JOGL

java input output package

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About the Tutorial

Java binding for **O**pen**GL** (JOGL) is an open source library for binding OpenGL graphics in Java. This tutorial provides a basic understanding of JOGL library and its features. It also explains how to develop 2D and 3D graphics applications using JOGL.

Audience

This tutorial is designed for all enthusiastic students and professionals in the domain of web development who want to learn how to integrate OpenGL bindings in their Java applications.

Prerequisites

You need to have a basic understanding of Java programming with exposure to concepts such as AWT and Swings. In addition, it is required that you have an awareness of OpenGL graphics.

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1. OVERVIEW

This chapter introduces OpenGL, its functions, the OpenGL bindings in java (GL4java, LWJGL, JOGL), and the advantages of JOGL over other OpenGL bindings.

Java binding for **O**pen**GL** (JOGL) is the recent binding for OpenGL graphics API in Java. It is a wrapper library, which can access OpenGL API, and it is designed to create 2D and 3D graphics applications coded in Java. JOGL is an open-source library initially developed by former MIT graduate students Ken Russell and Chris Kline. Later, it was adopted by the gaming group at Sun Microsystems, and now it is maintained by Java on Graphics Audio and Processing (JOGAMP). JOGL functions on various operating systems such as Windows, Solaris, Mac OS X, and Linux (on x86).

What is OpenGL?

OpenGL stands for Open Graphics Library, which is a collection of commands to create 2D and 3D graphics. With OpenGL, you can create complicated 3D shapes using very basic primitives such as points, lines, polygons, bitmaps, and images.

Here are a few features of OpenGL:

- It can work on multiple platforms.
- It has bindings in several languages such as C++, Python, etc.
- It can render 2D and 3D vector graphics.
- It interacts with Graphical Processing Unit (GPU) for achieving speedy and high quality rendering. Rendering is the process of creating an image from a 2D or 3D model.
- It is an industry standard API for writing 3D Graphics applications. For example, games, screensavers, etc.
- It contains around 150 commands, which programmers can use to specify objects and operations to develop applications.
- It contains OpenGL Utility Library (GLU) that provides various modeling features, such as quadric surfaces and NURBS curves. GLU is a standard component of OpenGL.
- The design of OpenGL is focused on efficiency, effectiveness, and its implementation on multiple platforms using multiple languages. To maintain simplicity of an OpenGL API, windowing tasks are not included.

Therefore, OpenGL depends on other programming languages for windowing tasks.

Java Binding for OpenGL API

It is a Java Specification Request (JSR) API specification, which allows to use OpenGL on Java platform.

Specifications	Details
JSR 231	This Java binding package supports Java SE platform.
JSR 239	This Java binding package supports Java ME platform.

There are various OpenGL bindings in Java. They are discussed below.

GL4java

It is known as OpenGL for Java technology. It has links to OpenGL 1.3 and to nearly all vendor extensions. Also, it can be used with Abstract Window Toolkit (AWT) and Swings. It is a game focused OpenGL binding, which is a single window that displays full screen applications.

LWJGL

- Light Weight Java Game Library (LWJGL), uses OpenGL 1.5 and works with latest version of java.
- It can use full screen capabilities of JSE 1.4. It has limited support for AWT / Swings.
- It is suitable for lightweight devices such as mobile phones, embedded devices, etc.

JOGL

- JOGL focuses only on 2D and 3D Rendering. The interfaces dealing with sound and input-output are not included in JOGL.
- It includes Graphics Utility Library (GLU), GL Utility toolkit (GLUT), and its own API - Native Windowing Toolkit (NEWT).

Why JOGL?

- It provides full access to the OpenGL APIs (version 1.0, 4.3, ES 1, ES 2 and ES 3) as well as nearly all the vendor extensions. Hence, all the features in OpenGL are included in JOGL.

- JOGL integrates with the AWT, Swing, and Standard Widget Toolkit (SWT). It also includes its own Native Windowing Toolkit (NEWT). Hence, it provides complete support for windowing.

History of JOGL

- 1992 - Silicon Graphics Inc. released the first OpenGL specification.

- 2003 - Java.net website was launched with new features and JOGL was published for the first time on the same website.

- 2010 – Since year 2010, it has been independent open source project under BSD license, which is a liberal license for computer software.

2. INSTALLATION

This chapter covers setting up of the environment to use JOGL on your system using different Integrated Development Environments (IDEs).

Installing JOGL

For JOGL Installation, you need to have following system requirements:

System Requirements

The first requirement is to have the Java Development Kit (JDK) installed on your machine.

Requirement	Description
JDK Version	1.4 or above
Memory	no minimum requirement
Disk Space	no minimum requirement
Operating System	no minimum requirement

You need to follow the given steps to setup your environment to start with JOGL application development:

Step 1 - Verifying Java Installation on Your Machine

Open console of your system and execute the following java command:

Platform	TASK	COMMAND
Windows	Open Command Console	C:\>java-version
Linux	Open Command terminal	$java- version
MAC	Open Terminal	Machine:~ joseph$ java -version

Verify the output on the respective operating system.

Platform	Output
Windows	**Java "1.6.0.21"** java(TM) SE Runtime Environment(build 1..6.0_21-b07)Java HotSpot(TM) Client VM(build 17.0-b7, mixed mode, sharing)
Linux	**Java "1.6.0.21"** java(TM) SE Runtime Environment(build 1..6.0_21-b07)Java HotSpot(TM) Client VM(build 17.0-b7, mixed mode, sharing)
MAC	**Java "1.6.0.21"** java(TM) SE Runtime Environment(build 1..6.0_21-b07)Java HotSpot(TM) Client VM (build 17.0-b7, mixed mode, sharing)

Step 2 – Setting up Java Development Kit (JDK)

If Java is not installed on your machine, then you need to install Java SDK from the Oracle website: www.oracle.com/technetwork/java/javase/downloads/. You can find instructions for installing the JDK from the downloaded files. You need to follow the given instructions to install and configure the setup. Finally, set PATH and JAVA_HOME environment variables to refer to the directory that contains java.exe and javac.exe files, typically java_install_dir/bin and java_install_dir respectively.

Set **Java-home** environment variable to point to the base directory location on the same path, where Java is installed on your machine.

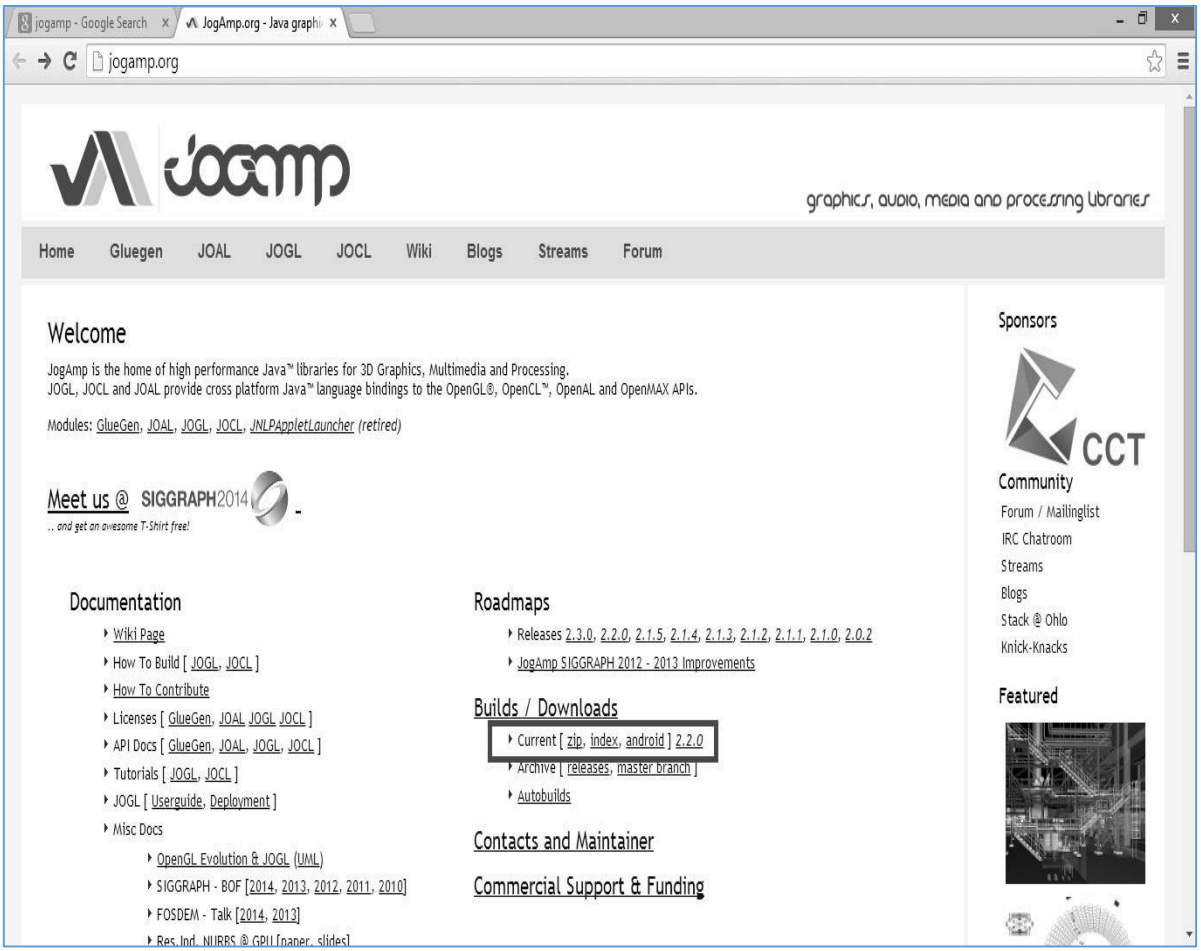
Platform	Command
Windows	Set the environment variable JAVA_HOME to C:\ProgramFiles\Java\Jdk1.6.0_21
Linux	Export JAVA_HOME=/usr/local/java-current
MAC	Export JAVA_HOME=/Library/Java/Home

Append Java compiler location to System Path as follows:

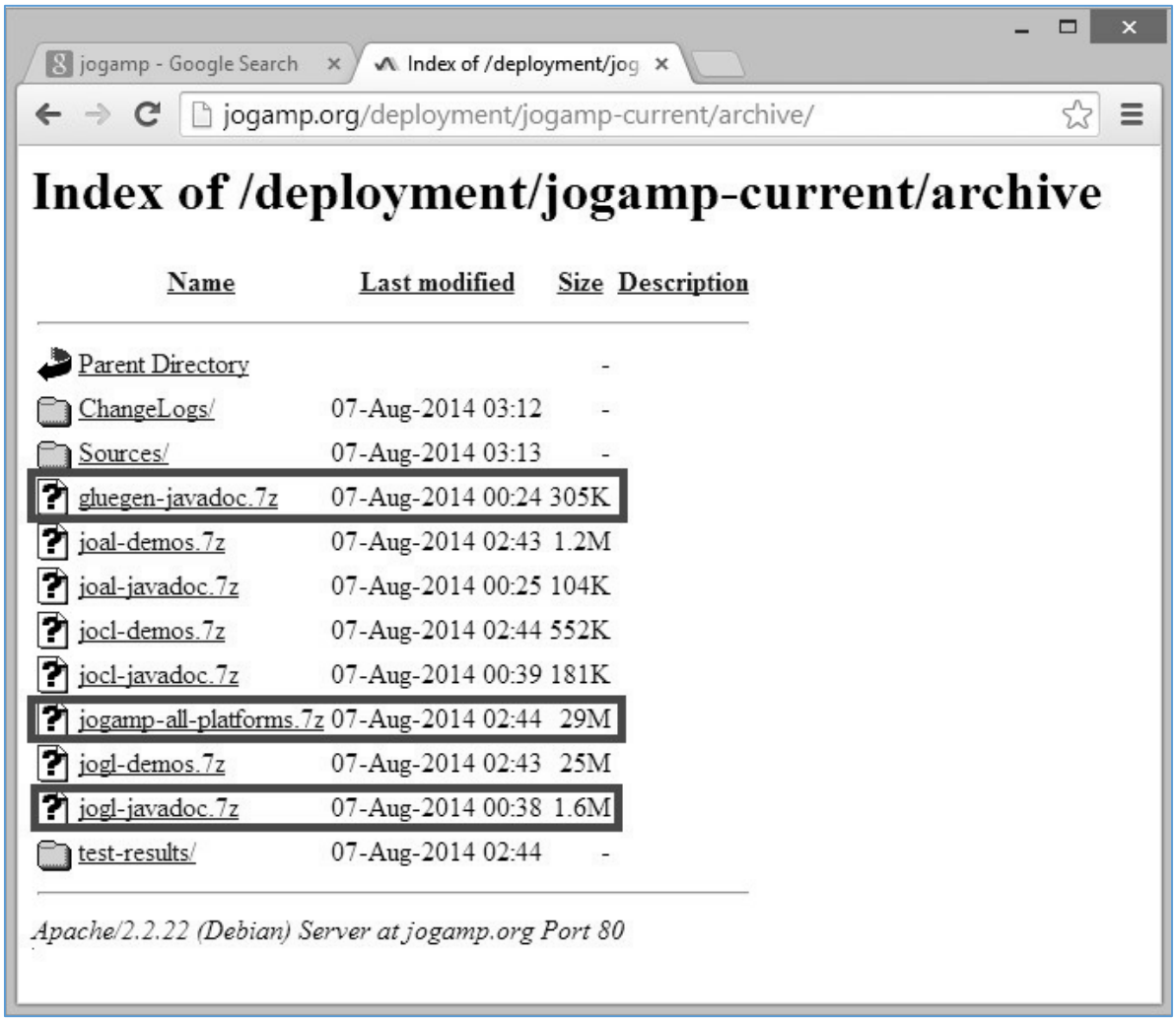
Platform	Command
Windows	Append the string ;%JAVA_HOME% bin at the end of the system variable and path
Linux	Export PATH=$PATH:$JAVA_HOME/bin/
MAC	Not required

Step 3 – Downloading JOGL

- You can download latest version of JOGL from the website www.jogamp.org
- Go to the home page of www.jogamp.org
- Click on Builds/Downloads > Current (zip).

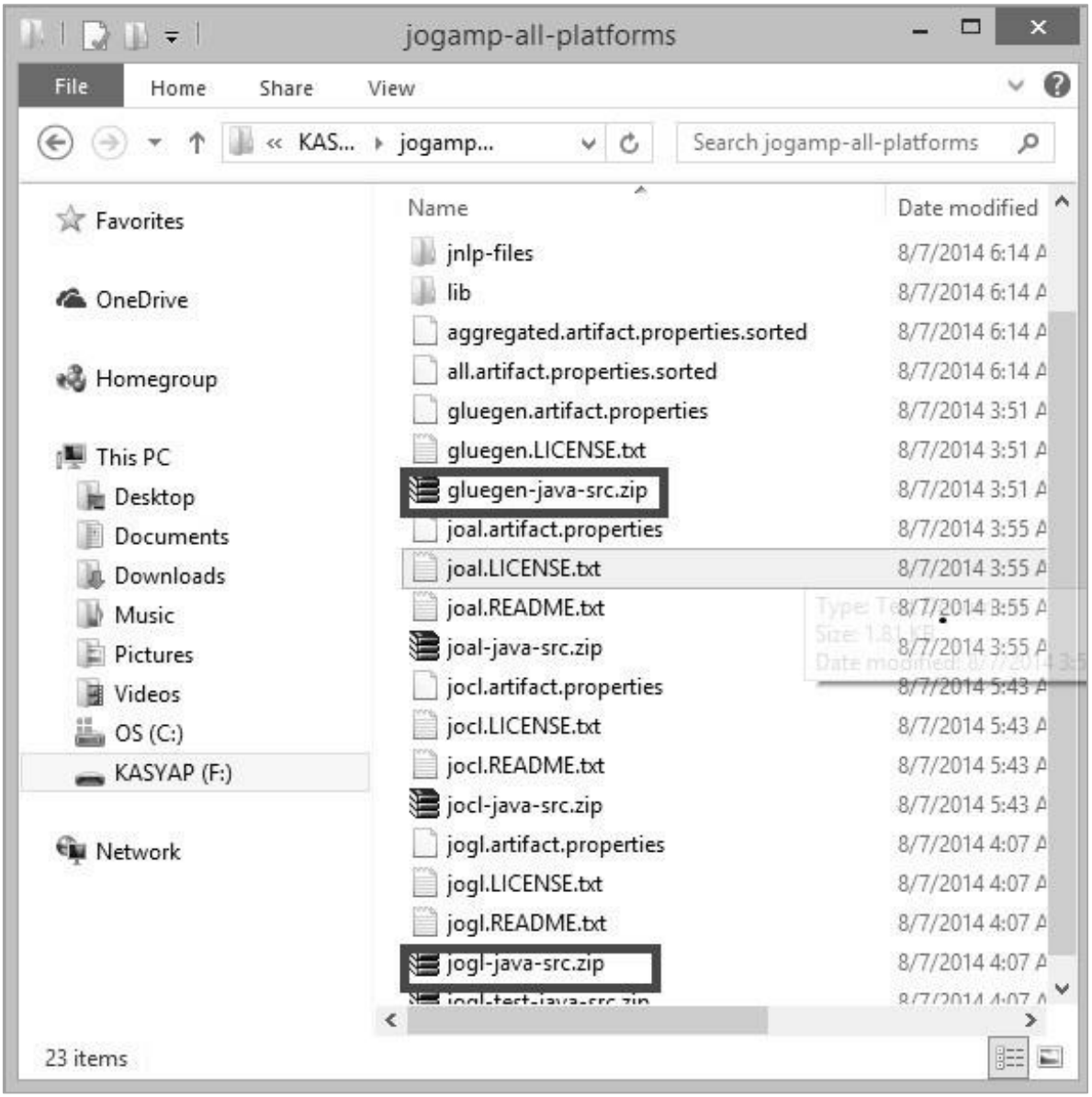


This takes you to the list of .jar files for all APIs maintained by the website.



- Download the library .jar file jogamp-all-platforms.7z, java documentations for OpenGL native library glugen-javadoc.7z, and JOGL jogl-javadocs.7z.
- Extract the downloaded .jar files using any zip extracting software.

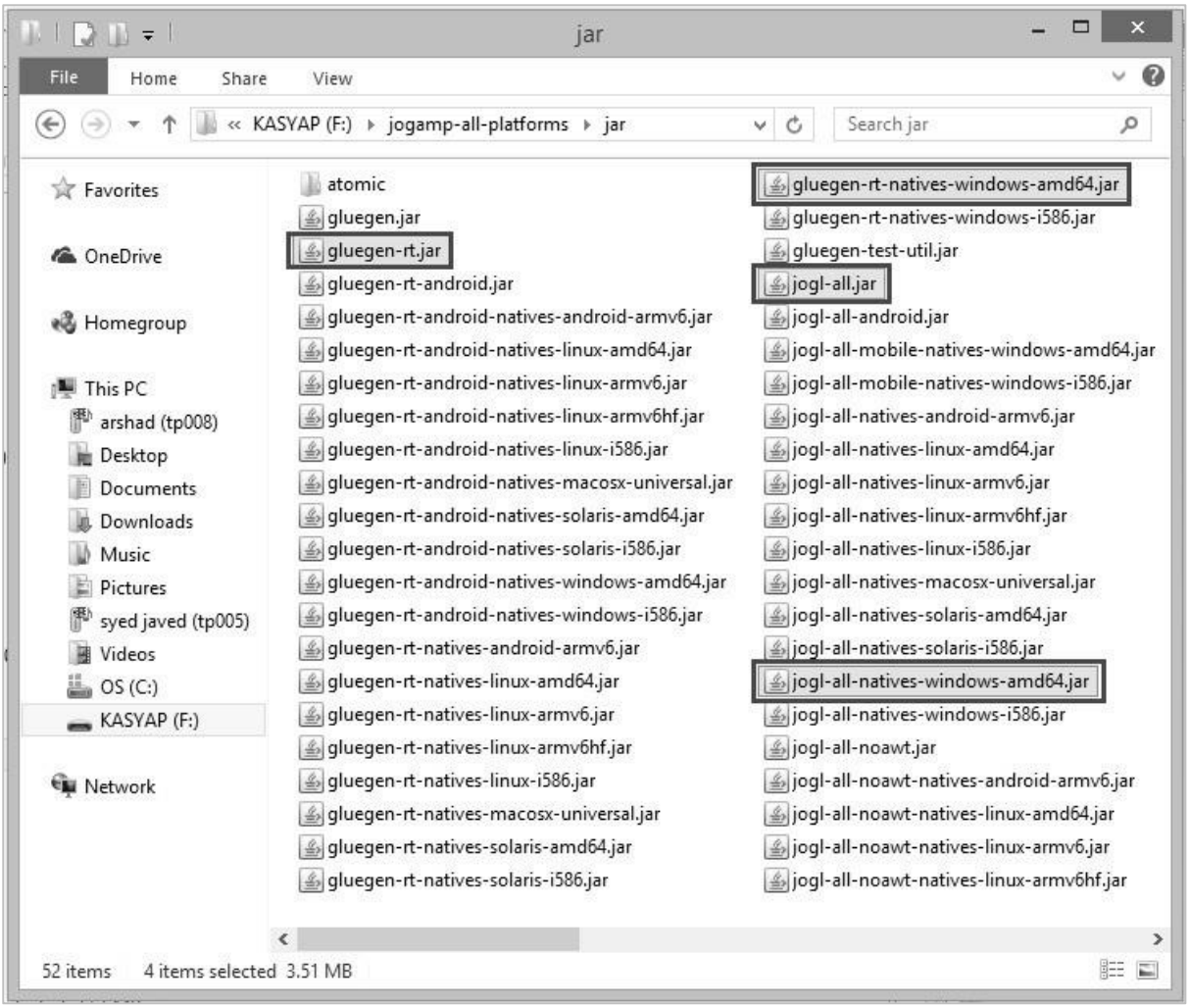
When you open the extracted folder, you will find jar folder, source-codes, and other files.



Get the source codes gluegen-java-src.zip and jogl-java-src.zip for supporting IDE. This is optional.

- Inside the jar folder, there are multiple .jar files. This collection of files belongs to Glugen and JOGL.

