JAVA DATABASE PROGRAMS

Java Database Programming (JDBC) by Examples with MySQL:

Relational Database and Structure Query Language (SQL)
https://www3.ntu.edu.sg/home/ehchua/programming/sql/MySQL_HowTo.html#intro

Setting-up MySQL

the MySQL Relational Database Management System.

Downloads:

https://dev.mysql.com/downloads/mysql/

Assume that the MySQL server is running on **the default TCP port number 3306.**

Mysql theory prior knowledge:

https://www3.ntu.edu.sg/home/ehchua/programming/sql/MySQL_HowTo.html

Install JDK and Programming Editor

JDK JRE

Create a Directory to Keep all your Works

I shall assume that you have created a directory called "c:\myWebProject" (for Windows).

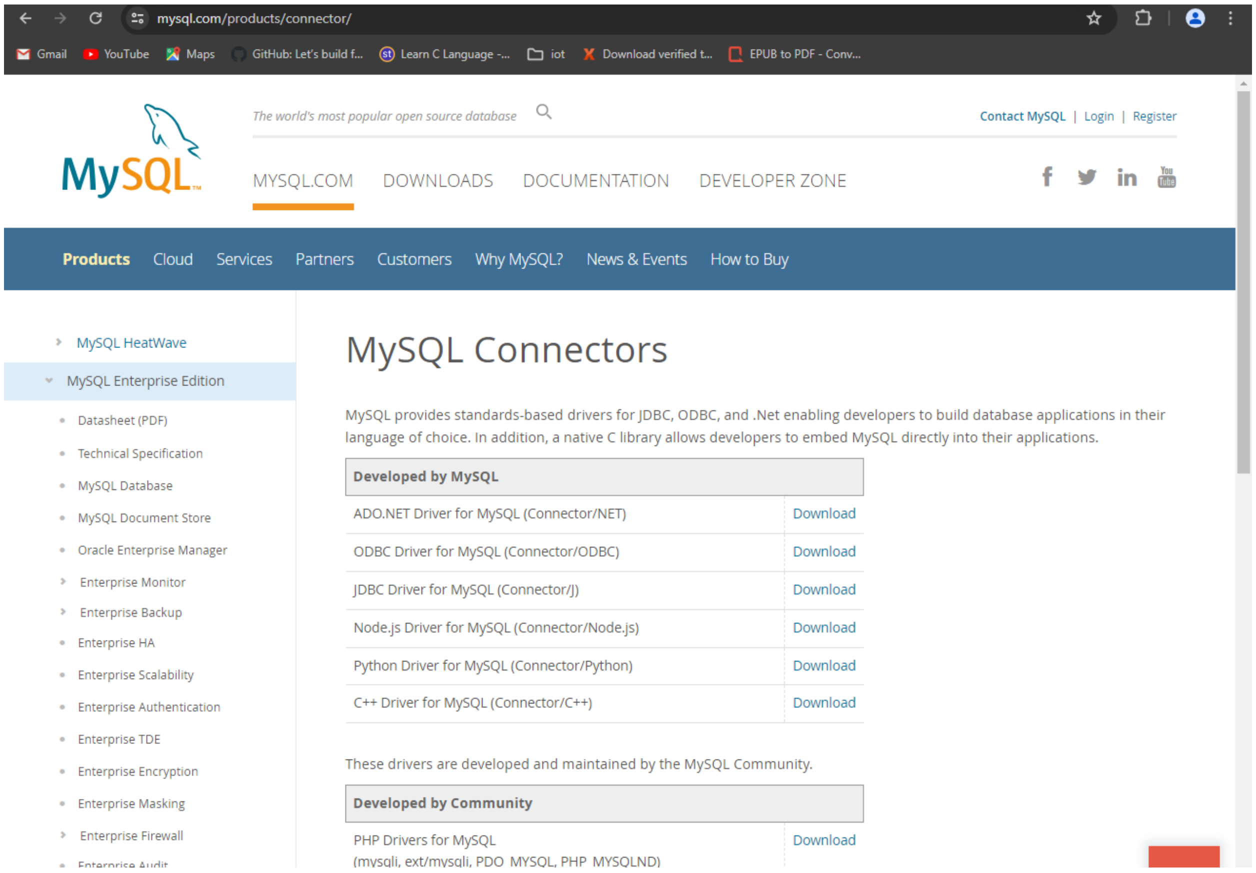
This step is important; otherwise, you will be out-of-sync with this article and may not be able to find your files later

Install MySQL JDBC DRIVER (IMPORTANT - Don't MISS This Step!)

