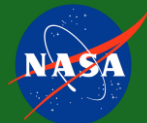


MySQL Database Administrator

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MySQL Server Usage



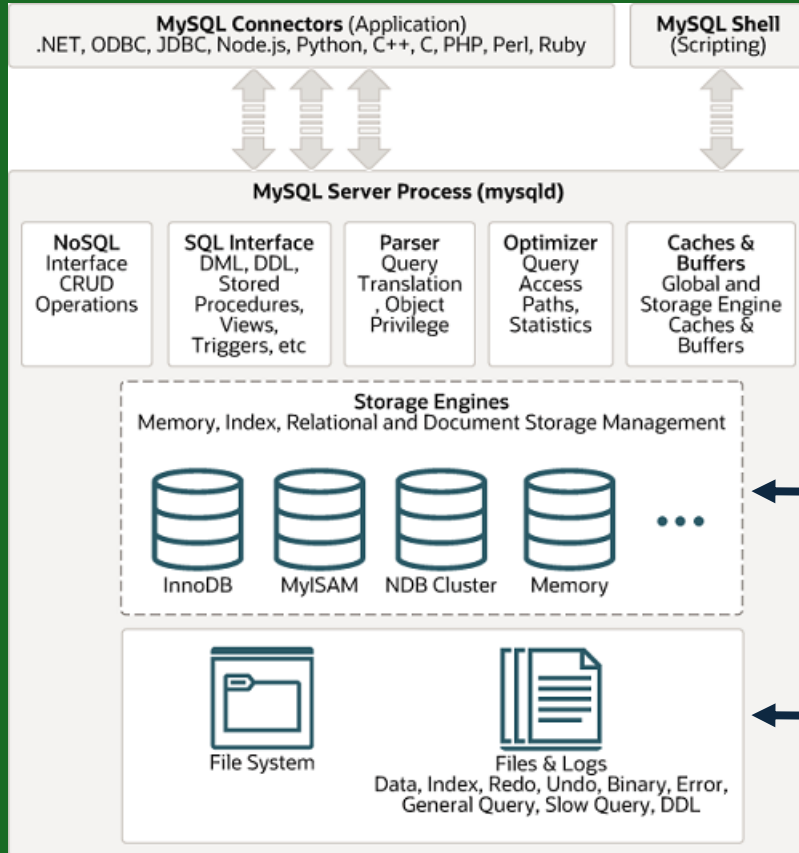
Course Introduction

- ❖ New Database Installations, Customization, Backup & Recovery
- ❖ Database Management -
- ❖ Database Upgrades - Both Major and Minor Upgrades
- ❖ InnoDB Storage Engine Tuning
- ❖ Database Replication, Troubleshooting, Performance Tuning

Course Objectives

- ❖ MySQL Server Installation
- ❖ Exploring MySQL Server
- ❖ MySQL Server Database Administration
- ❖ MySQL Storage Engines
- ❖ MySQL User Administration
- ❖ MySQL Server Configuration
- ❖ InnoDB Storage Engine
- ❖ MySQL Backup & Restore
- ❖ MySQL Replication
- ❖ Upgrading MySQL Server
- ❖ MySQL Performance and Monitoring

