Creating a 2D Game Engine for Android OS

Introduction

This tutorial will lead you through the foundations of creating a 2D animated game for the Android Operating System. The goal here is not to create a complex, multilevel game. Rather, the goal is to create and understand within the elements of the Control-Model-View method of game software design. In addition, we will create this engine from "scratch" – meaning that we will code every aspect of the game in Java with Eclipse to gain a deeper understanding to the interplay between classes in a game simulation. Once you have built this engine, you may add deeper layers of complexity, characters, scenes, and game logic.

Resources Needed:

Eclipse IDE and Java installed on your system.
Android SDK installed within Eclipse with Emulator Software
Android Device (optional, but highly recommended)
Graphics Resources: (You may download these at
http://www.nebomusic.net/androidlessons/gameimages)
(Save these in a folder on your desktop)

Vocabulary:

- Control-Model-View
- XML Layout
- Frame Based Animation
- X and Y coordinate System (0,0 in upper left corner)
- Emulator
- Java:
  - Class
  - Constructor
  - Public
  - Private
  - Void
  - Data Types:
    - int
    - float
    - String
  - Function
- Android SDK Terms:
  - Gesture Detector
  - Handler
  - Runnable
  - View
  - onDraw()
  - invalidate()
  - Canvas
  - Bitmap

BitmapDrawable
Resources
Activity

Control-Model-View

In mobile device programming, the Control-Model-View (CMV) metaphor for software design allows the programmer to model the user input, logic, and animation/output for their game, animation, or simulation. The CMV metaphor as related to Java-Android is as follows:

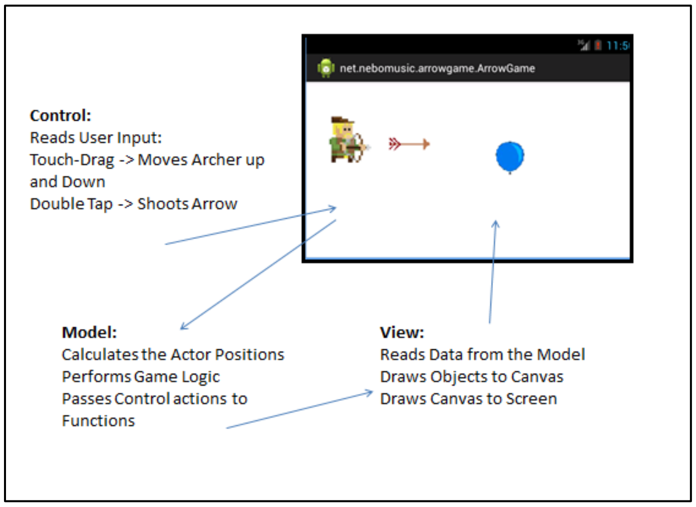
Control: Represents the "user" input and timed events within the software game. By design, Android programming is event driven. The user touches the screen, shakes the phone, presses a button and the software responds with an action. In the structure of an animated game, usually a timer will trigger animation events 30 times a second in addition to user input. In the structure of an Android program, the Control is the "Main Activity" that first opens on execution of the program.

Model: Represents the data structure of the objects and the functions that govern the flow of logic and action in a game. I think of the model in two parts:

1. The actual game pieces as modeled in classes.
2. The actions of the game pieces in relation to movement and each other. (Functions)
3. The "Game Logic." (Rules of the game)

In Android software development, the Model can be a separate Class that "holds the objects and action" or the Model can be interwoven within the View Class.

View: The View's job is to retrieve positions, orientation, data, and graphics from the Model and draw them on the Screen. The Runnable and the Handler will call events 30 times a second that causes the view to retrieve this data and then draw the image to the screen. In Android Programming the View is usually represented as a "GameView.java" class that extends the Android class of View. The View holds the "Game Loop" that calls on the Model to update the positions of the game.


net.nebomusic.arrowgame.ArrowGame
Control:
Reads User Input:
Touch-Drag -> Moves Archer up and Down
Double Tap -> Shoots Arrow
Model:
Calculates the Actor Positions
Performs Game Logic
Passes Control actions to Functions
View:
Reads Data from the Model
Draws Objects to Canvas
Draws Canvas to Screen

Structure of Our Sample Engine:

ArrowGame.java -> Holds the Control. Listens to the Gestures from the screen and then calls methods from the View to update Actor Positions

- Data Elements:
  - Private Instance of ArrowGameView arrowGameView
  - Instance of Gesture Detector
  - Private inner class of SimpleOnGestureListener

ArrowGameView.java -> Holds the View and the Game Logic Loop. Also Holds the “cast” of Actor instances that will take part in the Game.

- Data Elements:
  - Public Instance of Actor archer
  - Public Instance of Actor arrow
  - Public Instance of Actor balloon
  - Private Handler h
  - Private constant int FRAME_RATE = 30

Actor.java -> This data structure will model the “characters” in the game.

- Data Elements:
  - Private Context context
  - Private int x
  - Private int y
  - Private String name
  - Private int costume
  - Private int currentCostume
  - Private Array BitMapDrawable[] graphic

res/drawable: Holds the .png files that will make up the game
(available at: www.nebomusic.net/androidlessons/gameimages)

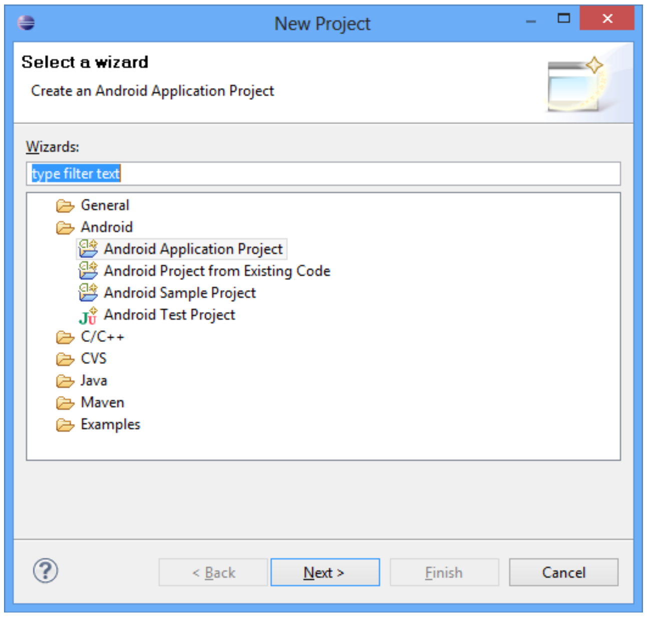
- archer.png
- arrow.png
- blueballoon.png
- drwho.png
- popballoon.png
- tardis.png

activity_arrow_game.xml: Holds the XML code that will control the layout of the View