You need to install an appropriate JDBC (Java Database Connectivity) driver

to run your Java database programs.

The MySQL's JDBC driver is called "**MySQL Connector/J**" and is available at MySQL mother site.



mysql.com/products/connector/

MySQL Connectors

MySQL provides standards-based drivers for JDBC, ODBC, and .Net enabling developers to build database applications in their language of choice. In addition, a native C library allows developers to embed MySQL directly into their applications.

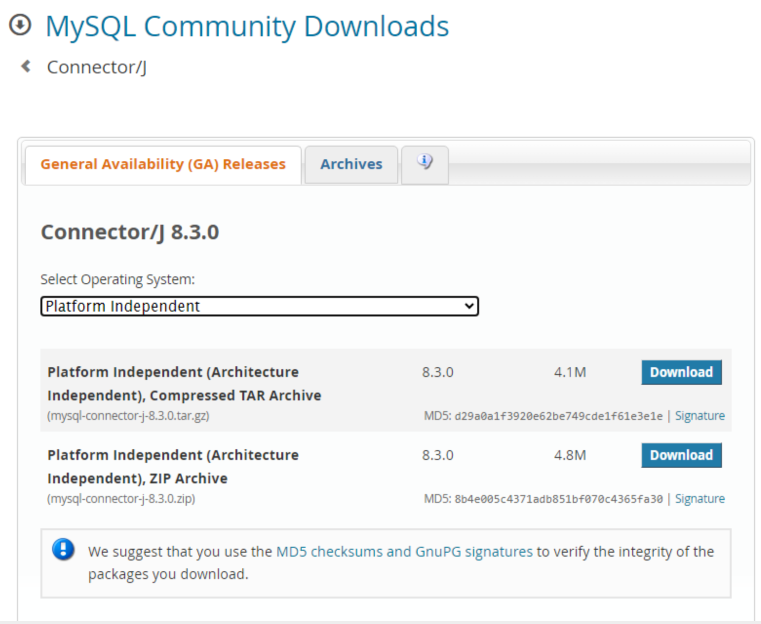
Developed by MySQL	
ADO.NET Driver for MySQL (Connector/NET)	Download
ODBC Driver for MySQL (Connector/ODBC)	Download
JDBC Driver for MySQL (Connector/J)	Download
Node.js Driver for MySQL (Connector/Node.js)	Download
Python Driver for MySQL (Connector/Python)	Download
C++ Driver for MySQL (Connector/C++)	Download

These drivers are developed and maintained by the MySQL Community.

Developed by Community	
PHP Drivers for MySQL (mysqli, ext/mysqli, PDO_MYSQL, PHP_MYSQLND)	Download

For Windows

1. Download the "latest" MySQL JDBC driver from http://dev.mysql.com/downloads ⇒ "Connector/J" ⇒ Connector/J 8.03.{xx}, where {xx} is the latest update number ⇒ In "Select Operating System", choose "**Platform Independent**" ⇒ **ZIP Archive** (e.g., "mysql-connector-j-8.3.{xx}.zip" ⇒ "No thanks, just start my download".



Connector/J 8.3.0

Select Operating System: Platform Independent

Platform Independent (Architecture Independent), Compressed TAR Archive (mysql-connector-j-8.3.0.tar.gz)	8.3.0	4.1M	MD5: d29a0a1f3920e62be749cde1f61e3e1e
Platform Independent (Architecture Independent), ZIP Archive (mysql-connector-j-8.3.0.zip)	8.3.0	4.8M	MD5: 8b4e005c4371adb851bf070c4365fa30

We suggest that you use the MD5 checksums and GnuPG signatures to verify the integrity of the packages you download.