- JOAMP provides native libraries that support various operating systems such as Windows, Solraris, Linux and Android. Hence, you need to take appropriate jar files which can execute on your desired platform. For example, if you are using Windows 64-bit operating system, then get the following .jar files from the jar folder:
  - gluegenrt.jar
  - jogl-all.jar
  - gluegen-rt-natives-windows-amd64.jar
  - jogl-all-natives-windowsamd64.jar

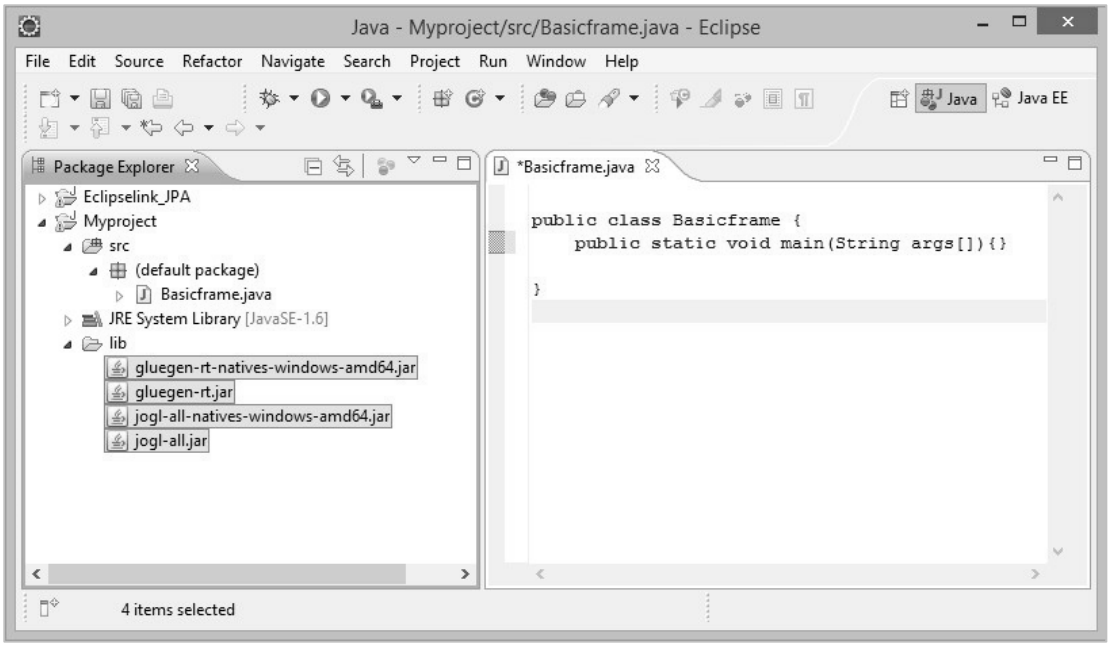


Setting up JOGL for Eclipse 4.4

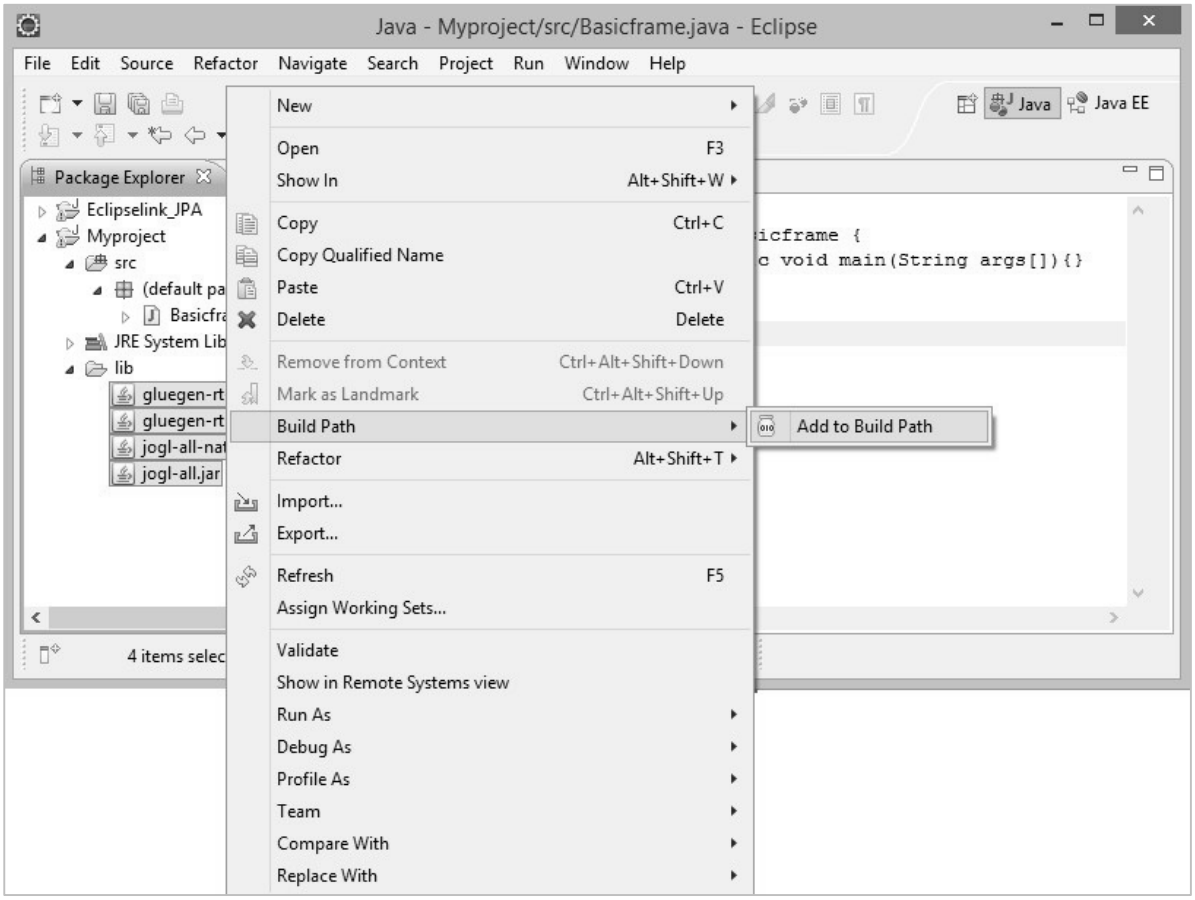
Follow the given procedure for setting up JOGL:

Adding Libraries

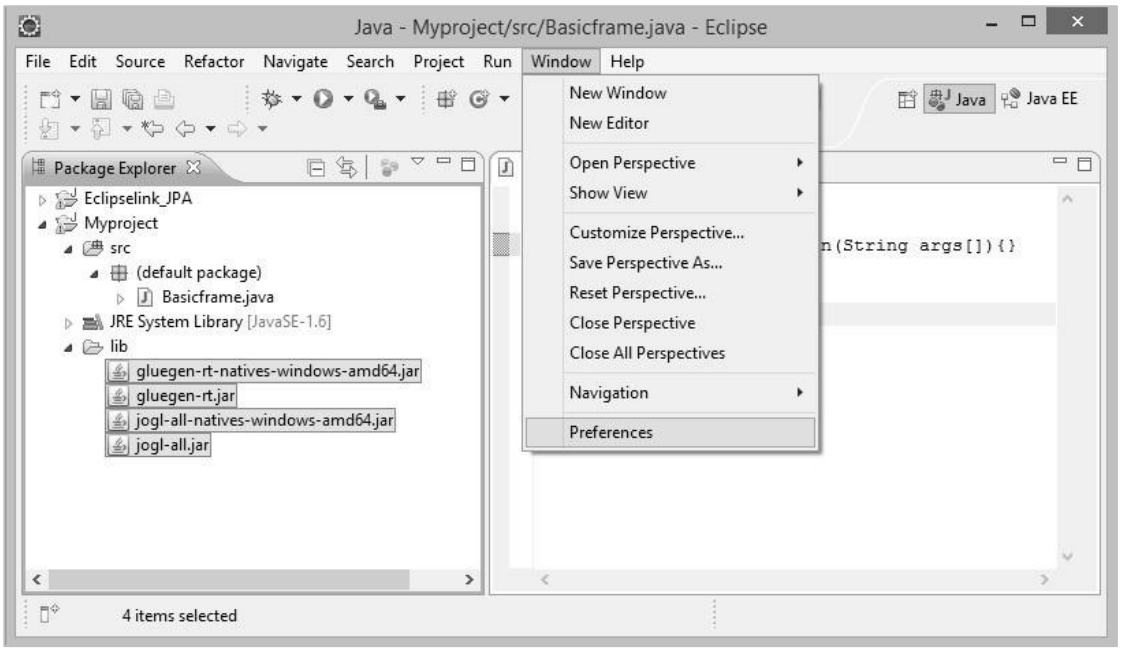
1. Open Eclipse.
2. Create a new project.
3. Create a new folder named *lib* in the project folder.
4. Copy the files **gluegen-rt-natives-windows-amd64.jar, gluegen-rt.jar, jogl-all-natives-windowsamd64.jar** and **jogl-all.jar** into the *lib* folder.

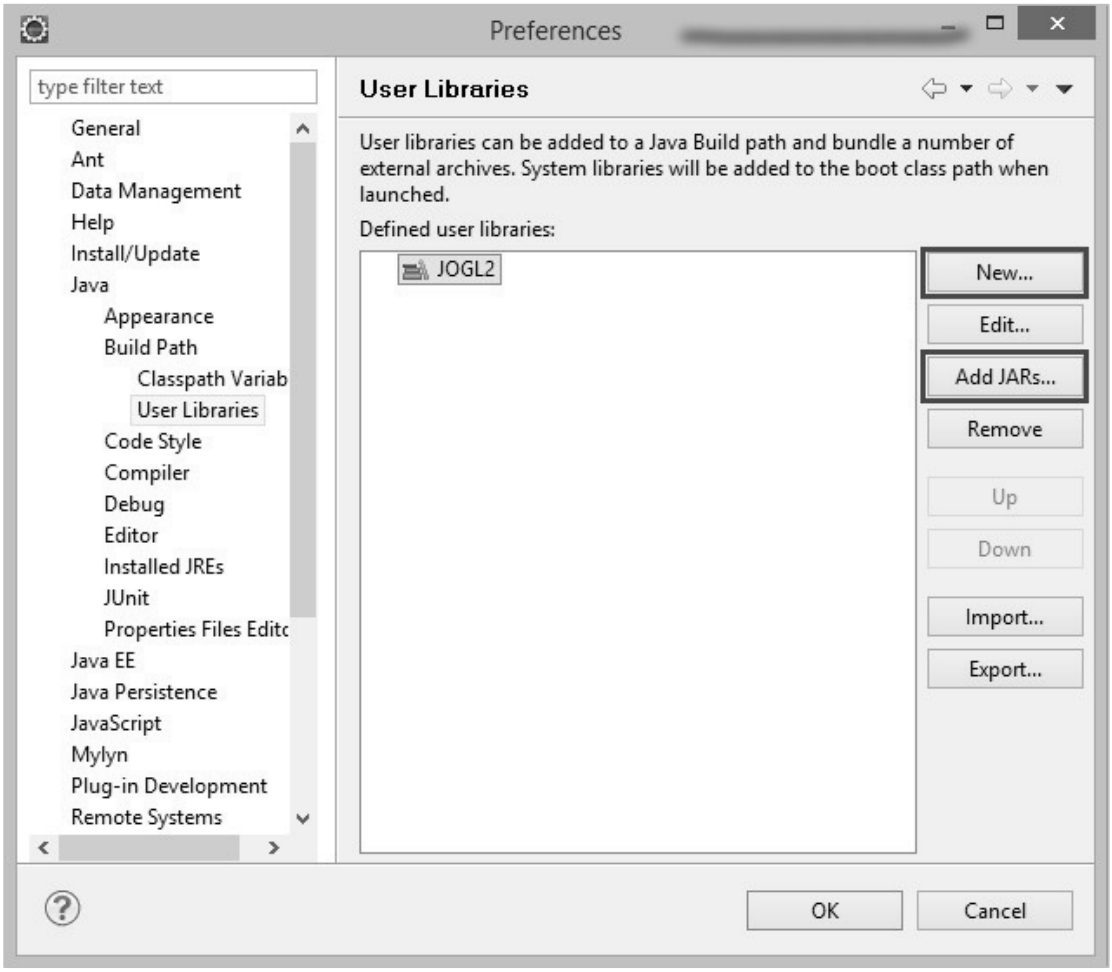


5. Now select these files and right click your mouse button. A shortcut menu is displayed, which contains **Build Path > Add to Build Path.**



6. To make all .jar files available to other projects, go to main menu. Select Window > Preferences. The Preferences window appears.





- In preferences window, in the drop down menu on the left hand side, follow the hierarchy- Java-> Build Path -> User Libraries.
- Click on "New…" button.
- It opens up a dialog box. Enter the library name as jogl2.1.
- Add jar files **glugen-rt.jar** and **jogl-all.jar** using button "Add External JARs...".
- It creates a new user library named **jogl2.1.**

In the same way, we can add java documentation and source code for the added .jar files.

Adding Native Libraries

1. Expand the jogl-all.jar node, select Javadoc location (none).
2. Click on "New…" button. Enter the name for JOGL Java Document.
3. Click on "Add External JARs…" button.
4. It opens a dialog box where you need to select the location of JOGL Java documentation, which we already have downloaded earlier.

Adding source code

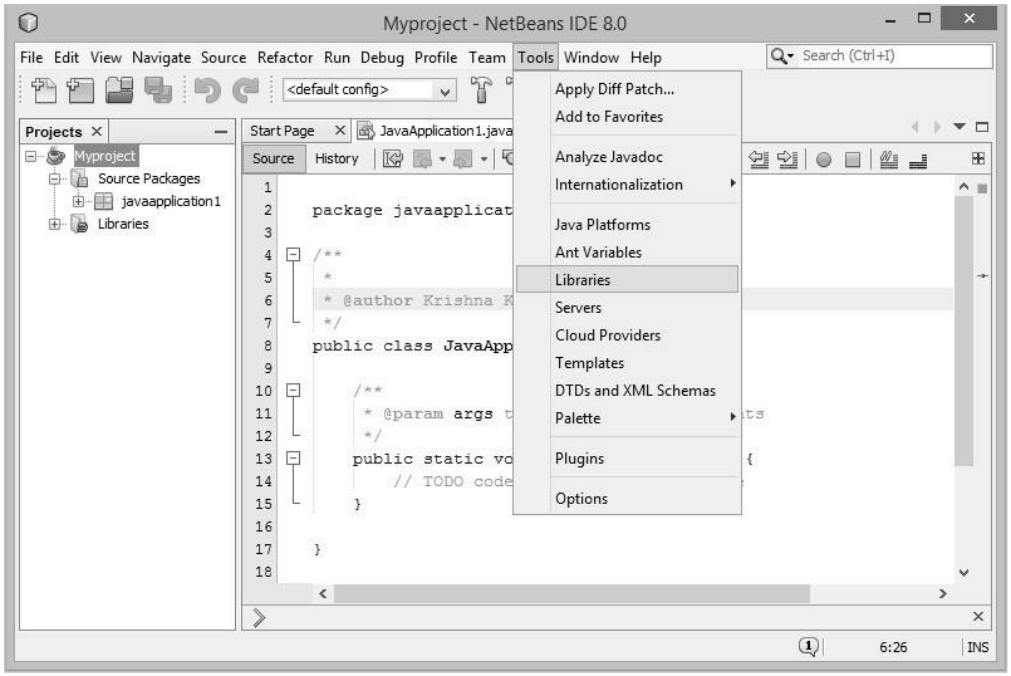
1. Select the node Native library location: (None).
2. Click on "New…" button.
3. Enter name for native libraries and click "OK" button.
4. Click on "Add External JARs…" button.
5. Now select the path where native library files (**'gluegen-rt-natives-windows-amd64.jar and joglall-natives-windows-amd64.jar'**) are located.
6. Repeat the same procedure for source code.
7. We can set the locations for Javadoc, source code and jar files in the same way as given above for both native library files **glegen-rt.jar** and **glugen-natives-windows-amd64.jar.**

Setting up JOGL for NetBeans 4.4

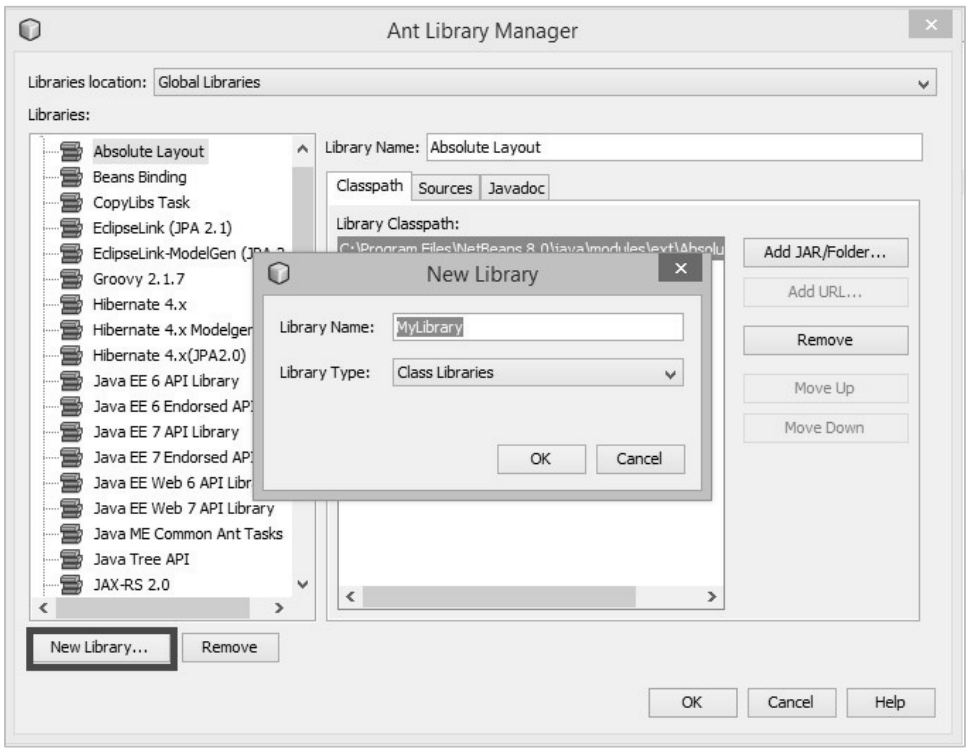
Let us go through the steps for setting up JOGL for NetBeans 4.4:

Adding Libraries

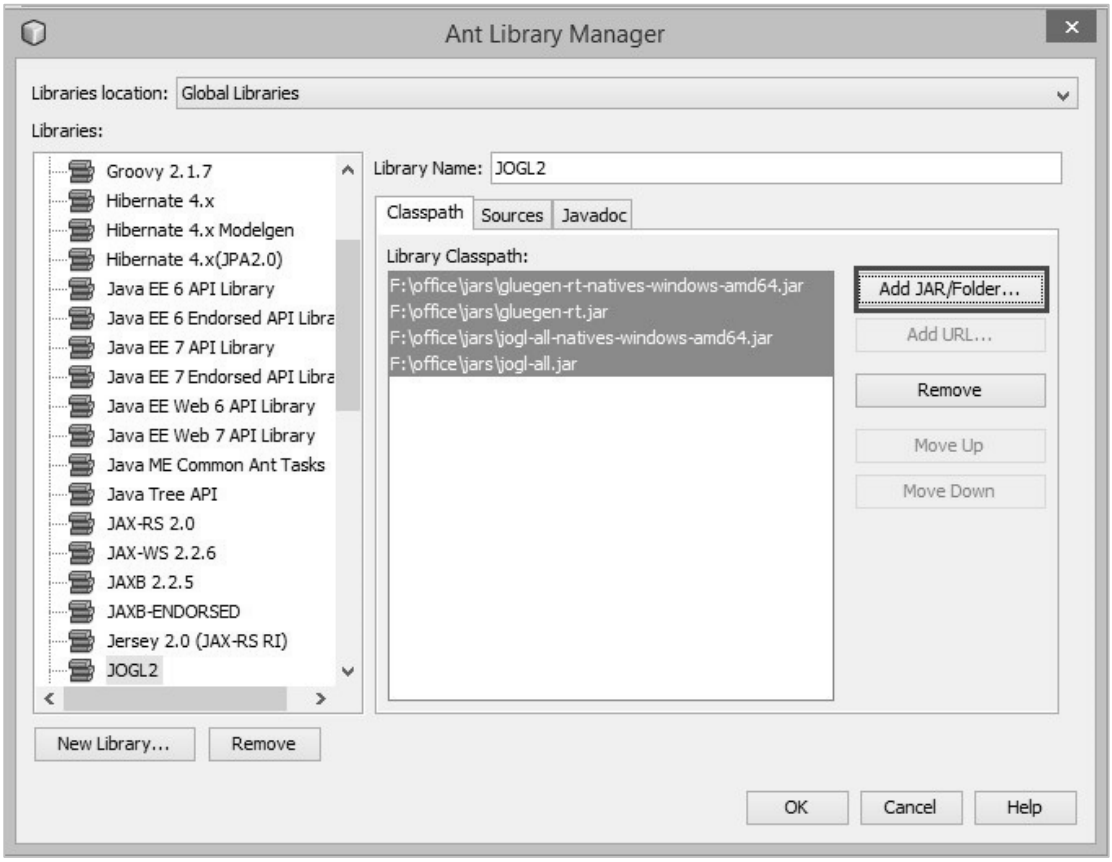
1. In the main menu, select **Tools > Libraries**.



2. It leads you to Ant Library Manager.



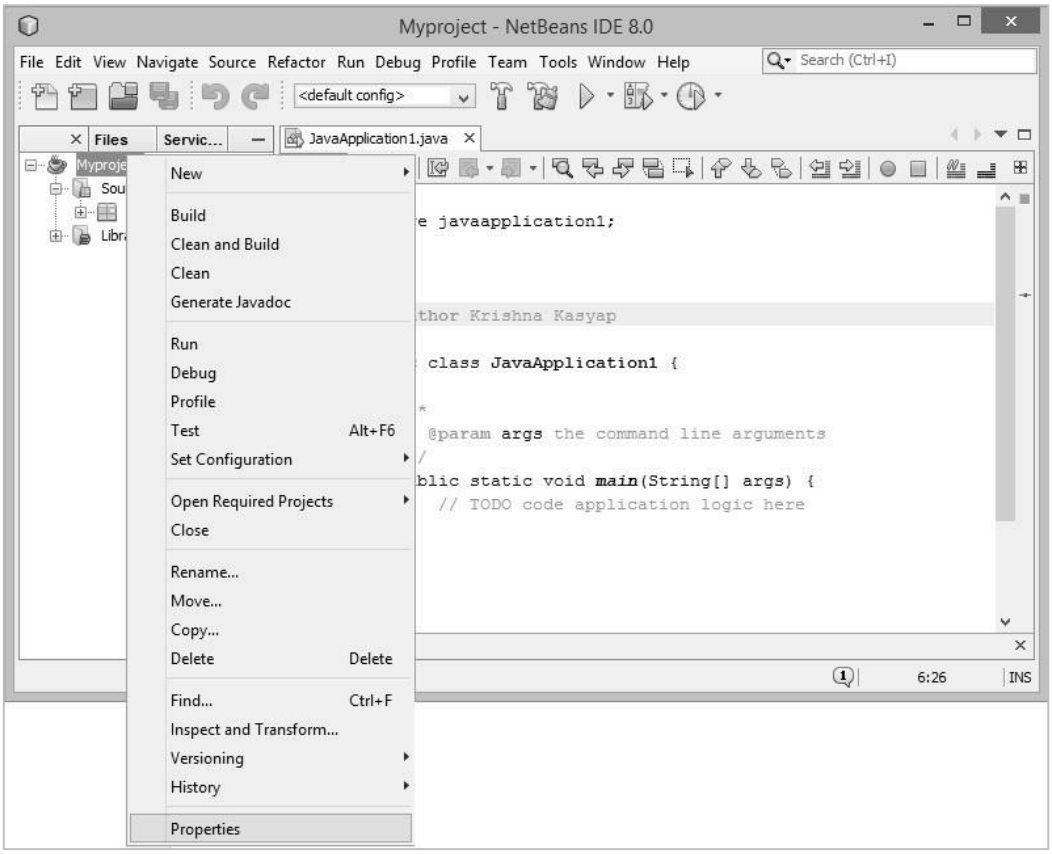
3. Under the **Classpath** tab, click **New Library** button located on the left lower corner. It opens a small dialog box.
4. Enter Library name as **JoGl2.0.**
5. Click on "OK" button.



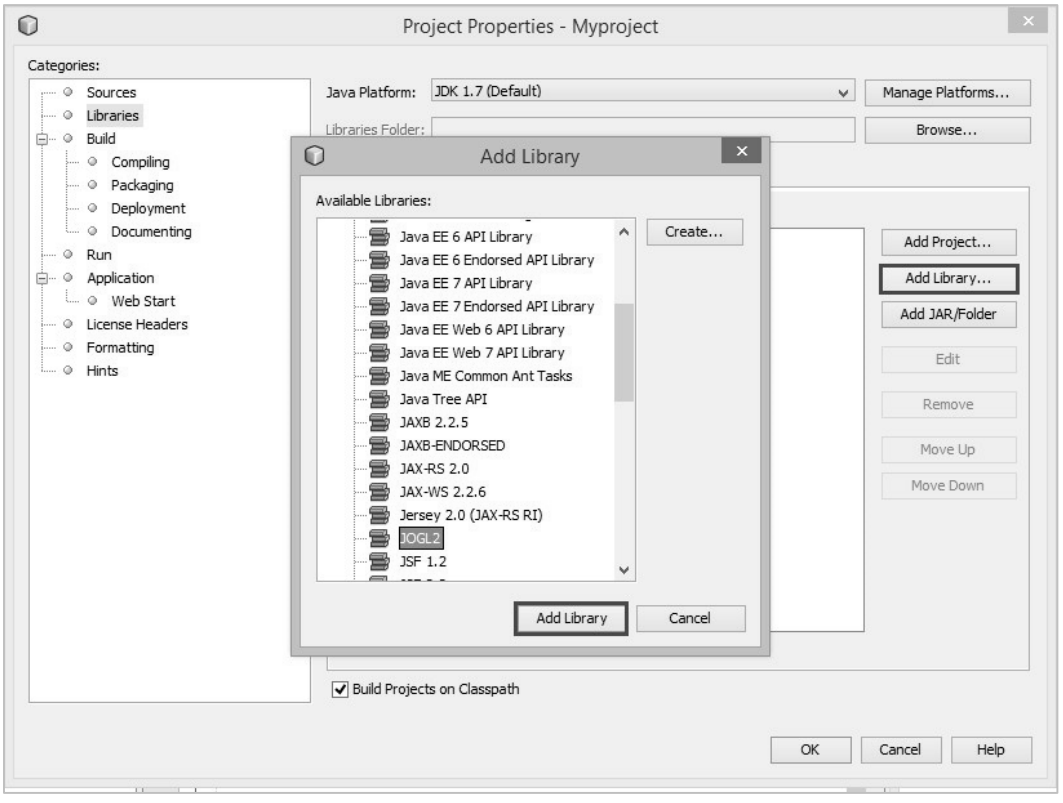
6. Click on "Add JAR/Folder…" button.
7. Select the path where .jar files **jogl.all.jar** and **gluegen-rt.jar** are located.