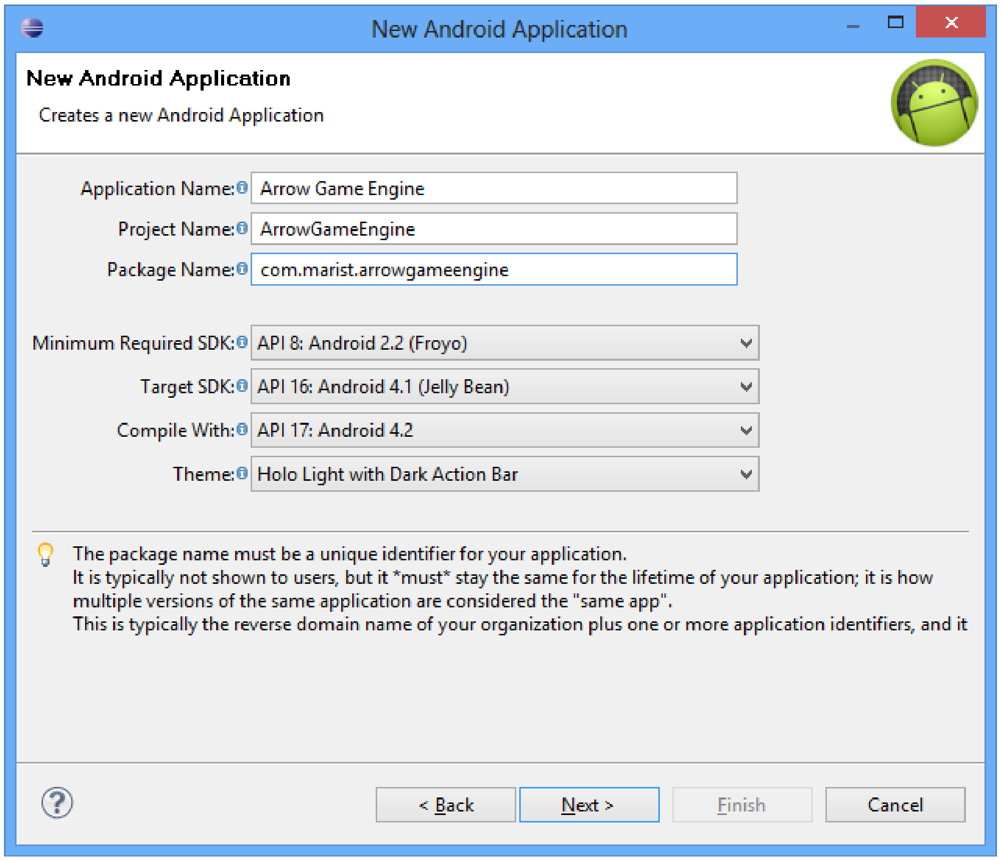
Building The Engine Process:

Phase 1: Setup ArrowGame Project on Eclipse

1. Start Eclipse and select “Android Application Project”



2. Fill out the Wizard form as shown below:
    a. Application Name: ArrowGameEngine
    b. Project Name: ArrowGameEngine
    c. Package name: com.marist.arrowgameengine



New Android Application

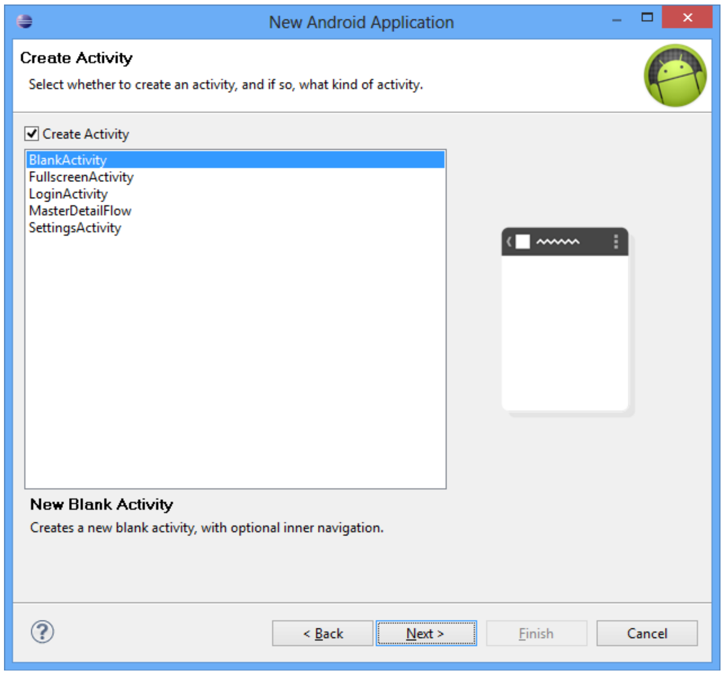
Creates a new Android Application

Application Name:	Arrow Game Engine
Project Name:	ArrowGameEngine
Package Name:	com.marist.arrowgameengine
Minimum Required SDK:	API 8: Android 2.2 (Froyo)
Target SDK:	API 16: Android 4.1 (Jelly Bean)
Compile With:	API 17: Android 4.2
Theme:	Holo Light with Dark Action Bar

The package name must be a unique identifier for your application.
It is typically not shown to users, but it *must* stay the same for the lifetime of your application; it is how multiple versions of the same application are considered the "same app".
This is typically the reverse domain name of your organization plus one or more application identifiers, and it

3. Click next at the Configure Project Window
4. Click next at the Configure Launcher Icon. (We can set this later)

5. Select “Blank Activity” on Create Activity and Click Next


New Android Application

Create Activity

Select whether to create an activity, and if so, what kind of activity.

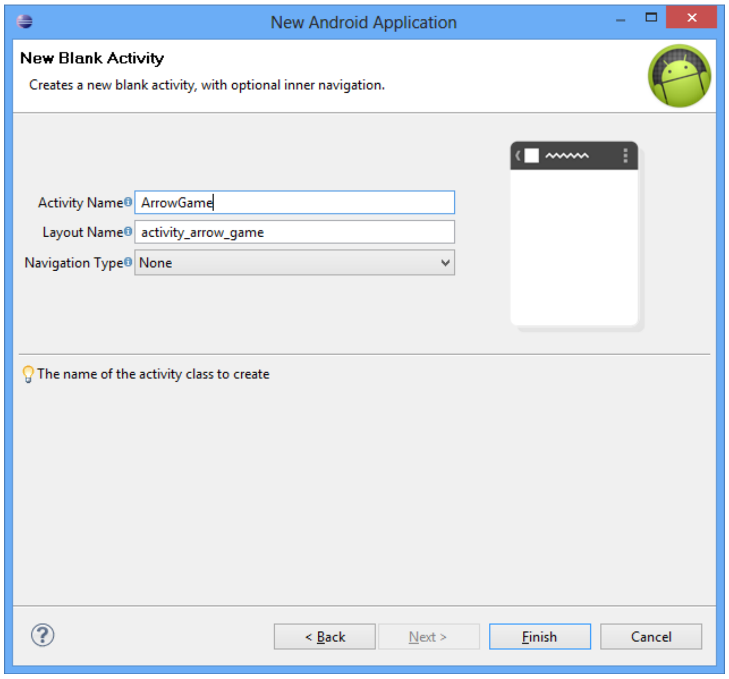
☑ Create Activity

- BlankActivity
- FullscreenActivity
- LoginActivity
- MasterDetailFlow
- SettingsActivity

New Blank Activity

Creates a new blank activity, with optional inner navigation.

6. Name the Activity “ArrowGame.” Click Finish


New Android Application

New Blank Activity

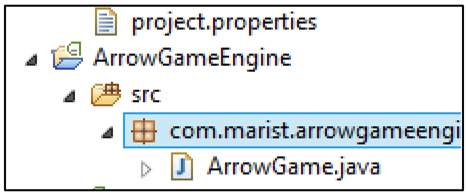
Creates a new blank activity, with optional inner navigation.