2. UNZIP (right-click and extract all) the download file into your project directory "C:\myWebProject".

   C:\myWebProject

3. Open the unzipped folder. Look for the JAR file "mysql-connector-j-8.3.{xx}.jar".

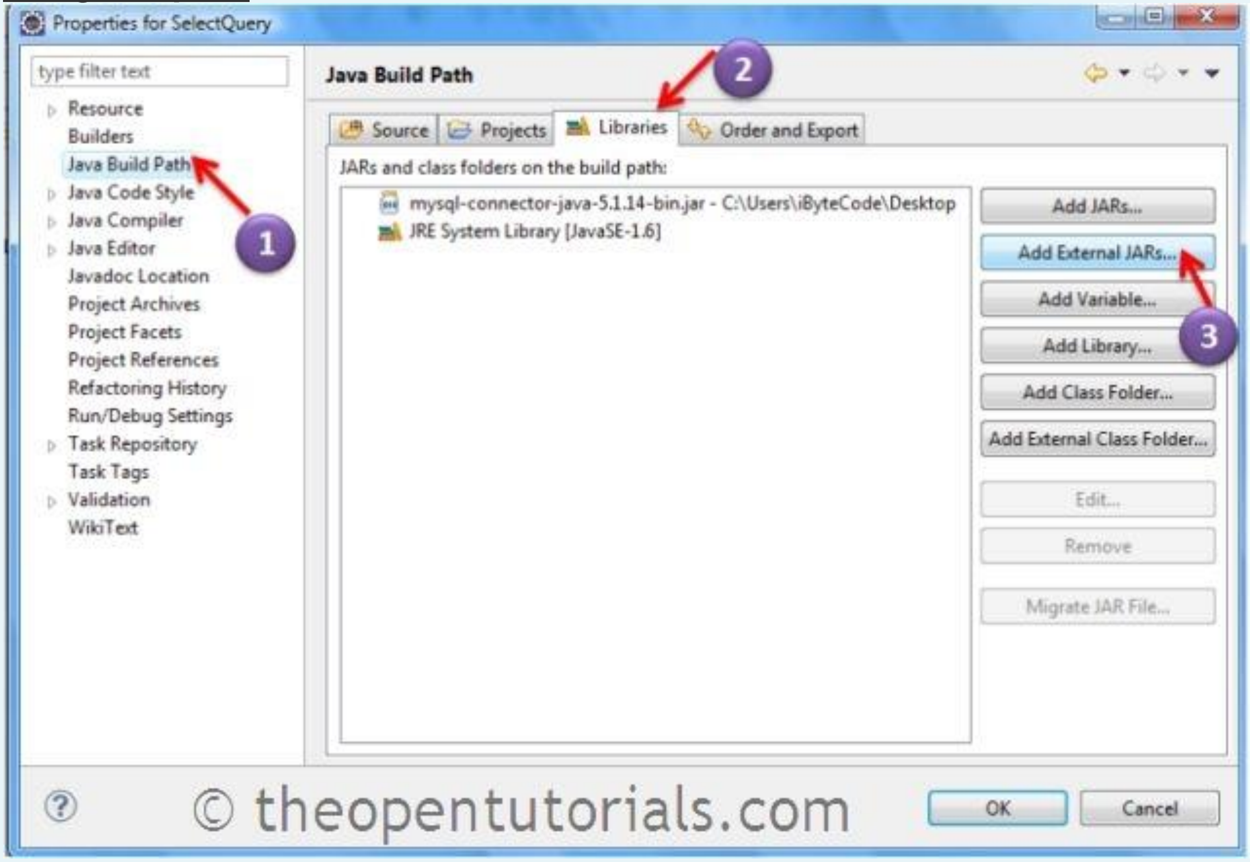
   The Absolute Full-path Filename for this JAR file is "C:\myWebProject\mysql-connector-j-3.0.{xx}\mysql-connector-j-8.3.{xx}.jar".
   Take note of this super-long filename that you will need later. COPY and SAVE in a scratch pad so that you can retrieve later.
   “C:\myWebProject\mysql-connector-j-8.3.0\mysql-connector-j-8.3.0.jar”

(For Advanced User Only) **CLASSPATH**

You can compile Java database programs without the JDBC driver. But to run the JDBC programs, the JDBC driver's JAR-file must be included in the environment variable CLASSPATH,
or in the java's command-line option -cp (or -classpath or --class-path).
You can set the -cp option for Java runtime as follows:

```
// For windows
java -cp .;/path/to/mysql-connector-j-8.3.{xx}.jar JDBCClassToRun
```

using eclipse:



You need to add the downloaded Java MySQL Connector JAR in client **project's classpath** . To do this, **right click on your Java Project (JDBCMySQLSample) -> Properties -> Buildpath -> Libraries -> Add External JAR and select "mysql-connector-java-5.1.14-bin.jar" JAR file**.

https://ibytecode.com/blog/jdbc-mysql-connection-tutorial/

Setup Database

We have to set up a database before embarking on our database programming.