To include JOGL library into each project, follow the steps given below:

1. Right-click on the **project name.** It shows a short-cut menu.



2. Select **Properties.** It opens a window named **Project properties.**



3. Select **Libraries** from Categories on the left hand side

4. Select **Compile tab** and click on "Add Library..." button. Add library dialog box comes up.

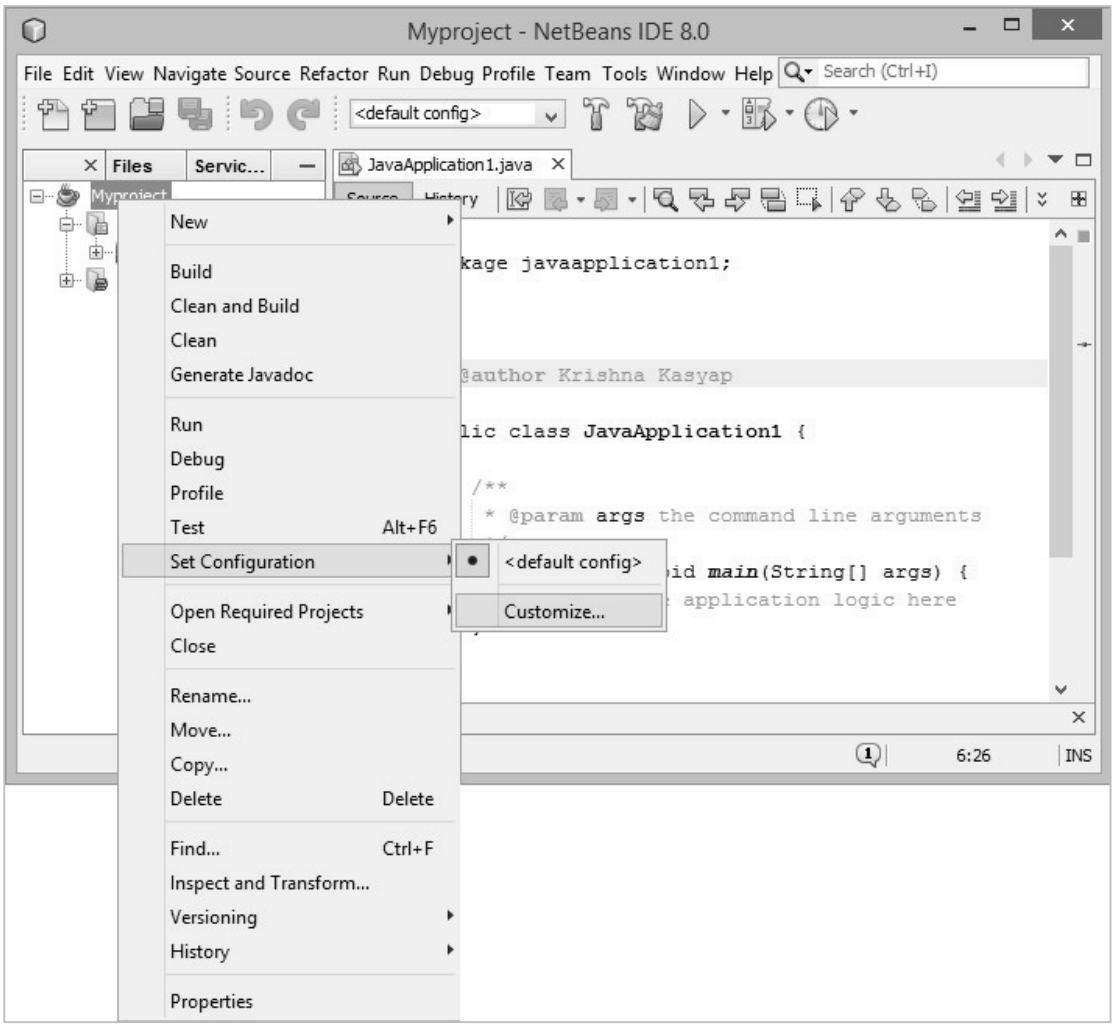
5. Now add JOGL2.0 library, which you created earlier.

Including Native Library in Each Project

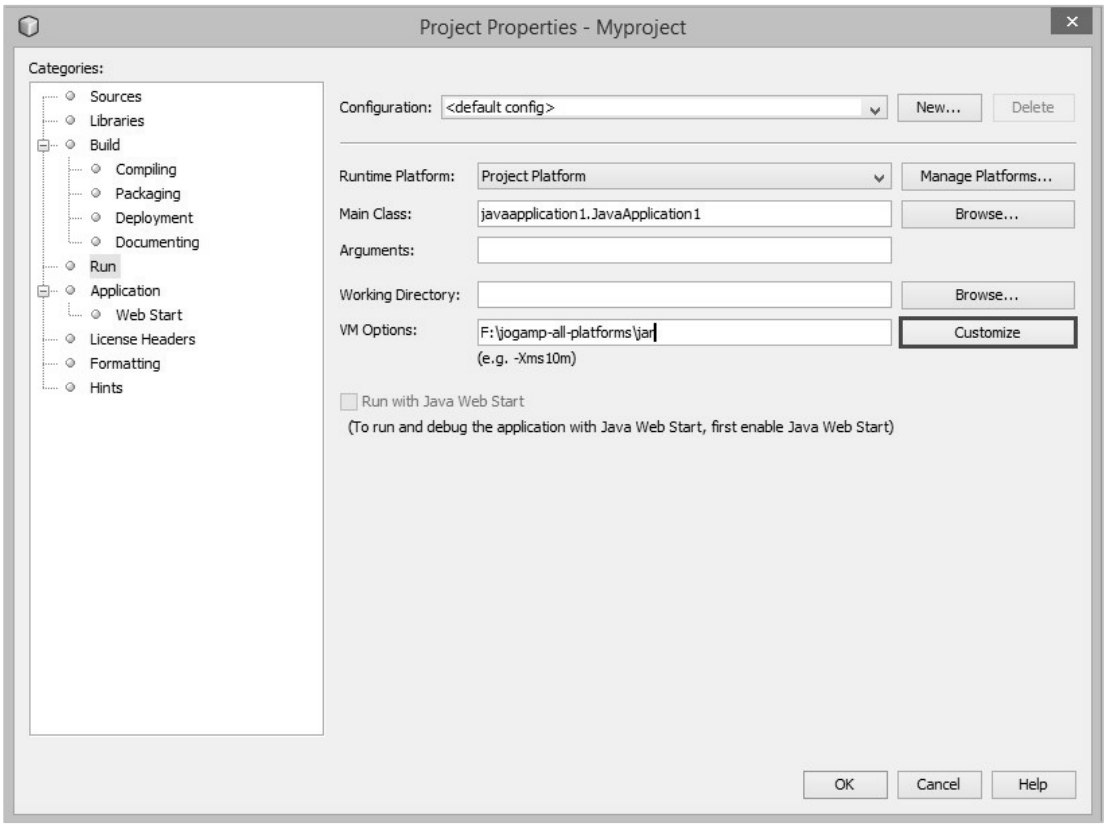
Follow the given steps to include native library in each project:

1. Right-click the project.

2. Select **Set Configuration > Customize...**



It leads you to the **Project Properties** window.



3. On the right hand side, in **VM options,** click on "Customize" button.

4. Browse for the path that contains JOGL native libraries **gluegen-rt-natives-windows-amd64.jar''** and **'jogl-all-natives-windows-amd64.jar.**

Adding Java Documentation of Native Libraries

You need to open Ant library manager again to make sources and Javadoc available for each project. Follow the given procedure:

1. Open main menu.
2. Select Tools > Libraries. This leads you to Library manager.
3. Under the JavaDoc tab, click on "New Library…" button.
4. Enter JOGLJavadoc name. (You can enter any desired name.)
5. Click on "Add jars/libraries…" button.
6. Select the path where unzipped JOGL documentation code is located.

Adding Source Code of Native Libraries

1. Under **Sources** tab, click on "New Library…" button.
   Enter **JOGLsources** name.

2. Click on "Add jars/libraries…" button. Select the path where unzipped source code is located.

Customizing the JDK Editor

1. Set Classpath for files jogl.all.jar and gluegen-rt.jar.
2. Set path to native libraries gluegen-rt-natives-windows-amd64.jar and jogl-all-natives-windowsamd64.jar or copy all the jar files from the folder where you have downloaded them and paste them into the jse lib folder.

3. BASIC TEMPLATE

This chapter explains how to write a JOGL basic template.

To make your program capable of using JOGL graphical API, you need to implement **GLEventListener** interface.

GLEventListener Interface

You can find the **GLEventListener** interface in the **javax.media.opengl** package.

- **Interface:** GLEventListener
- **Package:** javax.media.opengl

The following table provides the details of various methods and descriptions of **GLEventListener** interface:

Sr. No.	Methods and Descriptions
1	**Void display(GLAutoDrawable drawable)** It is called by the object of GLAutoDrawable interface to initiate OpenGL rendering by the client. i.e., this method contains the logic used to draw graphical elements using OpenGL API.
2	**Void dispose(GLAutoDrawable drawable)** This method signals the listener to perform the release of all OpenGL resources per each GLContext, such as memory buffers and GLSL programs.
3	**Void init(GLAutoDrawble drawble)** It is called by the object of GLAutoDrawable interface immediately after the OpenGL context is initialized.
4	**Void reshape(GLAutoDrawble drawble, int x, int y, int width, int height)** It is called by the object of GLAutoDrawable interface during the first repaint after the component has been resized. It is also called whenever the position of the component on the window, is changed.

All the methods of **GLEventListener** require object of **GLAutoDrawable** interface as a parameter.

GLAutoDrawable Interface

This interface supplies an event-based mechanism **(GLEventListener)** for performing OpenGL rendering. **GLAutoDrawable** automatically creates a primary rendering context which is associated with **GLAutoDrawable** for the lifetime of the object.

Interface: GLAutoDrawble

Package: javax.media.opengl

Sr. No.	Methods and Descriptions
1	**GL getGL()** Returns the GL pipeline object that is used by the current object of GLAutoDrawable interface.
2	**void addGLEventListener(GLEventListener Listener)** Adds the given listener to the end of current drawable queue.
3	**void addGLEventListener(int index, GLEventListener listener)** Adds the given listener at the given index of this drawable queue.
4	**void destroy()** Destroys all resources associated with this object of GLAutoDrawable interface, including the GLContext.

Note: There are other methods in this package. Only a few important methods pertaining to template are discussed in this interface.

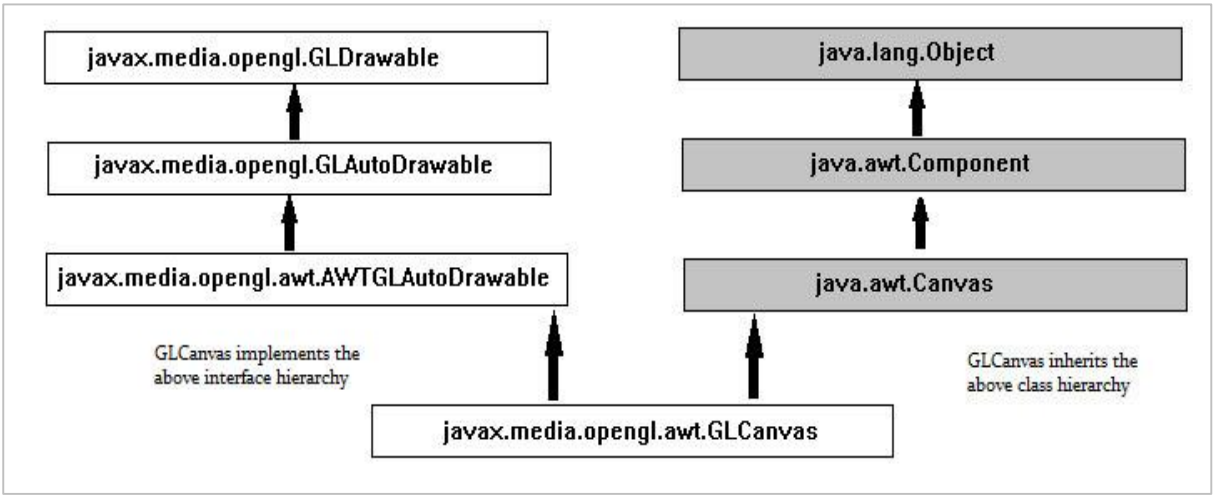
GLCanvas Class

GLCanvas and **GLJpanel** are the two main classes of JOGL GUI that implement **GLAutoDrawable** interface, which can be utilized as drawing surfaces for OpenGL commands.

GLCanvas is a heavyweight AWT component which provides OpenGL rendering support. This is the primary implementation of an **AWTAutoGLDrawable** interface. It also inherits **java.awt.Canvas** class. Since it is a heavyweight component, in certain cases, **GLJCanvas** may not integrate with swing component

correctly. Therefore, care must be taken while using it with Swing. Whenever you face problems with **GLJCanvas,** then you must use **GLJPanel** class.

The hierarchical diagram of class **GLCanvas** can be as shown below:



- **GLEventistener** interface works along with **GLCanvas** class. It responds to the changes in **GLCanvas** class and to the drawing requests made by them.

- Whenever **GLCanvas** class is instantiated, the **init()** method of **GLEventListener** is invoked. You can override this method to initialize the OpenGL state.

- Whenever **GLCanvas** is drawn initially (instantiated) or resized, the **reshape()** method of **GLEventListener** is executed. It is used to initialize the OpenGL viewport and projection matrix. It is also called whenever the component's location is changed.

- The display() method of **GLEventListener** contains the code for rendering 3D scene. It is invoked whenever display() method of **GLCanvas** is invoked.

class: GLCanvas

package: javax.media.opengl.awt

Constructor

```
GLCanvas()
```

It creates a new GLCanvas component with a default set of OpenGL capabilities, using the default OpenGL capabilities selection mechanism, on the default screen device.

```
GLCanvas(GLCapabilitiesImmutable)
```

It creates a new GLCanvas component with the requested set of OpenGL capabilities using the default OpenGL capabilities selection mechanism on the default screen device.

Sr. No.	Methods and Description
1	**void addGLEventListener(GLEventListener listener)** Adds the given listener to the end of this drawable queue
2	**void addGLEventListener(int indexGLEventListener listener)** Adds the given listener at the given index of this drawable queue.

To instantiate **GLCanvas** class, you need the object of **GLCapabilitiesImmutable** interface, which specifies an immutable set of OpenGL capabilities.

One of the ways to get an object of **CapabilitiesImmutable** interface is to instantiate **GLCapabilities** class, which implements the interface. An instance of **GLCapabilities** class can be used to serve the purpose.

GLCapabilities Class

This class specifies a set of OpenGL capabilities. It takes GLCapabilities object as a parameter. The **GLCapabilities** class describes the desired capabilities that a rendering context must support, such as the OpenGL profile.

class: GLCapabilities

package: javax.media.opengl

Constructor

```
GLCapabilities(GLProfile glprofile)
```

It creates a GLCapabilities object.

To instantiate **GLCanvas** class, you need an object of GLCapabilitiesImmutable interface, which specifies an immutable set of OpenGL capabilities.

One of the ways to get an object of **CapabilitiesImmutable** interface is to instantiate **GLCapabilities** class, which implements the interface. The instance of **GLCapabilities** class can be used to serve the purpose.

The **GLCapabilities** class in turn requires a **GLProfile** object.

GLProfile Class

Since several versions of OpenGL API were released; you need to specify the exact version of OpenGL API being used in your program to your Java Virtual Machine (JVM). This is done using the **GLProfile** class.

The **get()** method of this class accepts different predefined **String** objects as parameters. Each String object is a name of an interface and each interface supports certain versions of OpenGL. If you initialize this class as static and singleton, it gives you singleton **GLProfile** objects for each available JOGL profile.

class: GLProfile

package: javax.media.opengl

Sr. No.	Method and Description
1	**Static GLProfile get(String profile)** Uses the default device.

As this is a static method, you need to invoke it using the class name, and it requires a predefined static string variable as parameter. There are 12 such variables in this class, each represents an individual implementation of GL interface.

```
GLProfile.get(GLProfile.GL2);
```

The following table shows the String parameters of the **get()** method of **GLProfile** class:

Sr. No.	Predefined String value (Interface name) and Description
1	**GL2** This interface contains all OpenGL [1.0 … 3.0] methods as well as most of its extensions defined at the time of this specification.
2	**GLES1** This interface contains all OpenGL ES [1.0 ... 1.1] methods as well as most of its extensions defined at the time of this specification
3	**GLES2**

	This interface contains all OpenGL ES 2.0 methods as well as most of its extensions defined at the time of this specification.
4	**GLES3** This interface contains all OpenGL ES 3.0 methods as well as most of its extensions defined at the time of this specification.
5	**GL2ES1** This Interface contains the common subset of GL2 and GLES1.
6	**GL2ES2** This Interface contains the common subset of GL3, GL2, and GLES2.
7	**GL2GL3** This Interface contains the common subset of core GL3 (OpenGL 3.1+) and GL2.
8	**GL3** This interface contains all OpenGL [3.1 ... 3.3] *core* methods as well as most of its extensions defined at the time of this specification.
9	**GL3bc** This interface contains all OpenGL [3.1 ... 3.3] *compatibility* methods, as well as most of its extensions defined at the time of this specification.
10	**GL3ES3** This interface contains the common subset of core GL3 (OpenGL 3.1+) and GLES3 (OpenGL ES 3.0).
11	**GL4** This interface contains all OpenGL [4.0 ... 4.3] *core* methods, as well as most of its extensions defined at the time of this specification.
12	**GL4bc** This interface contains all OpenGL [4.0 ... 4.3] *compatibility profile, as well as most of its extensions defined at the time of this specification.*

13	**GL4ES3** Interface containing the common subset of core GL4 (OpenGL 4.0+) and GLES3 (OpenGL ES 3.0).

Now everything is set for our first program using JOGL.

Basic Template using Canvas with AWT

Using JOGL programming, it is possible to draw various graphical shapes such as straight lines, triangles, 3D shapes including special effects such as rotation, lighting, colors, etc.

The basic template of JOGL programming is given below:

Step 1: Creating the Class

Initially create a class that implements **GlEventListener** interface and import the package javax.media.opengl. Implement all four methods **display(), dispose(), reshape(), init().** Since this is the basic frame, primitive tasks such as creating canvas class, adding it to frame were discussed. All the **GLEVentListener** interface methods were left unimplemented.

Step 2: Preparing the Canvas

(a) Constructing the **GLCanvas** class object

```
final GLCanvas glcanvas = new GLCanvas( xxxxxxx );


  //here capabilities obj should be passed as parameter
```

(b) Instantiating the **GLCapabilities** class

```
GLCapabilities capabilities = new GLCapabilities( xxxxx );


   //here profile obj should be passed as parameter
```

(c) Generating **GLProfile** object

As it is the static method, it is invoked using class name. Since this tutorial is about JOGL2, let us generate GL2 interface object.

```
final GLProfile profile = GLProfile.get( GLProfile.GL2 );
```

```
// both, variable and method are static hence both are called using

class name.
```

Let us see the code snippet for canvas

```
//getting the capabilities object of GL2 profile


final GLProfile profile = GLProfile.get(GLProfile.GL2);

GLCapabilities capabilities = new GLCapabilities(profile);

// The canvas

final GLCanvas glcanvas = new GLCanvas(capabilities);
```

(d) Now add **GLEventListener** to the canvas using the method **addGLEventListener()**. This method needs object of **GLEventListener** interface as parameter. Hence, pass object of a class that implements **GLEventListener.**

```
BasicFrame basicframe=newBasic Frame( );// class which implements

GLEventListener interface

glcanvas.addGLEventListener( basicframe );
```

(e) Set size of the frame using setSize() method inherited by GLCanvas from javax.media.opengl.awt.AWTGLAutoDrawable.

```
  glcanvas.setSize( 400, 400 );
```

Now you are ready with **GLCanvas.**

Step 3: Creating the Frame

Create the frame by instantiating the **Frame** class Object of JSE AWT frame component.

Add canvas to it and make the frame visible.

```
//creating frame

 final Frame frame = new frame( " Basic Frame" );
```

```
  //adding canvas to frame
```

```
frame.add( glcanvas );

 frame.setVisible( true );
```

Step 4: Viewing the Frame in Full Screen

To view the frame in full screen, get the default screen size using **java.awt.Toolkit** class. Now, using those default screen size dimensions, set the frame size using **setSize()** method.

```
Dimension screenSize =

Toolkit.getDefaultToolkit().getScreenSize();

frame.setSize(screenSize.width, screenSize.height);
```

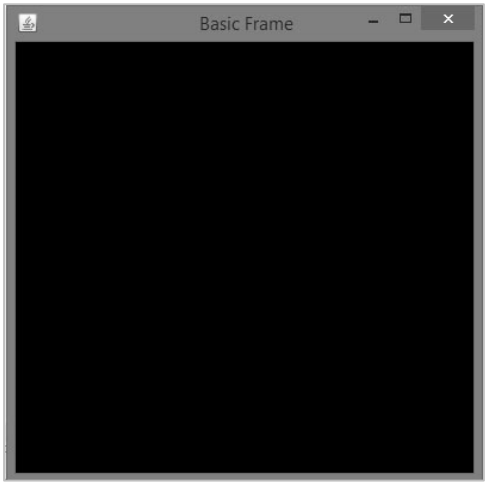
Let us go through the program to generate the basic frame using AWT:

```
import javax.media.opengl.GLAutoDrawable;

import javax.media.opengl.GLCapabilities;

import javax.media.opengl.GLEventListener;

import javax.media.opengl.GLProfile;

import javax.media.opengl.awt.GLCanvas;

import javax.swing.JFrame;


public class BasicFrame implements GLEventListener{

          @Override

          public void display(GLAutoDrawable arg0) {

                // method body

          }

          @Override

          public void dispose(GLAutoDrawable arg0) {

                //method body

          }
```

```
            @Override
            public void init(GLAutoDrawable arg0) {
                  // method body
            }
            @Override
            public void reshape(GLAutoDrawable arg0, int arg1, int arg2,
            int arg3, int arg4) {
                  // method body
            }
public static void main(String[] args) {
     //getting the capabilities object of GL2 profile
     final GLProfile profile = GLProfile.get(GLProfile.GL2);
     GLCapabilities capabilities = new GLCapabilities(profile);

     // The canvas
     final GLCanvas glcanvas = new GLCanvas(capabilities);
     BasicFrame b = new BasicFrame();
     glcanvas.addGLEventListener(b);
     glcanvas.setSize(400, 400);

     //creating frame
     final JFrame frame = new JFrame (" Basic Frame");

     //adding canvas to frame
     frame.getContentPane().add(glcanvas);
     frame.setSize(frame.getContentPane().getPreferredSize());
     frame.setVisible(true);
```

```
        }
    }
```

If you compile and execute the above program, the following output is generated. It shows a basic frame formed when we use **GLCanvas** class with AWT:



Using Canvas with Swing

Using Canvas with AWT gives you a graphical frame with heavyweight features. For having a lightweight graphical frame, you need to use **GLCanvas** with Swing. While using **GLCanvas** with Swing, you can place **GLCanvas** in the **JFrame** window directly, or you can add it to **JPanel.**

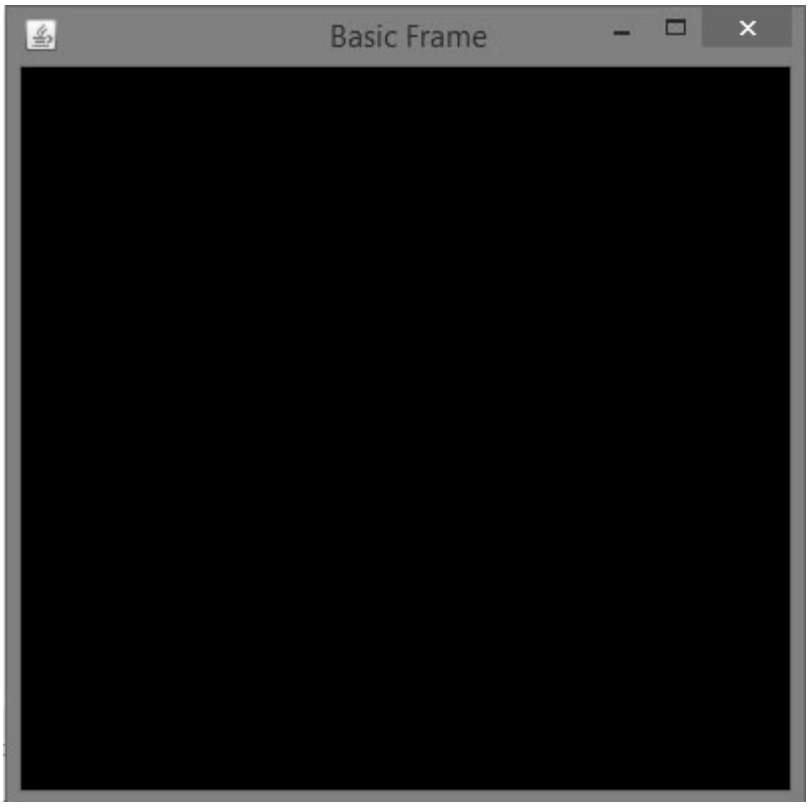
The following program generates a basic frame using **GLCanvas** with Swing window:

```
import javax.media.opengl.GLAutoDrawable;

import javax.media.opengl.GLCapabilities;

import javax.media.opengl.GLEventListener;

import javax.media.opengl.GLProfile;

import javax.media.opengl.awt.GLCanvas;

import javax.swing.JFrame;

public class BasicFrame implements GLEventListener{

        @Override

        public void display(GLAutoDrawable arg0) {

            // method body
```

```
        }
        @Override
        public void dispose(GLAutoDrawable arg0) {
              //method body
        }
        @Override
        public void init(GLAutoDrawable arg0) {
              // method body
        }
        @Override
        public void reshape(GLAutoDrawable arg0, int arg1, int arg2,
        int arg3, int arg4) {
              // method body
              }
         public static void main(String[] args) {
              //getting the capabilities object of GL2 profile

              final GLProfile profile = GLProfile.get(GLProfile.GL2);
              GLCapabilities capabilities = new GLCapabilities(profile);


               // The canvas
              final GLCanvas glcanvas = new GLCanvas(capabilities);
              BasicFrame b = new BasicFrame();
              glcanvas.addGLEventListener(b);
              glcanvas.setSize(400, 400);
              //creating frame
              final JFrame frame = new JFrame (" Basic Frame");
              //adding canvas to it
```

```
                frame.getContentPane().add(glcanvas);


                frame.setSize(frame.getContentPane().getPreferredSize());
                frame.setVisible(true);
            }//end of main
        }//end of classimport
```

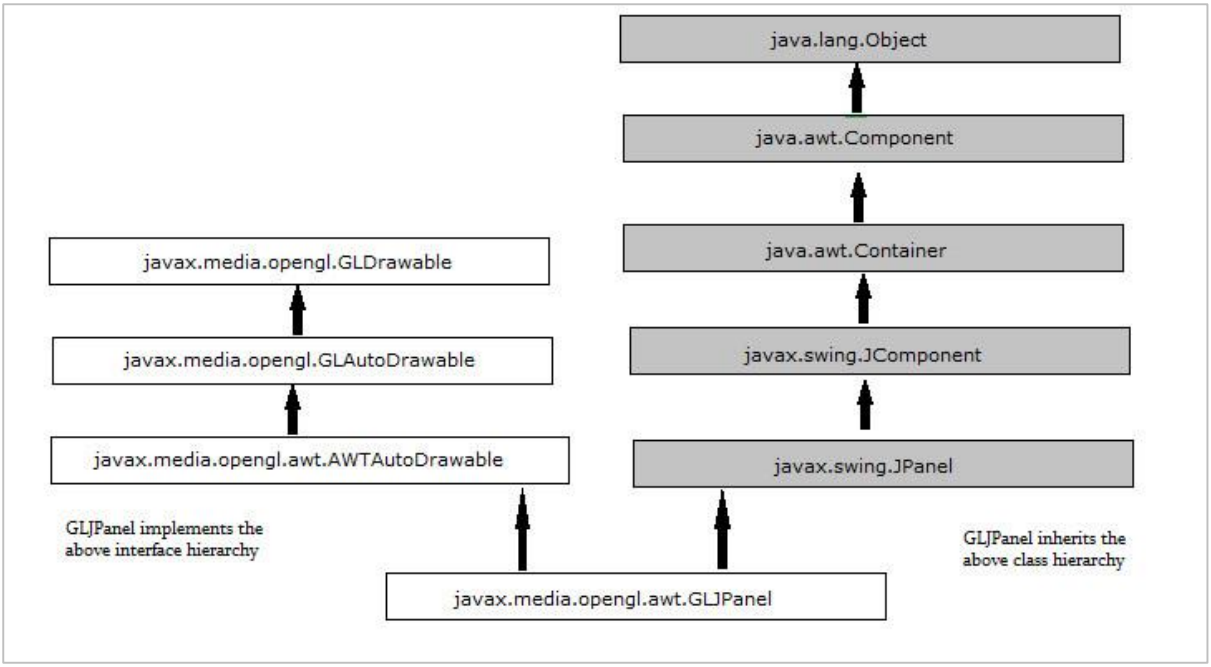
If you compile and execute the above program, the following output is generated. It shows a basic frame formed when we use **GLCanvas** with Swing window.