MySQL Architecture



End-User/Client-Layer

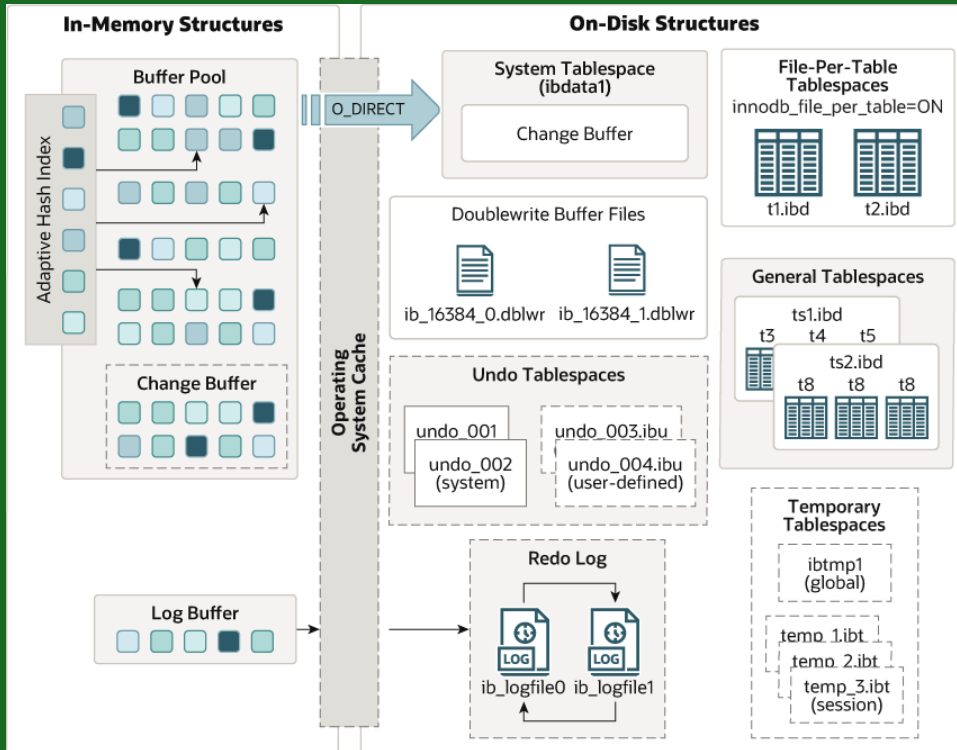
Daemon Process

MySQL Brain

Physical Storage

MySQL InnoDB Architecture

InnoDB Architecture:



In-Memory Structure:

- ❖ **Buffer Pool** - Area in main memory where InnoDB caches table & index data as it is accessed
- ❖ **Change Buffer** - caches changes to non-clustered indexes
- ❖ **Adaptive Hash Index** - acts like in-memory db
- ❖ **Log Buffer** - memory area that holds data to be written to the log files on disk

On-Disk Structure:

- ❖ System Tablespace
- ❖ Doublewrite Buffer Files
- ❖ Undo Tablespaces
- ❖ Redo Log Files
- ❖ File-Per-Table Tablespaces
- ❖ General Tablespaces
- ❖ Temporary Tablespaces

MySQL User Administration

- ❖ DBA Account
- ❖ MySQL Permissions
- ❖ **WITH GRANT OPTION**
- ❖ MySQL Workbench
- ❖ MySQL Roles
- ❖ Difference between **Roles** & **Users**
- ❖ Granting Permissions -> Roles, Roles -> Users
- ❖ Expired Account, Unlock Account
- ❖ Explore **mysql.user** table

MySQL Configuration

Option Files:

- ❖ Also called MySQL **Configuration Files**
- ❖ Most MySQL programs can read **startup options** from **option files** (configuration)
- ❖ Convenient way to specify commonly used options so need not to specify on command-line
- ❖ mysqld, mysqladmin, mysqlimport, mysqldump, mysql - examples of MySQL programs
- ❖ **program -verbose -help** - To get which default option file this programs uses
- ❖ Any program starts with **-no-defaults** option reads no option file other than **.mylogin.cnf**

MySQL Backup & Recovery

What do you want to protect?

- ❖ MySQL Instance - **Physical Backup**
- ❖ Option Files/Configuration Files - **Source Control**
- ❖ Database(s) - **Logical Backup**
- ❖ Table(s) - **Logical Backup**

MySQL Upgrades

Upgrade Types:

- ❖ Minor MySQL Version Upgrade
- ❖ Major MySQL Version Upgrade

Popular MySQL Servers

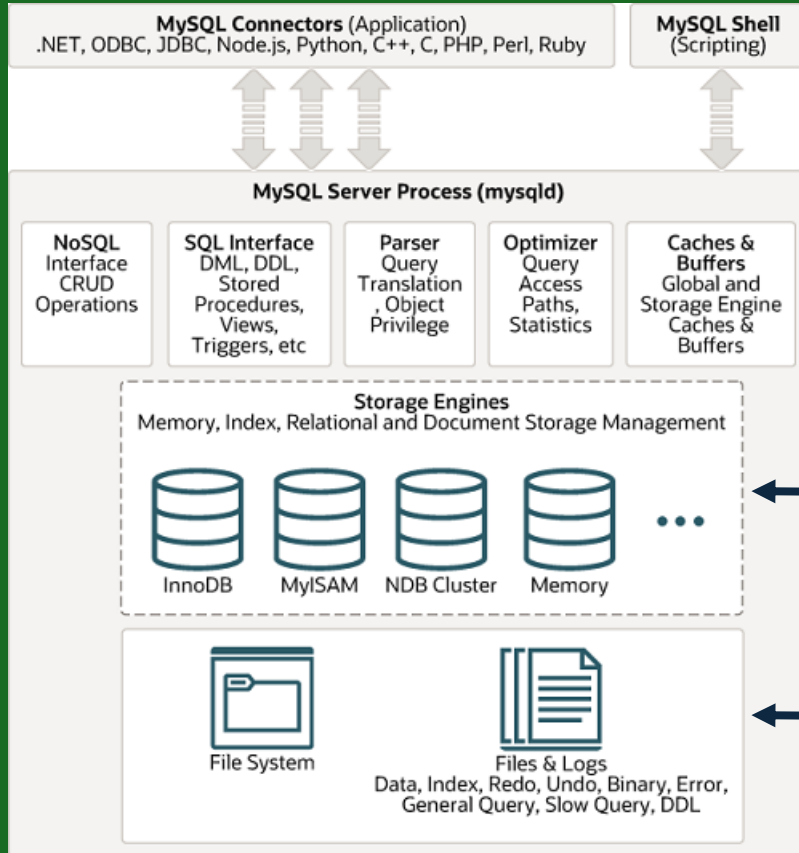
Oracle MySQL, MariaDB, Percona MySQL are **forks** of original MySQL