We shall call our database "ebookshop" which contains a table called "books", with 5 columns, as below:

```
Database: ebookshop
Table: books
+-------+----------------------------+---------------+---------+-------+
| id    | title                      | author        | price   | qty   |
| (INT) | (VARCHAR(50))              | (VARCHAR(50)) | (FLOAT) | (INT)
|
+-------+----------------------------+---------------+---------+-------+
| 100   | Java for dummies           | Tan Ah Teck   |  11.11  |   11
|
| 1002 | More Java for dummies       | Tan Ah Teck   | 22.22   |   22
|
| 1003 | More Java for more dummies | Mohammad Ali  | 33.33
|  33   |
| 1004  | A Cup of Java              | Kumar         | 44.44  |  44  |
| 1005  | A Teaspoon of Java         | Kevin Jones   | 55.55  |  55  |
```

Start MySQL Server: **Start the MySQL server** and verify the server's TCP port number from the console messages.
I shall assume that MySQL server is running on the default port number of 3306.

```
// For Windows: assume that MySQL is installed in "c:\myWebProject
\mysql"
c:
cd \myWebProject\mysql\bin
mysqld --console
```

Start a MySQL client: I shall also assume that there is an authorized user called "root" with password "root".

```
// For Windows: assume that MySQL is installed in "c:\myWebProject
\mysql"
c:
cd \myWebProject\mysql\bin
>>mysql –u root -p
```

```
Enter password root
```

Run the following SQL statements to create our test database and table.

```
create database if not exists ebookshop;
use ebookshop;
drop table if exists books;
create table books (id int,title varchar(50),author varchar(50),price f
loat,qty int,primary key (id));

insert into books values (1001, ‘java’, ‘himanshu’, 1000, 50);
insert into books values (1002, ‘python’, ‘himanshu2’, 999, 50);
insert into books values (1003, ‘arduino‘,‘himanshu’760,50);
insert into books values (1004, 'A Cup of Java', 'Kumar', 550, 20);
insert into books values (1005, 'A Teaspoon of Java', 'Kevin Jones', 55
.55, 55);

select * from books;
```

3. Introduction to JDBC Programming by Examples

A JDBC program comprises the following 5 steps:

- **STEP 1: Connect to the database via a Connection object.**
- **STEP 2: Allocate a Statement object, under the Connection created earlier, for holding a SQL command.**
- **STEP 3: Write a SQL query and execute the query via the Statement.executeQuery()|executeUpdate().**
- **STEP 4: Process the query result.**
- **STEP 5: Close the Statement and Connection to free up the resources.**

We shall illustrate Java Database programming by the following examples.