GLJPanel Class

It is a lightweight Swing component which provides OpenGL rendering support. It is provided for compatibility with Swing.

GLJPanel Class Hierarchy



class: GLJPanel

package: javax.media.opengl.awt

Constructors

```
GJPanel()
```

It creates a new **GLJPanel** component with a default set of OpenGL capabilities.

```
(GLCapabilitiesImmutable)
```

It creates a new **GLJPanel** component with the requested set of OpenGL capabilities.

```
GLJPanel(GLCapabilitiesImmutable userCapsRequest,

GLCapabilitiesChooser chooser)
```

It creates a new **GLJPanel** component.

Sr. No.	Methods and Description

1	**void addGLEventListener(GLEventListener listener)** This method adds the given listener to the end of this drawable queue.
2	**void addGLEventListener(int indexGLEventListener listener)** This method adds the given listener at the given index of this drawable queue.

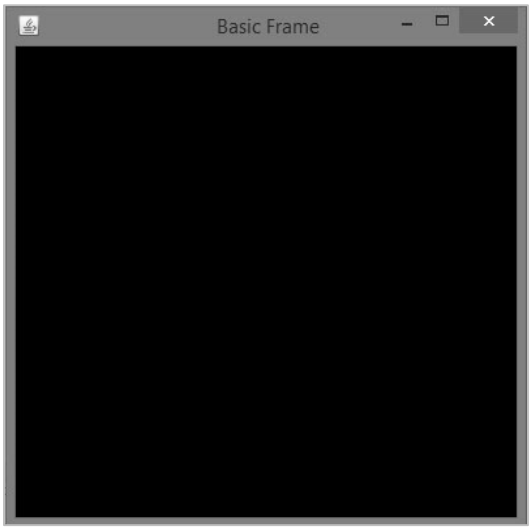
Using GLJPanel with Swing Window

The following program generates a basic frame using **GLJPanel** with Swing window:

```
import javax.media.opengl.GLAutoDrawable;

import javax.media.opengl.GLCapabilities;

import javax.media.opengl.GLEventListener;

import javax.media.opengl.GLProfile;

import javax.media.opengl.awt.GLCanvas;

import javax.swing.JFrame;

public class BasicFrame implements GLEventListener{

           @Override

           public void display(GLAutoDrawable arg0) {

                 // method body

           }

           @Override

           public void dispose(GLAutoDrawable arg0) {

                 //method body

           }

           @Override

           public void init(GLAutoDrawable arg0) {

                 // method body
```

```
        }
        @Override
        public void reshape(GLAutoDrawable arg0, int arg1, int arg2,
        int arg3, int arg4) {
              // method body
              }
     public static void main(String[] args) {
              //getting the capabilities object of GL2 profile

              final GLProfile profile = GLProfile.get(GLProfile.GL2);
              GLCapabilities capabilities = new GLCapabilities(profile);
              // The canvas
              final GLCanvas glcanvas = new GLCanvas(capabilities);
              BasicFrame b = new BasicFrame();
              glcanvas.addGLEventListener(b);
              glcanvas.setSize(400, 400);
              //creating frame
              final JFrame frame = new JFrame (" Basic Frame");
              //adding canvas to it
              frame.getContentPane().add(glcanvas);


              frame.setSize(frame.getContentPane().getPreferredSize());
              frame.setVisible(true);
        }//end of main
   }//end of classimport
```

If you compile and execute the above program, the following output is generated. It shows a basic frame formed when we use **GLJPanel** with swing window:

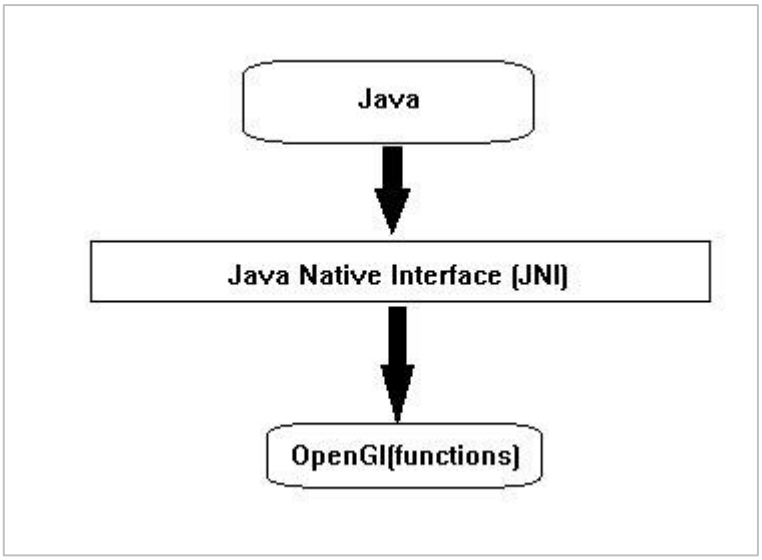

Basic Frame

4. GRAPHICAL SHAPES

This chapter describes how to draw various shapes. OpenGL API has provided primitive methods for drawing basic graphical elements such as point, vertex, line, etc. Using these methods, you can develop shapes such as triangle, polygon, and circle in both 2D and 3D dimensions.

Drawing Objects

To access programs which are specific to a hardware and operating system platforms and where the libraries are written in other languages such as C and C++ (native applications), Java uses a programming framework called **Java Native Interface (JNI)**. JOGL uses this interface internally to access OpenGL functions as shown in the following diagram.



All the four methods of **GLEventListener** interface have the code (java JOGL methods) to call OpenGL functions internally. Naming of those JOGL methods is also similar to the naming conventions of OpenGL. If the function name in OpenGL is **glBegin()**, it is used as **gl.glBegin()**.

Whenever the **gl.glBegin()** method of java JOGL is called, it internally invokes the **glBegin()** method of OpenGL. This is the reason for installing native library files on the user system at the time of installing JOGL.

The Display() Method

This is an important method which holds the code for developing graphics. It requires the **GLAutoDrawable** interface object as its parameter.

The **display()** method initially gets OpenGL context using the object of GL interface (GL inherits GLBase interface which contains methods to generate all OpenGL context objects). Since this tutorial is about JOGL2, let us generate a GL2 object.

The following code snippet shows how to generate a GL2 Object:

```
//Generating GL object

GL gl=drawable.getGL();

GL gl=drawable.getGL();

//Using this Getting the Gl2 Object

//this can be written in a single line like

final GL2 gl = drawable.getGL().getGL2();
```

Using the object of GL2 interface, one can access the members of this interface, which in turn provide access to OpenGL [1.0... 3.0] functions.

Drawing a Line

GL2 interface contains a huge list of methods but here three main important methods are discussed namely **glBegin()**, **glVertex()**, and **glEnd()**.

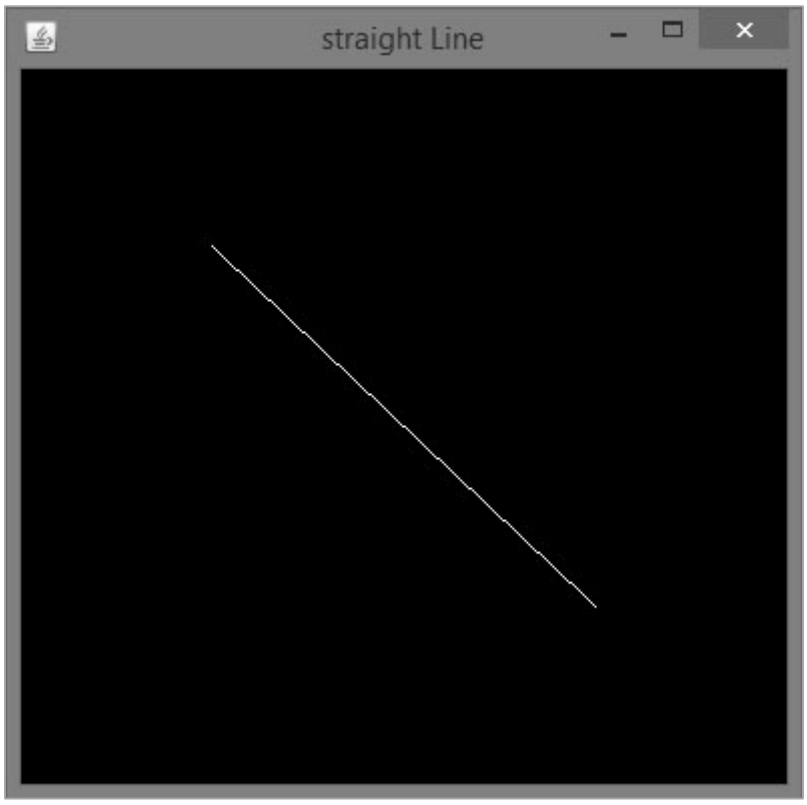
Sr. No.	Methods and Description
1	**glBegin()** This method starts the process of drawing a line. It takes predefined string integer "GL_LINES" as a parameter, which is inherited from GL interface.
2	**glVertex3f()/glVertex2f()** This method creates the vertex and we have to pass coordinates as parameters 3f and 2f, which denote 3-dimensional floating point coordinates and 2-dimensional floating point coordinates respectively.
3	**glEnd()** ends the line

Let us go through the program to draw a line:

```
import javax.media.opengl.GL2;
import javax.media.opengl.GLAutoDrawable;
import javax.media.opengl.GLCapabilities;
import javax.media.opengl.GLEventListener;
import javax.media.opengl.GLProfile;
import javax.media.opengl.awt.GLCanvas;
import javax.swing.JFrame;

public class Line implements GLEventListener{

	@Override
	public void display(GLAutoDrawable drawable) {
	final GL2 gl = drawable.getGL().getGL2();

		gl.glBegin (GL2.GL_LINES);//static field
		gl.glVertex3f(0.50f,-0.50f,0);
		gl.glVertex3f(-0.50f,0.50f,0);
		gl.glEnd();

	}

	@Override
	public void dispose(GLAutoDrawable arg0) {
		//method body

	}
```

```
@Override
public void init(GLAutoDrawable arg0) {
      // method body

}

@Override
public void reshape(GLAutoDrawable arg0, int arg1, int arg2,
int arg3, int arg4) {
      // method body
      }
public static void main(String[] args) {
      //getting the capabilities object of GL2 profile

      final GLProfile profile = GLProfile.get(GLProfile.GL2);
      GLCapabilities capabilities = new GLCapabilities(profile);
      // The canvas
      final GLCanvas glcanvas = new GLCanvas(capabilities);
      Line l = new Line();
      glcanvas.addGLEventListener(l);
      glcanvas.setSize(400, 400);
      //creating frame
      final JFrame frame = new JFrame ("straight Line");
      //adding canvas to frame
      frame.getContentPane().add(glcanvas);

      frame.setSize(frame.getContentPane().getPreferredSize());
```

```
                frame.setVisible(true);

            }//end of main

        }//end of classimport javax.media.opengl.GL2;
```



Drawing Shapes using GL_Lines

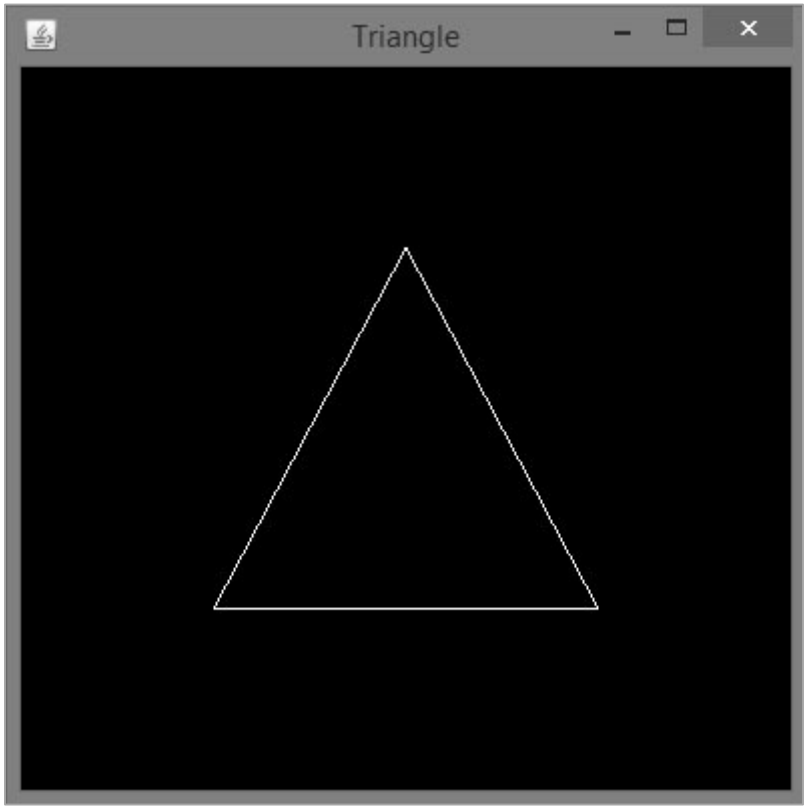
Let us go through a program to draw a triangle using GL_LINES:

```
import javax.media.opengl.GL2;

import javax.media.opengl.GLAutoDrawable;

import javax.media.opengl.GLCapabilities;

import javax.media.opengl.GLEventListener;

import javax.media.opengl.GLProfile;

import javax.media.opengl.awt.GLCanvas;

import javax.swing.JFrame;


public class Triangle implements GLEventListener{
```

```
@Override
public void display(GLAutoDrawable drawable) {
final GL2 gl = drawable.getGL().getGL2();
gl.glBegin (GL2.GL_LINES);
//drawing the base
gl.glBegin (GL2.GL_LINES);
gl.glVertex3f(-0.50f, -0.50f, 0);
gl.glVertex3f(0.50f, -0.50f, 0);
gl.glEnd();
//drawing the right edge
gl.glBegin (GL2.GL_LINES);
gl.glVertex3f(0f, 0.50f, 0);
gl.glVertex3f(-0.50f, -0.50f, 0);
gl.glEnd();
//drawing the lft edge
gl.glBegin (GL2.GL_LINES);
gl.glVertex3f(0f, 0.50f, 0);
gl.glVertex3f(0.50f, -0.50f, 0);
gl.glEnd();
gl.glFlush();
}
@Override
public void dispose(GLAutoDrawable arg0) {
      //method body
}
@Override
public void init(GLAutoDrawable arg0) {
```

```
            // method body
        }
        @Override
        public void reshape(GLAutoDrawable arg0, int arg1, int arg2,
        int arg3, int arg4) {
            // method body
            }
    public static void main(String[] args) {

            //getting the capabilities object of GL2 profile

            final GLProfile profile = GLProfile.get(GLProfile.GL2);
            GLCapabilities capabilities = new GLCapabilities(profile);
            // The canvas
            final GLCanvas glcanvas = new GLCanvas(capabilities);
            Triangle l = new Triangle();
            glcanvas.addGLEventListener(l);
            glcanvas.setSize(400, 400);
            //creating frame
            final JFrame frame = new JFrame ("Triangle");
            //adding canvas to frame
            frame.getContentPane().add(glcanvas);

            frame.setSize(frame.getContentPane().getPreferredSize());
            frame.setVisible(true);
        }//end of main
}//end of classimport javax.media.opengl.GL2;
```

If you compile and execute the above program, the following output is generated. It shows a triangle drawn using GL_LINES of **glBegin()** method.



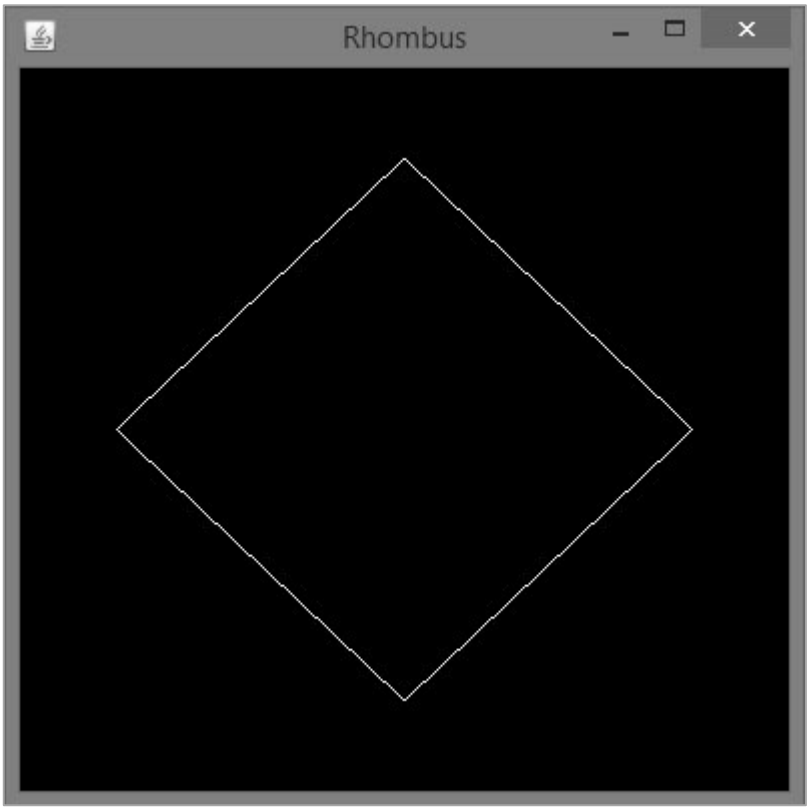
Let us go through a program to draw a rhombus using GL_LINES:

```
import javax.media.opengl.GL2;

import javax.media.opengl.GLAutoDrawable;

import javax.media.opengl.GLCapabilities;

import javax.media.opengl.GLEventListener;

import javax.media.opengl.GLProfile;

import javax.media.opengl.awt.GLCanvas;

import javax.swing.JFrame;


public class Rhombus implements GLEventListener{

           @Override

           public void display( GLAutoDrawable drawable ) {

           final GL2 gl = drawable.getGL().getGL2();
```

```
        //edge1
        gl.glBegin( GL2.GL_LINES );
        gl.glVertex3f( 0.0f,0.75f,0 );
        gl.glVertex3f( -0.75f,0f,0 );
        gl.glEnd();
        //edge2
        gl.glBegin( GL2.GL_LINES );
        gl.glVertex3f( -0.75f,0f,0 );
        gl.glVertex3f( 0f,-0.75f, 0 );
        gl.glEnd();
        //edge3
        gl.glBegin( GL2.GL_LINES );
        gl.glVertex3f( 0f,-0.75f, 0 );
        gl.glVertex3f( 0.75f,0f, 0 );
        gl.glEnd();
        //edge4
        gl.glBegin( GL2.GL_LINES );
        gl.glVertex3f( 0.75f,0f, 0 );
        gl.glVertex3f( 0.0f,0.75f,0 );
        gl.glEnd();
        gl.glFlush();
        }
        @Override
        public void dispose( GLAutoDrawable arg0 ) {
              //method body
        }
        @Override
```

```
        public void init(GLAutoDrawable arg0 ) {
              // method body
        }
        @Override
        public void reshape( GLAutoDrawable arg0, int arg1, int arg2,
        int arg3, int arg4 ) {
              // method body
              }
        public static void main( String[] args ) {
              //getting the capabilities object of GL2 profile

              final GLProfile profile = GLProfile.get( GLProfile.GL2 );
              GLCapabilities capabilities = new GLCapabilities(profile);
              // The canvas
              final GLCanvas glcanvas = new GLCanvas( capabilities );
              Rhombus rhombus = new Rhombus();
              glcanvas.addGLEventListener( rhombus );
              glcanvas.setSize( 400, 400 );
              //creating frame
              final JFrame frame = new JFrame ( "Rhombus" );
              //adding canvas to frame
              frame.getContentPane().add( glcanvas );
              frame.setSize(frame.getContentPane().getPreferredSize() );
              frame.setVisible( true );
        }
    }
```

If you compile and execute the above program, you get the following output. It shows a rhombus generated using GL_LINES of **glBegin()** method.



Let us go through a program to draw a house using GL_LINES:

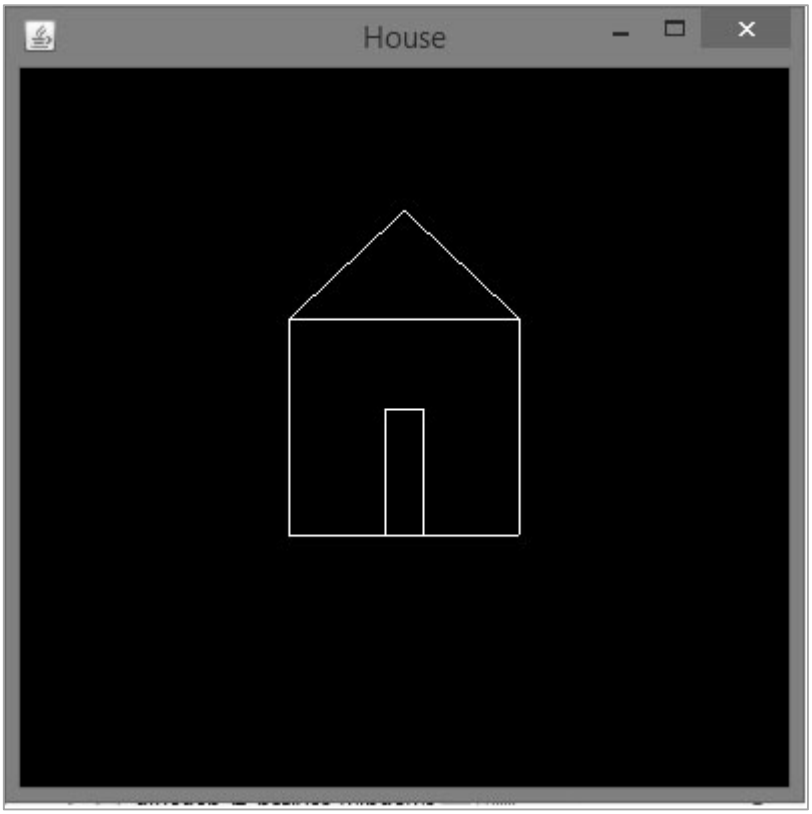
```
import javax.media.opengl.GL2;

import javax.media.opengl.GLAutoDrawable;

import javax.media.opengl.GLCapabilities;

import javax.media.opengl.GLEventListener;

import javax.media.opengl.GLProfile;

import javax.media.opengl.awt.GLCanvas;

import javax.swing.JFrame;


public class House implements GLEventListener{

           @Override

           public void display( GLAutoDrawable drawable ) {

           final GL2 gl = drawable.getGL().getGL2();

           //drawing top

           gl.glBegin ( GL2.GL_LINES );
```

```
gl.glVertex3f( -0.3f, 0.3f, 0 );
gl.glVertex3f( 0.3f,0.3f, 0 );
gl.glEnd();
//drawing bottom
gl.glBegin( GL2.GL_LINES );
gl.glVertex3f( -0.3f,-0.3f, 0 );
gl.glVertex3f( 0.3f,-0.3f, 0 );
gl.glEnd();
//drawing the right edge
gl.glBegin( GL2.GL_LINES );
gl.glVertex3f( -0.3f,0.3f, 0 );
gl.glVertex3f( -0.3f,-0.3f, 0 );
gl.glEnd();
//drawing the left edge
gl.glBegin( GL2.GL_LINES );
gl.glVertex3f( 0.3f,0.3f,0 );
gl.glVertex3f( 0.3f,-0.3f,0 );
gl.glEnd();
//building roof
//building lft dia
gl.glBegin( GL2.GL_LINES );
gl.glVertex3f( 0f,0.6f, 0 );
gl.glVertex3f( -0.3f,0.3f, 0 );
gl.glEnd();
//building rt  dia
gl.glBegin( GL2.GL_LINES );
gl.glVertex3f( 0f,0.6f, 0 );
```

```
        gl.glVertex3f( 0.3f,0.3f, 0 );
        gl.glEnd();
        //building door
        //drawing top
        gl.glBegin ( GL2.GL_LINES );
        gl.glVertex3f( -0.05f, 0.05f, 0 );
        gl.glVertex3f( 0.05f, 0.05f, 0 );
        gl.glEnd();
        //drawing the left edge
        gl.glBegin ( GL2.GL_LINES );
        gl.glVertex3f( -0.05f, 0.05f, 0 );
        gl.glVertex3f( -0.05f, -0.3f, 0 );
        gl.glEnd();
        //drawing the right edge
        gl.glBegin ( GL2.GL_LINES );
        gl.glVertex3f( 0.05f, 0.05f, 0 );
        gl.glVertex3f( 0.05f, -0.3f, 0 );
        gl.glEnd();
        }
        @Override
        public void dispose( GLAutoDrawable arg0 ) {
              //method body
        }
        @Override
        public void init( GLAutoDrawable arg0 ) {
              // method body
        }
```

```
        @Override
        public void reshape( GLAutoDrawable arg0, int arg1, int arg2,
        int arg3, int arg4 ) {
              // method body
              }
     public static void main( String[] args ) {
              //getting the capabilities object of GL2 profile

              final GLProfile profile = GLProfile.get( GLProfile.GL2 );
              GLCapabilities capabilities = new GLCapabilities(profile);
              // The canvas
              final GLCanvas glcanvas = new GLCanvas( capabilities );
              House house = new House();
              glcanvas.addGLEventListener( house );
              glcanvas.setSize(400, 400);
              //creating frame
              final JFrame frame = new JFrame( "House" );
              //adding canvas to frame
              frame.getContentPane().add( glcanvas );
              frame.setSize(frame.getContentPane().getPreferredSize() );
              frame.setVisible( true );
        }//end of main
   }//end of class
```

If you compile and execute the above program, you get the following output. It shows a house diagram generated using GL_LINES() method.



Using Parameters of glBegin() for More Shapes

Other than **GL_LINES** predefined string parameter, the **glBegin()** method accepts eight more parameters. You can use them to draw different shapes. These are used the same way as GL_LINES.

The following table shows the **glBegin()** method parameters along with their description:

Sr. No.	Parameters and Description
1	**GL_LINES** Creates each pair of vertices as an independent line segment.
2	**GL_LINE_STRIP** Draws a connected group of line segments from the first vertex to the last.
3	**GL_LINE_LOOP** Draws a connected group of line segments from the first vertex to the last, again back to the first.

4	**GL_TRIANGLES** Treats each triplet of vertices as an independent triangle.
5	**GL_TRIANGLE_STRIP** Draws a connected group of triangles. One triangle is defined for each vertex presented after the first two vertices.
6	**GL_TRIANGLE_FAN** Draws a connected group of triangles. One triangle is defined for each vertex presented after the first two vertices.
7	**GL_QUADS** Treats each group of four vertices as an independent quadrilateral.
8	**GL_QUAD_STRIP** Draws a connected group of quadrilaterals. One quadrilateral is defined for each pair of vertices presented after the first pair.
9	**GL_POLYGON** Draws a single, convex polygon. Vertices 1,…,n define this polygon.

Let us see some examples using **glBegin()** parameters.

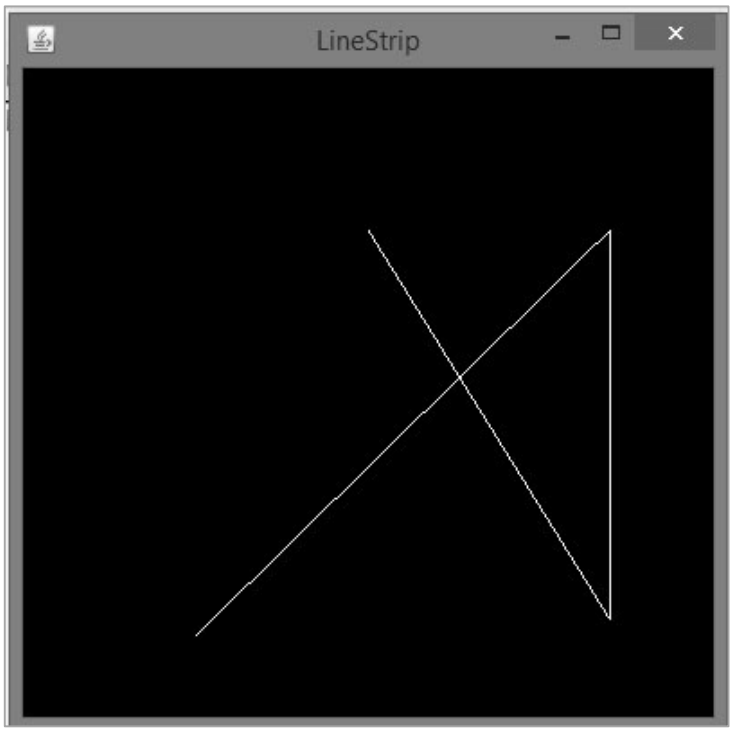
Program to draw a Line Strip:

```
import javax.media.opengl.GL2;

import javax.media.opengl.GLAutoDrawable;

import javax.media.opengl.GLCapabilities;

import javax.media.opengl.GLEventListener;

import javax.media.opengl.GLProfile;

import javax.media.opengl.awt.GLCanvas;

import javax.swing.JFrame;
```

```
public class LineStrip implements GLEventListener{
           @Override
           public void display(GLAutoDrawable drawable) {
           final GL2 gl = drawable.getGL().getGL2();
           gl.glBegin (GL2.GL_LINE_STRIP);
           gl.glVertex3f(-0.50f,-0.75f, 0);
           gl.glVertex3f(0.7f,0.5f, 0);
           gl.glVertex3f(0.70f,-0.70f, 0);
           gl.glVertex3f(0f,0.5f, 0);
           gl.glEnd();
           }
           @Override
           public void dispose(GLAutoDrawable arg0) {
                 //method body
           }
           @Override
           public void init(GLAutoDrawable arg0) {
                 // method body
           }
           @Override
           public void reshape(GLAutoDrawable arg0, int arg1, int arg2,
           int arg3, int arg4) {
                 // method body
                 }
        public static void main(String[] args) {
                 //getting the capabilities object of GL2 profile

                 final GLProfile profile = GLProfile.get(GLProfile.GL2);
```

```
                GLCapabilities capabilities = new GLCapabilities(profile);
                // The canvas
                final GLCanvas glcanvas = new GLCanvas(capabilities);
                LineStrip r = new LineStrip();
                glcanvas.addGLEventListener(r);
                glcanvas.setSize(400, 400);
                //creating frame
                final JFrame frame = new JFrame ("LineStrip");
                //adding canvas to frame
                frame.getContentPane().add(glcanvas);

                frame.setSize(frame.getContentPane().getPreferredSize());
                frame.setVisible(true);
            }//end of main
        }//end of classimport javax.media.opengl.GL2;
```

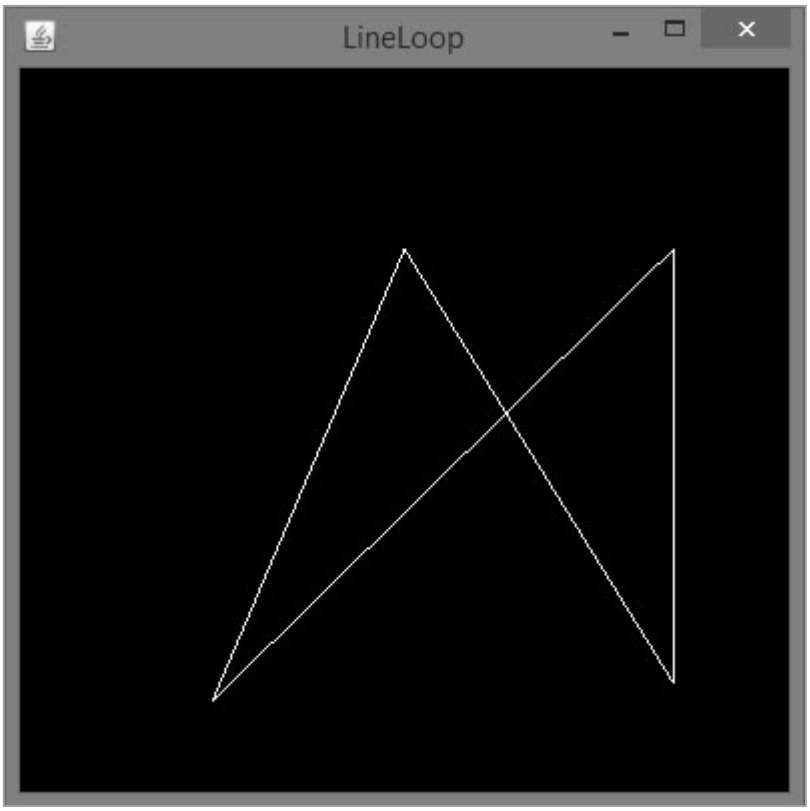
If you compile and execute the above code, the following output is generated:



Code snippet for display() method to draw a Line Loop:

```
public void display(GLAutoDrawable drawable) {

     final GL2 gl = drawable.getGL().getGL2();

     gl.glBegin (GL2.GL_LINE_LOOP);

     gl.glVertex3f( -0.50f, -0.75f, 0);

     gl.glVertex3f(0.7f, .5f, 0);

     gl.glVertex3f(0.70f,  -0.70f, 0);

     gl.glVertex3f(0f, 0.5f, 0);

     gl.glEnd();

     }
```

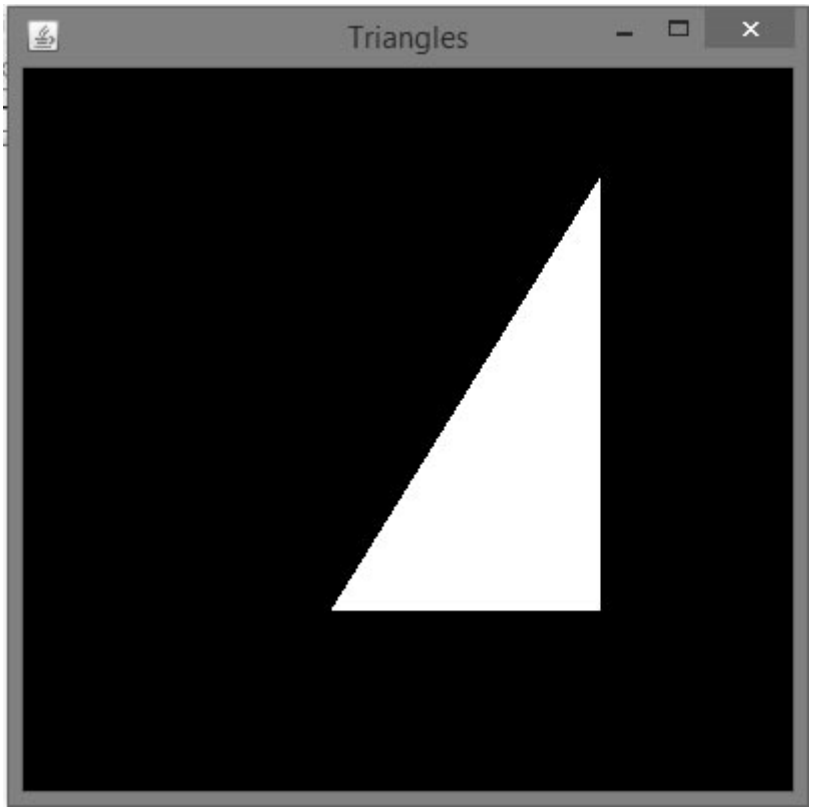
If you replace the **display()** method of any of the basic template programs with the above code, compile, and execute it, the following output is generated:



Code snippet for display() method to draw a triangle using GL_TRIANGLES:

```
public void display(GLAutoDrawable drawable) {

          final GL2 gl = drawable.getGL().getGL2();

          gl.glBegin(GL2.GL_TRIANGLES);       // Drawing Using Triangles

          gl.glVertex3f(0.5f,0.7f,0.0f);      // Top

          gl.glVertex3f(-0.2f,-0.50f,0.0f);   // Bottom Left

          gl.glVertex3f(0.5f,-0.5f,0.0f);     //Bottom Right

          gl.glEnd();

          }
```

If you replace the **display()** method of any of the basic template programs with the above code, compile, and execute it, the following output is generated:

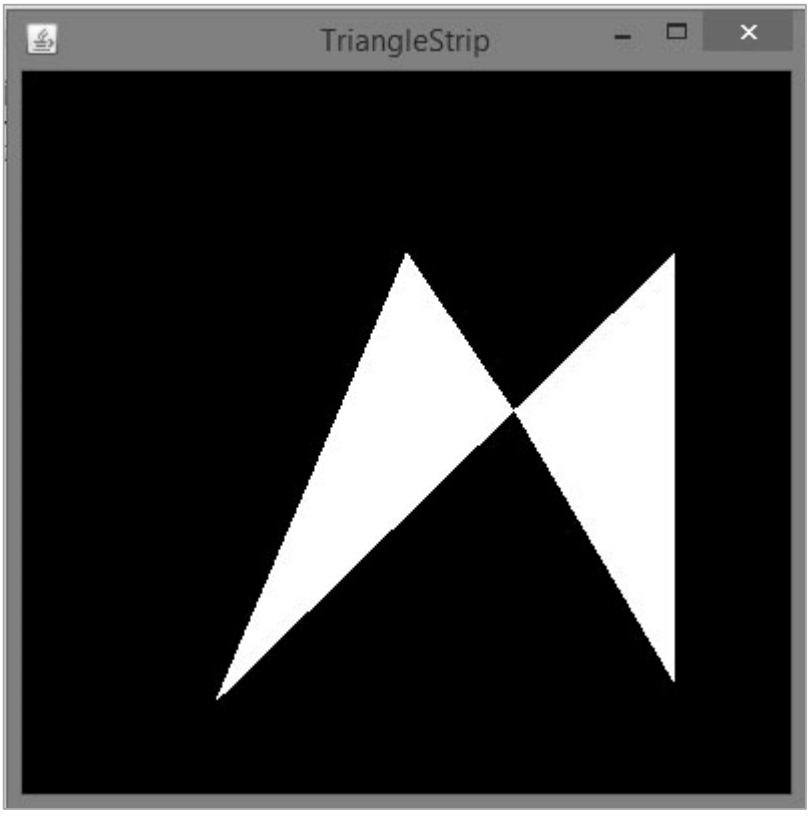


Code snippet for display() method to draw a Triangle Strip:

```
public void display(GLAutoDrawable drawable) {
```

```
            final GL2 gl = drawable.getGL().getGL2();

            gl.glBegin (GL2.GL_TRIANGLE_STRIP);

            gl.glVertex3f(0f,0.5f,0);

            gl.glVertex3f(-0.50f,-0.75f,0);

            gl.glVertex3f(0.28f,0.06f,0);

            gl.glVertex3f(0.7f,0.5f,0);

            gl.glVertex3f(0.7f,-0.7f,0);

            gl.glEnd();

            }
```

If you replace the **display()** method of any of the basic template programs with the above code, compile and execute it, the following output is generated:

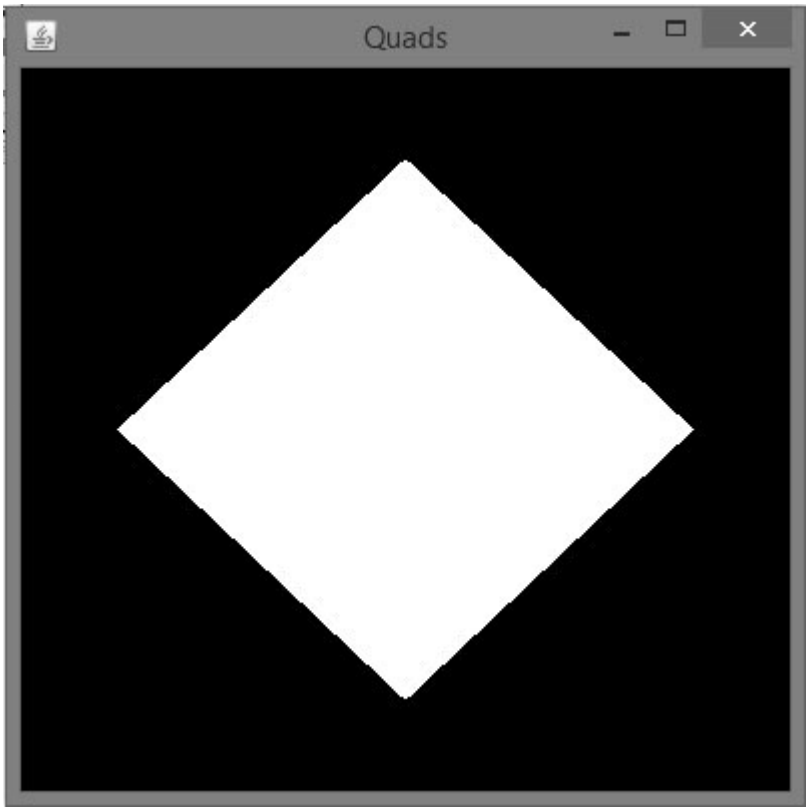


Code snippet for display() method to draw a quadrilateral:

```
public void display(GLAutoDrawable drawable) {

            final GL2 gl = drawable.getGL().getGL2();
```

```
            gl.glBegin(GL2.GL_QUADS);

            gl.glVertex3f( 0.0f,0.75f,0);

            gl.glVertex3f(-0.75f,0f,0);

            gl.glVertex3f(0f,-0.75f,0);

            gl.glVertex3f(0.75f,0f,0);

            gl.glEnd();

            }
```

If you replace the **display()** method of any of the basic template programs with the above code, compile, and execute it, the following output is generated:

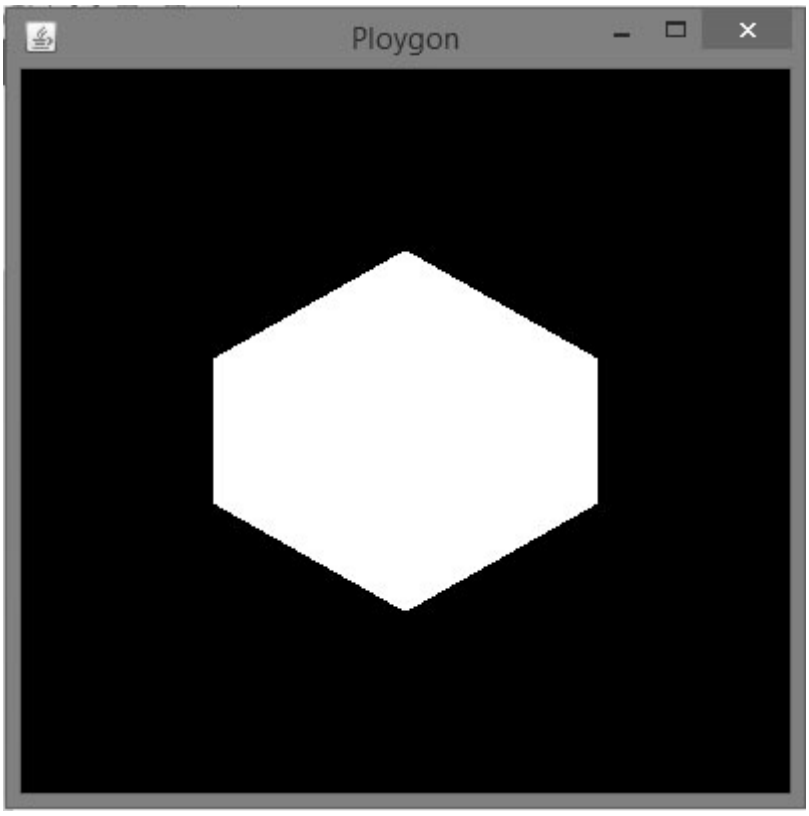


Code snippet for display() method to draw a polygon:

```
public void display(GLAutoDrawable drawable) {

            final GL2 gl = drawable.getGL().getGL2();

            gl.glBegin(GL2.GL_POLYGON);

            gl.glVertex3f(0f,0.5f,0f);
```

```
        gl.glVertex3f(-0.5f,0.2f,0f);
        gl.glVertex3f(-0.5f,-0.2f,0f);
        gl.glVertex3f(0f,-0.5f,0f);
        gl.glVertex3f(0f,0.5f,0f);
        gl.glVertex3f(0.5f,0.2f,0f);
        gl.glVertex3f(0.5f,-0.2f,0f);
        gl.glVertex3f(0f,-0.5f,0f);
        gl.glEnd();
        }
```

If you replace **display()** method of any of the basic template programs with the above code, compile, and execute it, the following output is generated



5. TRANSFORMATION OF OBJECTS

OpenGL provides more features such as applying colors to an object, scaling, lighting, rotating an object, etc. This chapter describes some of the transformations on objects using JOGL.

Moving an Object on the Window

In earlier chapters, we discussed the programs for drawing a line and drawing various shapes using simple lines. The shapes created in this way can be displayed on any location within the window. It is done using the method **glTranslatef (float x, float y, float z)**.

This method belongs to the **GLMatrixFunc** interface, which is in the **javax.media.opengl.fixedfunc** package.

GLMatrixFunc Interface

interface: GLMatrixFunc

package: javax.media.opengl.fixedfunc

The following table lists some important methods of this interface:

Sr. No.	Methods and Description
1	**void glRotatef(float angle, float x, float y, float z)** Rotates the current matrix.
2	**void glScalef(float x, float y, float z)** Used to scale the current matrix.
3	**void glTranslatef(float x, float y,float z)** Used to translate the current matrix.
4	**void glLoadIdentity()** Loads the current matrix with identity matrix.

The **glTranslate()** method moves the origin of the coordinate system to the point specified by the parameters (x,y,z), passed to the **glTranslate()** method as

argument. To save and restore the untranslated coordinate system, **glPushMatrix()** and **glPopMatrix()** methods are used.

```
gl.glTranslatef(0f, 0f, -2.5f);
```

Whenever **glTranslate()** is used, it changes the position of the component on the screen. Hence, the **reshape()** method of **GLEventListener** interface should be overridden and OpenGL viewport and projection matrix should be initialized.

The following code shows the template to initialize a view port and projection matrix:

```
public void reshape(GLAutoDrawable drawable, int x,  int y, int width,
int height)

    {


          // TODO Auto-generated method stub

          final GL2 gl = drawable.getGL().getGL2();


          // get the OpenGL 2 graphics object

          if(height <=0)    height =1;


          //preventing devided by 0 exception height =1;

          final float h = (float) width / (float) height;


          // display area to cover the entire window

          gl.glViewport(0, 0, width, height);


          //transforming projection matrix

          gl.glMatrixMode(GL2.GL_PROJECTION);

          gl.glLoadIdentity();

          glu.gluPerspective(45.0f, h, 1.0, 20.0);
```

```
        //transforming model view gl.glLoadIdentity();
        gl.glMatrixMode(GL2.GL_MODELVIEW);
        gl.glLoadIdentity();
    }
```

Applying Color to an Object

To apply color to an object, use the method **glColor()** of **GL2** class.

Syntax

```
gl.glColorXY(1f,0f,0f);
```

where,

- X denotes the number of colors used, 3 (red, blue, green) or 4(red, blue, green, alpha). To get various color combinations, the values of these colors are passed as parameters. The sequence of the color parameters must be maintained in that order.

  Example

  If you pass color values as (1, 0, 0), then you get red color. Similarly, (1, 1, 0) gives you yellow color.

- Y denotes the datatype which accepts parameters such as byte(b), double(d), float(f), int(i), short(s), ubyte(ub), uint(ui), and ushort(us).

```
gl.glColor3f(1f,0f,0f);   //gives us red
gl.glColor3f(0f,1f,0f);   //gives us blue
gl.glColor3f(0f,0f,1f);   //gives us green
```

In case of triangle, you can apply different colors for each vertex.

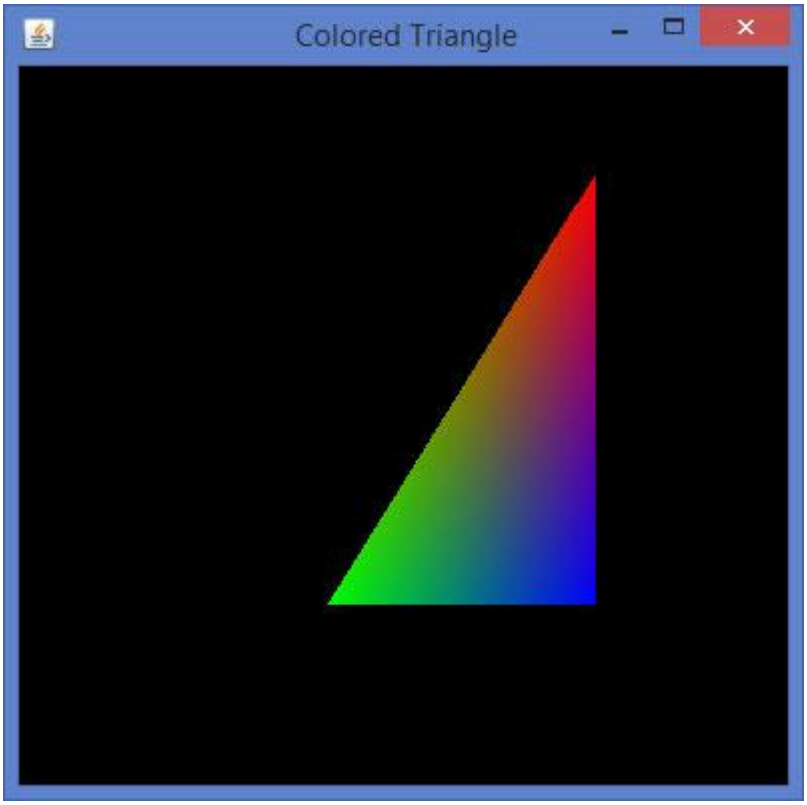
Let us go through the program to apply colors to a triangle:

```
import javax.media.opengl.GL2;
import javax.media.opengl.GLAutoDrawable;
import javax.media.opengl.GLCapabilities;
import javax.media.opengl.GLEventListener;
import javax.media.opengl.GLProfile;
import javax.media.opengl.awt.GLCanvas;
import javax.swing.JFrame;

public class TriangleColor implements GLEventListener{
	@Override
	public void display( GLAutoDrawable drawable ) {
		final GL2 gl = drawable.getGL().getGL2();
		gl.glBegin( GL2.GL_TRIANGLES );
		// Drawing Using Triangles

		gl.glColor3f( 1.0f, 0.0f, 0.0f );   // Red
		gl.glVertex3f( 0.5f,0.7f,0.0f );    // Top
		gl.glColor3f( 0.0f,1.0f,0.0f );     // blue
		gl.glVertex3f( -0.2f,-0.50f,0.0f ); // Bottom Left
		gl.glColor3f( 0.0f,0.0f,1.0f );     // green
		gl.glVertex3f( 0.5f,-0.5f,0.0f );   // Bottom Right
		gl.glEnd();
		}
	@Override
	public void dispose( GLAutoDrawable arg0 ) {
		//method body
```

```
}
@Override
public void init( GLAutoDrawable arg0 ) {
      // method body
}
@Override
public void reshape( GLAutoDrawable arg0, int arg1, int arg2,
int arg3, int arg4 ) {
      // method body
      }
 public static void main( String[] args ) {
      //getting the capabilities object of GL2 profile

      final GLProfile profile = GLProfile.get( GLProfile.GL2 );
      GLCapabilities capabilities = new GLCapabilities(profile);

      // The canvas
      final GLCanvas glcanvas = new GLCanvas( capabilities );
      TriangleColor triangle = new TriangleColor();
      glcanvas.addGLEventListener( triangle );
      glcanvas.setSize( 400, 400 );
      //creating frame
      final JFrame frame = new JFrame (" Colored Triangle");

      //adding canvas to it
      frame.getContentPane().add( glcanvas );
      frame.setSize( frame.getContentPane().getPreferredSize());
      frame.setVisible( true );
}//end of main
```

```
    }//end of class
```

When you compile and execute the above program, you get the following colored triangle:



Applying Color to a Polygon

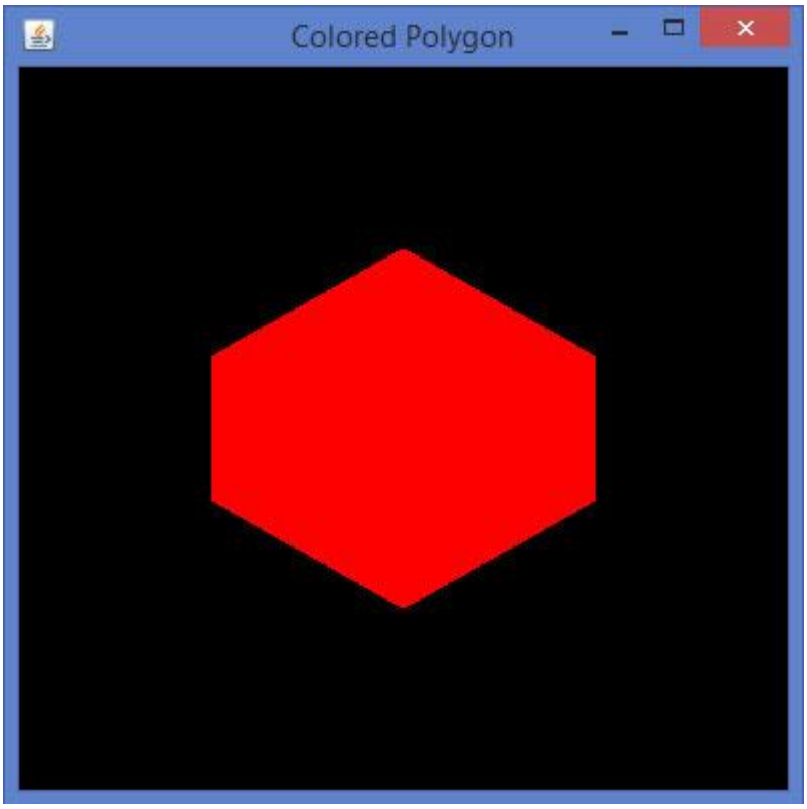
Let us go through the program to apply colors to a polygon:

```
import javax.media.opengl.GL2;

import javax.media.opengl.GLAutoDrawable;

import javax.media.opengl.GLCapabilities;

import javax.media.opengl.GLEventListener;

import javax.media.opengl.GLProfile;

import javax.media.opengl.awt.GLCanvas;

import javax.swing.JFrame;


public class PolygonColor implements GLEventListener{
```

```
@Override
public void display( GLAutoDrawable drawable ) {
      final GL2 gl = drawable.getGL().getGL2();
      gl.glColor3f( 1f,0f,0f ); //applying red
      gl.glBegin( GL2.GL_POLYGON );
      gl.glVertex3f( 0f,0.5f,0f  );
      gl.glVertex3f( -0.5f,0.2f,0f );
      gl.glVertex3f( -0.5f,-0.2f,0f );
      gl.glVertex3f( 0f,-0.5f,0f );
      gl.glVertex3f( 0f,0.5f,0f );
      gl.glVertex3f( 0.5f,0.2f,0f );
      gl.glVertex3f( 0.5f,-0.2f,0f );
      gl.glVertex3f( 0f,-0.5f,0f );
      gl.glEnd();
      }
@Override
public void dispose( GLAutoDrawable arg0 ) {
      //method body
      }
@Override
public void init( GLAutoDrawable arg0 ) {
      // method body
      }
@Override
public void reshape( GLAutoDrawable arg0, int arg1, int arg2,
int arg3, int arg4 ) {
      // method body
```

```
            }
   public static void main( String[] args ) {
            //getting the capabilities object of GL2 profile

            final GLProfile profile = GLProfile.get( GLProfile.GL2 );
            GLCapabilities capabilities = new GLCapabilities(profile);
            // The canvas
            final GLCanvas glcanvas = new GLCanvas( capabilities );
            PolygonColor polygon = new PolygonColor();
            glcanvas.addGLEventListener( polygon );
            glcanvas.setSize( 400, 400 );
            //creating frame
            final JFrame frame = new JFrame ( "Colored Polygon" );
            //adding canvas to frame
            frame.getContentPane().add( glcanvas );
            frame.setSize(frame.getContentPane().getPreferredSize() );
            frame.setVisible( true );
        }//end of main
   }//end of class
```

When you compile and execute the above program, the following output is generated:



Scaling

Scaling an object is done by using the **glScalef(float x, float y, float z)** method of **GLMatrixFunc** interface. This method accepts three floating point parameters, using which we specify the scale factors along the x, y, and z axes respectively.

For example, in the following program, a triangle is diminished to 50%. Here, the value 50 is passed as parameter along all the axes.

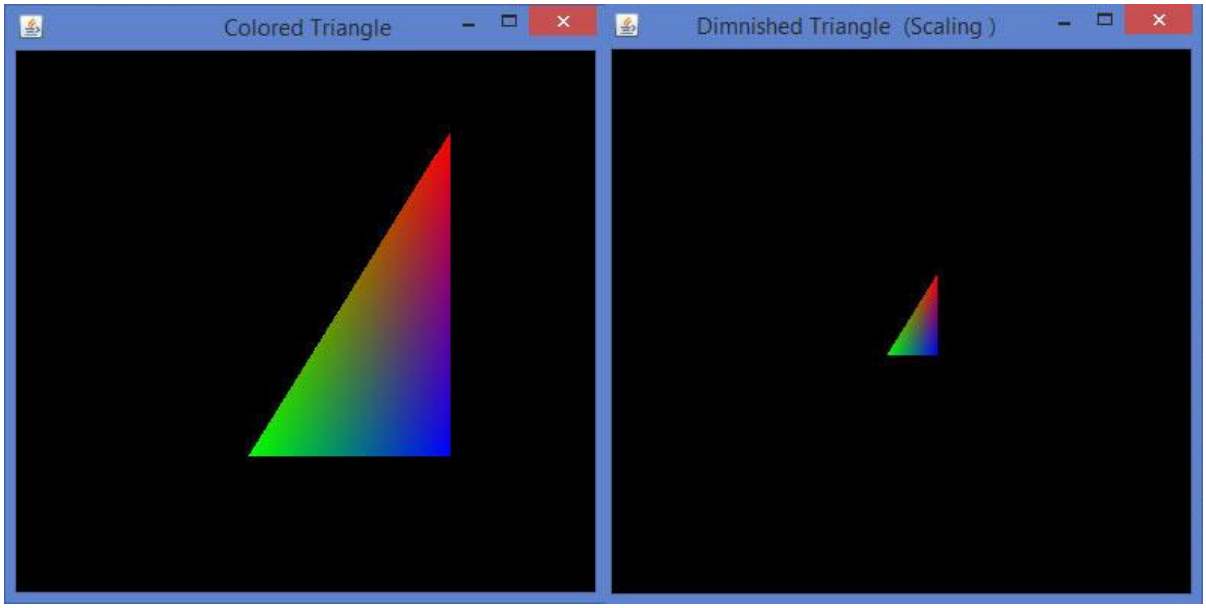
Let us go through the program to scale a triangle:

```
import javax.media.opengl.GL2;

import javax.media.opengl.GLAutoDrawable;

import javax.media.opengl.GLCapabilities;

import javax.media.opengl.GLEventListener;

import javax.media.opengl.GLProfile;

import javax.media.opengl.awt.GLCanvas;

import javax.swing.JFrame;
```

```
public class Scaling implements GLEventListener{
	@Override
	public void display( GLAutoDrawable drawable ) {
		final GL2 gl = drawable.getGL().getGL2();
		gl.glScalef( 0.50f,0.25f,0.50f );
		gl.glBegin( GL2.GL_TRIANGLES );
		// Drawing Using Triangles

		gl.glColor3f( 1.0f, 0.0f, 0.0f );   // Red
		gl.glVertex3f( 0.5f,0.7f,0.0f );    // Top
		gl.glColor3f( 0.0f,1.0f,0.0f );     // blue
		gl.glVertex3f( -0.2f,-0.50f,0.0f ); // Bottom Left
		gl.glColor3f( 0.0f,0.0f,1.0f );     // green
		gl.glVertex3f( 0.5f,-0.5f,0.0f );   // Bottom Right
		gl.glEnd();
		}
	@Override
	public void dispose( GLAutoDrawable arg0 ) {
		//method body
	}
	@Override
	public void init( GLAutoDrawable arg0 ) {
		// method body
	}
	@Override
	public void reshape( GLAutoDrawable arg0, int arg1, int arg2,
```

```
            int arg3, int arg4 ) {
                  // method body
                  }
             public static void main( String[] args ) {
                  //getting the capabilities object of GL2 profile

                  final GLProfile profile = GLProfile.get( GLProfile.GL2 );
                  GLCapabilities capabilities = new GLCapabilities(profile);


                  // The canvas
                  final GLCanvas glcanvas = new GLCanvas( capabilities );
                  Scaling scaling = new Scaling();
                  glcanvas.addGLEventListener( scaling );
                  glcanvas.setSize( 400, 400 );


                  //creating frame
                  final JFrame frame
                  = new JFrame (" Dimnished Triangle (Scaling )");


                  //adding canvas to it
                  frame.getContentPane().add(glcanvas);
                  frame.setSize(frame.getContentPane().getPreferredSize());
                  frame.setVisible(true);
            }//end of main
      }//end of classimport javax.media.opengl.GL2;
```

On compiling and executing the above program, we get the following output. Here, you can observe a diminished triangle as compared to the original triangle produced by TriangleColor.java:



Rotation

Rotation of objects can be done along any of the three axes, using the **glRotatef(float angle, float x, float y, float z)** method of **GLMatrixFunc** interface. You need to pass an angle of rotation and x, y, z axes as parameters to this method.

The following steps guide you to rotate an object successfully:

- Clear the color buffer and depth buffer initially using **gl.glClear(GL2.GL_COLOR_BUFFER_BIT | GL2.GL_DEPTH_BUFFER_BIT)** method. This method erases the previous state of the object and makes the view clear.

- Reset the projection matrix using the **glLoadIdentity()** method.

Instantiate the animator class and start the animator using the **start()** method.

FPSAnimator Class

Class:

- FPSAnim
- ator

Package: javax.media.opengl.util

Constructors:

```
FPSAnimator(GLAutoDrawable drawable, int fps)
```

It creates an FPSAnimator with a given target frames-per-second value and an initial drawable to animate.

```
FPSAnimator(GLAutoDrawable drawable, int fps, boolean
cheduleAtFixedRate)
```

It creates an FPSAnimator with a given target frames-per-second value, an initial drawable to animate, and a flag indicating whether to use fixed-rate scheduling.

```
FPSAnimator(int fps)
```

It creates an FPSAnimator with a given target frames-per-second value.

```
FPSAnimator(int fps, boolean scheduleAtFixedRate)
```

It creates an FPSAnimator with a given target frames-per-second value and a flag indicating whether to use fixed rate scheduling.

start() and **stop()** are the two important methods in this class.

Rotate a Triangle

The following program shows how to rotate a triangle:

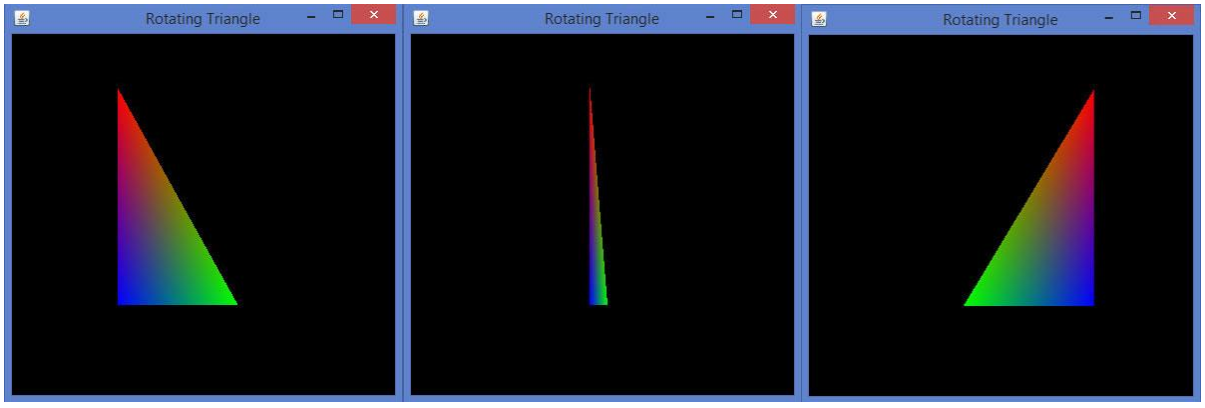
```
import javax.media.opengl.GL2;

import javax.media.opengl.GLAutoDrawable;

import javax.media.opengl.GLCapabilities;

import javax.media.opengl.GLEventListener;

import javax.media.opengl.GLProfile;

import javax.media.opengl.awt.GLCanvas;

import javax.swing.JFrame;

import com.jogamp.opengl.util.FPSAnimator;

public class TriangleRotation implements GLEventListener{

    private float rtri;  //for angle of rotation
```

```
@Override
public void display( GLAutoDrawable drawable ) {

      final GL2 gl = drawable.getGL().getGL2();
      gl.glClear (GL2.GL_COLOR_BUFFER_BIT |
      GL2.GL_DEPTH_BUFFER_BIT );
      // Clear The Screen And The Depth Buffer
      gl.glLoadIdentity();    // Reset The View

      //triangle rotation
      gl.glRotatef( rtri, 0.0f, 1.0f, 0.0f );

      // Drawing Using Triangles
      gl.glBegin( GL2.GL_TRIANGLES );
      gl.glColor3f( 1.0f, 0.0f, 0.0f );   // Red
      gl.glVertex3f( 0.5f,0.7f,0.0f );    // Top
      gl.glColor3f( 0.0f,1.0f,0.0f );     // blue
      gl.glVertex3f( -0.2f,-0.50f,0.0f ); // Bottom Left
      gl.glColor3f( 0.0f,0.0f,1.0f );     // green
      gl.glVertex3f( 0.5f,-0.5f,0.0f );   // Bottom Right
      gl.glEnd();
      gl.glFlush();
      rtri +=0.2f;  //assigning the angle
}
@Override
public void dispose( GLAutoDrawable arg0 ) {
      //method body
```

```
}
@Override
public void init( GLAutoDrawable arg0 ) {
      // method body
}
@Override
public void reshape( GLAutoDrawable drawable, int x, int y,
int width, int height ) {

      public static void main( String[] args ) {
            //getting the capabilities object of GL2 profile
            final GLProfile profile
            = GLProfile.get(GLProfile.GL2 );

            GLCapabilities capabilities
            = new GLCapabilities( profile );

            // The canvas
            final GLCanvas glcanvas = new GLCanvas( capabilities);
            TriangleRotation triangle = new TriangleRotation();
            glcanvas.addGLEventListener( triangle );
            glcanvas.setSize( 400, 400 );

            // creating frame
            final JFrame frame = new JFrame ("Rotating Triangle");

            // adding canvas to it
```

```
                    frame.getContentPane().add( glcanvas );


                    frame.setSize(frame.getContentPane()
                    .getPreferredSize());


                    frame.setVisible( true );


                    //Instantiating and Initiating Animator
                    final FPSAnimator animator
                    = new FPSAnimator(glcanvas, 300,true);
                    animator.start();
            }//end of main
    }//end of class
```

If you compile and execute the above program, it generates the following output. Here, you can observe various snapshots of a rotating the colored triangle around the x-axis.



Lighting

To set lighting, initially enable lighting using the **glEnable()** method. Then apply lighting for the objects, using the **glLightfv(int light, int pname, float[] params, int params_offset)** method of **GLLightingFunc** interface. This method takes four parameters.

The following table describes the parameters of **gllightfv()** method.

Sr. No.	Parameter Name and Description
1	**Light** Specifies a light. The number of lights depends on the implementation, but at least eight lights are supported. It accepts ten values, those parameters are discussed in a separate table named Light Source Parameters given below.
2	**Pname** Specifies a single valued light source parameter. For light source, there are ten parameters as discussed below.
3	**Params** Specifies a pointer to the value or values that is set to the parameter *pname* of light source *light.*
4	**Light source parameter** You can use any of the light source parameters given below.

Light source parameters:

Sr. No.	Parameter and Description
1	**GL_AMBIENT** It contains the parameters that specify the ambient intensity of the light.
2	**GL_DIFFUSE** It contains the parameters that specify the diffuse intensity of the light.
3	**GL_SPECULAR** It contains the parameters that specify the specular intensity of the light.
4	**GL_POSITION**

	It contains four integer or floating-point values that specify the position of the light in homogeneous object coordinates.
5	**GL_SPOT_DIRECTION** It contains parameters that specify the direction of light in homogeneous object coordinates.
6	**GL_SPOT_EXPONENT** Its parameters specify the intensity distribution of light.
7	**GL_SPOT_CUTOFF** The single parameter of this specifies the maximum spread angle of the light.
8	**GL_CONSTANT_ATTENUATION or GL_LINEAR_ATTENUATION or GL_QUADRATIC_ATTENUATION** You can use any of these attenuation factors, which is represented by a single value.

Lighting is enabled or disabled using **glEnable()** and **glDisable** () methods with the argument **GL_LIGHTING.**

The following template is given for lighting:

```
gl.glEnable(GL2.GL_LIGHTING);

gl.glEnable(GL2.GL_LIGHT0);

gl.glEnable(GL2.GL_NORMALIZE);

float[] ambientLight = { 0.1f, 0.f, 0.f,0f };       // weak RED ambient

gl.glLightfv(GL2.GL_LIGHT0, GL2.GL_AMBIENT, ambientLight, 0);

float[] diffuseLight = { 1f,2f,1f,0f };       // multicolor diffuse

gl.glLightfv(GL2.GL_LIGHT0, GL2.GL_DIFFUSE, diffuseLight, 0);
```

Applying Light to a Rotating Polygon

Follow the given steps for applying light to a rotating polygon.

Rotate the polygon using glRotate() method:

```
gl.glClear(GL2.GL_COLOR_BUFFER_BIT | GL2.GL_DEPTH_BUFFER_BIT);
// Clear The Screen And The Depth Buffer
gl.glLoadIdentity();
// Reset The View
gl.glRotatef(rpoly, 0.0f, 1.0f, 0.0f);
```

Let us go through the program to apply light to a rotating polygon:

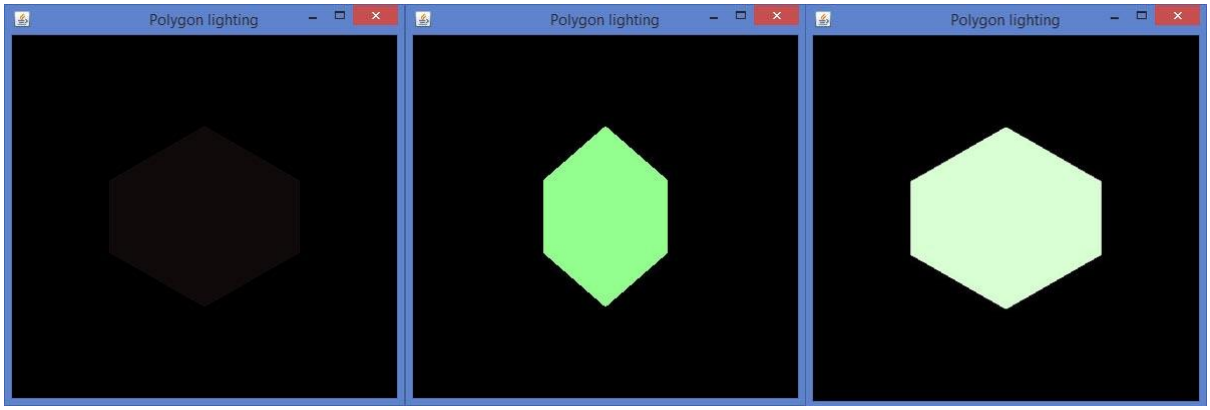
```
import javax.media.opengl.GL2;
import javax.media.opengl.GLAutoDrawable;
import javax.media.opengl.GLCapabilities;
import javax.media.opengl.GLEventListener;
import javax.media.opengl.GLProfile;
import javax.media.opengl.awt.GLCanvas;
import javax.swing.JFrame;
import com.jogamp.opengl.util.FPSAnimator;

public class PolygonLighting implements GLEventListener{
          private float rpoly;
          @Override
          public void display( GLAutoDrawable drawable ) {
                final GL2 gl = drawable.getGL().getGL2();
                gl.glColor3f(1f,0f,0f); //applying red
                // Clear The Screen And The Depth Buffer
                 gl.glClear( GL2.GL_COLOR_BUFFER_BIT |
                GL2.GL_DEPTH_BUFFER_BIT );
                gl.glLoadIdentity();       // Reset The View
```

```
gl.glRotatef( rpoly, 0.0f, 1.0f, 0.0f );
gl.glBegin( GL2.GL_POLYGON );
gl.glVertex3f( 0f,0.5f,0f );
gl.glVertex3f( -0.5f,0.2f,0f );
gl.glVertex3f( -0.5f,-0.2f,0f );
gl.glVertex3f( 0f,-0.5f,0f );
gl.glVertex3f( 0f,0.5f,0f );
gl.glVertex3f( 0.5f,0.2f,0f );
gl.glVertex3f( 0.5f,-0.2f,0f );
gl.glVertex3f( 0f,-0.5f,0f );
gl.glEnd();
gl.glFlush();
rpoly +=0.2f;  //assigning the angle
gl.glEnable( GL2.GL_LIGHTING );
gl.glEnable( GL2.GL_LIGHT0 );
gl.glEnable( GL2.GL_NORMALIZE );

// weak RED ambient
float[] ambientLight = { 0.1f, 0.f, 0.f,0f };
gl.glLightfv(GL2.GL_LIGHT0, GL2.GL_AMBIENT,
ambient-Light, 0);

// multicolor diffuse
float[] diffuseLight = { 1f,2f,1f,0f };
gl.glLightfv( GL2.GL_LIGHT0, GL2.GL_DIFFUSE,
diffuse-Light, 0 );
}
```

```
        @Override
        public void dispose( GLAutoDrawable arg0 ) {
              //method body
        }
        @Override
        public void init( GLAutoDrawable arg0 ) {
              // method body
        }
        @Override
        public void reshape( GLAutoDrawable arg0, int arg1, int arg2,
        int arg3, int arg4 ) {
              // method body
              }
      public static void main( String[] args ) {
              //getting the capabilities object of GL2 profile

              final GLProfile profile = GLProfile.get( GLProfile.GL2 );
              GLCapabilities capabilities = new GLCapabilities( profile);

              // The canvas
              final GLCanvas glcanvas = new GLCanvas( capabilities );
              PolygonLighting polygonlighting = new PolygonLighting();
              glcanvas.addGLEventListener( polygonlighting );
              glcanvas.setSize( 400, 400 );

              //creating frame
              final JFrame frame = new JFrame (" Polygon lighting ");
```

```
                //adding canvas to it
                frame.getContentPane().add( glcanvas );
                frame.setSize( frame.getContentPane().getPreferredSize());
                frame.setVisible( true );

                //Instantiating and Initiating Animator
                final FPSAnimator animator
                = new FPSAnimator(glcanvas, 300,true );
                animator.start();
            }//end of main
    }//end of class
```

If you compile and execute the above program, it generates the following output. Here, you can observe various snapshots of a rotating polygon with lighting.



6. 3D GRAPHICS

In this chapter, let us see how to deal with 3D graphics.

Drawing a 3D Line

Let us draw a simple line with z-axis and see the difference between 2D and 3D lines. Draw a simple line first, then draw the second line 3 units into the window.