Activity Name	ArrowGame
Layout Name	activity_arrow_game
Navigation Type	None

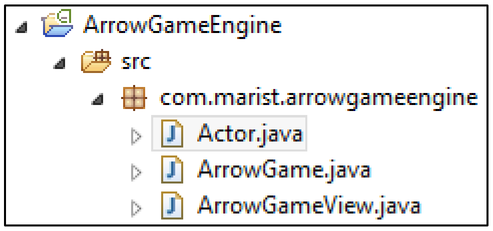
The name of the activity class to create

Phase 2: Define the Classes and Import the Graphics

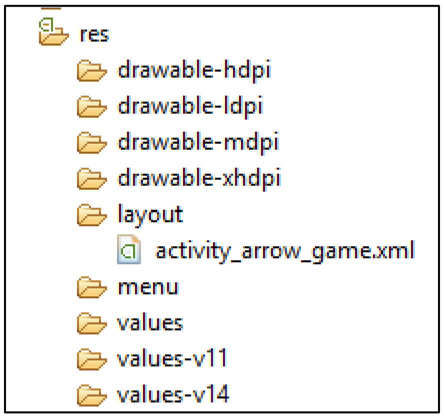
1. Go to src/com.marist.arrowgameengine and right click



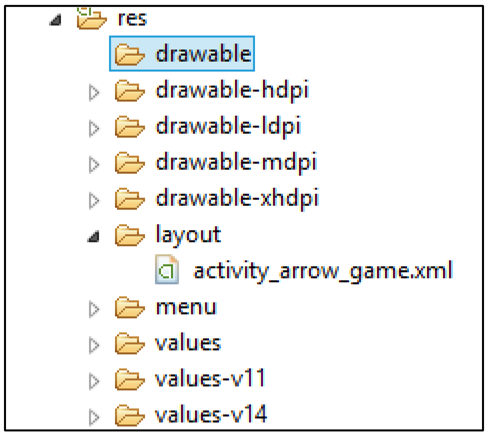
2. Select New Class and name the class "ArrowGameView"
3. Right again and Create a New Class called "Actor". The Screen should look like this:



4. Right click on the "res" folder (stands for resources)

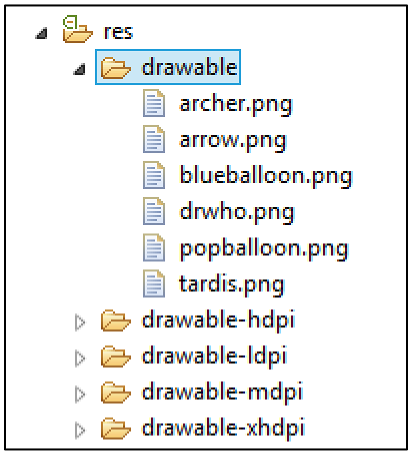


5. Select New – Folder and name the folder “drawable.” It should look like this:



6. Download the .png files located at <nebomusic.net/androidlessons/gameimages> Copy and drag these images into the “drawable” folder. (Select “Copy Files”)

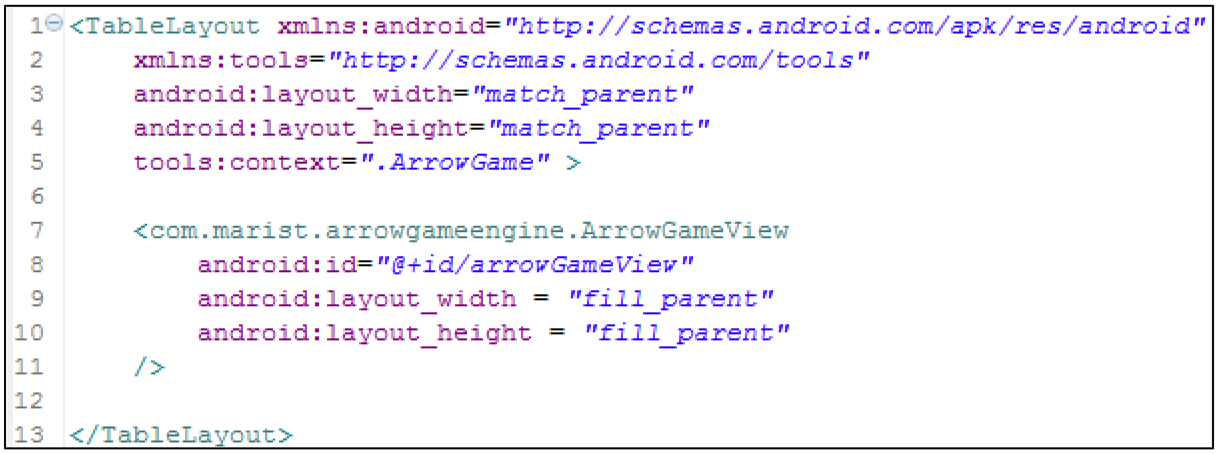
7. It should look like this:



8. ***Very Super Important Step!!!*** After adding resources (images and sound) – Select Project -> Clean and make sure the ArrowGameEngine is checked. This sets the constants for the Image or sound resources. If your code will not compile – Clean the project. This usually fixes errors with the “R.drawable” folder.

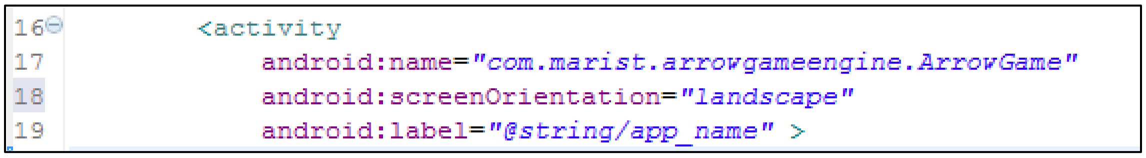
Phase 3: Setup the XML for the Main View

1. We are going to completely re-write the XML for the activity_arrow_game.xml. Click on the res/layout folder and double click the activity_arrow_game.xml. Place the following text into the .xml file. Do not worry if it shows an error – we will define the ArrowGameView later.



```xml
<TableLayout xmlns:android="http://schemas.android.com/apk/res/android"
    xmlns:tools="http://schemas.android.com/tools"
    android:layout_width="match_parent"
    android:layout_height="match_parent"
    tools:context=".ArrowGame" >

    <com.marist.arrowgameengine.ArrowGameView
        android:id="@+id/arrowGameView"
        android:layout_width = "fill_parent"
        android:layout_height = "fill_parent"
    />

</TableLayout>
```

2. Modify the AndroidManifest.xml document to include ‘android:screenOrientation=”landscape”’ on line 18. This holds the App in Landscape (sideways) view.