https://www3.ntu.edu.sg/home/ehchua/programming/sql/MySQL_HowTo.html

3.1 Example 1: SQL SELECT

Try out the following JDBC program, which issues an SQL SELECT to MySQL from a Java Program.
Use a Programming Text Editor (e.g., **NOTEPAD**) to create the following program and save as "**JdbcSelectTest.java**" in your project directory "c:\myWebProject" (Windows)

```
import java.sql.*;
// Using 'Connection', 'Statement' and 'ResultSet' classes in java.sql
package
public class JdbcSelectTest
{   // Save as "JdbcSelectTest.java"
   public static void main(String[] args)
{
      try (
         // Step 1: Connect to the database via a 'Connection' object
called 'conn'
         Connection conn = DriverManager.getConnection(

"jdbc:mysql://localhost:3306/ebookshop?allowPublicKeyRetrieval=tr
ue&useSSL=false&serverTimezone=UTC",
               "root", "root");
// For MySQL only

// The format is: "jdbc:mysql://hostname:port/databaseName",
"username", "password"


// Step 2: Construct a 'Statement' object called 'stmt' inside the
Connection created
         Statement stmt = conn.createStatement();
      )
 {
// Step 3: Write a SQL query string. Execute the SQL query via the
'Statement'.
         //  The query result is returned in a 'ResultSet' object called 'rset'.

String strSelect = "select title, price, qty from books";
System.out.println("The SQL statement is: " + strSelect + "\n");
// Echo For debugging
ResultSet rset = stmt.executeQuery(strSelect);
// Step 4: Process the 'ResultSet' by scrolling the cursor forward via
next().
//  For each row, retrieve the contents of the cells with
getXxx(columnName).
        System.out.println("The records selected are:");
        int rowCount = 0;
        // Row-cursor initially positioned before the first row of the
'ResultSet'.
        // rset.next() inside the whole-loop repeatedly moves the
cursor to the next row.
        // It returns false if no more rows.

while(rset.next())
 {   // Repeatedly process each row
           String title = rset.getString("title");
// retrieve a 'String'-cell in the row
           double price = rset.getDouble("price");
// retrieve a 'double'-cell in the row
           int    qty   = rset.getInt("qty");
// retrieve a 'int'-cell in the row
           System.out.println(title + ", " + price + ", " + qty);
           ++rowCount;
}
        System.out.println("Total number of records = " + rowCount);


     }
catch(SQLException ex)
{
        ex.printStackTrace();
     }
 // Step 5: Close conn and stmt - Done automatically by try-with-
resources (JDK 7)
   }
```

```
}
```

Compile

To compile the program:

```
// Windows: The Java source directory is "c:\myWebProject"
```

```
c:
cd \myWebProject
javac JdbcSelectTest.java
```

Run

It is rather difficult to run the program, as you need to include the MySQL JDBC Driver in the "classpath" (via -cp or -classpath or --class-path option) as follows. Replace {xx} with your installation number.

```
// For windows
c:
cd \myWebProject
java -cp .;C:\myWebProject\mysql-connector-j-8.3.{xx}\mysql-co
nnector-j-8.3.{xx}.jar JdbcSelectTest
```

You should COPY and SAVE this command to a scratch pad,

so that you don't need to type this super-long command again and again.

The -cp includes two paths separated by a ";" (Windows) or ":" (macOS). The "." denotes the current directory (to locate the JdbcSelectTest) followed by the full-path filename of the MySQL JDBC Driver JAR-file (that I asked you to take note earlier).

(Skip Unless...) Read "Common Errors in JDBC Programming on MySQL".

(For Eclipse IDE User) If you use Eclipse IDE, check my Eclipse article on how to add an external JAR file into an Eclipse project.

Dissecting the Program

1. The JDBC operations are carried out through the "Connection", "Statement" and "ResultSet" objects (defined in

package java.sql). However, you need not know the details, but merely the public methods defined in the API (Application Program Interface). You also need not re-invent the wheels by creating these classes yourself (which will take you many years?!). "Re-using" software component is a main strength of OOP.

2. Notice that there is little programming involved in using JDBC programming. You only have to specify the *database-URL*, write the SQL query, and process the query result. The rest of the codes are kind of "standard JDBC program template". Again, this is because the wheels have been invented.
3. In Line 7, we allocate a Connection object (called conn) via DriverManager.getConnection(*database-url*, *db-user*, *password*). The Java program uses a so-called *database-URL* to connect to the server:
   - For MySQL:

```
// Syntax
Connection conn = DriverManager.getConnection("jdbc:mysql://{host}:{port}/{database-name}", "{user}", "{password}");
// Example
Connection conn = DriverManager.getConnection("jdbc:mysql://localhost:3306/ebookshop", "myuser", "xxxx");
```

     The database-url is in the form of "jdbc:mysql://{host}:{port}/{database-name}", with protocol jdbc and sub-protocol mysql. The port specifies the MySQL server's TCP port number; user/password is an authorized MySQL user. In our example, "localhost" (with a special IP address of 127.0.0.1) is the hostname for local loop-back testing; "3306" is the server's TCP port number, and ebookshop is the database name.
   - Others: Read "Other Databases".
4. In Line 13, we allocate a Statement object (called stmt) inside the Connection created in the previous step via conn.createStatement().
5. In Line 16, we write a SQL SELECT command string (called strSelect).