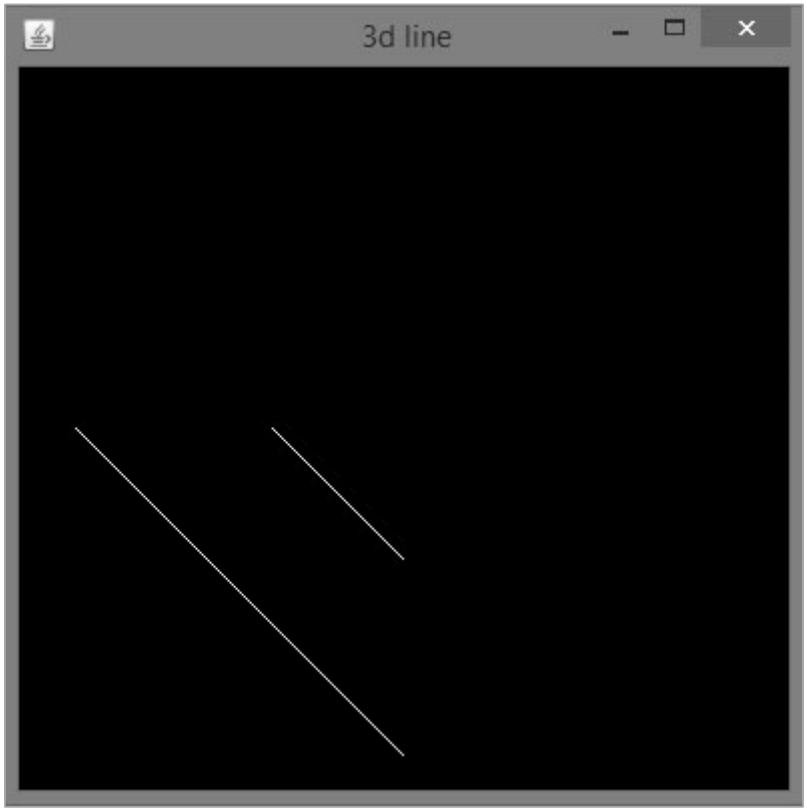
Let us go through the program to draw a 3D line:

```
import javax.media.opengl.GL2;

import javax.media.opengl.GLAutoDrawable;

import javax.media.opengl.GLCapabilities;

import javax.media.opengl.GLEventListener;

import javax.media.opengl.GLProfile;

import javax.media.opengl.awt.GLCanvas;

import javax.media.opengl.glu.GLU;

import javax.swing.JFrame;


public class Line3d implements GLEventListener{

     private GLU glu = new GLU();

           @Override

           public void display( GLAutoDrawable drawable ) {

                 final GL2 gl = drawable.getGL().getGL2();

                 gl.glTranslatef( 0f, 0f, -2.5f );

                 gl.glBegin( GL2.GL_LINES );

                 gl.glVertex3f( -0.75f,0f,0 );

                 gl.glVertex3f( 0f,-0.75f, 0 );

                 gl.glEnd();

                 //3d line
```

```
                gl.glBegin( GL2.GL_LINES );
                gl.glVertex3f( -0.75f,0f,3f );// 3 units into the
window
                gl.glVertex3f( 0f,-0.75f,3f );
                gl.glEnd();
        }
        @Override
        public void dispose( GLAutoDrawable arg0 ) {
              //method body
        }
        @Override
        public void init( GLAutoDrawable arg0 ) {
              // method body
        }
        @Override
        public void reshape( GLAutoDrawable drawable, int x, int y,
        int width, int height ) {
              GL2 gl = drawable.getGL().getGL2();
              if( height <=0 )
                    height =1;
              final float h = ( float ) width / ( float ) height;
              gl.glViewport( 0, 0, width, height );
              gl.glMatrixMode( GL2.GL_PROJECTION );
              gl.glLoadIdentity();
              glu.gluPerspective( 45.0f, h, 1.0, 20.0 );
              gl.glMatrixMode( GL2.GL_MODELVIEW );
              gl.glLoadIdentity();
        }
```

```
    public static void main( String[] args ) {
            //getting the capabilities object of GL2 profile

            final GLProfile profile = GLProfile.get( GLProfile.GL2 );
            GLCapabilities capabilities = new GLCapabilities(profile);


            // The canvas
            final GLCanvas glcanvas = new GLCanvas( capabilities );
            Line3d line3d = new Line3d();
            glcanvas.addGLEventListener( line3d );
            glcanvas.setSize( 400, 400 );

            //creating frame
            final JFrame frame = new JFrame (" 3d line");

            //adding canvas to it
            frame.getContentPane().add( glcanvas );
            frame.setSize(frame.getContentPane().getPreferredSize() );
            frame.setVisible( true );
       }//end of main
}//end of class
```

When you compile and execute the above program, the following output is generated:



3D shapes can be drawn by giving non-zero values to z quadrant of the **glVertex3f()** method, which generates the above view. Now joining the remaining lines will lead to a 3D edge.

Program to develop a 3D edge:

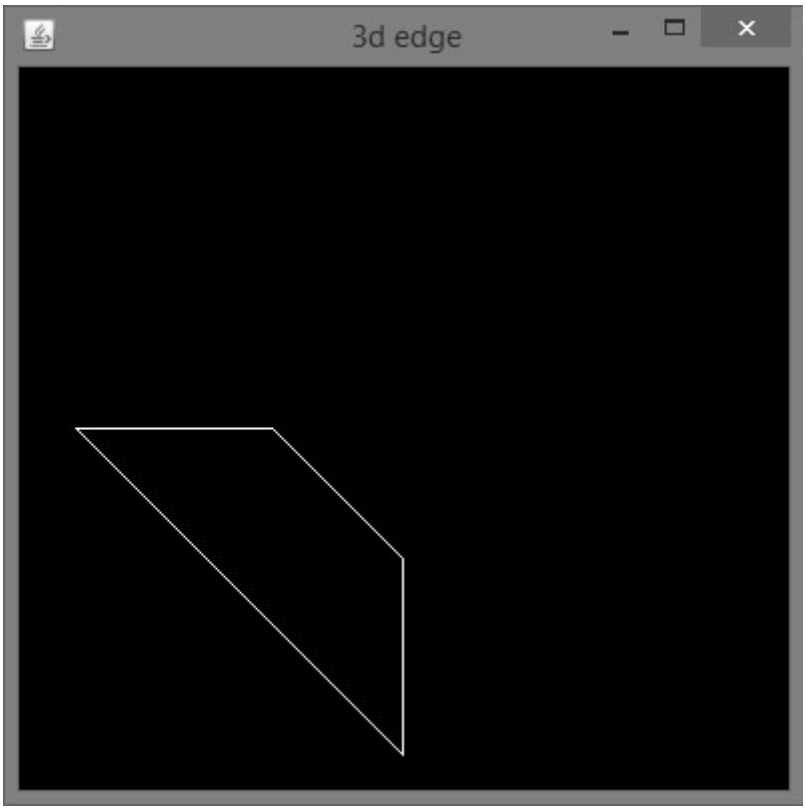
```
import javax.media.opengl.GL2;

import javax.media.opengl.GLAutoDrawable;

import javax.media.opengl.GLCapabilities;

import javax.media.opengl.GLEventListener;

import javax.media.opengl.GLProfile;

import javax.media.opengl.awt.GLCanvas;

import javax.media.opengl.glu.GLU;

import javax.swing.JFrame;


public class Edge1 implements GLEventListener{
```

```
    private GLU glu = new GLU();

          @Override

          public void display(GLAutoDrawable drawable) {

                // TODO Auto-generated method stub

                final GL2 gl = drawable.getGL().getGL2();

                gl.glTranslatef(0f, 0f, -2.5f);

                gl.glBegin(GL2.GL_LINES);

                gl.glVertex3f(-0.75f,0f,0);

                gl.glVertex3f(0f,-0.75f, 0);

                gl.glEnd();


                //3d line

                gl.glBegin(GL2.GL_LINES);


                //3 units in to the window

                gl.glVertex3f(-0.75f,0f,3f);
                gl.glVertex3f(0f,-0.75f,3f);

                gl.glEnd();


                //top

                gl.glBegin(GL2.GL_LINES);

                gl.glVertex3f(-0.75f,0f,0);

                gl.glVertex3f(-0.75f,0f,3f);

                gl.glEnd();


                //bottom

                gl.glBegin(GL2.GL_LINES);
```

```
            gl.glVertex3f(0f,-0.75f, 0);
            gl.glVertex3f(0f,-0.75f,3f);
            gl.glEnd();
            }
      @Override
       public void dispose(GLAutoDrawable arg0) {
            //method body
       }
       @Override
       public void init(GLAutoDrawable arg0) {
            // method body
       }
       @Override
       public void reshape(GLAutoDrawable drawable, int x, int y,
       int width, int height) {
            // TODO Auto-generated method stubfinal
            GL2 gl = drawable.getGL().getGL2();

            if(height <=0)
                  height =1;
            final float h = (float) width / (float) height;
            gl.glViewport(0, 0, width, height);
            gl.glMatrixMode(GL2.GL_PROJECTION);
            gl.glLoadIdentity();
            glu.gluPerspective(45.0f, h, 1.0, 20.0);
            gl.glMatrixMode(GL2.GL_MODELVIEW);
            gl.glLoadIdentity();
```

```
        }
         public static void main(String[] args) {
              //getting the capabilities object of GL2 profile
              final GLProfile profile = GLProfile.get(GLProfile.GL2);
              GLCapabilities capabilities = new GLCapabilities(profile);

              // The canvas
              final GLCanvas glcanvas = new GLCanvas(capabilities);
              Edge1 b = new Edge1();
              glcanvas.addGLEventListener(b);
              glcanvas.setSize(400, 400);

              //creating frame
              final JFrame frame = new JFrame (" 3d edge");

              //adding canvas to it
              frame.getContentPane().add(glcanvas);
              frame.setSize(frame.getContentPane().getPreferredSize());
              frame.setVisible(true);
        }//end of main
    }//end of class
```

When you compile and execute the above program, the following output is generated:



In the same way, by developing 3D edges to corresponding sides of any 2D quadrilateral and joining the adjacent vertices, you can get a 3D quadrilateral.

Program to draw a rhombus:

```
import javax.media.opengl.GL2;

import javax.media.opengl.GLAutoDrawable;

import javax.media.opengl.GLCapabilities;

import javax.media.opengl.GLEventListener;

import javax.media.opengl.GLProfile;

import javax.media.opengl.awt.GLCanvas;

import javax.media.opengl.glu.GLU;

import javax.swing.JFrame;
```

```
public class Rhombus implements GLEventListener{

          private GLU glu = new GLU();

          @Override

          public void display(GLAutoDrawable drawable) {

          final GL2 gl = drawable.getGL().getGL2();

          gl.glTranslatef(0f, 0f, -2.5f);


          //drawing edge1.....

          gl.glBegin(GL2.GL_LINES);

          gl.glVertex3f(-0.75f,0f,0);

          gl.glVertex3f(0f,-0.75f, 0);

          gl.glEnd();

          gl.glBegin(GL2.GL_LINES);

          gl.glVertex3f(-0.75f,0f,3f);  // 3 units into the window

          gl.glVertex3f(0f,-0.75f,3f);

          gl.glEnd();


          //top

          gl.glBegin(GL2.GL_LINES);

          gl.glVertex3f(-0.75f,0f,0);

          gl.glVertex3f(-0.75f,0f,3f);

          gl.glEnd();


          // bottom

          gl.glBegin(GL2.GL_LINES);

          gl.glVertex3f(0f,-0.75f, 0);

          gl.glVertex3f(0f,-0.75f,3f);
```

```
        gl.glEnd();
        // edge 2....
        gl.glBegin(GL2.GL_LINES);
        gl.glVertex3f(0f,-0.75f, 0);
        gl.glVertex3f(0.75f,0f, 0);
        gl.glEnd();
        gl.glBegin(GL2.GL_LINES);
        gl.glVertex3f(0f,-0.75f, 3f);
        gl.glVertex3f(0.75f,0f, 3f);
        gl.glEnd();
        gl.glBegin(GL2.GL_LINES);
        gl.glVertex3f(0f,-0.75f, 0);
        gl.glVertex3f(0f,-0.75f, 3f);
        gl.glEnd();
        gl.glBegin(GL2.GL_LINES);
        gl.glVertex3f(0.75f,0f, 0);
        gl.glVertex3f(0.75f,0f, 3f);
        gl.glEnd();

        //Edge 3.............
        gl.glBegin(GL2.GL_LINES);
        gl.glVertex3f( 0.0f,0.75f,0);
        gl.glVertex3f(-0.75f,0f,0);
        gl.glEnd();
        gl.glBegin(GL2.GL_LINES);
        gl.glVertex3f( 0.0f,0.75f,3f);
        gl.glVertex3f(-0.75f,0f,3f);
```

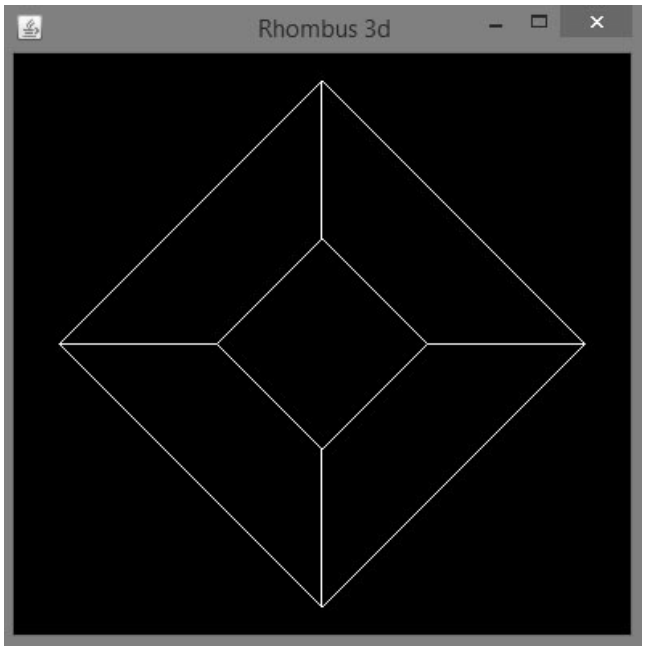
```
            gl.glEnd();
            gl.glBegin(GL2.GL_LINES);
            gl.glVertex3f( 0.0f,0.75f,0);
            gl.glVertex3f( 0.0f,0.75f,3f);
            gl.glEnd();
            gl.glBegin(GL2.GL_LINES);
            gl.glVertex3f(-0.75f,0f,0);
            gl.glVertex3f(-0.75f,0f,3f);
            gl.glEnd();

            //final edge
            gl.glBegin(GL2.GL_LINES);
            gl.glVertex3f(0.75f,0f, 0);
            gl.glVertex3f( 0.0f,0.75f,0);
            gl.glEnd();
            gl.glBegin(GL2.GL_LINES);
            gl.glVertex3f(0.75f,0f,3f);
            gl.glVertex3f( 0.0f,0.75f,3f);
            gl.glEnd();
            gl.glBegin(GL2.GL_LINES);
            gl.glVertex3f(0.75f,0f, 0);
            gl.glVertex3f(0.75f,0f,3f);
            gl.glEnd();
            gl.glBegin(GL2.GL_LINES);
            gl.glVertex3f( 0.0f,0.75f,0);
            gl.glVertex3f( 0.0f,0.75f,3f);
            gl.glEnd();
         }
```

```
@Override
public void dispose(GLAutoDrawable arg0) {
      //method body
}
```

```
@Override
public void init(GLAutoDrawable arg0) {
      // method body
}
@Override
public void reshape(GLAutoDrawable drawable, int x, int y,
int width, int height) {
      // TODO Auto-generated method stub final
      GL2 gl = drawable.getGL().getGL2();
      if(height <=0)
            height =1;
      final float h = (float) width / (float) height;
      gl.glViewport(3, 6, width, height);
      gl.glMatrixMode(GL2.GL_PROJECTION);
      gl.glLoadIdentity();
      glu.gluPerspective(45.0f, h, 1.0, 20.0);
      gl.glMatrixMode(GL2.GL_MODELVIEW);
      gl.glLoadIdentity();
}
  public static void main(String[] args) {
      //getting the capabilities object of GL2 profile
      final GLProfile profile = GLProfile.get(GLProfile.GL2);

      GLCapabilities capabilities = new GLCapabilities(profile);
```

```
            // The canvas
            final GLCanvas glcanvas = new GLCanvas(capabilities);
            Rhombus b = new Rhombus();
            glcanvas.addGLEventListener(b);
            glcanvas.setSize(400, 400);

            //creating frame
            final JFrame frame = new JFrame (" Rhombus 3d");

            //adding canvas to it
            frame.getContentPane().add(glcanvas);
            frame.setSize(frame.getContentPane().getPreferredSize());
            frame.setVisible(true);
        }//end of main
    }//end of classimport javax.media.opengl.GL2;
```

When you compile and execute the above program, the following output is generated. It shows a rhombus drawn using 3D lines.



The predefined parameters of **glBegin()** method can be used for drawing 3D shapes.

Program to draw a 3D triangle (without depth test):

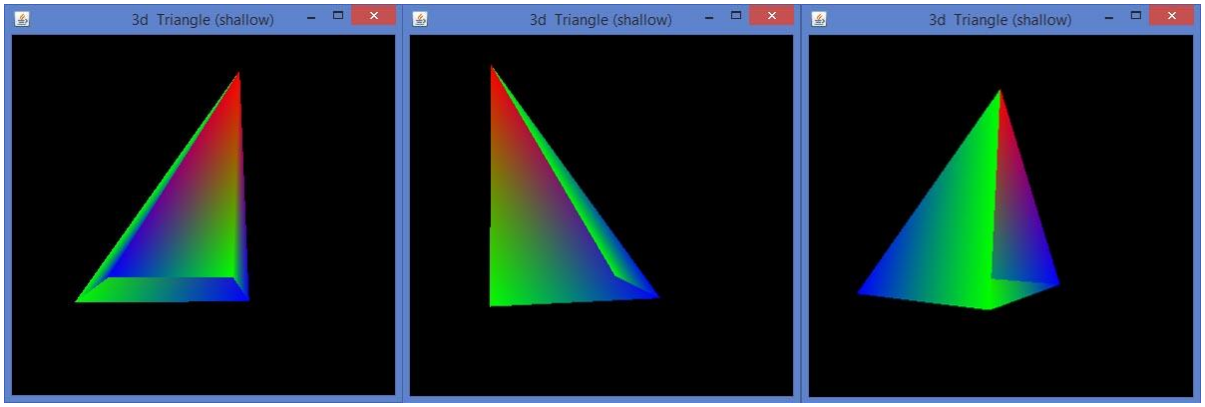
```
import javax.media.opengl.GL2;
import javax.media.opengl.GLAutoDrawable;
import javax.media.opengl.GLCapabilities;
import javax.media.opengl.GLEventListener;
import javax.media.opengl.GLProfile;
import javax.media.opengl.awt.GLCanvas;
import javax.media.opengl.glu.GLU;
import javax.swing.JFrame;
import com.jogamp.opengl.util.FPSAnimator;
public class Triangle3d implements GLEventListener{
     private GLU glu = new GLU();
     private float rtri =0.0f;
     @Override
     public void display(GLAutoDrawable drawable) {
        final GL2 gl = drawable.getGL().getGL2();

        // Clear The Screen And The Depth Buffer
        gl.glClear( GL2.GL_COLOR_BUFFER_BIT | GL2.GL_DEPTH_BUFFER_BIT );
        gl.glLoadIdentity();       // Reset The View
        gl.glTranslatef( -0.5f, 0.0f, -6.0f );       // Move the triangle
        gl.glRotatef( rtri, 0.0f, 1.0f, 0.0f );
        gl.glBegin(  GL2.GL_TRIANGLES );

        //drawing triangle in all dimensions
```

```
        // Front
        gl.glColor3f( 1.0f, 0.0f, 0.0f ); // Red
        gl.glVertex3f( 1.0f, 2.0f, 0.0f ); // Top Of Triangle (Front)
        gl.glColor3f( 0.0f, 1.0f, 0.0f ); // Green
        gl.glVertex3f( -1.0f, -1.0f, 1.0f ); // Left Of Triangle (Front)
        gl.glColor3f( 0.0f, 0.0f, 1.0f ); // Blue
        gl.glVertex3f( 1.0f, -1.0f, 1.0f ); // Right Of Triangle (Front)

        // Right
        gl.glColor3f( 1.0f, 0.0f, 0.0f );      // Red
        gl.glVertex3f( 1.0f, 2.0f, 0.0f );     // Top Of Triangle (Right)
        gl.glColor3f( 0.0f, 0.0f, 1.0f );      // Blue
        gl.glVertex3f( 1.0f, -1.0f, 1.0f );    // Left Of Triangle (Right)
        gl.glColor3f( 0.0f, 1.0f, 0.0f );      // Green
        gl.glVertex3f( 1.0f, -1.0f, -1.0f );   // Right Of Triangle (Right)

        // Left
        gl.glColor3f( 1.0f, 0.0f, 0.0f );      // Red
        gl.glVertex3f( 1.0f, 2.0f, 0.0f );     // Top Of Triangle (Back)
        gl.glColor3f( 0.0f, 1.0f, 0.0f );      // Green
        gl.glVertex3f( 1.0f, -1.0f, -1.0f );   // Left Of Triangle (Back)
        gl.glColor3f( 0.0f, 0.0f, 1.0f );      // Blue
        gl.glVertex3f( -1.0f, -1.0f, -1.0f );  // Right Of Triangle (Back)

        //left
        gl.glColor3f( 0.0f, 1.0f, 0.0f );      // Red
        gl.glVertex3f( 1.0f, 2.0f, 0.0f );     // Top Of Triangle (Left)
```

```
      gl.glColor3f( 0.0f, 0.0f, 1.0f );      // Blue
      gl.glVertex3f( -1.0f, -1.0f, -1.0f );  // Left Of Triangle (Left)
      gl.glColor3f( 0.0f, 1.0f, 0.0f );      // Green
      gl.glVertex3f( -1.0f, -1.0f, 1.0f );   // Right Of Triangle (Left)
      gl.glEnd(); // Done Drawing 3d  triangle (Pyramid)
      gl.glFlush();
      rtri +=0.2f;
   }
   @Override
   public void dispose( GLAutoDrawable drawable ) {
        //method body
   }
   @Override
   public void init( GLAutoDrawable drawable ) {
        //method body
   }
   @Override
   public void reshape( GLAutoDrawable drawable, int x, int y, int
   width, int height ) {
         // TODO Auto-generated method stub
         final GL2 gl = drawable.getGL().getGL2();
         if(height <=;)
               height =1;
         final float h = ( float ) width / ( float ) height;
         gl.glViewport( 0, 0, width, height );
         gl.glMatrixMode( GL2.GL_PROJECTION );
         gl.glLoadIdentity();
         glu.gluPerspective( 45.0f, h, 1.0, 20.0 );
```

```
            gl.glMatrixMode( GL2.GL_MODELVIEW );
            gl.glLoadIdentity();
      }
      public static void main( String[] args ) {
            // TODO Auto-generated method stub
            final GLProfile profile = GLProfile.get( GLProfile.GL2 );
            GLCapabilities capabilities = new GLCapabilities( profile );

            // The canvas
            final GLCanvas glcanvas = new GLCanvas( capabilities );
            Triangle3d triangle = new Triangle3d();
            glcanvas.addGLEventListener( triangle );
            glcanvas.setSize( 400, 400 );
            final JFrame frame = new JFrame ( "3d  Triangle (shallow)" );
            frame.getContentPane().add( glcanvas );
            frame.setSize( frame.getContentPane().getPreferredSize() );
            frame.setVisible( true );
            final FPSAnimator animator = new FPSAnimator(glcanvas,300,true);
            animator.start();
      }
}
```

When you compile and execute the above program, the following output is generated. Here, you have the snapshots of rotating 3D triangle. Since this program does not includes depth test, the triangle is generated hollow.



