Fortunately, MySQL offers a specific `EXPLAIN` statement that you may use to evaluate your queries alongside `SELECT`, `DELETE`, `INSERT`, `REPLACE`, AND `UPDATE` commands.
MySQL shows information from the optimizer about the anticipated execution plan when user attaches the query before a SQL statement.

Normalizing Tables: First, even if it means certain trade-offs, standardize all database tables. For example, if user is constructing two databases to store customer data and orders, user should

refer to the customer on the orders table by their customer id rather than repeating the client's name. User’s database will bloat when delayed.

Use Optimal Data Types: Among the data types supported by MySQL are integer, float, double, date, date-time, varchar, and text. Inform students that when it comes to the table design, remember that ‘shorter is usually better.’ For example, if the user is creating a system user's table with fewer than 100 users, the user should utilizes the 'TINYINT' data type for the 'user id' field because it can handle any value from -128 to 128. Also, if a field expects a date value (for example, sales order date), a date-time data type is ideal since, it eliminates the need to run expensive methods to convert the field to date when obtaining records using SQL.

Avoid Null Values: The absence of any value in a column is known as null. This type of number should be avoided as much as possible because it can affect your database findings. For example, if the user wishes to retrieve the sum of all orders in a database but one of the order records has a null amount unless use MySQL's 'ifnull' statement returns an alternate value if a record is null, the intended result may misbehave. If records do not have to have a mandatory value for that particular column/field, the user may need to provide a default value for that field.

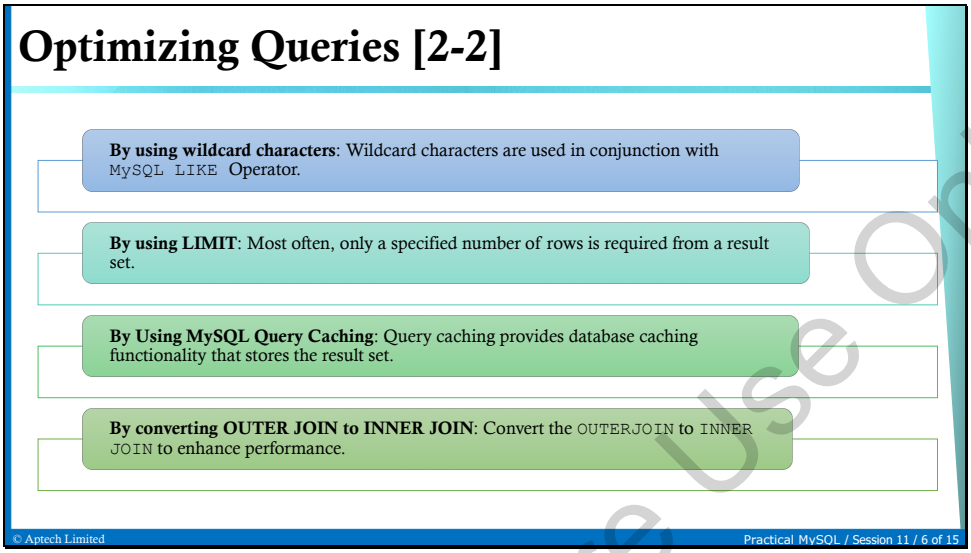
Avoid Too Many Columns: Wide tables can be very costly and take a lot of CPU time to process. If at all feasible, do not exceed a hundred unless business logic clearly requires it. Inform students to consider dividing the table into logical components rather than one large table. For example, if the user is constructing a customer database and realize that a customer can have several addresses, it is better to create a separate record for addresses that refer back to the customers table via the 'customer id' field.

Additional Links:

Refer to following links for more information:

https://www.cloudways.com/blog/mysql-performance-tuning/
https://dzone.com/articles/how-to-optimize-mysql-queries-for-speed-and-performance

Slide 6



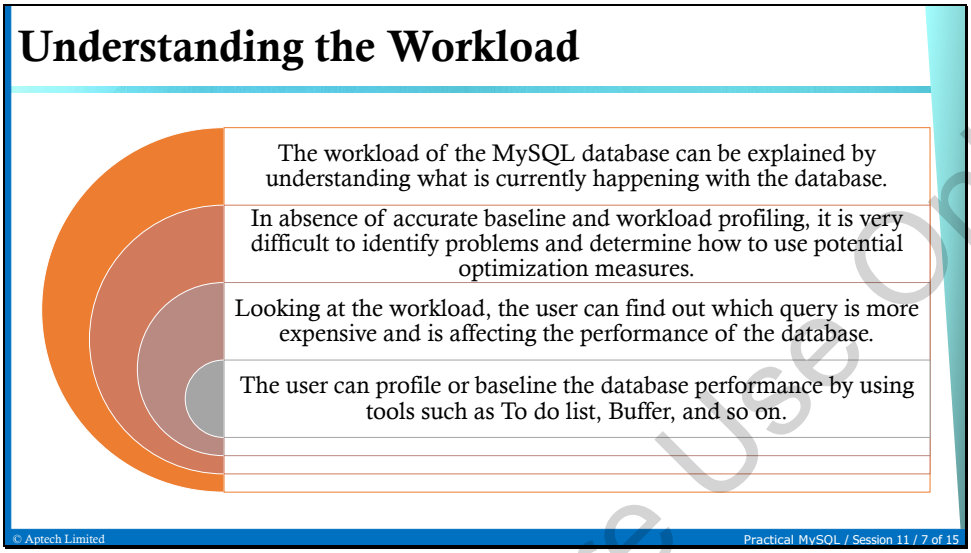
Instruction(s) to the trainer:
Show slide 6 and explain students about Optimizing Queries.

- Leading Wildcards: When a query has a leading wildcard, MySQL is unable to use indexes.

- Optimize Joins: In Join statements, use fewer tables if possible. It is possible that a SQL query with a bad pattern and a lot of joins would not work. As a general guideline, each query should have at least a dozen joins.

- MySQL Query Caching: If a Website or program conducts a lot of select queries, the user should use MySQL query caching. When reading operations are performed, this will improve performance. The technology works by caching the select query as well as the data set. Because the query is fetched from memory if it is executed more than once, it runs faster. However, if the application often refreshes the table, any cached queries and result sets will be invalidated.

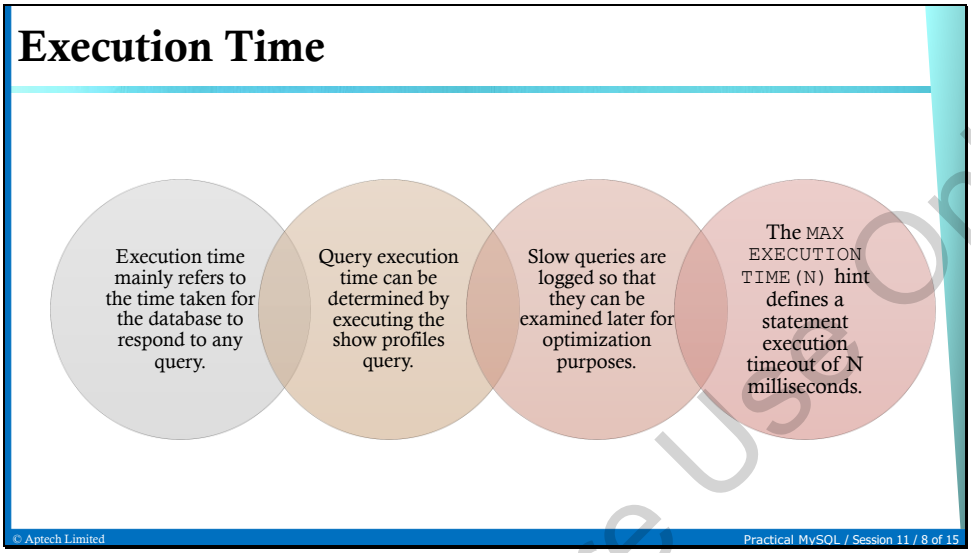
Slide 7



Instruction(s) to the trainer:
Show slide 7 and give students a brief introduction to the workload in MySQL. Similar to other relational databases, it is a sophisticated database that can come to a halt at any time, leaving applications in the lurch and putting the business at risk. The truth is that most MySQL speed issues are caused by common errors. It is critical to eradicate these errors, which are typically masked by nuance in the workload or a configuration trap, to guarantee that MySQL server runs at full speed and provides steady and consistent performance.