6. To execute the SQL command, we invoke method stmt.executeQuery(strSelect). It returns the query result in a ResultSet object (called rset).
7. The ResultSet models the returned table, which can be access via a *row cursor*. The cursor is initially positioned before the first row in the ResultSet. The method rset.next() moves the cursor to the first row. You can then use rset.getXxx(*columnName*) to retrieve the value of the column for that row, where Xxx corresponds to the type of the column, such as int, float, double and String.
8. The while-loop issue rset.next() repeatedly to move the cursor to the next row, and processes row-by-row.
9. The rset.next() returns false at the last row of the ResultSet, which terminates the while-loop.
10. You could use rset.getString(*columnName*) to retrieve all types (int, double, etc).
11. For maximum portability, ResultSet columns within each row should be read in left-to-right order, and *each column should be read only once* via the getXxx() methods. Issue getXxx() to a cell more than once may trigger a strange error.
12. In this example, we use JDK 7's new feature called try-with-resources, which automatically closes all the opened resources in the try-clause, in our case, the Connection and Statement objects.

Exercises: Modify the above program to issue the following SELECT statements and display all the columns retrieved. Make sure that you modify the ResultSet processing to process only the columns retrieved (otherwise, you will get a "Column not found" error).

1. SELECT * FROM books
2. SELECT title, author, price, qty FROM books WHERE author = 'Tan Ah Teck' OR price >= 30 ORDER BY price DESC, id ASC

3.2 Example 2: SQL UPDATE

To execute a SQL UPDATE, you have to invoke the method executeUpdate() of the Statement object, which returns

an int indicating the number of records affected (Line 19). Recall that for SELECT, we use **executeQuery**(), which returns a ResultSet object modeling the returned table (Line 25). SQL UPDATE|INSERT|DELETE does not return a table, but an int indicating the number of records affected.
Save the program as "JdbcUpdateTest.java" in your project directory "c:\myWebProject" (Windows) or "~/myWebProject" (macOS).

```
import java.sql.*;     // Use classes in java.sql package

public class JdbcUpdateTest {    // Save as "JdbcUpdateTest.java"
   public static void main(String[] args) {
      try (
         // Step 1: Allocate a database 'Connection' object
         Connection conn = DriverManager.getConnection(

"jdbc:mysql://localhost:3306/ebookshop?allowPublicKeyRetrieval=tru
e&useSSL=false&serverTimezone=UTC",
               "root", "root");    // for MySQL only

         // Step 2: Allocate a 'Statement' object in the Connection
         Statement stmt = conn.createStatement();
      ) {
         // Step 3 and 4: Execute a SQL UPDATE via executeUpdate()
         //   which returns an int indicating the number of rows affected.
         // Increase the price by 7% and qty by 1 for id=1001
         String strUpdate = "update books set price = price*1.07, qty =
qty+1 where id = 1001";
         System.out.println("The SQL statement is: " + strUpdate + "\n");  //
Echo for debugging
         int countUpdated = stmt.executeUpdate(strUpdate);
         System.out.println(countUpdated + " records affected.\n");

         // Step 3 and 4 (again): Issue a SELECT (via executeQuery()) to
check the UPDATE.
         String strSelect = "select * from books where id = 1001";
```

```
       System.out.println("The SQL statement is: " + strSelect + "\n");  //
Echo for debugging
       ResultSet rset = stmt.executeQuery(strSelect);
       while(rset.next()) {   // Move the cursor to the next row
         System.out.println(rset.getInt("id") + ", "
                + rset.getString("author") + ", "
                + rset.getString("title") + ", "
                + rset.getDouble("price") + ", "
                + rset.getInt("qty"));
       }
     } catch(SQLException ex) {
       ex.printStackTrace();
     }  // Step 5: Close conn and stmt - Done automatically by try-
with-resources
   }
}
```

See the previous example on how to compile and run this program! Point to this Java file "JdbcUpdateTest**"!**

Exercises: Modify your Java program to issue the following SQL statements:

1. Increase the price by 50% for "A Cup of Java".
2. Set the qty to 0 for "A Teaspoon of Java".

3.3 Example 3: SQL INSERT and DELETE

Similarly, use the executeUpdate() to execute 'INSERT INTO' and 'DELETE FROM' (Line 20, 26, 34, 40). The method returns an int indicating the number of records affected.