To make the triangle solid, you need to enable depth test by using **glEnable(GL_DEPTH_TEST)**. Enabling the depth buffer gives you a blank screen. This can be cleared by clearing the color using **glClear(GL_COLOR_BUFFERBIT | GL_DEPTH_BUFFER_BIT)** method. To enable depth test in the init() method or in the **glDisplay()** method, write the following code:

```
public void init(GLAutoDrawable drawable) {

     final GL2 gl = drawable.getGL().getGL2();

     gl.glShadeModel(GL2.GL_SMOOTH);

     gl.glClearColor(0f, 0f, 0f, 0f);

     gl.glClearDepth(1.0f);

     gl.glEnable(GL2.GL_DEPTH_TEST);

     gl.glDepthFunc(GL2.GL_LEQUAL);

     gl.glHint(GL2.GL_PERSPECTIVE_CORRECTION_HINT, GL2.GL_NICEST);

}
```

Program to draw a 3D triangle (with depth test):

```
import javax.media.opengl.GL2;

import javax.media.opengl.GLAutoDrawable;

import javax.media.opengl.GLCapabilities;

import javax.media.opengl.GLEventListener;

import javax.media.opengl.GLProfile;
```

```
import javax.media.opengl.awt.GLCanvas;
import javax.media.opengl.glu.GLU;
import javax.swing.JFrame;
import com.jogamp.opengl.util.FPSAnimator;

public class Triangledepthtest implements GLEventListener{
    private GLU glu = new GLU();
    private float rtri =0.0f;
    @Override
    public void display( GLAutoDrawable drawable ) {
          final GL2 gl = drawable.getGL().getGL2();
          gl.glShadeModel( GL2.GL_SMOOTH );
          gl.glClearColor( 0f, 0f, 0f, 0f );
          gl.glClearDepth( 1.0f );
          gl.glEnable( GL2.GL_DEPTH_TEST );
          gl.glDepthFunc( GL2.GL_LEQUAL );
          gl.glHint(GL2.GL_PERSPECTIVE_CORRECTION_HINT, GL2.GL_NICEST);

          // Clear The Screen And The Depth Buffer
          gl.glClear(GL2.GL_COLOR_BUFFER_BIT | GL2.GL_DEPTH_BUFFER_BIT);
          gl.glLoadIdentity();    // Reset The View
          gl.glTranslatef( -0.5f,0.0f,-6.0f );      // Move the triangle
          gl.glRotatef( rtri, 0.0f, 1.0f, 0.0f );
          gl.glBegin( GL2.GL_TRIANGLES );

          //drawing triangle in all dimensions
          //front
```

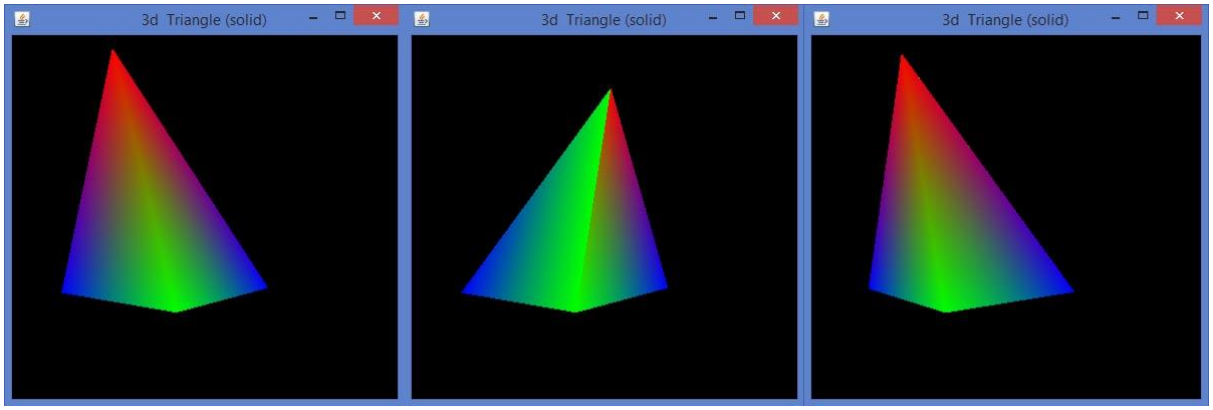
```
gl.glColor3f( 1.0f, 0.0f, 0.0f ); // Red
gl.glVertex3f( 1.0f, 2.0f, 0.0f ); // Top
gl.glColor3f( 0.0f, 1.0f, 0.0f ); // Green
gl.glVertex3f( -1.0f, -1.0f, 1.0f ); // Left
gl.glColor3f( 0.0f, 0.0f, 1.0f ); // Blue
gl.glVertex3f( 1.0f, -1.0f, 1.0f ); // Right)

//right
gl.glColor3f( 1.0f, 0.0f, 0.0f );
gl.glVertex3f( 1.0f, 2.0f, 0.0f ); // Top
gl.glColor3f( 0.0f, 0.0f, 1.0f );
gl.glVertex3f( 1.0f, -1.0f, 1.0f ); // Left
gl.glColor3f( 0.0f, 1.0f, 0.0f );
gl.glVertex3f( 1.0f, -1.0f, -1.0f ); // Right

//left
gl.glColor3f( 1.0f, 0.0f, 0.0f );
gl.glVertex3f( 1.0f, 2.0f, 0.0f ); // Top
gl.glColor3f( 0.0f, 1.0f, 0.0f );
gl.glVertex3f( 1.0f, -1.0f, -1.0f ); // Left
gl.glColor3f( 0.0f, 0.0f, 1.0f );
gl.glVertex3f( -1.0f, -1.0f, -1.0f ); // Right

//top
gl.glColor3f( 0.0f, 1.0f, 0.0f );
gl.glVertex3f( 1.0f, 2.0f, 0.0f ); // Top
gl.glColor3f( 0.0f, 0.0f, 1.0f );
gl.glVertex3f( -1.0f, -1.0f, -1.0f ); // Left
```

```
        gl.glColor3f( 0.0f, 1.0f, 0.0f );
        gl.glVertex3f( -1.0f, -1.0f, 1.0f ); // Right
        gl.glEnd(); // Done Drawing 3d  triangle (Pyramid)

        gl.glFlush();
        rtri +=0.2f;
    }
    @Override
    public void dispose( GLAutoDrawable drawable ) {
    }
    @Override
    public void init( GLAutoDrawable drawable  ) {
        final GL2 gl = drawable.getGL().getGL2();
        gl.glShadeModel( GL2.GL_SMOOTH );
        gl.glClearColor( 0f, 0f, 0f, 0f );
        gl.glClearDepth( 1.0f );
        gl.glEnable( GL2.GL_DEPTH_TEST );
        gl.glDepthFunc( GL2.GL_LEQUAL );
        gl.glHint(GL2.GL_PERSPECTIVE_CORRECTION_HINT, GL2.GL_NICEST );
    }
    @Override
    public void reshape(GLAutoDrawable drawable, int x, int y,
    int width, int height ) {
        // TODO Auto-generated method stub
        final GL2 gl = drawable.getGL().getGL2();
        if( height <=0 )
            height =1;
        final float h = ( float ) width / ( float ) height;
```

```
            gl.glViewport( 0, 0, width, height );
            gl.glMatrixMode( GL2.GL_PROJECTION );
            gl.glLoadIdentity();
            glu.gluPerspective( 45.0f, h, 1.0, 20.0 );
            gl.glMatrixMode( GL2.GL_MODELVIEW );
            gl.glLoadIdentity();
      }
      public static void main( String[] args ) {
            // TODO Auto-generated method stub
            final GLProfile profile = GLProfile.get( GLProfile.GL2 );
            GLCapabilities capabilities = new GLCapabilities( profile );
            // The canvas
            final GLCanvas glcanvas = new GLCanvas( capabilities );
            Triangledepthtest triangledepthtest = new Triangledepthtest();
            glcanvas.addGLEventListener( triangledepthtest );
            glcanvas.setSize( 400, 400 );
            final JFrame frame = new JFrame ( "3d  Triangle (solid)" );
            frame.getContentPane().add(glcanvas);
            frame.setSize( frame.getContentPane().getPreferredSize() );
            frame.setVisible( true );
            final FPSAnimator animator = new FPSAnimator( glcanvas, 300,true);
            animator.start();
      }
}
```

When you compile and execute the above program, the following output is generated.

Here, you can see the snapshots of a rotating 3D triangle. Since this program includes code for depth test, the triangle is generated solid.



Drawing a 3D Cube

In the same way, let us draw a 3D cube and apply colors to it. Let us go through the program to create a 3D cube:

```
import java.awt.DisplayMode;

import javax.media.opengl.GL2;

import javax.media.opengl.GLAutoDrawable;

import javax.media.opengl.GLCapabilities;

import javax.media.opengl.GLEventListener;

import javax.media.opengl.GLProfile;

import javax.media.opengl.awt.GLCanvas;

import javax.media.opengl.glu.GLU;

import javax.swing.JFrame;

import com.jogamp.opengl.util.FPSAnimator;

public class Cube implements GLEventListener{

     public static DisplayMode dm, dm_old;

     private GLU glu = new GLU();

     private float rquad=0.0f;

     @Override

     public void display( GLAutoDrawable drawable ) {

        final GL2 gl = drawable.getGL().getGL2();

        gl.glClear(GL2.GL_COLOR_BUFFER_BIT | GL2.GL_DEPTH_BUFFER_BIT );
```

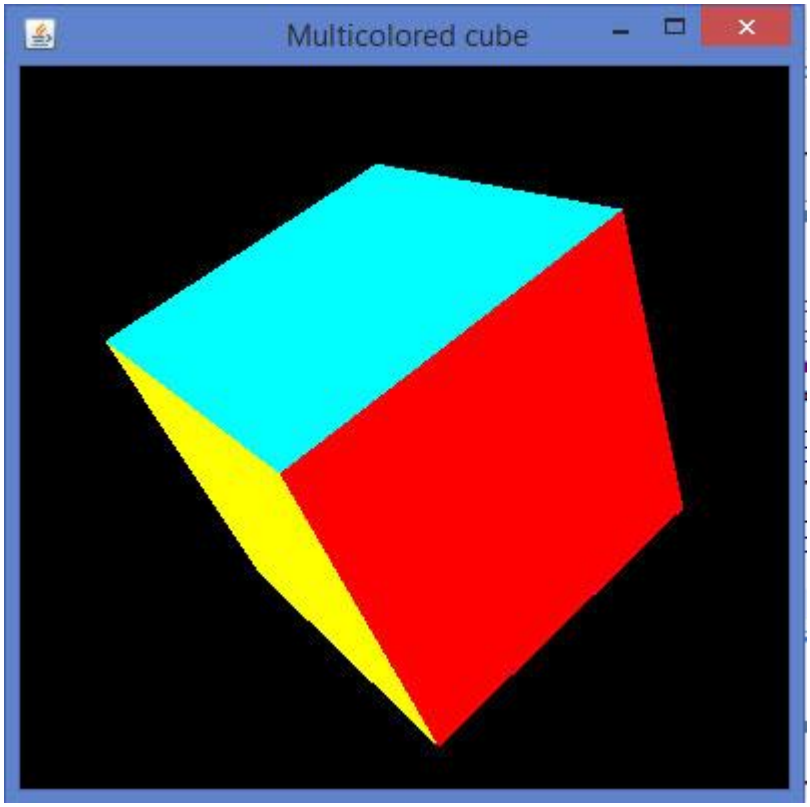
```
        gl.glLoadIdentity();
        gl.glTranslatef( 0f, 0f, -5.0f );

        // Rotate The Cube On X, Y & Z
        gl.glRotatef(rquad, 1.0f, 1.0f, 1.0f);

        //giving different colors to different sides
        gl.glBegin(GL2.GL_QUADS); // Start Drawing The Cube
        gl.glColor3f(1f,0f,0f);   //red color
        gl.glVertex3f(1.0f, 1.0f, -1.0f); // Top Right Of The Quad (Top)
        gl.glVertex3f( -1.0f, 1.0f, -1.0f); // Top Left Of The Quad
(Top)
        gl.glVertex3f( -1.0f, 1.0f, 1.0f ); // Bottom Left Of The Quad
(Top)
        gl.glVertex3f( 1.0f, 1.0f, 1.0f ); // Bottom Right Of The Quad
(Top)

        gl.glColor3f( 0f,1f,0f ); //green color
        gl.glVertex3f( 1.0f, -1.0f, 1.0f ); // Top Right Of The Quad
        gl.glVertex3f( -1.0f, -1.0f, 1.0f ); // Top Left Of The Quad
        gl.glVertex3f( -1.0f, -1.0f, -1.0f ); // Bottom Left Of The Quad
        gl.glVertex3f( 1.0f, -1.0f, -1.0f ); // Bottom Right Of The Quad

        gl.glColor3f( 0f,0f,1f ); //blue color
        gl.glVertex3f( 1.0f, 1.0f, 1.0f ); // Top Right Of The Quad (Front)
        gl.glVertex3f( -1.0f, 1.0f, 1.0f ); // Top Left Of The Quad (Front)
        gl.glVertex3f( -1.0f, -1.0f, 1.0f ); // Bottom Left Of The Quad
        gl.glVertex3f( 1.0f, -1.0f, 1.0f ); // Bottom Right Of The Quad
```

```
        gl.glColor3f( 1f,1f,0f ); //yellow (red + green)
        gl.glVertex3f( 1.0f, -1.0f, -1.0f ); // Bottom Left Of The Quad
        gl.glVertex3f( -1.0f, -1.0f, -1.0f ); // Bottom Right Of The Quad
        gl.glVertex3f( -1.0f, 1.0f, -1.0f ); // Top Right Of The Quad
(Back)
        gl.glVertex3f( 1.0f, 1.0f, -1.0f ); // Top Left Of The Quad (Back)


        gl.glColor3f( 1f,0f,1f ); //purple (red + green)
        gl.glVertex3f( -1.0f, 1.0f, 1.0f ); // Top Right Of The Quad (Left)
        gl.glVertex3f( -1.0f, 1.0f, -1.0f ); // Top Left Of The Quad (Left)
        gl.glVertex3f( -1.0f, -1.0f, -1.0f ); // Bottom Left Of The Quad
        gl.glVertex3f( -1.0f, -1.0f, 1.0f ); // Bottom Right Of The Quad


        gl.glColor3f( 0f,1f, 1f ); //sky blue (blue +green)
        gl.glVertex3f( 1.0f, 1.0f, -1.0f ); // Top Right Of The Quad
(Right)
        gl.glVertex3f( 1.0f, 1.0f, 1.0f ); // Top Left Of The Quad
        gl.glVertex3f( 1.0f, -1.0f, 1.0f ); // Bottom Left Of The Quad
        gl.glVertex3f( 1.0f, -1.0f, -1.0f ); // Bottom Right Of The Quad
        gl.glEnd(); // Done Drawing The Quad
        gl.glFlush();
        rquad -=0.15f;
    }


    @Override
    public void dispose( GLAutoDrawable drawable ) {
          // TODO Auto-generated method stub
    }
```

```
@Override
public void init( GLAutoDrawable drawable ) {
      final GL2 gl = drawable.getGL().getGL2();
      gl.glShadeModel( GL2.GL_SMOOTH );
      gl.glClearColor( 0f, 0f, 0f, 0f );
      gl.glClearDepth( 1.0f );
      gl.glEnable( GL2.GL_DEPTH_TEST );
      gl.glDepthFunc( GL2.GL_LEQUAL );
      gl.glHint( GL2.GL_PERSPECTIVE_CORRECTION_HINT, GL2.GL_NICEST );
}
@Override
public void reshape( GLAutoDrawable drawable, int x, int y, int
width, int height ) {
      // TODO Auto-generated method stub
      final GL2 gl = drawable.getGL().getGL2();
      if( height <=0 )
            height =1;
      final float h = ( float ) width / ( float ) height;
      gl.glViewport( 0, 0, width, height );
      gl.glMatrixMode( GL2.GL_PROJECTION );
      gl.glLoadIdentity();
      glu.gluPerspective( 45.0f, h, 1.0, 20.0 );
      gl.glMatrixMode( GL2.GL_MODELVIEW );
      gl.glLoadIdentity();
}

public static void main( String[] args ) {
      final GLProfile profile = GLProfile.get( GLProfile.GL2 );
```

```
            GLCapabilities capabilities = new GLCapabilities( profile );
            // The canvas
            final GLCanvas glcanvas = new GLCanvas( capabilities );
            Cube cube = new Cube();
            glcanvas.addGLEventListener( cube );
            glcanvas.setSize( 400, 400 );
            final JFrame frame = new JFrame ( " Multicolored cube" );
            frame.getContentPane().add( glcanvas );
            frame.setSize( frame.getContentPane().getPreferredSize() );
            frame.setVisible( true );
            final FPSAnimator animator = new FPSAnimator(glcanvas, 300,true);
            animator.start();

    }
}
```

When you compile and execute the above program, the following output is generated. It shows a colored 3D cube.



Applying Texture to the Cube

The following steps are given to apply texture to a cube:

- You can bind required texture to the cube using the **gl.glBindTexture(GL2.GL_TEXTURE_2D.texture)** method of the **Drawable** interface.
- This method requires texture (int) argument along with **GL2.GL_TEXTURE_2D(int)**.
- Before you execute **Display()**, you need to create texture variable.
- In the **init()** method or in the starting lines of **glDisplay()** method, enable the texture **using gl.glEnable(GL2.GL_TEXTURE_2D)** method.
- Create the texture object, which needs a file object as a parameter, which in turn needs the path of the image used as the texture to the object.

```
File file=new File("c:\\pictures\\boy.jpg");

Texture t=textureIO.newTexture(file, true);

texture=t.getTextureObject(gl);
```

- Handle the 'file not found' exception.

Program to apply texture to a cube:

```
import java.awt.DisplayMode;
import java.io.File;
import java.io.IOException;
import javax.media.opengl.GL2;
import javax.media.opengl.GLAutoDrawable;
import javax.media.opengl.GLCapabilities;
import javax.media.opengl.GLEventListener;
import javax.media.opengl.GLProfile;
import javax.media.opengl.awt.GLCanvas;
import javax.media.opengl.glu.GLU;
import javax.swing.JFrame;
import com.jogamp.opengl.util.FPSAnimator;
import com.jogamp.opengl.util.texture.Texture;
import com.jogamp.opengl.util.texture.TextureIO;

public class CubeTexture implements GLEventListener {
     public static DisplayMode dm, dm_old;
     private GLU glu = new GLU();
     private float xrot,yrot,zrot;
     private int texture;
     @Override
     public void display(GLAutoDrawable drawable) {
           // TODO Auto-generated method stub
           final GL2 gl = drawable.getGL().getGL2();
           gl.glClear(GL2.GL_COLOR_BUFFER_BIT | GL2.GL_DEPTH_BUFFER_BIT);
           gl.glLoadIdentity();        // Reset The View
```

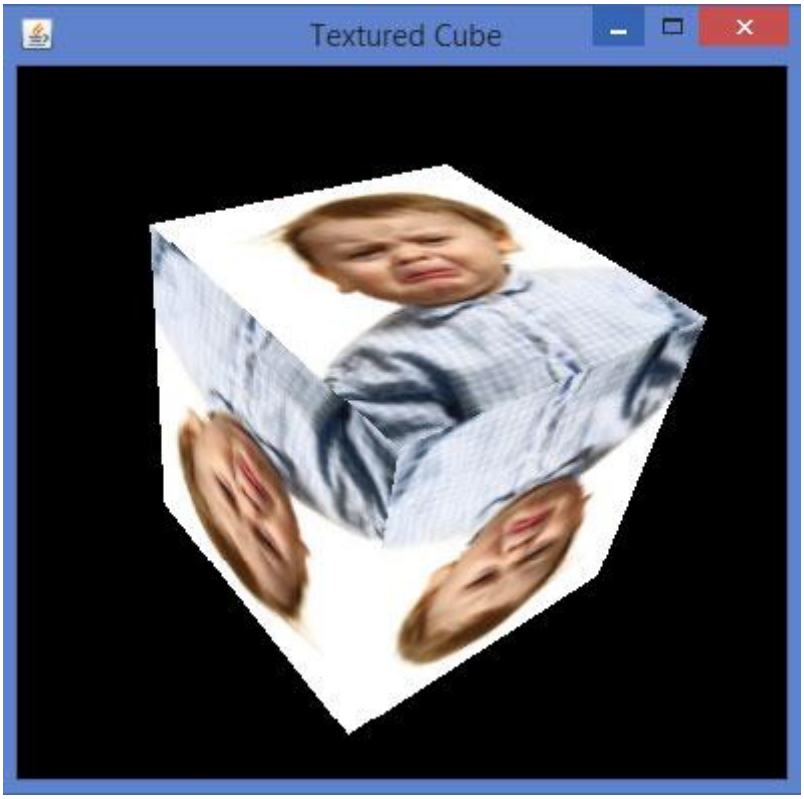
```
        gl.glTranslatef(0f, 0f, -5.0f);
        gl.glRotatef(xrot, 1.0f, 1.0f, 1.0f);
        gl.glRotatef(yrot, 0.0f, 1.0f, 0.0f);
        gl.glRotatef(zrot, 0.0f, 0.0f, 1.0f);
        gl.glBindTexture(GL2.GL_TEXTURE_2D, texture);
        gl.glBegin(GL2.GL_QUADS);

        // Front Face
        gl.glTexCoord2f(0.0f, 0.0f); gl.glVertex3f(-1.0f, -1.0f,  1.0f);
        gl.glTexCoord2f(1.0f, 0.0f); gl.glVertex3f( 1.0f, -1.0f,  1.0f);
        gl.glTexCoord2f(1.0f, 1.0f); gl.glVertex3f( 1.0f,  1.0f,  1.0f);
        gl.glTexCoord2f(0.0f, 1.0f); gl.glVertex3f(-1.0f,  1.0f,  1.0f);

        // Back Face
        gl.glTexCoord2f(1.0f, 0.0f); gl.glVertex3f(-1.0f, -1.0f, -1.0f);
        gl.glTexCoord2f(1.0f, 1.0f); gl.glVertex3f(-1.0f,  1.0f, -1.0f);
        gl.glTexCoord2f(0.0f, 1.0f); gl.glVertex3f( 1.0f,  1.0f, -1.0f);
        gl.glTexCoord2f(0.0f, 0.0f); gl.glVertex3f( 1.0f, -1.0f, -1.0f);

        // Top Face
        gl.glTexCoord2f(0.0f, 1.0f); gl.glVertex3f(-1.0f,  1.0f, -1.0f);
        gl.glTexCoord2f(0.0f, 0.0f); gl.glVertex3f(-1.0f,  1.0f,  1.0f);
        gl.glTexCoord2f(1.0f, 0.0f); gl.glVertex3f( 1.0f,  1.0f,  1.0f);
        gl.glTexCoord2f(1.0f, 1.0f); gl.glVertex3f( 1.0f,  1.0f, -1.0f);

        // Bottom Face
        gl.glTexCoord2f(1.0f, 1.0f); gl.glVertex3f(-1.0f, -1.0f, -1.0f);
        gl.glTexCoord2f(0.0f, 1.0f); gl.glVertex3f( 1.0f, -1.0f, -1.0f);
```

```
        gl.glTexCoord2f(0.0f, 0.0f); gl.glVertex3f( 1.0f, -1.0f,  1.0f);
        gl.glTexCoord2f(1.0f, 0.0f); gl.glVertex3f(-1.0f, -1.0f,  1.0f);

        // Right face
        gl.glTexCoord2f(1.0f, 0.0f); gl.glVertex3f( 1.0f, -1.0f, -1.0f);
        gl.glTexCoord2f(1.0f, 1.0f); gl.glVertex3f( 1.0f,  1.0f, -1.0f);
        gl.glTexCoord2f(0.0f, 1.0f); gl.glVertex3f( 1.0f,  1.0f,  1.0f);
        gl.glTexCoord2f(0.0f, 0.0f); gl.glVertex3f( 1.0f, -1.0f,  1.0f);

        // Left Face
        gl.glTexCoord2f(0.0f, 0.0f); gl.glVertex3f(-1.0f, -1.0f, -1.0f);
        gl.glTexCoord2f(1.0f, 0.0f); gl.glVertex3f(-1.0f, -1.0f,  1.0f);
        gl.glTexCoord2f(1.0f, 1.0f); gl.glVertex3f(-1.0f,  1.0f,  1.0f);
        gl.glTexCoord2f(0.0f, 1.0f); gl.glVertex3f(-1.0f,  1.0f, -1.0f);
        gl.glEnd();
        gl.glFlush();

        //change the speeds here
        xrot+=.1f;
        yrot+=.1f;
        zrot+=.1f;
    }
    @Override
    public void dispose(GLAutoDrawable drawable) {
        // method body
    }
    @Override
    public void init(GLAutoDrawable drawable) {
```

```
        final GL2 gl = drawable.getGL().getGL2();
        gl.glShadeModel(GL2.GL_SMOOTH);
        gl.glClearColor(0f, 0f, 0f, 0f);
        gl.glClearDepth(1.0f);
        gl.glEnable(GL2.GL_DEPTH_TEST);
        gl.glDepthFunc(GL2.GL_LEQUAL);
        gl.glHint(GL2.GL_PERSPECTIVE_CORRECTION_HINT, GL2.GL_NICEST);

        //
        gl.glEnable(GL2.GL_TEXTURE_2D);
        try{
              File im = new File("E:\\office\\boy.jpg ");
              Texture t = TextureIO.newTexture(im, true);
              texture= t.getTextureObject(gl);

        }catch(IOException e){
              e.printStackTrace();
        }
        }
    @Override
    public void reshape(GLAutoDrawable drawable, int x, int y,
    int width, int height) {
        // TODO Auto-generated method stub
        final GL2 gl = drawable.getGL().getGL2();
        if(height <=0)
           height =1;
        final float h = (float) width / (float) height;
        gl.glViewport(0, 0, width, height);
```

```
            gl.glMatrixMode(GL2.GL_PROJECTION);
            gl.glLoadIdentity();
            glu.gluPerspective(45.0f, h, 1.0, 20.0);
            gl.glMatrixMode(GL2.GL_MODELVIEW);
            gl.glLoadIdentity();
      }
      public static void main(String[] args) {
            // TODO Auto-generated method stub
            final GLProfile profile = GLProfile.get(GLProfile.GL2);
            GLCapabilities capabilities = new GLCapabilities(profile);
            // The canvas
            final GLCanvas glcanvas = new GLCanvas(capabilities);
            CubeTexture r = new CubeTexture();
            glcanvas.addGLEventListener(r);
            glcanvas.setSize(400, 400);
            final JFrame frame = new JFrame (" Textured Cube");
            frame.getContentPane().add(glcanvas);
            frame.setSize(frame.getContentPane().getPreferredSize());
            frame.setVisible(true);
            final FPSAnimator animator = new FPSAnimator(glcanvas, 300, true);
            animator.start();
      }
}
```

When you compile and execute the above program, the following output is generated. You can see a 3D cube with desired texture applied on it.



Appendix

GPU - Graphical processing unit, it is a special electronic device that accelerates the rendering of images.

JNI - Java Native Interface. Using which, java access native methods.

Model – They are the objects constructed from basic graphics primitives such as points, lines and polygons.

Pixel – Smallest unit of display seen on the screen.

Projection - The method of mapping the coordinates of an object to a two-dimensional plane is called projection.

Projection matrix - It is a linear transformation of an object on the 2D surface.

Rendering – A process by which computer creates images from models.

Viewport - A viewport is a viewing region on the screen in computer graphics.