The best approach to figure out how a server spends its time is to look at its workload profile. Users can reveal the most expensive queries for additional tweaking by evaluating their workload. When user runs a query against the server, the only thing that matters is how quickly it completes, time is the most significant metric. The easiest method to profile workload is to use a tool such as MySQL Enterprise Monitor's query analyzer or Percona Toolkit's pt-query-digest. These tools capture server queries and return a table of tasks organized by decreasing response time, bringing the most expensive and time-consuming processes to the top so that users can understand where to focus their efforts.

Slide 8



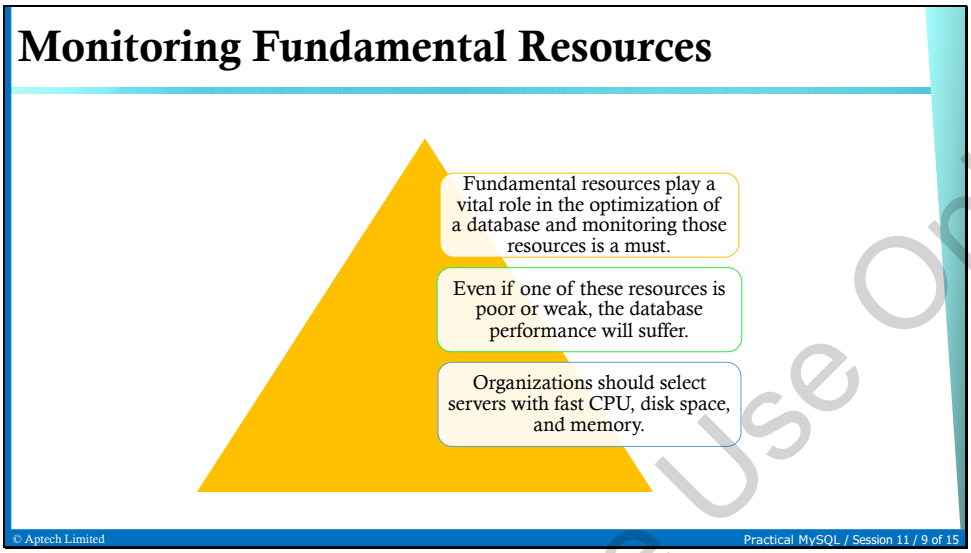
Instruction(s) to the trainer:
Show slide 8 and explain students about Execution Time in MySQL.
Only `SELECT` statements are allowed to use the `MAX EXECUTION TIME` hint. It sets a timeout value of N milliseconds on how long a statement can run before being terminated by the server.

`MAX_EXECUTION_TIME(N)`
`MAX EXECUTION TIME(N)` hint specifies an N-millisecond statement execution timeout. If this option is not specified or N is 0, the statement timeout determined by the system variable max execution time is used.

`MAX EXECUTION TIME` tip is useful in the following situations:

- `MAX EXECUTION TIME` applies to the entire statement and must appear after the first `SELECT` keyword in statements containing multiple `SELECT` keywords, such as unions or statements with subqueries.
- It applies to `SELECT` statements that are read-only.
- Statements that invoke a stored function that affects data as a side effect are not read only.
- It is ignored when it comes to `SELECT` statements in stored programmes.

Slide 9



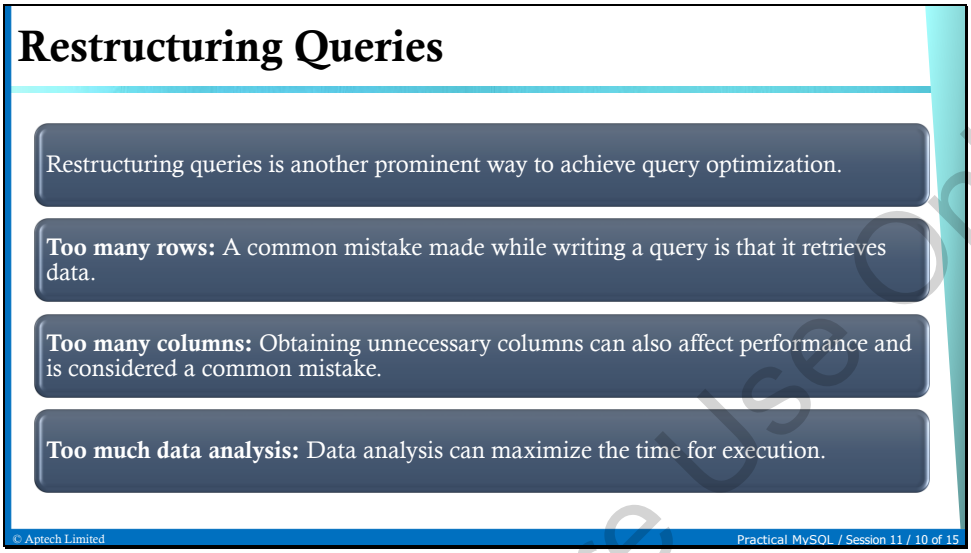
Instruction(s) to the trainer:
Show slide 9 and explain students about monitoring fundamental resources in MySQL. Inform students that major technology giants such as Microsoft, Google, and Amazon offer systems that are completely configurable. These systems are called virtual machines. The CPU, memory, disk space, and all facets of the system are changeable even after deployment. Instead of spending on hardware, most companies around the world have started relying on virtual machines for their hardware requirement.

Additional Links:

Refer to following links for more information:

https://www.metricfire.com/blog/a-modern-guide-to-mysql-performance-monitoring/
https://www.mysql.com/products/enterprise/monitor-features.html

Slide 10



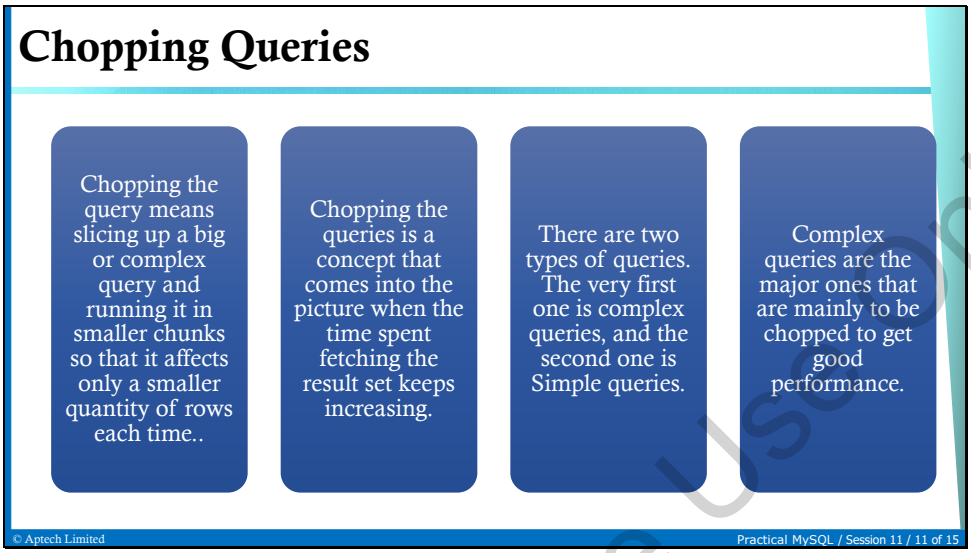
Instruction(s) to the trainer:
Show slide 10 and explain students about restructuring queries in MySQL. As user has the ability to restructure problematic queries, first priority should be to find a different way to get the desired outcome. User can convert the query into its equivalent form while processing it, bearing in mind the internal effect in the MySQL server. One option to make in query design is whether to prioritize one complex query over multiple simple queries or vice versa. The traditional database design strategy is to perform as many tasks as feasible with as few queries as possible. The rationale for this is that creating a database connection with a single large/complex query is more cost effective. Network consumption, query processing/optimization, and resource utilization are all advantages of cost reduction in favor of sophisticated queries.

Additional Information:

Refer to following links for more information:

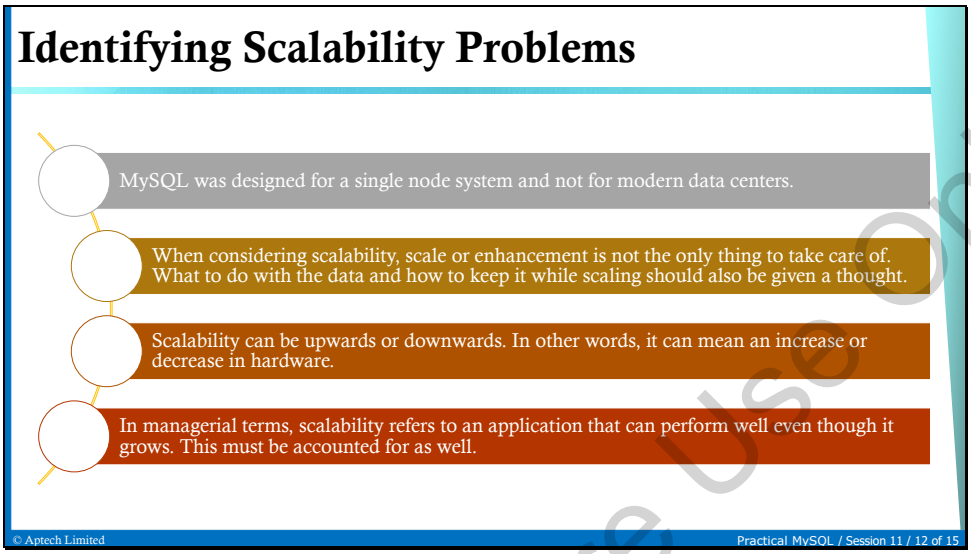
https://stackoverflow.com/questions/37400242/need-help-restructuring-a-query
https://dev.mysql.com/doc/refman/5.7/en/key-cache-restructuring.html

Slide 11



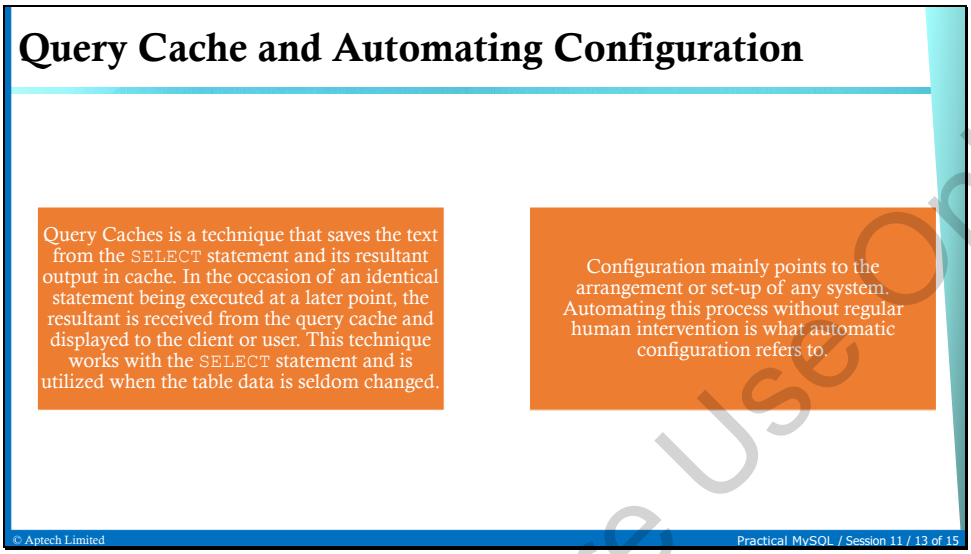
Instruction(s) to the trainer:
Show slide 11 and explain Chopping Queries to the students. Chopping a query refers to slicing up a large or complex query and running it in smaller portions so that only a limited number of rows are affected each time. A larger or more complicated query can produce the necessary results, but it may lock the rows for longer periods of time. The optimizer of the database engine determines how a query must be sliced. While certain database engines can handle longer queries, it is usually advisable to break them up into smaller parts for optimum optimization. When the time spent fetching the result set keeps increasing, the concept of chopping the queries comes into play. There are two different kinds of questions. Complex questions are the first, while simple questions are the second.

Slide 12



Instruction(s) to the trainer:
Show slide 12 and explain how to identify scalability problems in MySQL. A monolithic MySQL database with scalability problems can be turned into a distributed MySQL database while maintaining its relational principles utilizing a declarative, policy-based data distribution technique. The current database structure and commands of the program are in line with a well-thought-out data distribution policy. Related data from other tables must be located and aggregated in order to stay localized in a single database instance. 'Data that play together should stay together,' to put it another way (and to paraphrase a well-known proverb). Our goal is to be able to effectively complete 'reads' and 'writes' using only data from one distributed database instance (or shared).

Slide 13



Instruction(s) to the trainer:
Show slide 13 and explain about query cache and automating configuration.

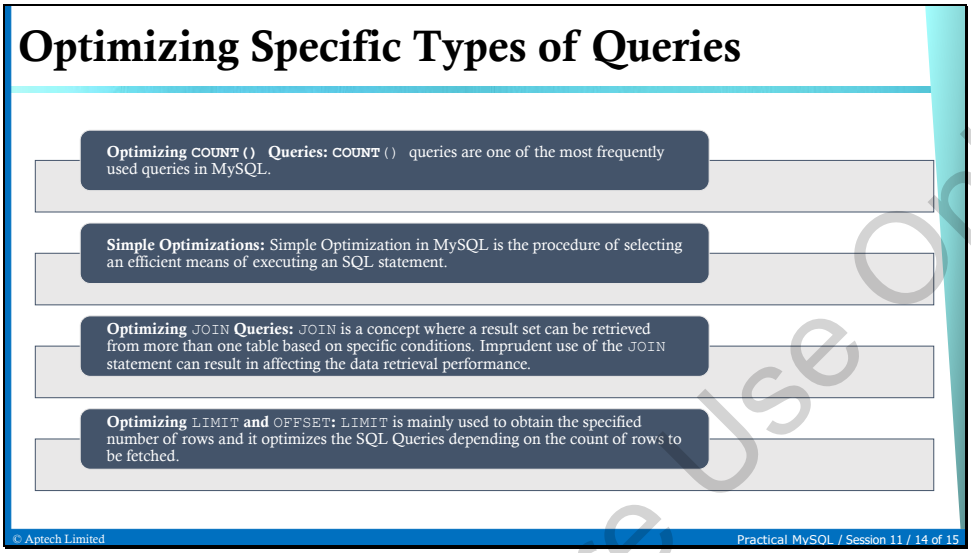
- The query cache keeps track of the text of `SELECT` statements as well as the results that were delivered to the client. If the server receives a similar command later, it obtains the results from the query cache rather than parsing and executing it again. Because the query cache is shared between sessions, a result set generated by one client might be transmitted in response to a query performed by another. The query cache can be useful in situations when tables do not update frequently and the server receives a large number of identical queries. This is a common occurrence for many Web servers that generate a large number of dynamic pages from database content. The query cache does not provide any results.

When innodb_dedicated_server is enabled, InnoDB automatically configures following variables:
innodb_buffer_pool_size
innodb_log_file_size
innodb_log_files_in_group(as of MySQL 8.0.14)
innodb_flush_method

Only consider enabling innodb_dedicated_server, if the MySQL instance resides on a dedicated server where it can use all available system resources. For example, consider enabling if the user

runs MySQL Server in a Docker container or dedicated VM that only runs MySQL.
Enabling innodb_dedicated_server is not recommended if the MySQL instance shares system resources with other applications.
The information that follows describes how each variable is automatically configured.
innodb_buffer_pool_size is configured according to the amount of memory detected on the server.

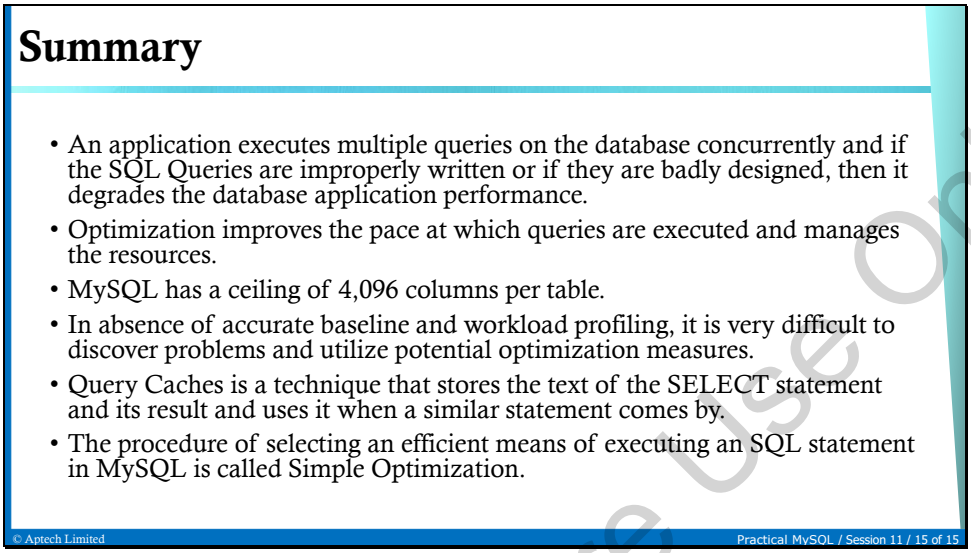
Slide 14



Instruction(s) to the trainer:
Show slide 14 and explain about optimizing specific types of queries. Tell students that the practice of retrieving the result set of certain queries in less time is known as query optimization. The two ways are as follows:
1. Cost-based Optimization (Physical)
2. Cost-based Optimization (Logical)

- `COUNT()` queries are one of the most commonly used MySQL queries. Though there is no guaranteed strategy for optimising `COUNT()`, using it without any other clauses can improve efficiency.
- In MySQL, simple optimization is the process of choosing the most efficient way to execute a SQL statement. When it comes to running complex SQL statements, optimization is crucial. The goals of query optimization are to reduce system resources and provide the proper set to the user at a faster rate.
- A `JOIN` is a notion in which a result set can be fetched from many tables based on certain criteria. Using the `JOIN` statement incorrectly can have an impact on data retrieval performance. When several tables and conditions are used in the statement, data retrieval becomes very slow, and it is worth noting that only `LEFTJOIN` is the fastest of the join types.
- `LIMIT` is mostly used to get a specific number of rows and optimizes SQL Queries based on the number of rows to be fetched.

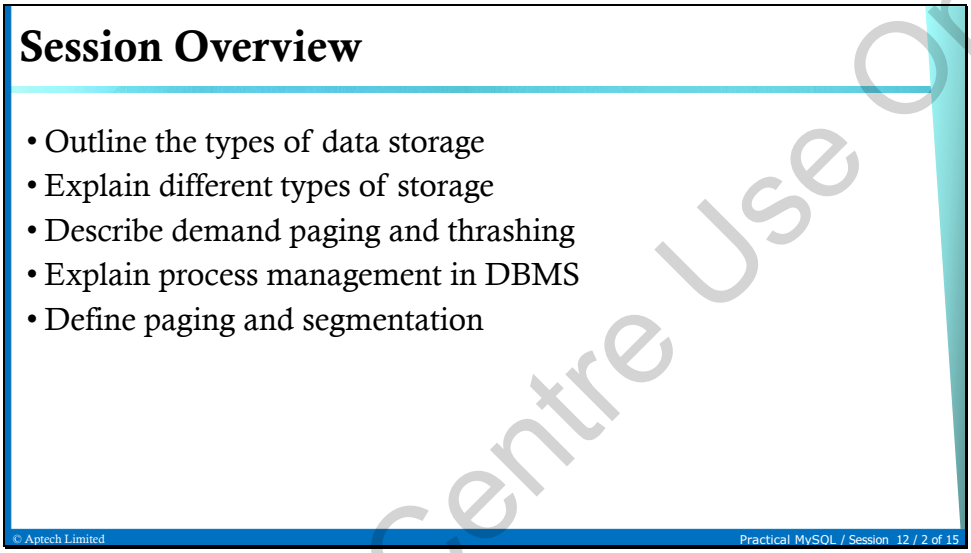
Slide 15



Instruction(s) to the trainer:
Use slide 15 to summarize the session. End the session, with a brief summary of what has been taught in the session. Tell the students pointers of the session. This will be a revision of the current session.

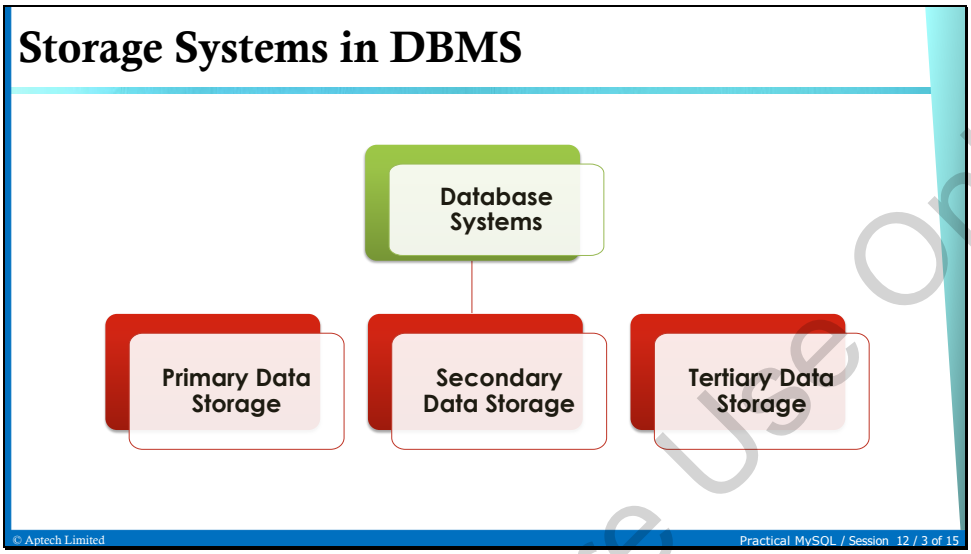
Session 12: Concept of Storage System and Management

Slide 2



Instruction(s) to the trainer:
Show slide 2 and give students a brief overview of the current session in the form of session objectives. Inform students that the session begins with an overview of storage systems and memory management in database management systems. The session further explains the types of data storage and discusses virtual memory, demand paging, and thrashing. It also discusses the concept of process management, paging, and segmentation.

Slide 3



In-Class Explanations

Instruction(s) to the trainer:

Use slide 3 to explain students the concept of data storage in DBMS and the types of data storage systems. Tell them that managing storage systems improves the performance of data storage resources.

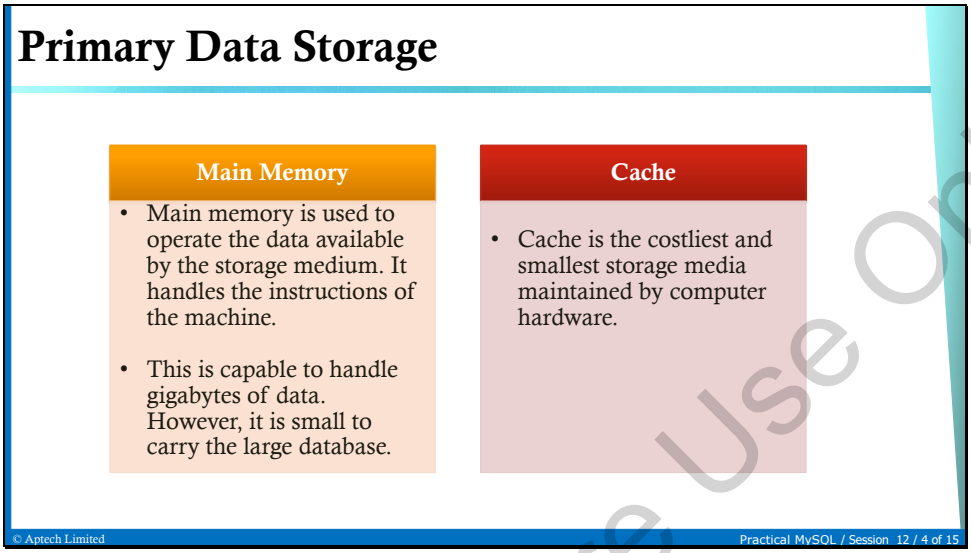
Explain to students that based on their speed and accessibility, there are three types of storage systems-primary data storage, secondary data storage, and tertiary data storage.

Additional Information:

Refer to following links for more information:

https://www.tutorialspoint.com/dbms/dbms_storage_system.htm
https://www.seagate.com/in/en/products/storage/data-storage-systems

Slide 4



Instruction(s) to the trainer:

Show slide 4 and explain students that primary storage or memory allows the central processing unit of the server to access the data without using other devices. Primary storage is a kind of volatile storage that can access data much faster than any other storage.

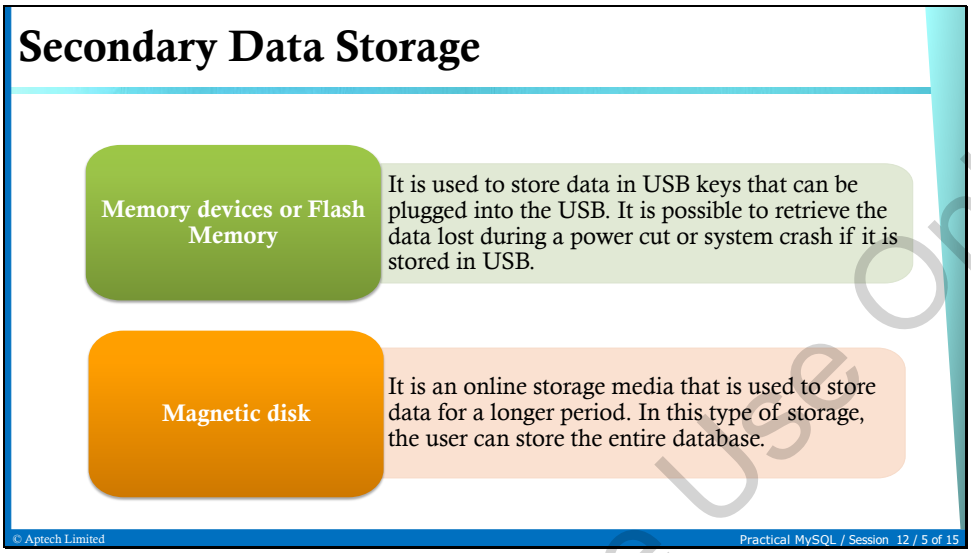
Inform students that though primary storage is fast, it is not a permanent storage and data can be lost, if not saved, in case of power cuts or system failures.
Move on to explain two kinds of primary storage in detail: Main memory and Cache.

Additional Information:

Refer to following links for more information:

https://www.seagate.com/in/en/products/storage/data-storage-systems
https://www.cdw.com/.../en/articles/datacenter/what-is-data-storage.html
https://www.educba.com/data-storage-in-database

Slide 5

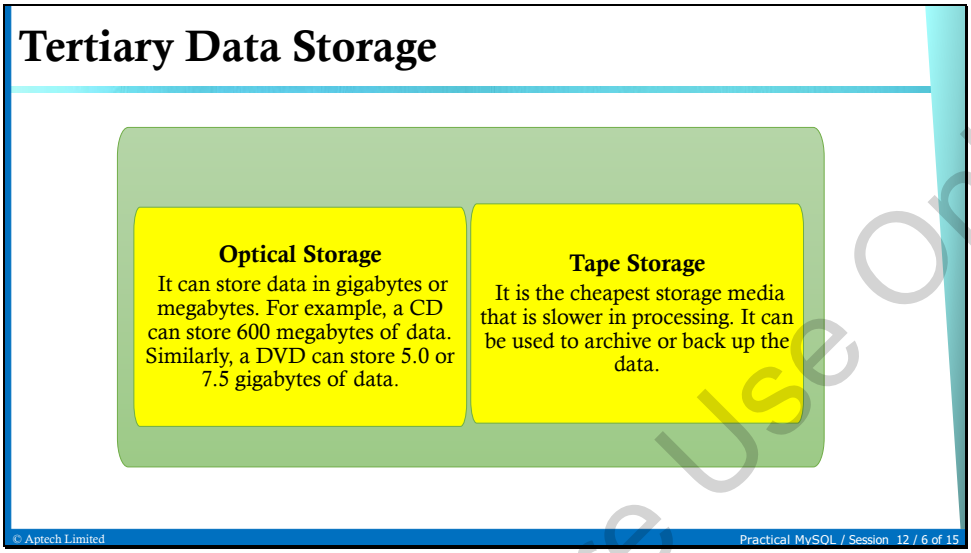


Instruction(s) to the trainer:

Show slide 5 and discuss secondary storage systems. As these systems allow users to store data permanently, they are also called online storage or non-volatile storage. Tell students that the data stored in secondary storage system does not get lost in case of power failures or system crash.
Different types of secondary storage include memory devices, Flash memory, and magnetic disk drives.

In-Class Question: Name a secondary storage device that can be used to store an entire database.
Answer: Magnetic disk

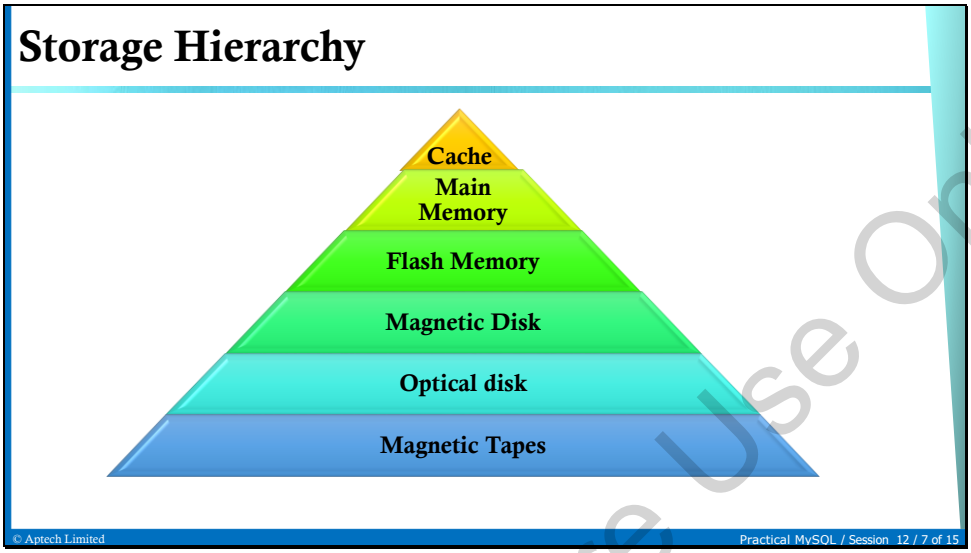
Slide 6



Instruction(s) to the trainer:

Slide 6 introduces the concept of tertiary storage systems. It is an offline storage system that can be used to store a huge amount of data. Tell students that as this storage is not a part of the current computer system, it is rather slow in fetching and processing data.
Some types of tertiary storage devices include Optical storage and Tape storage.

Slide 7



Instruction(s) to the trainer:

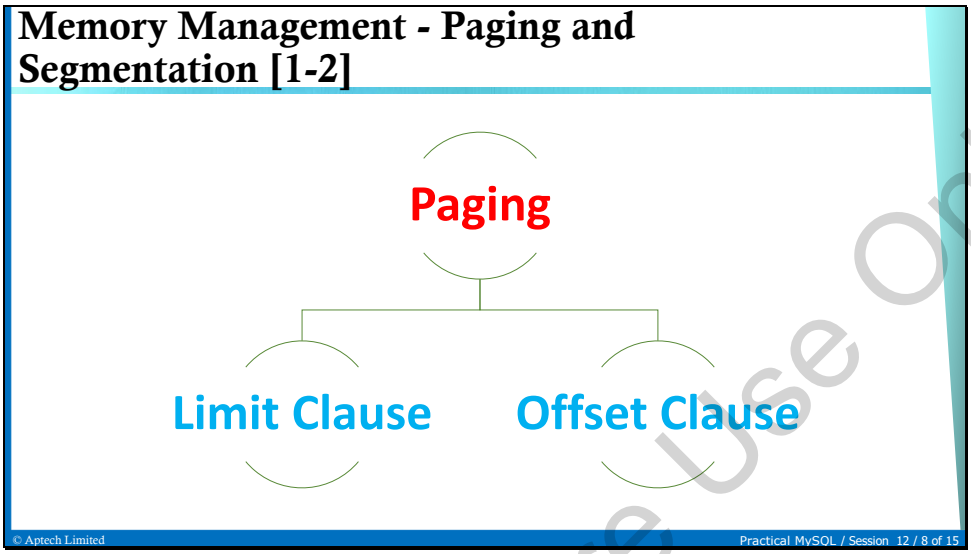
Show slide 7 and discuss the storage hierarchy of the memory of a computer system. Different storage types are organized on the basis of their accessing speed of the data, cost per unit of data, and medium's reliability.
For instance, cache memory, which is the fastest and most easily accessible memory is placed at the top of the pyramid; whereas, magnetic tapes, which are slow in accessing data, are at the bottom.

Additional Information:

Refer to following links for more information:

https://www.tutorialspoint.com/Storage-Device-Hierarchy
https://www.sciencedirect.com/topics/computer-science/storage-hierarchy

Slide 8



Instruction(s) to the trainer:

Use slide 8 and explain the concept of memory management in DBMS. Tell students that memory management relies completely on the main memory to store and access the data. It reduces the instruction set required to access data by eliminating latency and overhead of hard disk.
Tell students about some basic techniques to effectively manage memory in a database system. These techniques are paging and segmentation.

In Paging, a large dataset is divided into smaller parts, making it easy to read smaller chunks of data spread across multiple pages rather than a huge set of records on a single page.

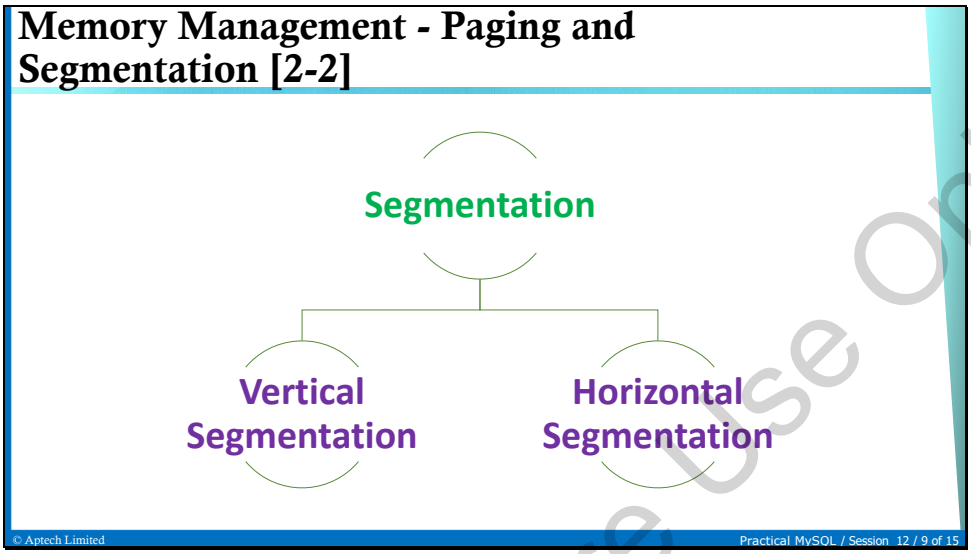
Pagination can be implemented by using `LIMIT` and `OFFSET` clauses in the `SELECT` query. The `LIMIT` clause is used to restrict the number of rows to be retrieved, while the `OFFSET` clause is used to view a specific number of rows.

Additional Information:

Refer to following links for more information:

https://www.tutorialspoint.com/operating_system/os_memory_management.htm
https://www.javatpoint.com/os-memory-management-introduction
https://www.studytonight.com/operating-system/memory-management-in-os

Slide 9



Instruction(s) to the trainer:

Show slide 9 and tell students that segmentation is a way to organize the database by grouping contacts and companies based on specific characteristics.
Explain that segmentation is a non-contiguous memory allocation scheme that divides the database into mounted size pages.

The data can be segmented in two ways:

- Vertical segmentation
- Horizontal segmentation

In vertical segmentation, the database is divided into vertical sub-library and vertical sub-table. In the vertical sub-library, the vertical database stores low-relevancy tables in other databases. In the vertical sub-table, it splits the columns with low coupling in the table with uncommon fields.

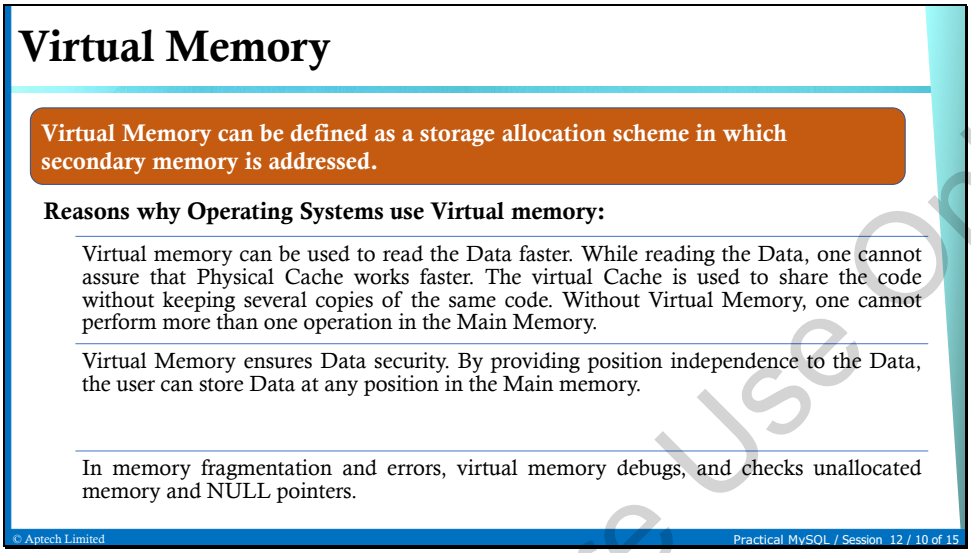
Horizontal segmentation is used to segment huge amounts of data. The data can be divided into horizontal sub-library and horizontal sub-table. Horizontal sub-library splits the single database into multiple databases.

Discuss the advantages and disadvantages of both types of segmentation techniques with students.

In-Class Question: You want to split a large database into small databases. Which type of segmentation would you choose?

Answer: Horizontal segmentation

Slide 10



Instruction(s) to the trainer:

Use slide 10 to define virtual memory as a storage allocation scheme in which secondary memory is addressed. Tell students that virtual memory helps resolve the problem of memory shortage. It is a temporary memory that maps program addresses into RAM addresses.

Next, explain how virtual memory works to improve the performance of database operations. MySQL allocates buffers and caches. The default configuration of running MySQL Server in virtual memory is approximately 512 MB RAM. One can improve MySQL performance by increasing the values of cache. If there is a lack of memory, the addresses will be mapped into the disk.

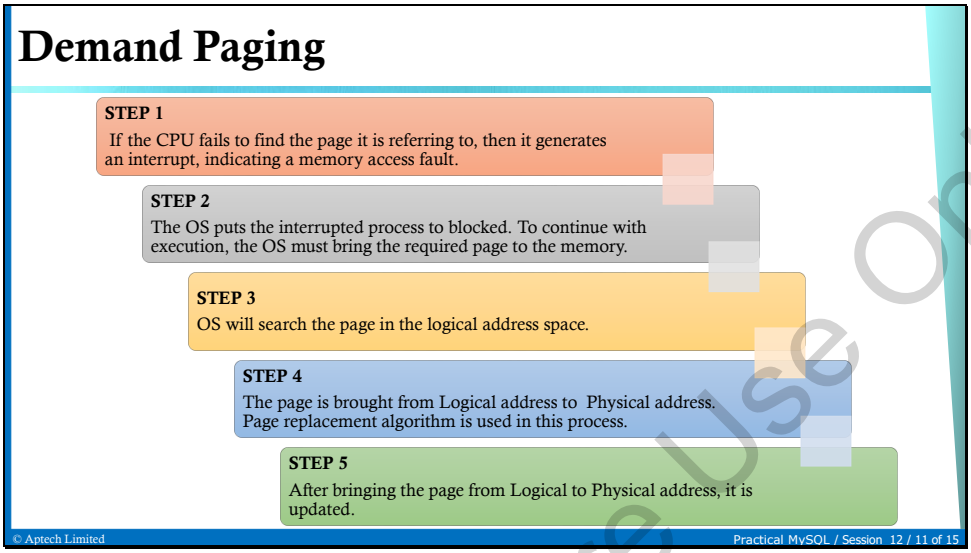
Discuss the reasons why all operating systems must use virtual memory.

Additional Information:

Refer to following links for more information:

https://www.javatpoint.com/os-virtual-memory
https://www.tutorialspoint.com/what-is-virtual-memory
https://www.geeksforgeeks.org/virtual-memory-in-operating-system

Slide 11



Instruction(s) to the trainer:

Show slide 11 and explain demand paging. It is a process where the page can be loaded into the main memory on demand. Explain how demand paging actually works with the help of the steps shown on the slide.

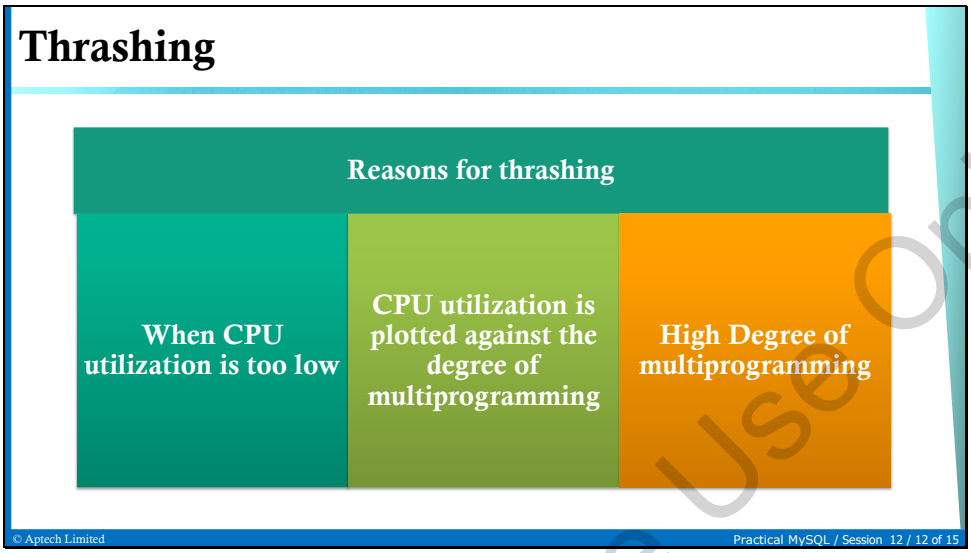
In demand paging, a page is fetched into the main memory only when it is needed or demanded by the CPU. Initially, only those pages are loaded that are required by the process immediately. The pages that are never accessed are therefore never loaded into the physical memory. This helps save memory space in DBMS.

Additional Information:

Refer to following links for more information:

http://prepinsta.com/operating-systems/implementation-of-demand-paging/
https://www.javatpoint.com/os-demand-paging
https://www.tutorialandexample.com/what-is-demand-paging

Slide 12



Instruction(s) to the trainer:

Use slide 12 to explain the concept of thrashing in an operating system. Thrashing mainly occurs when the required page is not allocated and generates a page fault. Inform students that thrashing degrades the computer performance.

Explain students various reasons that lead to thrashing.

Some ways to remove thrashing are as follows:

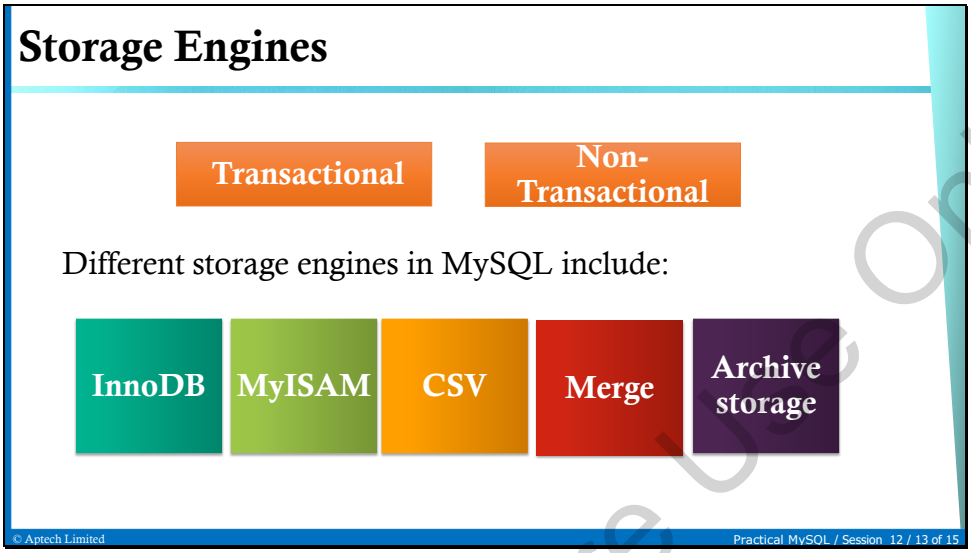
- Temporary solution for thrashing is to eliminate one or more running applications.
- Provide more memory to the main memory.
- Adjusting the size of swap files.
- Replace the program that takes more memory with the programs that take less memory.

Additional Information:

Refer to following links for more information:

https://www.studytonight.com/operating-system/thrashing
https://practice.geeksforgeeks.org/problems/thrashing-in-os
https://www.i2tutorials.com/os-introduction/os-thrashing-in-operating-system

Slide 13



Instruction(s) to the trainer:

Show slide 13 and explain storage engines to students. Storage engines can be defined as MySQL components that are used to handle the SQL operations for different table types to store and manage information in a database.

There are two major types of storage engines in MySQL:

- Transactional
- Non-transactional

The main difference between the transactional and non-transactional storage engines is that in a transactional storage engine, the tables record all the database operations in a log file. This allows you to get your data back even if MySQL crashes. However, this is not the case with non-transactional engines.

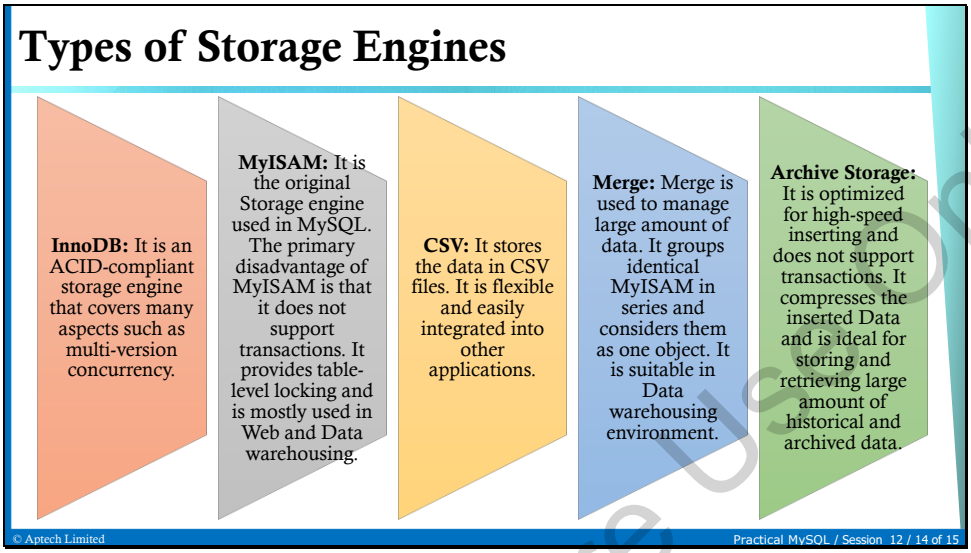
List different storage engines in MySQL.

Additional Information:

Refer to following links for more information:

https://www.w3resource.com/mysql/mysql-storage-engines.php
https://zetcode.com/mysql/storageengines
https://www.javatpoint.com/mysql-table-types-storage-engines

Slide 14



Instruction(s) to the trainer:

Show slide 14 and explain the working of various types of storage engines: InnoDB, MyISAM, CSV, Merge, and Archive Storage. Discuss specific situations and benefits of using each type of storage engine.

Tell students that while creating tables, they can also specify which storage engine to use.

Following command is used to specify or apply the storage engine:

```
CREATE TABLE Customers (Cust_Id INTEGER PRIMARY KEY, Name
VARCHAR(50), Age INTEGER) ENGINE='MyISAM';
```

Additional Information:

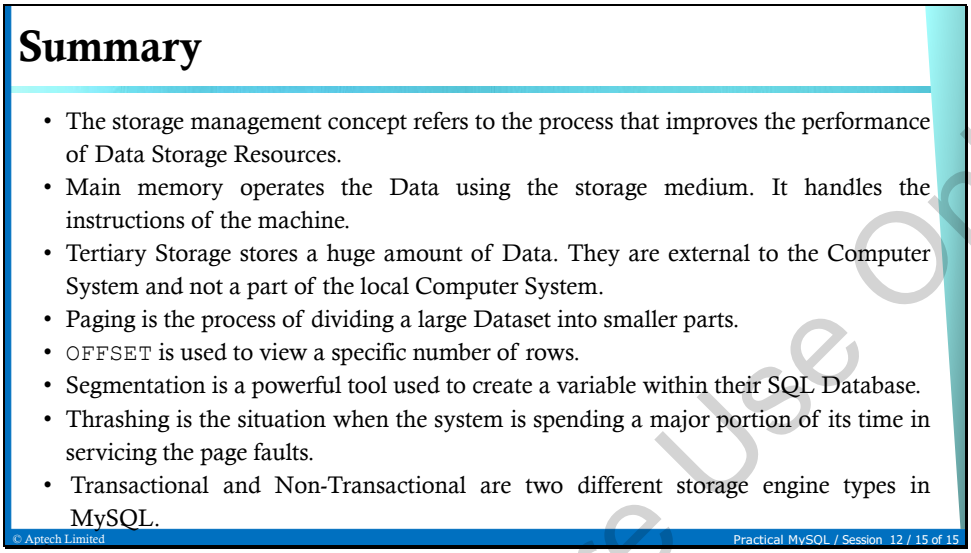
Refer to following links for more information:

https://www.w3resource.com/mysql/mysql-storage-engines.php
https://zetcode.com/mysql/storageengines
https://www.javatpoint.com/mysql-table-types-storage-engines
https://www.thegeekdiary.com/beginners-guide-to-storage-engines-in-mysql

In-Class Question: Which storage engine is capable of managing huge amounts of data and is generally used in data warehousing?

Answer: Merge

Slide 15



Instruction(s) to the trainer:

Use slide 15 to summarize the session. You will end the session with a summary of what has been taught in the session. Tell students the pointers of the session. This will be a revision of the current session.