MariaDB Provides: Columnar Storage, Temporal Tables, Transaction replay, non-blocking backups, Oracle Compatible, Pluggable Storage Engines

Percona Provides: XtraDB Cluster, Percona-Toolkit, XtraBackup, TokuDB, MyRocks Storage Engine, InnoDB Full-Text Search, Compressed Columns

Oracle MySQL Provides: HeatWave, mysqlcheck, Scalability, Dual Passwords, High Performance

MySQL Architecture



End-User/Client-Layer

Daemon Process

MySQL Brain

Physical Storage

MYSQL File Types

Installed MySQL Files Location :

DATA DIRECTORY:

- ❖ Also known as **datadir**
- ❖ Default location: **/var/lib/mysql**
- ❖ Owned by **mysql** os user as it's home directory
- ❖ All the new **databases** that we create, reside there as **folder**

LOG FILES:

- ❖ Default location is **/var/log/mysql/error.log**
- ❖ Very critical file and single source of truth for all errors, warnings, info etc
- ❖ Also contains initial **root** password - newly installed MySQL

GLOBAL CONFIGURATION FILE:

- ❖ Default location is **/etc/mysql/my.cnf**
- ❖ Contains all the configuration settings that will be loaded when server starts

MYSQL Executable Programs

mysql	mysqladmin	mysqlbinlog	mysqlcheck	mysql_config_editor
mysqld_pre_systemd	mysqld_safe	mysql_ssl_rsa_setup	mysql_tzinfo_to_sql	mysql_upgrade
mysqlslap	mysql_secure_installation	mysqlshow	mysqld_safe	mysqldump

MYSQL Shell Commands

help:

- ❖ \h or \?
- ❖ Prints help about MySQL Shell and all available shell commands
- ❖ Display help for any of the shell commands

quit:

- ❖ Quits or Exits from MySQL Shell - \q

status:

- ❖ Shortcut is \s
- ❖ For how long MySQL Server has been up, what is my connection id, version of MySQL
- ❖ Is the current user logged in locally or from a remote location

system:

- ❖ Shortcut is \!
- ❖ Run operating system commands within MySQL Shell

MYSQL Shell Commands

use:

- ❖ \u for short
- ❖ Use another database
- ❖ Takes database name as argument

source:

- ❖ \. - Execute SQL file (.sql extension)
- ❖ Takes SQL file name as argument

edit:

- ❖ Edit the SQL statement that you recently executed

MYSQL Socket File

mysql.sock:

- ❖ MySQL special file that manages **connections** to the mysql server
- ❖ Used for local clients - if user is on the database host and want to connect to mysql
- ❖ Local clients/users can't connect to MySQL without this file
- ❖ Owned by **mysql** user and default location is **/var/run/mysqld**
- ❖ Local connection = UNIX socket - Remote connection = TCP/IP
- ❖ This special file is empty but mysql creates another file **mysqld.sock.lock** and add pid

MYSQL Global Variables

Global Variables:

- ❖ MySQL server maintains many **system** variables that are used to configure how MySQL should operate.
- ❖ **GLOBAL scope & SESSION scope**
- ❖ Global variables affect the overall operation of MySQL server
- ❖ Each Global variable has **default** value which is initialized when server starts
- ❖ Default value can be changed in **option file** or on **command line**
- ❖ Identified by @@ sign
- ❖ SHOW GLOBAL <variable_name>; or SELECT @@<variable_name>;
- ❖ Examples of system variables:
 - max_connections
 - server_id
 - sql_mode