Save the program as "JdbcInsertTest.java" in your project directory "c:\myWebProject" (Windows) or "~/myWebProject" (macOS).

```
import java.sql.*;     // Use classes in java.sql package

public class JdbcInsertTest {    // Save as "JdbcUpdateTest.java"
   public static void main(String[] args) {
      try (
         // Step 1: Allocate a database 'Connection' object
         Connection conn = DriverManager.getConnection(
"jdbc:mysql://localhost:3306/ebookshop?allowPublicKeyRetrieval=tru
e&useSSL=false&serverTimezone=UTC",
            "root", "root"); // for MySQL only

         // Step 2: Allocate a 'Statement' object in the Connection
         Statement stmt = conn.createStatement();
      ) {
         // Step 3 and 4: Execute a SQL INSERT | DELETE statement via
executeUpdate(),
         //   which returns an int indicating the number of rows affected.

         // DELETE records with id>=3000 and id<4000
         String sqlDelete = "delete from books where id >= 3000 and id <
4000";
         System.out.println("The SQL statement is: " + sqlDelete + "\n");  //
Echo for debugging
         int countDeleted = stmt.executeUpdate(sqlDelete);
         System.out.println(countDeleted + " records deleted.\n");

         // INSERT a record
         String sqlInsert = "insert into books values (3001, 'Gone Fishing',
'Kumar', 11.11, 11)";
         System.out.println("The SQL statement is: " + sqlInsert + "\n");  //
Echo for debugging
         int countInserted = stmt.executeUpdate(sqlInsert);
         System.out.println(countInserted + " records inserted.\n");

         // INSERT multiple records
         sqlInsert = "insert into books values "
               + "(3002, 'Gone Fishing 2', 'Kumar', 22.22, 22),"
               + "(3003, 'Gone Fishing 3', 'Kumar', 33.33, 33)";
         System.out.println("The SQL statement is: " + sqlInsert + "\n");  //
Echo for debugging
         countInserted = stmt.executeUpdate(sqlInsert);
         System.out.println(countInserted + " records inserted.\n");
```

```
         // INSERT a partial record
         sqlInsert = "insert into books (id, title, author) values (3004,
'Fishing 101', 'Kumar')";
         System.out.println("The SQL statement is: " + sqlInsert + "\n");  //
Echo for debugging
         countInserted = stmt.executeUpdate(sqlInsert);
         System.out.println(countInserted + " records inserted.\n");

         // Step 3 and 4: Issue a SELECT (via executeQuery()) to check
the changes
         String strSelect = "select * from books";
         System.out.println("The SQL statement is: " + strSelect + "\n");  //
Echo For debugging
         ResultSet rset = stmt.executeQuery(strSelect);
         while(rset.next()) {   // Move the cursor to the next row
            System.out.println(rset.getInt("id") + ", "
                    + rset.getString("author") + ", "
                    + rset.getString("title") + ", "
                    + rset.getDouble("price") + ", "
                    + rset.getInt("qty"));
         }
      } catch(SQLException ex) {
         ex.printStackTrace();
      }  // Step 5: Close conn and stmt - Done automatically by try-
with-resources
   }
}
```

See the previous example on how to compile and run this program! Point to this Java file "JdbcInsertTest**"!**

Notes:

1. You cannot insert two records with the same primary key (i.e., id) value. Hence, we issue a DELETE before INSERT new record. In this way, you can re-run the program.

2. If you insert a partial record, the missing columns will be set to their default values.

Exercise: Modify your Java program to issue the following SQL statements:

1. Delete all books with id > 8000; and insert: (8001, 'Java ABC', 'Kevin Jones', 15.55, 55) and (8002, 'Java XYZ', 'Kevin Jones', 25.55, 55);

.1 *(Skip Unless...) How to Debug?*

SYMPTOM: Can compile the JDBC program but Runtime Error
ERROR MESSAGE:
(Windows) No suitable driver found
(macOS/Linux) NullPointerException
PROBABLE CAUSES: MySQL JDBC Driver Connector/J was NOT (prop erly) installed.
POSSIBLE SOLUTION:
1. Read "2.3 Install MySQL JDBC Driver" again, again and again...
2. You need to include MySQL JDBC driver via "cp" option to run y our JDBC program:
> java -cp .;*path-to*\mysql-connector-j-x.x.xx.jar *JdbcClassNam e*
3. For Tomcat, you may copy the driver JAR-file into Tomcat's "lib" directory.