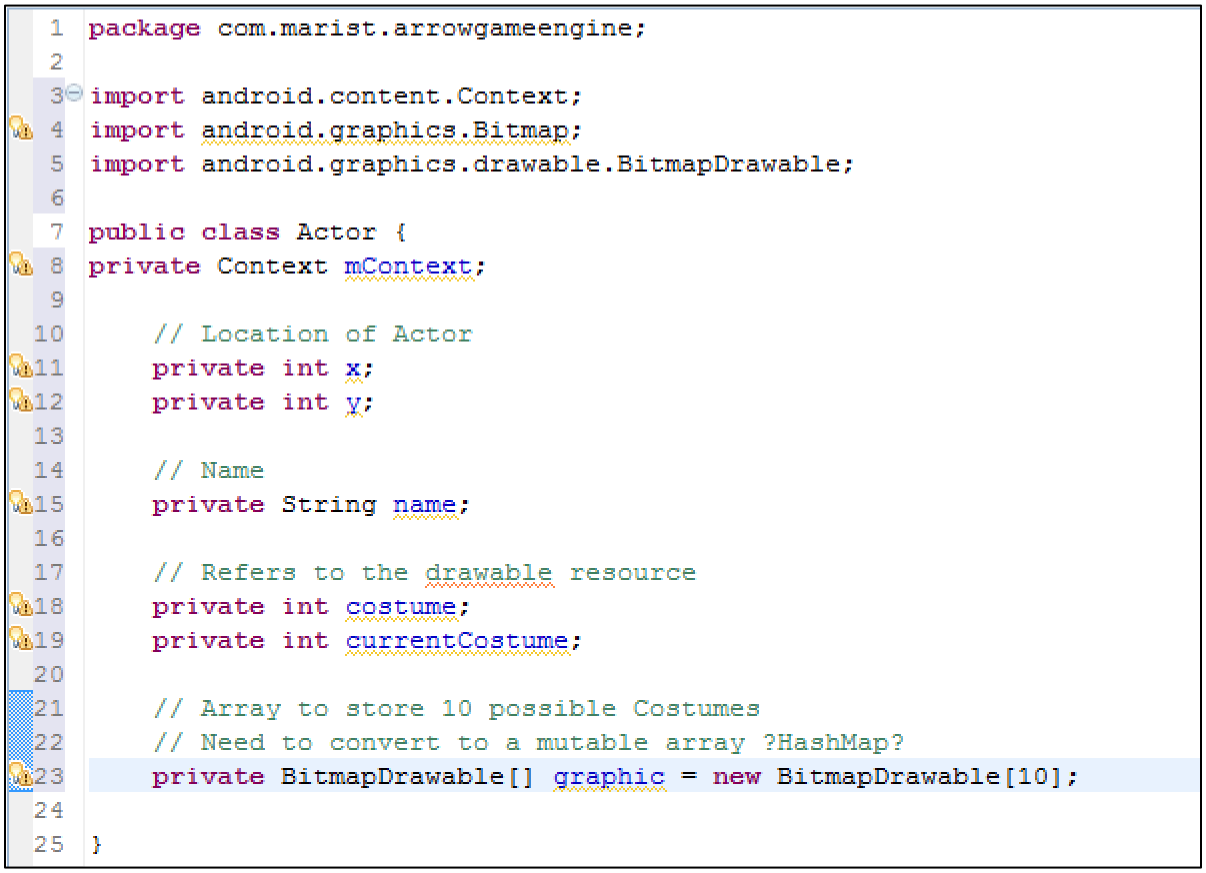


```xml
16        <activity
17            android:name="com.marist.arrowgameengine.ArrowGame"
18            android:screenOrientation="landscape"
19            android:label="@string/app_name" >
```

Phase 4: Define the Actor Class

We will develop the Code classes "Backwards" – working from the Actor.java to ArrowGameView.java and then the ArrowGame.java. Don't worry right away if the code shows errors. Many times errors will arise when we refer to functions or objects we have not defined yet. If you define an Android object, often you can hover over the error and Eclipse will suggest you import the Android library – follow these directives.

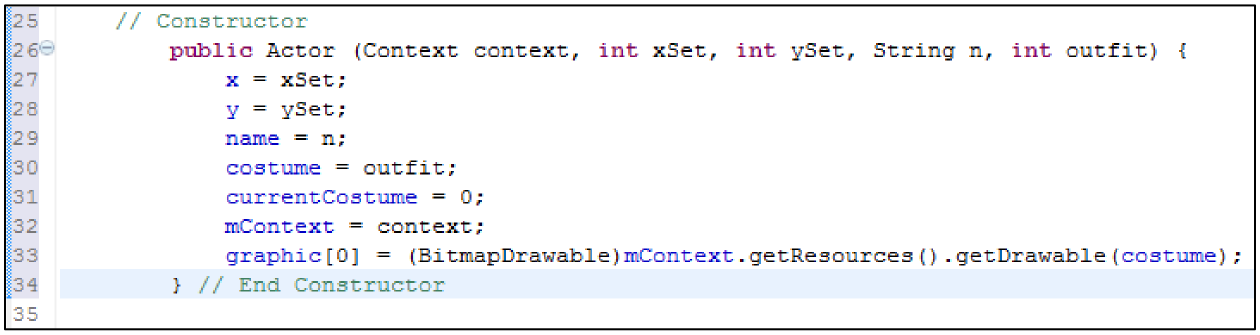
1. Go to the Actor Class and write the following code stating the Data objects in the class:



```java
package com.marist.arrowgameengine;

import android.content.Context;
import android.graphics.Bitmap;
import android.graphics.drawable.BitmapDrawable;

public class Actor {
private Context mContext;

    // Location of Actor
    private int x;
    private int y;

    // Name
    private String name;

    // Refers to the drawable resource
    private int costume;
    private int currentCostume;

    // Array to store 10 possible Costumes
    // Need to convert to a mutable array ?HashMap?
    private BitmapDrawable[] graphic = new BitmapDrawable[10];

}
```

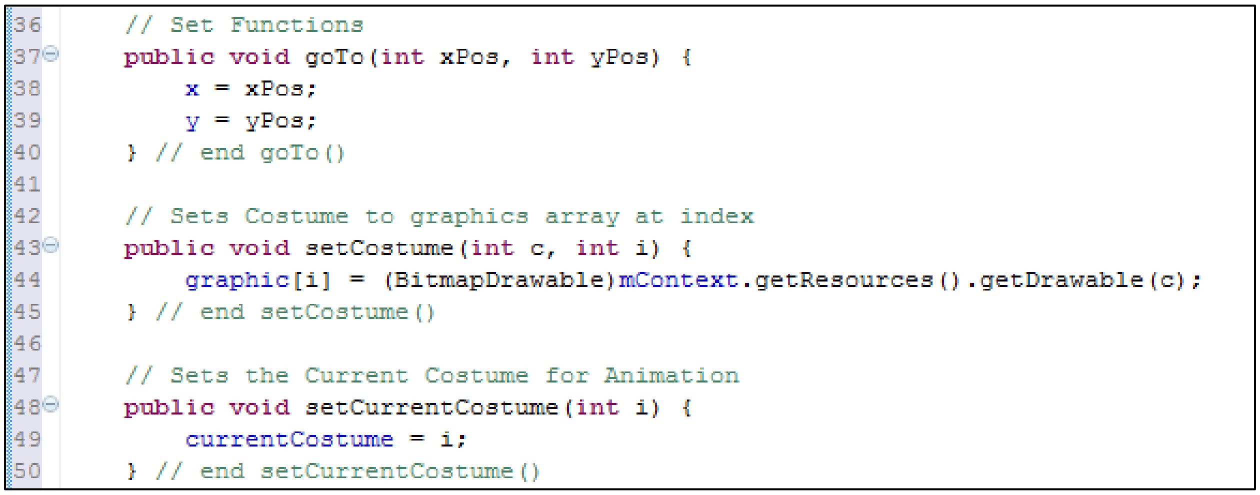
Again – note the warnings. These will resolve as we complete the code.

2. Write the Constructor for Actor.java:



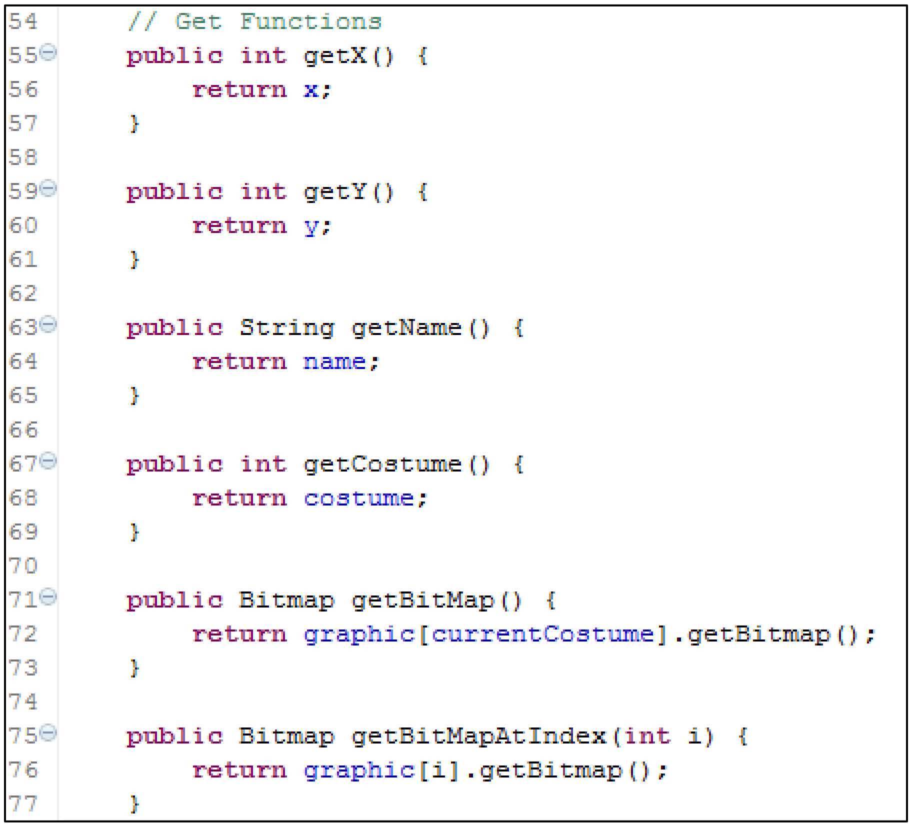
```java
    // Constructor
        public Actor (Context context, int xSet, int ySet, String n, int outfit) {
            x = xSet;
            y = ySet;
            name = n;
            costume = outfit;
            currentCostume = 0;
            mContext = context;
            graphic[0] = (BitmapDrawable)mContext.getResources().getDrawable(costume);
        } // End Constructor

```

3. Write the “Set Functions” These allow other classes to set the Values for Actor instances:



```java
    // Set Functions
    public void goTo(int xPos, int yPos) {
        x = xPos;
        y = yPos;
    } // end goTo()

    // Sets Costume to graphics array at index
    public void setCostume(int c, int i) {
        graphic[i] = (BitmapDrawable)mContext.getResources().getDrawable(c);
    } // end setCostume()

    // Sets the Current Costume for Animation
    public void setCurrentCostume(int i) {
        currentCostume = i;
    } // end setCurrentCostume()
```

4. Write the “Get Functions.” These allow other Classes to get Values for Actor instances:



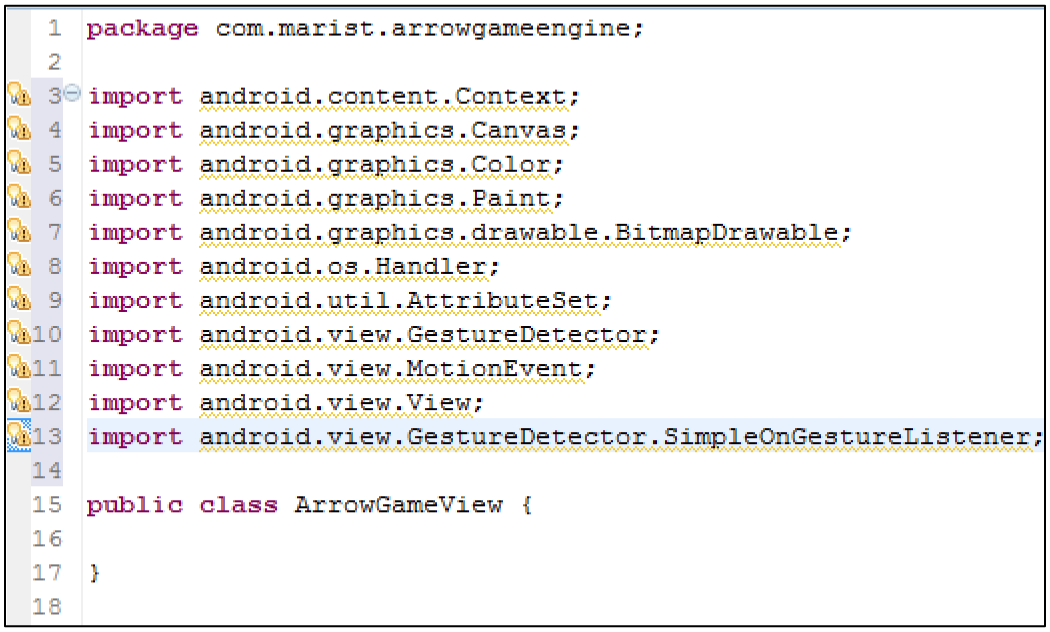
```java
    // Get Functions
    public int getX() {
        return x;
    }

    public int getY() {
        return y;
    }

    public String getName() {
        return name;
    }

    public int getCostume() {
        return costume;
    }

    public Bitmap getBitMap() {
        return graphic[currentCostume].getBitmap();
    }

    public Bitmap getBitMapAtIndex(int i) {
        return graphic[i].getBitmap();
    }
```

When these functions are written, the Actor Class should be free from errors.

Phase 5: Write the ArrowGameView class

This class acts as both the “Model” and the “View”. First we will define the Data structures and constructor. Then build the runnable and the onDraw() method. The onDraw() will hold the game loop that updates the logic and then draws the images to the canvas.

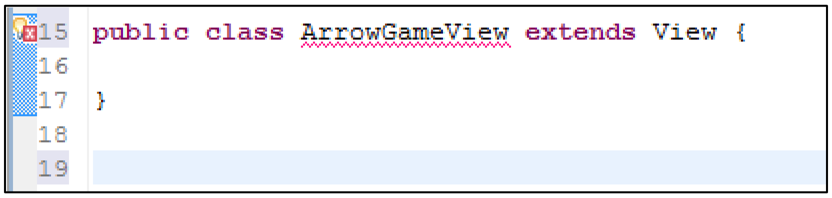
1. Define the Following imports and data for ArrowGameView:



```
package com.marist.arrowgameengine;

import android.content.Context;
import android.graphics.Canvas;
import android.graphics.Color;
import android.graphics.Paint;
import android.graphics.drawable.BitmapDrawable;
import android.os.Handler;
import android.util.AttributeSet;
import android.view.GestureDetector;
import android.view.MotionEvent;
import android.view.View;
import android.view.GestureDetector.SimpleOnGestureListener;

public class ArrowGameView {

}

```

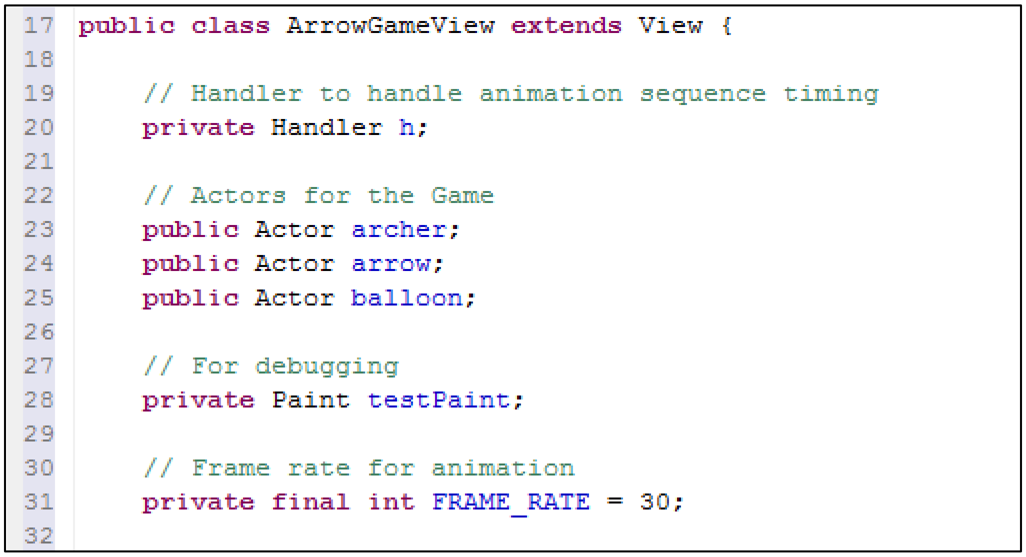
Again, ignore the errors for now.

3. Modify the Class declaration to add “extends view”



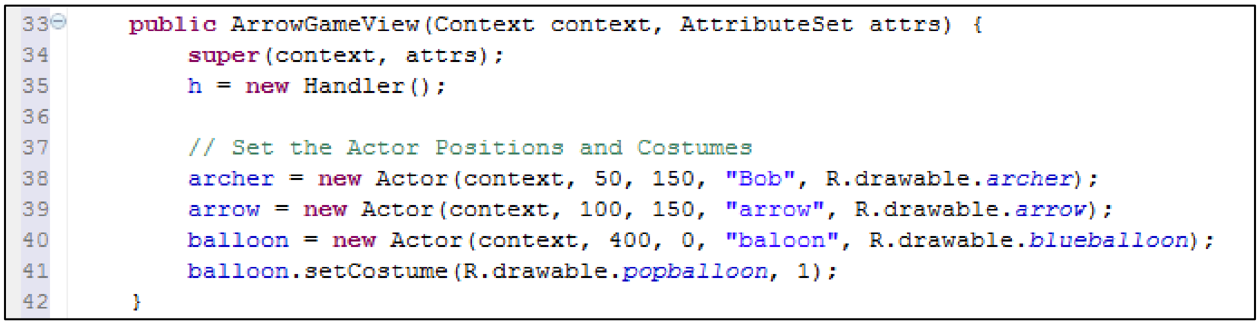
```
public class ArrowGameView extends View {

}

```

4. Add the Data for the Class:



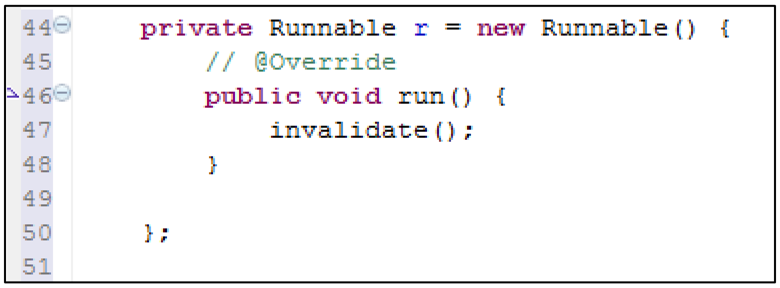
```
17 public class ArrowGameView extends View {
18
19     // Handler to handle animation sequence timing
20     private Handler h;
21
22     // Actors for the Game
23     public Actor archer;
24     public Actor arrow;
25     public Actor balloon;
26
27     // For debugging
28     private Paint testPaint;
29
30     // Frame rate for animation
31     private final int FRAME_RATE = 30;
32
```

5. Write the Constructor:



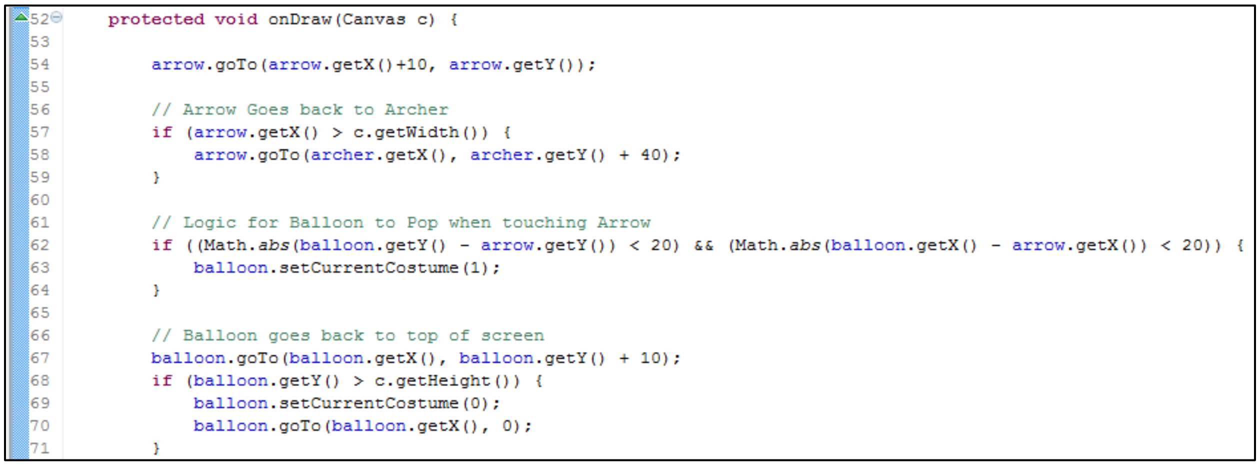
```
33     public ArrowGameView(Context context, AttributeSet attrs) {
34         super(context, attrs);
35         h = new Handler();
36
37         // Set the Actor Positions and Costumes
38         archer = new Actor(context, 50, 150, "Bob", R.drawable.archer);
39         arrow = new Actor(context, 100, 150, "arrow", R.drawable.arrow);
40         balloon = new Actor(context, 400, 0, "baloon", R.drawable.blueballoon);
41         balloon.setCostume(R.drawable.popballoon, 1);
42     }
```

6. Write an inner class Runnable (Part of the Game Loop): (Note the use of the semi-colon in line 51;



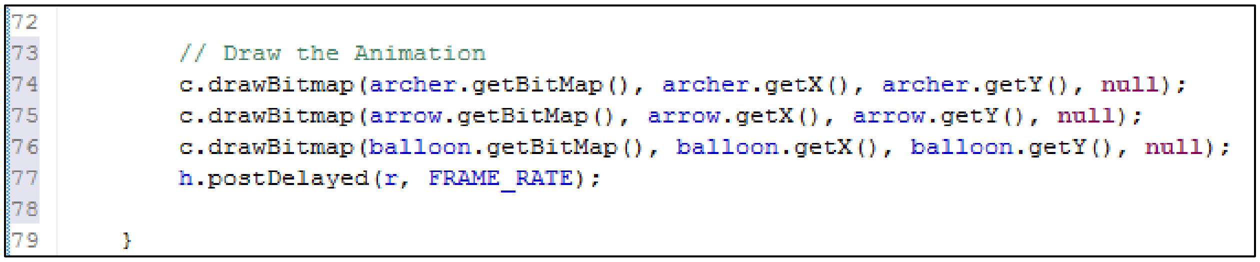
```
44     private Runnable r = new Runnable() {
45         // @Override
46         public void run() {
47             invalidate();
48         }
49
50     };
51
```

7. Write the First part of the onDraw() function. This contains the Game logic (as it is – very minimal now). This represents the model.



```java
    protected void onDraw(Canvas c) {

        arrow.goTo(arrow.getX()+10, arrow.getY());

        // Arrow Goes back to Archer
        if (arrow.getX() > c.getWidth()) {
            arrow.goTo(archer.getX(), archer.getY() + 40);
        }

        // Logic for Balloon to Pop when touching Arrow
        if ((Math.abs(balloon.getY() - arrow.getY()) < 20) && (Math.abs(balloon.getX() - arrow.getX()) < 20)) {
            balloon.setCurrentCostume(1);
        }

        // Balloon goes back to top of screen
        balloon.goTo(balloon.getX(), balloon.getY() + 10);
        if (balloon.getY() > c.getHeight()) {
            balloon.setCurrentCostume(0);
            balloon.goTo(balloon.getX(), 0);
        }
```

8. Finish the onDraw function with the commands to draw the graphics to the screen:



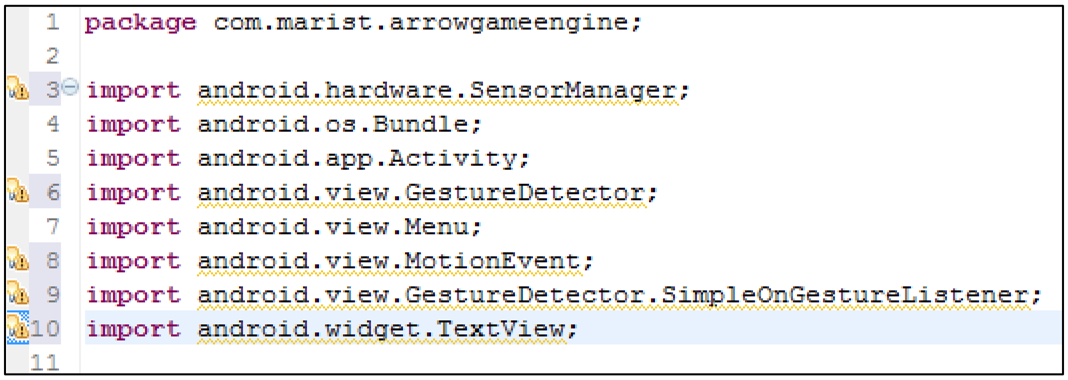
```java

        // Draw the Animation
        c.drawBitmap(archer.getBitMap(), archer.getX(), archer.getY(), null);
        c.drawBitmap(arrow.getBitMap(), arrow.getX(), arrow.getY(), null);
        c.drawBitmap(balloon.getBitMap(), balloon.getX(), balloon.getY(), null);
        h.postDelayed(r, FRAME_RATE);

    }
```

9. The Class is finished. You will see a few warnings for unused elements at the top of the class. Do not worry about those now. In the refactoring process, you can go through and eliminate unused objects.

Phase 6: Write the ArrowGame.java class (This is the “Control”)

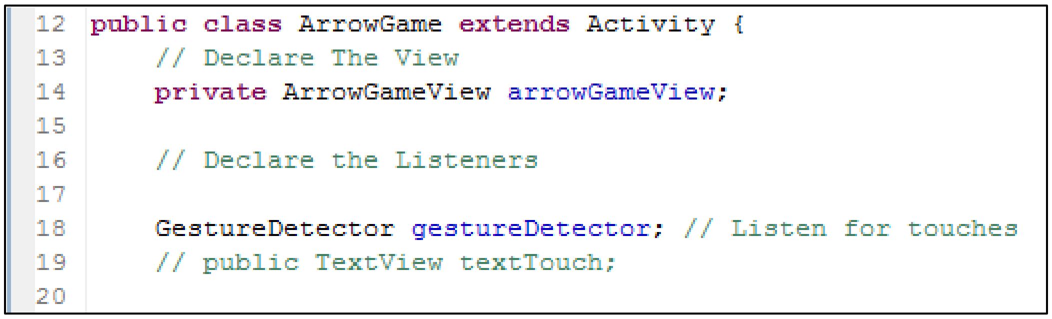
This class will connect the ArrowGameView class with the XML display and read gestures from the user.

1. Write the import statements:



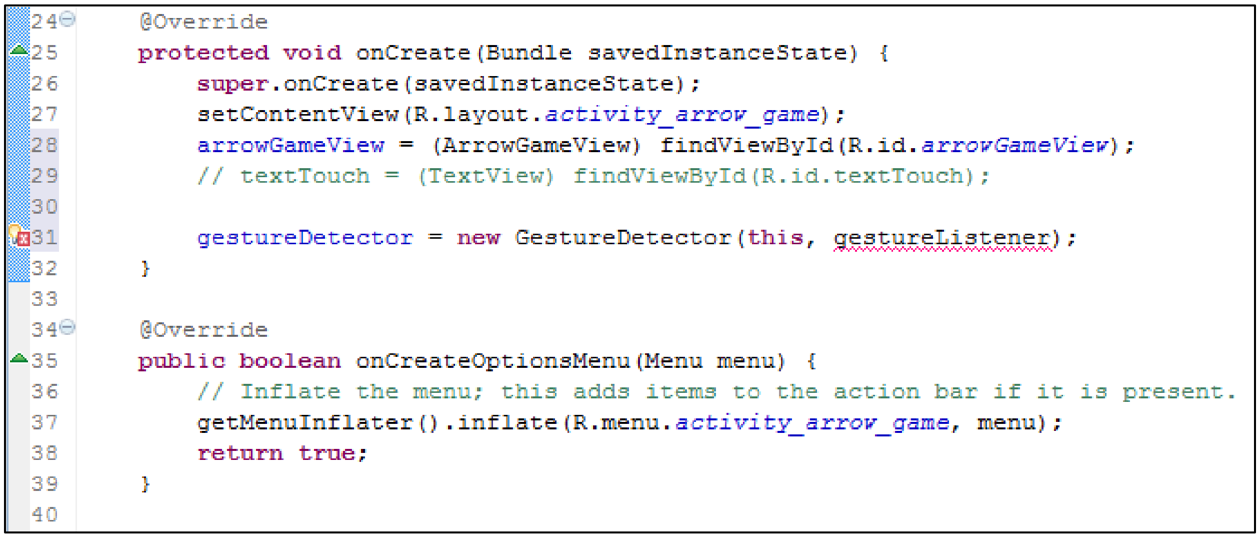
```java
package com.marist.arrowgameengine;

import android.hardware.SensorManager;
import android.os.Bundle;
import android.app.Activity;
import android.view.GestureDetector;
import android.view.Menu;
import android.view.MotionEvent;
import android.view.GestureDetector.SimpleOnGestureListener;
import android.widget.TextView;

```

2. Define the Values for the Class: Brings in an instance of ArrowGameView named “arrowGameView” and the GestureDetector “gestureDetector”. (The View and the Control)



```java
public class ArrowGame extends Activity {
    // Declare The View
    private ArrowGameView arrowGameView;

    // Declare the Listeners

    GestureDetector gestureDetector; // Listen for touches
    // public TextView textTouch;

```

3. Write the onCreate() and onCreateOptionsMenu Functions

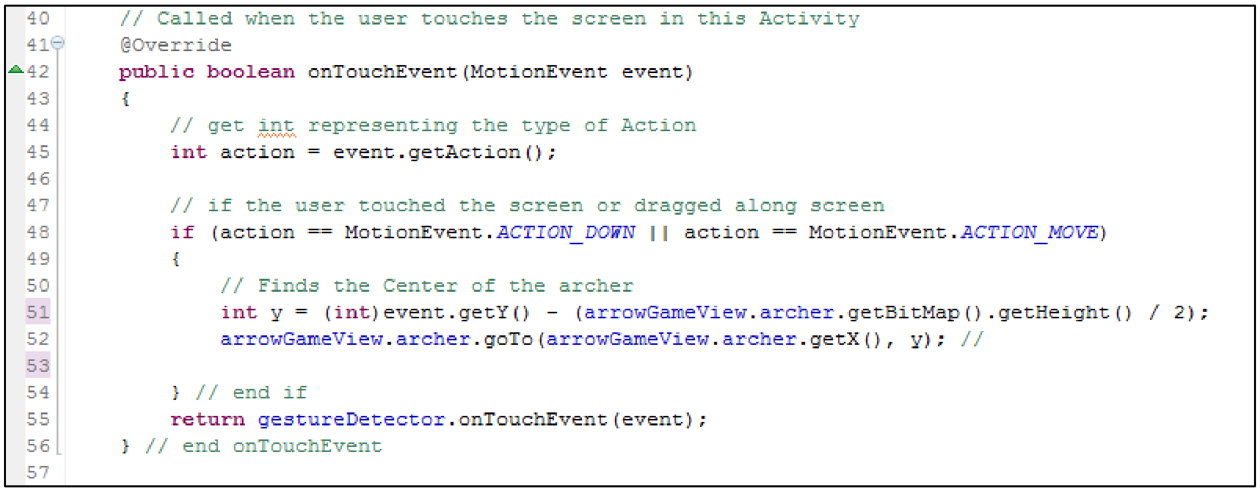


```
24      @Override
25      protected void onCreate(Bundle savedInstanceState) {
26          super.onCreate(savedInstanceState);
27          setContentView(R.layout.activity_arrow_game);
28          arrowGameView = (ArrowGameView) findViewById(R.id.arrowGameView);
29          // textTouch = (TextView) findViewById(R.id.textTouch);
30
31          gestureDetector = new GestureDetector(this, gestureListener);
32      }
33
34      @Override
35      public boolean onCreateOptionsMenu(Menu menu) {
36          // Inflate the menu; this adds items to the action bar if it is present.
37          getMenuInflater().inflate(R.menu.activity_arrow_game, menu);
38          return true;
39      }
40
```

Wait, Wait, Wait . . . Where is the constructor??? When writing Android "Activities" – the constructor is the "onCreate()" Function. This "inflates the view" when the App starts, connecting the objects in the Activity to the Objects in the layout XML (notice line 28).

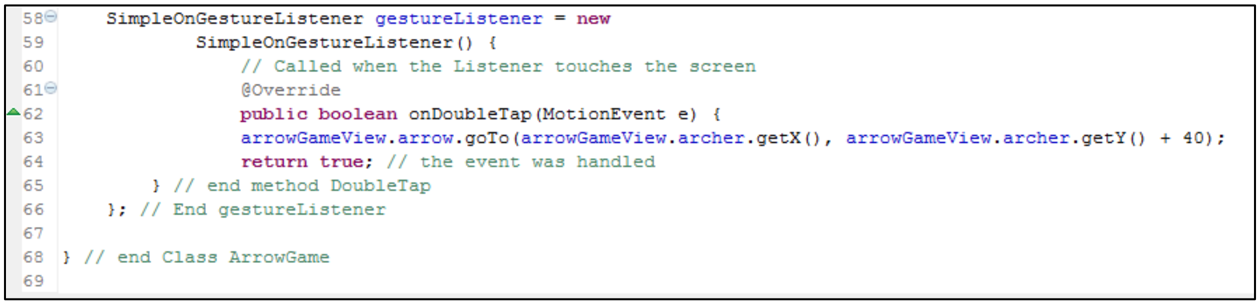
The error in line 31 will resolve later in the code when we define the gestureListener.

4. Write the on TouchEvent() code for the user Drag Touch event.



```
40      // Called when the user touches the screen in this Activity
41      @Override
42      public boolean onTouchEvent(MotionEvent event)
43      {
44          // get int representing the type of Action
45          int action = event.getAction();
46
47          // if the user touched the screen or dragged along screen
48          if (action == MotionEvent.ACTION_DOWN || action == MotionEvent.ACTION_MOVE)
49          {
50              // Finds the Center of the archer
51              int y = (int)event.getY() - (arrowGameView.archer.getBitMap().getHeight() / 2);
52              arrowGameView.archer.goTo(arrowGameView.archer.getX(), y); //
53
54          } // end if
55          return gestureDetector.onTouchEvent(event);
56      } // end onTouchEvent
57
```

5. Write the gestureListener for Double Taps



```
    SimpleOnGestureListener gestureListener = new
            SimpleOnGestureListener() {
                // Called when the Listener touches the screen
                @Override
                public boolean onDoubleTap(MotionEvent e) {
                arrowGameView.arrow.goTo(arrowGameView.archer.getX(), arrowGameView.archer.getY() + 40);
                return true; // the event was handled
        } // end method DoubleTap
    }; // End gestureListener

} // end Class ArrowGame

```

Yay!!! You are done! Save the code and run it on the phone or emulator. You might find some errors with the balloon, arrow, and archer positioning. This can be resolved by making changes to the manifest.xml code to reduce the "header" of the view.