MYSQL Session Variables

Session Variables:

- ❖ MySQL server maintains many **system** variables that are used to configure how MySQL should operate.
- ❖ **GLOBAL scope & SESSION scope**
- ❖ SESSION variables affect only the **current session**
- ❖ Default value for session variables can only be changed on **command line**
- ❖ Identified by @@ sign
- ❖ SHOW SESSION VARIABLES LIKE <variable_name>; or SELECT @@<variable_name>;
- ❖ Examples of session system variables:
 - sql_mode

MYSQL SHOW Command

SHOW Statements:

- ❖ SHOW DATABASES;
- ❖ SHOW TABLES LIKE '%view%';
- ❖ SHOW BINARY LOGS;
- ❖ SHOW BINLOG EVENTS;
- ❖ SHOW ENGINES;
- ❖ SHOW CREATE TABLE | USER | DATABASE;
- ❖ SHOW ERRORS;
- ❖ SHOW WARNINGS;
- ❖ SHOW EVENTS;
- ❖ SHOW TRIGGERS;
- ❖ SHOW PROCESSLIST;

Note: SHOW Statements also accepts **LIKE** clause

MySQL System Databases

System Databases:

- ❖ MySQL server comes with some default system databases
 - information_schema
 - mysql
 - performance_schema
 - sys
 - Test - Generally deleted by running `mysql_secure_installation`

MYSQL System Databases

information_shema:

- ❖ Each MySQL instance will have information_schema database
- ❖ Also called System Catalog or Data Dictionary
- ❖ Provides access to **metadata**, that is data about data
- ❖ The tables in this database are **read-only** - they are actually views
- ❖ So no INSERT, UPDATE, DELETE operations

mysql:

- ❖ Contains tables that store information required by MySQL server
- ❖ Grant information to user accounts, registry of event scheduler, plugins
- ❖ Replication System Tables
- ❖ System tables with timezone information

MySQL System Databases

performance_schema:

- ❖ Inspect internal execution of the server.
- ❖ Primarily focuses on performance data
- ❖ Information about events waits, database locks, memory allocation

sys:

- ❖ Collection of views, functions, and stored procedures that help MySQL admins to get insight into MySQL database usage.
- ❖ Similar to **performance_schema** but is more user friendly
- ❖ How many total connections a user has established, memory consumption
- ❖ Database host summary about memory, storage, io

MYSQL Connections

localhost-connection:

- ❖ localhost
- ❖ root@localhost

specific-host-connection:

- ❖ Host or IP Address webserver01 or 192.168.10.10
- ❖ app_user@webserver01

any-host-connection:

- ❖ %
- ❖ dba@%

MYSQL Config Editor

mysql_config_editor:

- ❖ Configure Authentication information for connecting to MySQL server
- ❖ Stores authentication credentials in an obfuscated login path file called **.mylogin.cnf - Encrypted**
- ❖ Location: user's home directory - Syntax: **mysql_config_editor set --login-path=client --host= --user= --password**
- ❖ login-path is option group that specify which MySQL server to connect and which account to auth
- ❖ By default mysql client reads **[client]** and **[mysql]** groups

MySQL Config Editor

.mylogin.cnf:

[client]

user = root

password =

host = localhost

[prod]

user = user

password = password

host = proddb01

MYSQL Admin Program

mysqladmin:

- ❖ MySQL Server Administration program
- ❖ Client for performing administrative operations:
 - shutdown
 - create <database_name>
 - current status
 - ping if MySQL is alive
 - Start Replica
 - Stop Replica
- ❖ Syntax: `mysqladmin options command`

Example:

- ❖ `mysqladmin status`
- ❖ `mysqladmin ping`
- ❖ `mysqladmin create database`
- ❖ `mysqladmin drop database`

MYSQL Execute SQL Files

source:

- ❖ From within mysql shell - using `\.` or `source`
- ❖ `mysql> source file.sql` or `mysql> \. file.sql`

mysql:

- ❖ By running mysql client program and accepting `.sql` file as input
- ❖ `mysql -host=host_name -user=user_name -password= database_name < file.sql`

shell script:

- ❖ By creating an `executable` shell script and executing it
- ❖ `mysql -host=host_name database_name < $1`

pipe method:

- ❖ `cat filename.sql | mysql`

MYSQL Execute SQL Files

Execute employees.sql - Create staff table in employees db

Syntax:

- ❖ `mysql>source employees.sql`
- ❖ `mysql -host=localhost employees < employees.sql`
- ❖ `bash employees.sh employees.sql`
- ❖ `cat employees.sql | mysql`

MYSQL mysqlimport

mysqlimport:

- ❖ mysqlimport is a data import program
- ❖ Takes .txt with tab-delimited file as input

Syntax:

- ❖ `mysqlimport [options] database file1.txt [file2.txt] ...`

Import Data Directory Configuration:

- ❖ `secure_file_priv` - denoted a directory from which data files can be loaded

MySQL mysqlimport

Load data from staff.txt - Populate staff table in employees db

Steps:

- ❖ We will use **mysqlimport** utility
- ❖ Fetch **secure_file_priv** value
- ❖ Copy file and change permissions
- ❖ Load Data mysqlimport [options] db_name \${secure_file_priv}/staff.txt

MYSQL mysqlcheck

mysqlcheck:

- ❖ mysqlcheck is a table maintenance program
- ❖ It checks, repairs, optimize, or analyze tables
- ❖ Table name as input

Note:

- ❖ Table will be **locked** while mysqlcheck is running - no db operations

Syntax:

- ❖ `mysqlcheck [options] db_name table_name`

MySQL mysqlcheck

Check the integrity of staff table

Steps:

- ❖ We will use **mysqlcheck** utility
- ❖ `mysqlcheck employees staff`

MYSQL mysqlshow

mysqlshow:

- ❖ Display database, table, and column information
- ❖ Takes database name and table name as input

Syntax:

- ❖ `mysqlshow [options] db_name table_name`
- ❖ `mysqlshow [options] db_name table_name [column_name]`

MYSQL Timezone Data

mysql_tzinfo_to_sql:

- ❖ Loads the time zone data from zoneinfo database into **system mysql** database
- ❖ Zoneinfo database is actually zone files that describe time zones
- ❖ Typical location on Linux is **/usr/share/zoneinfo**

Timezone Tables:

- ❖ Time_zone
- ❖ Time_zone_name
- ❖ Time_zone_transition
- ❖ Time_zone_transition_type
- ❖ time_zone_leap_second

Syntax:

- ❖ `mysql_tzinfo_to_sql zoneinfo_database | mysql [options] db_name`

MySQL Timezone Data

Load Timezone Data into MySQL

Steps:

- ❖ We will use `mysql_tzinfo_to_sql` utility
- ❖ `mysql_tzinfo_to_sql /usr/share/zoneinfo | mysql mysql`

MYSQL Example Databases

MySQL Example Databases:

- ❖ Free to download and use

Example Databases:

- ❖ employees
- ❖ world
- ❖ sakila

URL Information:

- ❖ <https://dev.mysql.com/doc/index-other.html>

MYSQL Storage Engines

FEDERATED	InnoDB	MyISAM	ARCHIVE
BLACKHOLE	CSV	MEMORY	PERFORMANCE_SCHEMA

- Pluggable storage engine architecture - load and unload on a running MySQL Server
- show engines - which storage engine your server support
- Shared library location for all the plugins - plugin_dir variable
- Can install & uninstall more storage engines

MYSQL Storage Engines

FEDERATED STORAGE ENGINE:

- ❖ **Disabled** by default
- ❖ Table created with FEDERATED Storage Engine, normally points to a table in another MySQL instance installed on a separate server.
- ❖ **Linked Server** - Microsoft SQL Server
- ❖ **Database Link** - Oracle
- ❖ Both tables should have the same name and definition
- ❖ The table in requester acts like a **view**
- ❖ Target table can have different storage engine but requester table should be created with FEDERATED

Syntax:

```
Create table employee_salaries (  
Employee_id int,  
Employee_salary int  
) ENGINE = FEDERATED  
CONNECTION = 'mysql://db_user@target-server:3306/employees/employee_salaries';
```

MYSQL Storage Engines

MEMORY STORAGE ENGINE:

- ❖ Called **HEAP** in older versions
- ❖ Very useful for **temporary** tables
- ❖ MEMORY will write table data in **memory**
- ❖ Not Persistent - Data lost on server crash
- ❖ Very fast data retrieval but memory is volatile so use only for read-only cache data or temp tables

USE CASE:

- ❖ Static Tables - lookup
- ❖ Temporary Tables

Caveats:

- ❖ No **Transactions** support
- ❖ No Referential Integrity support - No FK
- ❖ NO TEXT data type support - No BLOB column

MySQL Storage Engines

Create **continents** table in **MEMORY** - world database

Steps:

- ❖ Create table specifying **ENGINE=MEMORY**
- ❖ Insert data
- ❖ Verify data and also table definition from `information_schema.tables`
- ❖ Restart MySQL Service and observe table is there but data is gone

MYSQL Storage Engines

BLACKHOLE STORAGE ENGINE:

- ❖ Acts as a black hole, whatever goes into it, never comes back
- ❖ You can store as much data as you want, when you retrieve it, it returns empty result set
- ❖ Anything you write to it, disappears
- ❖ Does not support transactions

Syntax:

```
Create table employee_salaries (  
Employee_id int,  
Employee_salary int  
) ENGINE = BLACKHOLE;
```

MySQL Storage Engines

Create **continents** table in **BLACKHOLE** - world database

Steps:

- ❖ Create table specifying **ENGINE=BLACKHOLE**
- ❖ Insert data
- ❖ Verify empty result set will return

MYSQL Storage Engines

CSV STORAGE ENGINE:

- ❖ Stores table in text files using comma-separated values format
- ❖ MySQL creates a **.csv** file in the \$DATA_DIR - plain text file
- ❖ CSV format can be read, written by spreadsheet applications like **Excel**
- ❖ Does not support transactions
- ❖ CSV files are not indexed

USE CASE:

- ❖ When data need to be shared with other applications that also use CSV format

Syntax:

```
Create table continents (  
cid int NOT NULL,  
cname VARCHAR(25) NOT NULL  
) ENGINE = CSV;
```

MySQL Storage Engines

Create **continents** table in **CSV** - world database

Steps:

- ❖ Create table specifying **ENGINE=CSV**
- ❖ Insert data
- ❖ Search for continents.CSV file under \$DATA_DIR/world

MYSQL Storage Engines

MyISAM STORAGE ENGINE:

- ❖ MyISAM = My + ISAM = Indexed Sequential Access Method
- ❖ Indexing algorithm developed by IBM that allows retrieving information from large sets of data in a fast way
- ❖ MyISAM was default storage engine up until MySQL 5.5 - around 2009-2010
- ❖ Good speed advantages especially useful in Data warehouse scenario
- ❖ Replaced by InnoDB
- ❖ Does not support transactions - ACID Model

USE CASE:

- ❖ Data Warehouse - a lot of reads

MySQL Storage Engines

Create **continents** table in **MyISAM** - world database

Steps:

- ❖ Create table specifying **ENGINE=MyISAM**
- ❖ Insert data
- ❖ Start Transaction, Commit, Rollback

MYSQL Storage Engines

ARCHIVE STORAGE ENGINE:

- ❖ Produces special-purpose tables that store large amounts of **un-indexed** data in very small footprint
- ❖ Creates .ARZ files with same name as table name
- ❖ ARZ files are binary data files and are called MySQL Archive Storage Engine Data File
- ❖ Uses **gzip** to compress rows

CAVEAT:

- ❖ No DELETE or UPDATE operation
- ❖ No Partitioning

Syntax:

```
Create table continents (  
cid int NOT NULL,  
cname VARCHAR(25) NOT NULL  
) ENGINE = ARCHIVE;
```


MySQL Storage Engines

Create **continents** table in **ARCHIVE** - world database

Steps:

- ❖ Create table specifying **ENGINE=ARCHIVE**
- ❖ Insert data
- ❖ Look for .ARZ file

MYSQL Storage Engines

InnoDB STORAGE ENGINE:

- ❖ ACID compliant storage engine that support all types of transactions
- ❖ A - Atomicity, involves transactions COMMIT & ROLLBACK
- ❖ C - Consistency, mechanism for crash recovery
- ❖ I - Isolation, different isolation levels that applies at each transaction level
- ❖ D - Durability, storage engine interacts with underlying hardware to provide best performance
- ❖ Default storage engine, robust, fast, heart of MySQL
- ❖ Best for OLTP - Online Transaction Processing
- ❖ Row-level locking, indexing
- ❖ InnoDB maintains its own **buffer pool** (memory area where InnoDB cache table and indexed data)

MySQL Storage Engines

Create **continents** table in **InnoDB** - world database

Steps:

- ❖ Create table specifying **ENGINE=InnoDB** or skip
- ❖ Insert data
- ❖ Test all operations

REVIEW CONTENT

- ❖ Storage Engines
- ❖ InnoDB - Default Storage Engine
- ❖ Storage Engine Status
- ❖ Migrate table from one storage engine to other
- ❖ Disable storage engine