SYMPTOM: Can compile the JDBC program but Runtime Error
ERROR MESSAGE: com.mysql.jdbc.exceptions.jdbc4.Communicatio nsException: Communications link failure
PROBABLE CAUSES:
1. MySQL Server is NOT started, or

2. The program was connecting to a wrong TCP port number or wrong hostname (or IP address)
   in your database-URL jdbc:mysql://**localhost:port**/databaseName.

POSSIBLE SOLUTION:
1. Make sure that server has been started. Note down the server's port number
   from the server's console.
2. Check the database-URL's hostname and port number: jdbc:mysql://localhost:*port*/databaseName
3. Run a MySQL client, issue command "status" to confirm the server's TCP port number.
4. Run a mysql client, use "mysql -u root -p **--port=xxxx**" to specify the port number to
   confirm the server's port number.

SYMPTOM: Can compile the JDBC program but Runtime Error
ERROR MESSAGE: java.sql.SQLException: Access denied for user 'username'@'localhost' (using password: YES)
PROBABLE CAUSES: Wrong username or password in statement:
DriverManager.getConnection(***databaseURL, username, password***).
POSSIBLE SOLUTION: Obvious!

SYMPTOM: Can compile the JDBC program but Runtime Error
ERROR MESSAGE: java.sql.SQLNonTransientConnectionException: Public Key Retrieval is not allowed
POSSIBLE SOLUTION:
1. Check you userid and password by logging in thru mysql command-line client
2. Add allowPublicKeyRetrieval=true and/or useSSL=false to Connection's URL, e.g.,

```
jdbc:mysql://localhost:3306/ebookshop?allowPublicKeyRetrieval=tr
ue&useSSL=false&serverTimezone=UTC
```

SYMPTOM: Can compile the JDBC program but Runtime Error
ERROR MESSAGE: java.sql.SQLException: The server time zone value 'xxx' is unrecognized or represents more than one time zone.
POSSIBLE SOLUTION:
Add serverTimezone=UTC to Connnection's URL, e.g.,
jdbc:mysql://localhost:3306/ebookshop?allowPublicKeyRetrieval=tr
ue&useSSL=false&serverTimezone=UTC

SYMPTOM: Can compile the JDBC program but Runtime Error
ERROR MESSAGE: com.mysql.jdbc.exceptions.jdbc4.MySQLSyntaxErr
orException:
Unknown database 'xxxx'
PROBABLE CAUSES: DriverManager.getConnection("jdbc:mysql://lo
calhost:8888/**xxxx**", userid, password)
specifies a database that does not exist in the server.
POSSIBLE SOLUTION: Create the database using a client, before run
ning the Java program.

SYMPTOM: Can compile the JDBC program but Runtime Error
ERROR MESSAGE: com.mysql.jdbc.exceptions.jdbc4.MySQLSyntaxErr
orException:
Table 'xxxx.xxxx' doesn't exist
PROBABLE CAUSES: The SQL statement references a non-existence t
able.
POSSIBLE SOLUTION: Check your SQL statement and the database t
ables.

SYMPTOM: Can compile the JDBC program but Runtime Error
ERROR MESSAGE: java.sql.SQLException: Column 'xxx' not found.
PROBABLE CAUSES: The method ResultSet.getXxx(*columnName*) cannot locate
the requested *columnName* in the ResultSet.
POSSIBLE SOLUTION: Make sure that the column 'xxx' is included in the SELECT statement,
so that it is included in the ResultSet.

SYMPTOM: Can compile the JDBC program but Runtime Error
ERROR MESSAGE: com.mysql.jdbc.exceptions.jdbc4.MySQLSyntaxErrorException:
You have an error in your SQL syntax; check the manual that corresponds to
your MySQL server version for the right syntax to use near .... at line x
PROBABLE CAUSES: Syntax error in your SQL statement.
POSSIBLE SOLUTION: Obvious!

JAVA DATABASE CONNECTIVITY FULL IMPLEMENTATION PRACTICAL SCENARIO: