

Computer Science 2

Lecture 4

Programming Graphics and Event Handling



Extra material in Canvas



Overview

1. Console applications vs Graphical applications
2. Graphical applications
 - Graphical classes
 - Classes Color, BasicStroke and Font
 - Examples
3. Reading input
4. Event-handling model: events, sources, and listeners
5. Inner classes in listeners
6. Mouse adapter class
7. GUI components example

Learning goals

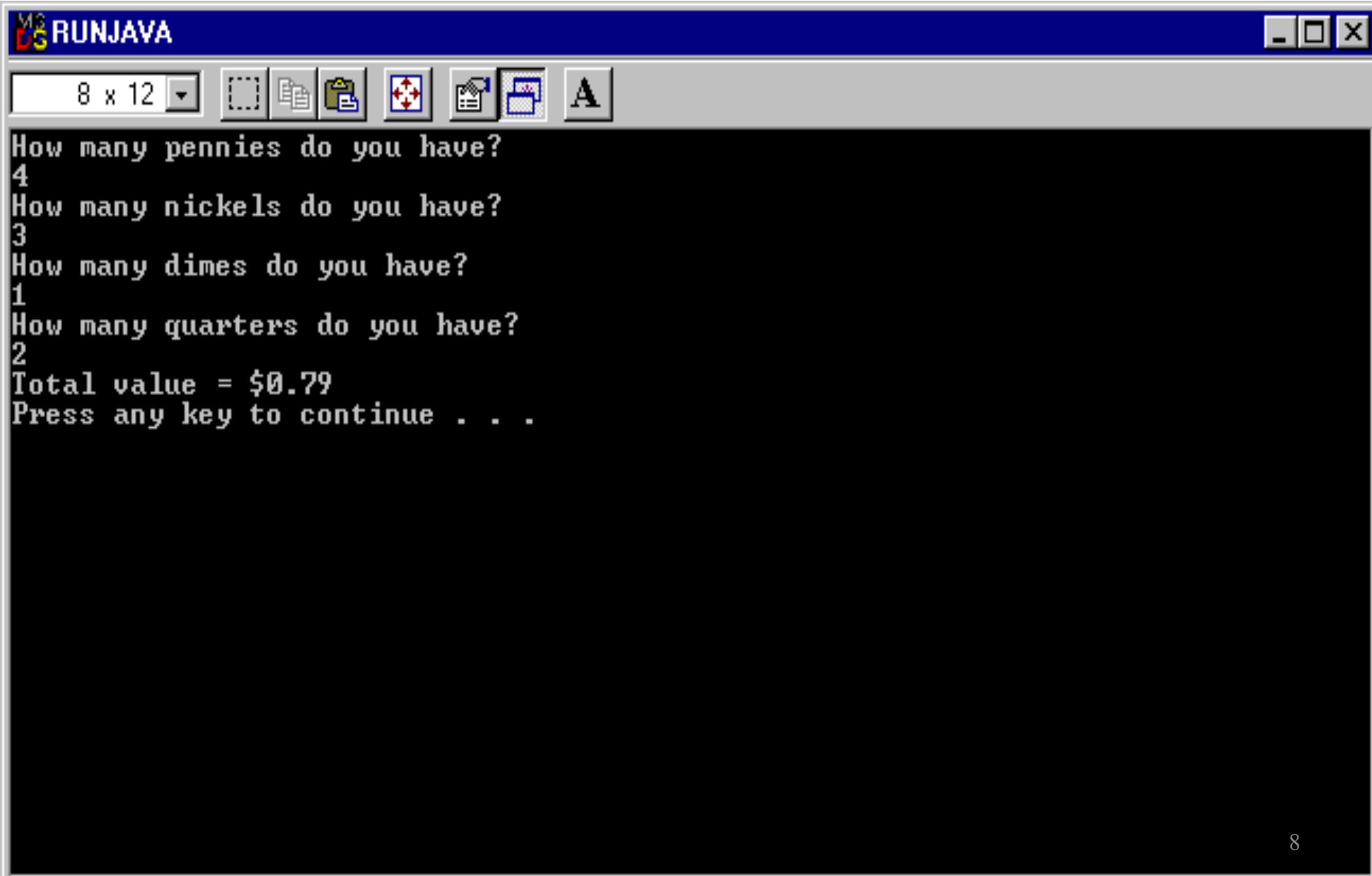
- Identify differences between console and *graphical application*
- Be able to configure and use *basic GUI components*
- Understand and be able to utilize commonly use *graphical classes*
- Understand and be able to implement the *event-handling model*
- Understand and be able to implement and use *inner classes*
- Implement *listener-based applications*
- Identify differences between *extends* and *implements*
- Identify the benefits of using *interfaces/adapters*
- Identify differences between *interfaces* and *adapters*

CONSOLE APPLICATIONS VS GRAPHICAL APPLICATIONS

Applications

- **Applications are stand-alone programs that can be launched from the command line.**
 - Each application has a main method;
 - Each application has no restrictions on what it can do;
 - There exist two types of applications:
 - Console applications: run in a single terminal window;
 - Graphical Applications: use one or more windows filled with graphical user interface (GUI) components such as buttons, text fields, and menus.

A console application

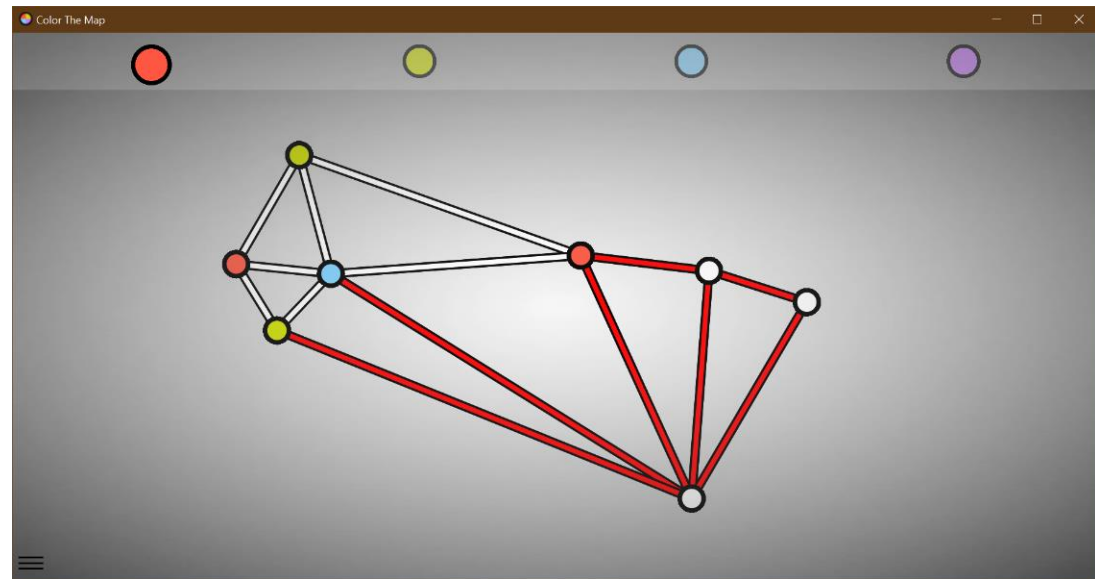
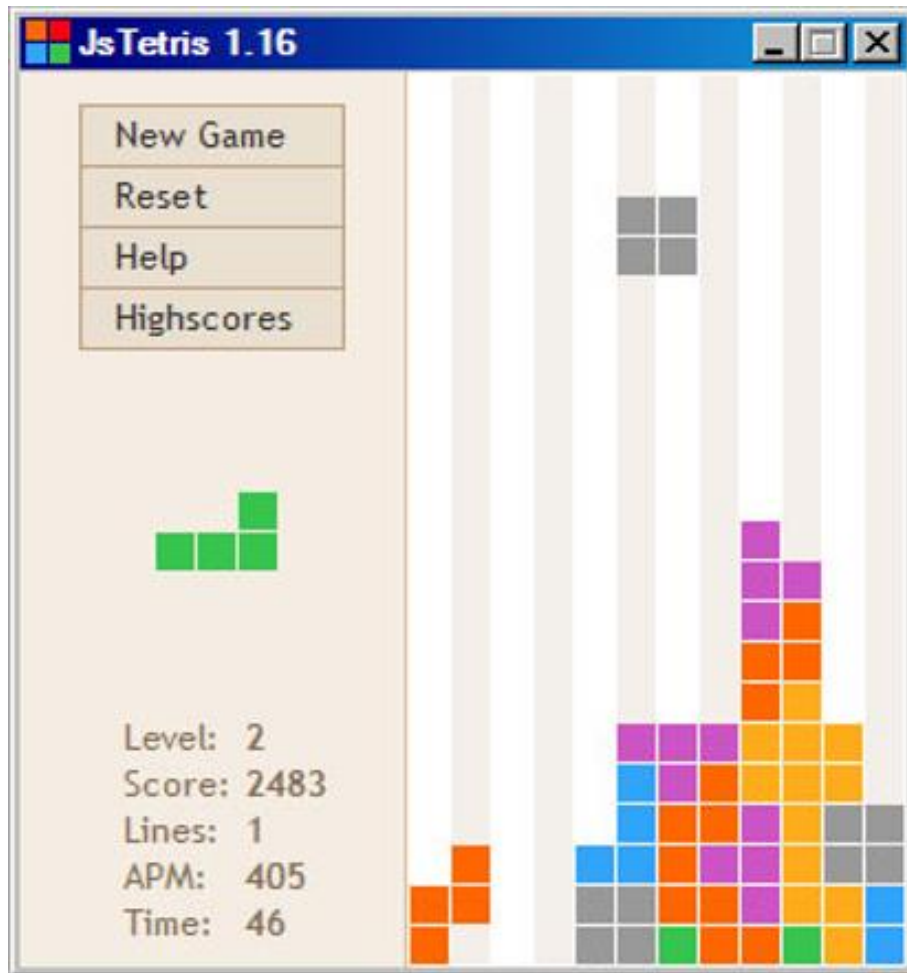


The screenshot shows a Windows console window titled "RUNJAVA". The window has a standard Windows interface with a title bar, a menu bar (File, Edit, Format, View, Help), and a toolbar. The console text is as follows:

```
How many pennies do you have?  
4  
How many nickels do you have?  
3  
How many dimes do you have?  
1  
How many quarters do you have?  
2  
Total value = $0.79  
Press any key to continue . . .
```

The text is displayed in a monospaced font, and the window has a blue title bar and a grey menu bar.

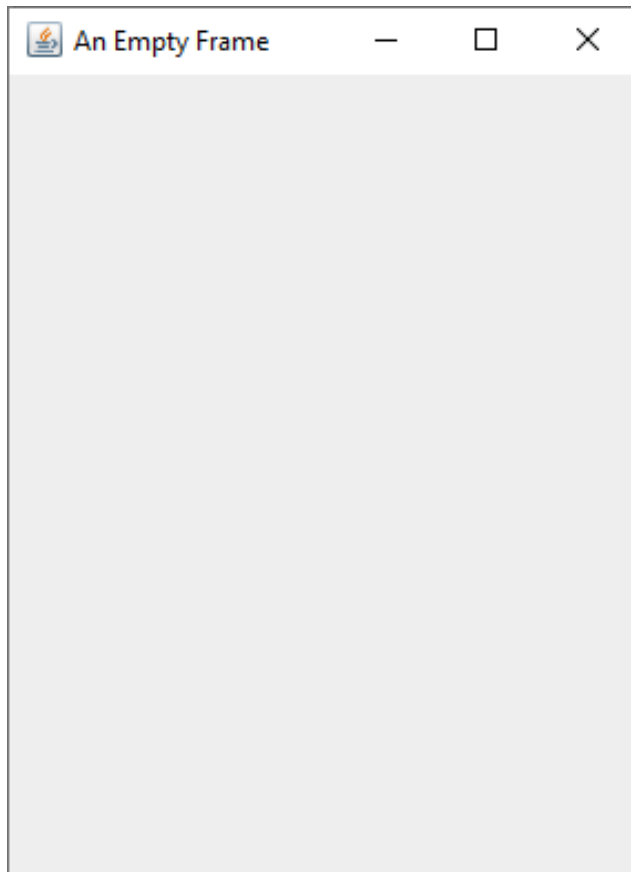
A graphical application



GRAPHICAL APPLICATIONS

Graphical applications

- A graphical application shows information in a frame window.



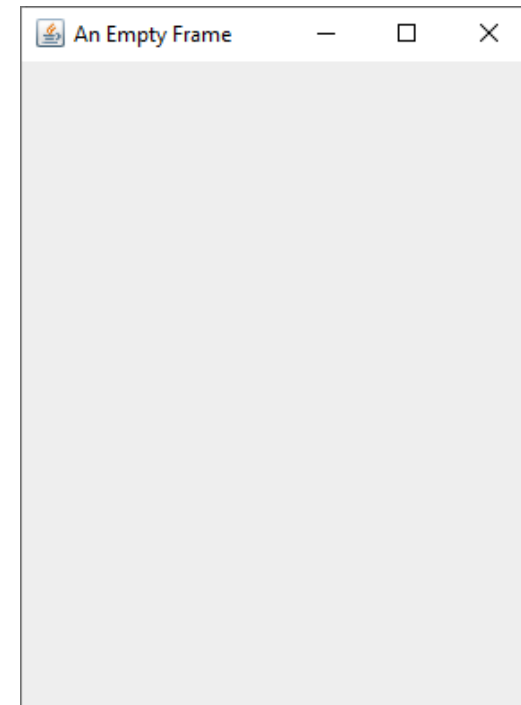
There exist three main graphics packages:

- **Abstract Windowing Toolkit (AWT)**
- **Swing**
- **JavaFX (Lecture 5)**

Graphical applications

Showing a frame in `swing`:

1. Construct an object of the `JFrame` class:
`JFrame frame = new JFrame();`
2. Set the size of the frame:
`frame.setSize(300, 400);`
3. Set the title of the frame:
`frame.setTitle("An Empty Frame");`
4. Set the default operation:
`frame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);`
5. Make the frame visible:
`frame.setVisible(true);`

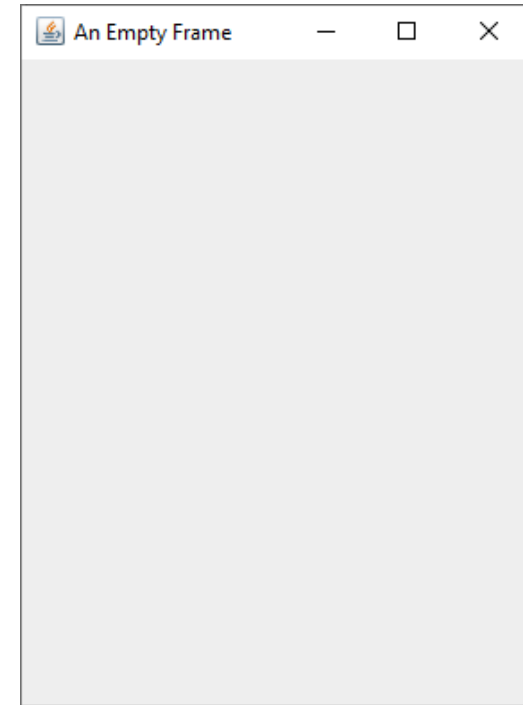




Graphical applications

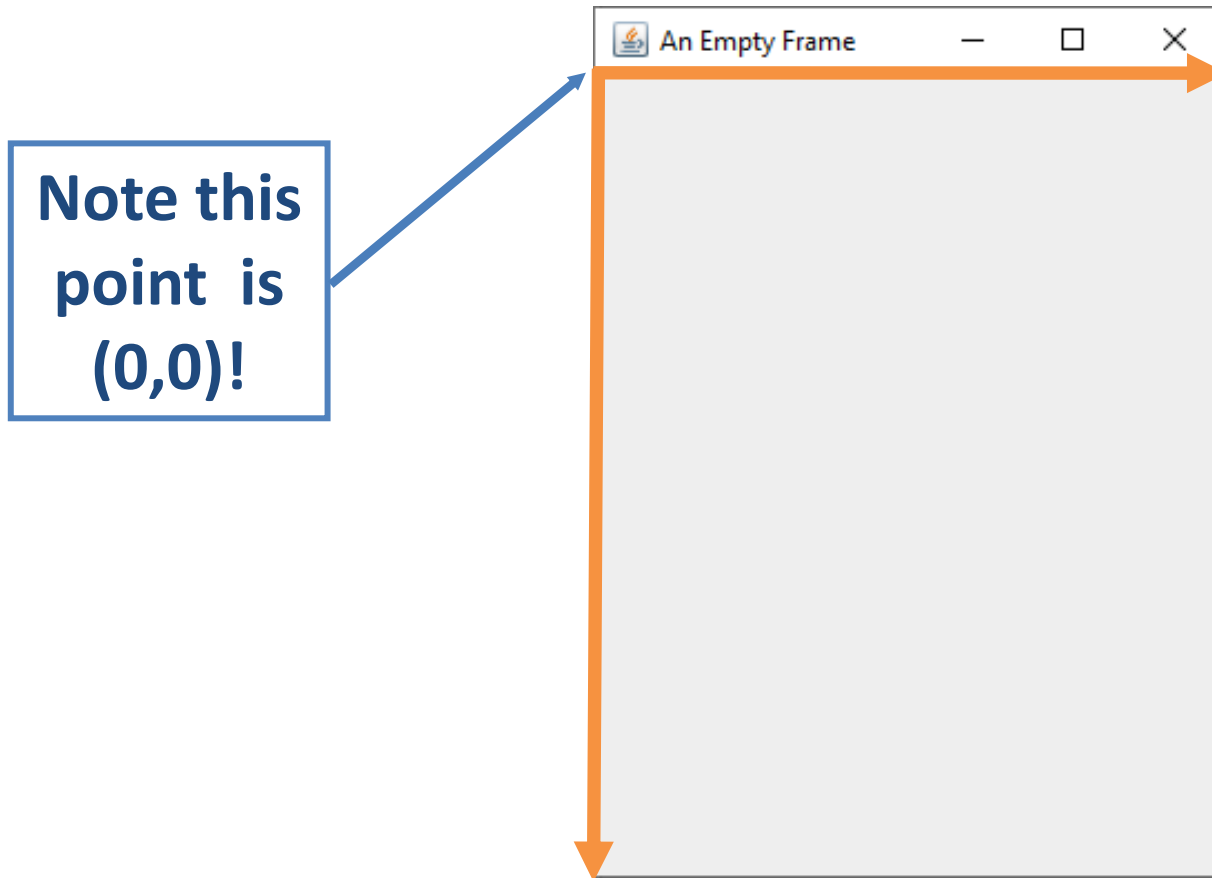
```
import javax.swing.*;

public class EmptyFrameViewer
{
    public static void main(String[] args)
    {
        JFrame frame = new JFrame();
        final int FRAME_WIDTH = 300;
        final int FRAME_HEIGHT = 400;
        frame.setSize(FRAME_WIDTH, FRAME_HEIGHT);
        frame.setTitle("An Empty Frame");
        frame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
        frame.setVisible(true);
    }
}
```



Note that to use the `JFrame` class you need to import `swing` package!

Graphical applications



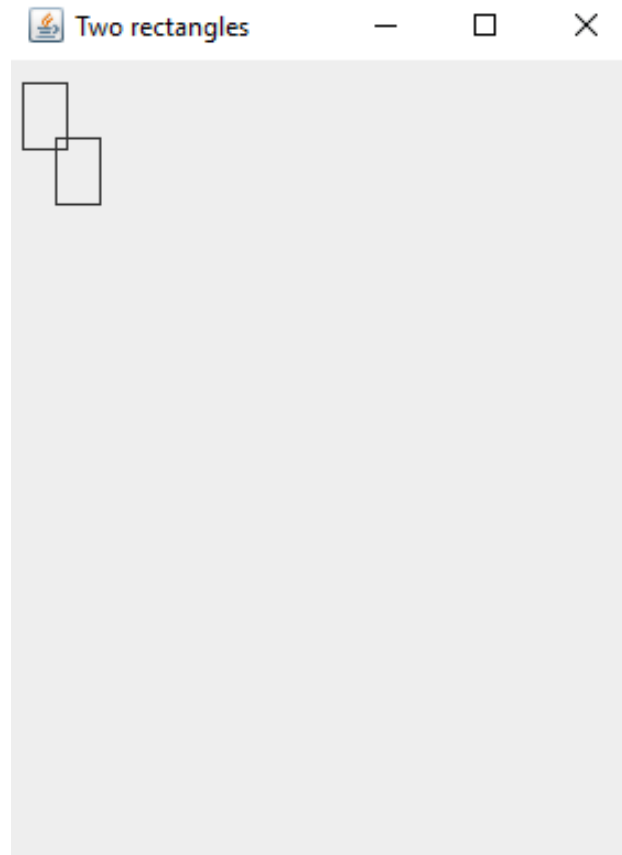
Graphical applications

- JFrame is a “container” UI element
 - Other elements “live in” JFrames
- By “live in” is meant
 - The coordinates of all elements in the JFrame are relative to the upper-left-hand corner of the JFrame
 - When the JFrame is moved, all the elements in the JFrame move with it
- In order to live in a container an object must extend the `java.awt.Component` abstract class
- Let us look at creating a Frame with a couple of rectangles in it

Graphical applications

- First we will look at creating the Component that will contain our Rectangle objects
- Then we will create a JFrame to hold it and display everything
- In the end it will look like the following

Graphical applications: drawing shapes



Graphical applications: drawing shapes

- To display a drawing, define a class (e.g. **RectangleComponent**) that extends the **JComponent** class
- The class **JComponent** is a standard Java class that represents a blank component
- To show anything in a frame, we override the method **paintComponent** in the **RectangleComponent** class, and then we construct a component object and add it to the frame.

```
public class RectangleComponent extends JComponent
{
    public void paintComponent(Graphics g)
    {
        // Recover Graphics2D
        Graphics2D g2 = (Graphics2D) g;
        // Put here your drawing operators
    }
}
```

paintComponent: called whenever the component needs to be repainted!

[Interlude: *graphics* and *graphics2D*]

```
public class RectangleComponent extends JComponent
{
    public void paintComponent(Graphics g)
    {
        // Recover Graphics2D
        Graphics2D g2 = (Graphics2D) g;
        // Put here your drawing operators
    }
}
```

- The drawing components inherit from the JComponent class
- Graphics is an abstract class (we cannot create an instance)
- Graphics was not intended as an object-oriented component
 - The 2D version was created to address the new programming paradigm
 - Graphics is still the input parameter of *paintComponent* to allow compatibility with previous versions)



Graphical applications: drawing shapes

```
import java.awt.Graphics;  
import java.awt.Graphics2D;  
import java.awt.Rectangle;  
import javax.swing.JComponent;
```

Abstract Windowing Toolkit

```
/**  
 * A component that draws two rectangles.  
 */  
public class RectangleComponent extends JComponent  
{  
    public void paintComponent(Graphics g)  
    {  
        // Recover Graphics2D  
        Graphics2D g2 = (Graphics2D) g;  
  
        // Construct a rectangle and draw it  
        Rectangle box = new Rectangle(5, 10, 20, 30);  
        g2.draw(box);  
  
        // Move rectangle 15 units to the right and 25 units down  
        box.translate(15, 25);  
        g2.draw(box);  
    }  
}
```



Graphical applications: drawing shapes

```
import javax.swing.JFrame;

public class RectangleViewer
{
    public static void main(String[] args)
    {
        JFrame frame = new JFrame();

        final int FRAME_WIDTH = 300;
        final int FRAME_HEIGHT = 400;

        frame.setSize(FRAME_WIDTH, FRAME_HEIGHT);
        frame.setTitle("Two rectangles");
        frame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);

        RectangleComponent component = new RectangleComponent();
        frame.add(component);
        frame.setVisible(true);
    }
}
```

Summary: Steps to draw in a Frame

1. Write your component class `MyComponent` inheriting from the class `JComponent`. Specify your graphics by providing code in the method `paintComponent(Graphics g)`.

2. Construct a frame:

```
JFrame frame = new JFrame();
```

3. Construct an object of your component class:

```
MyComponent component = new MyComponent();
```

4. Add the `component` to the frame:

```
frame.add(component);
```

5. Make the frame visible:

```
frame.setVisible(true);
```

Graphical applications

GRAPHICAL CLASSES

Graphical Classes

- There are many classes of graphical objects in the `java.awt.geom` package
 - Ellipses, lines, points, etc.
 - Any class that implements the `java.awt.Shape` interface will work
- We will not cover them all here
 - You can find them all at <https://docs.oracle.com/javase/8/docs/api/index.html?java/awt/Shape.html>
- It is worth noting that the graphical objects use `double` rather than `int` for measurement
 - For example, pixel location or width

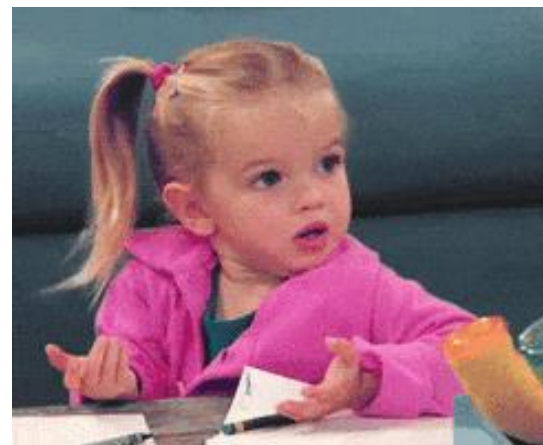
Graphical Classes

- This is to allow the programmer to do general-purpose calculations on geometric objects
- The point of geometric objects is to model the world
- Objects in the world do not always come in nice integer sizes
- Java will handle translating what an x-coordinate of 12.35 means in terms of pixels

Graphical classes: Double version

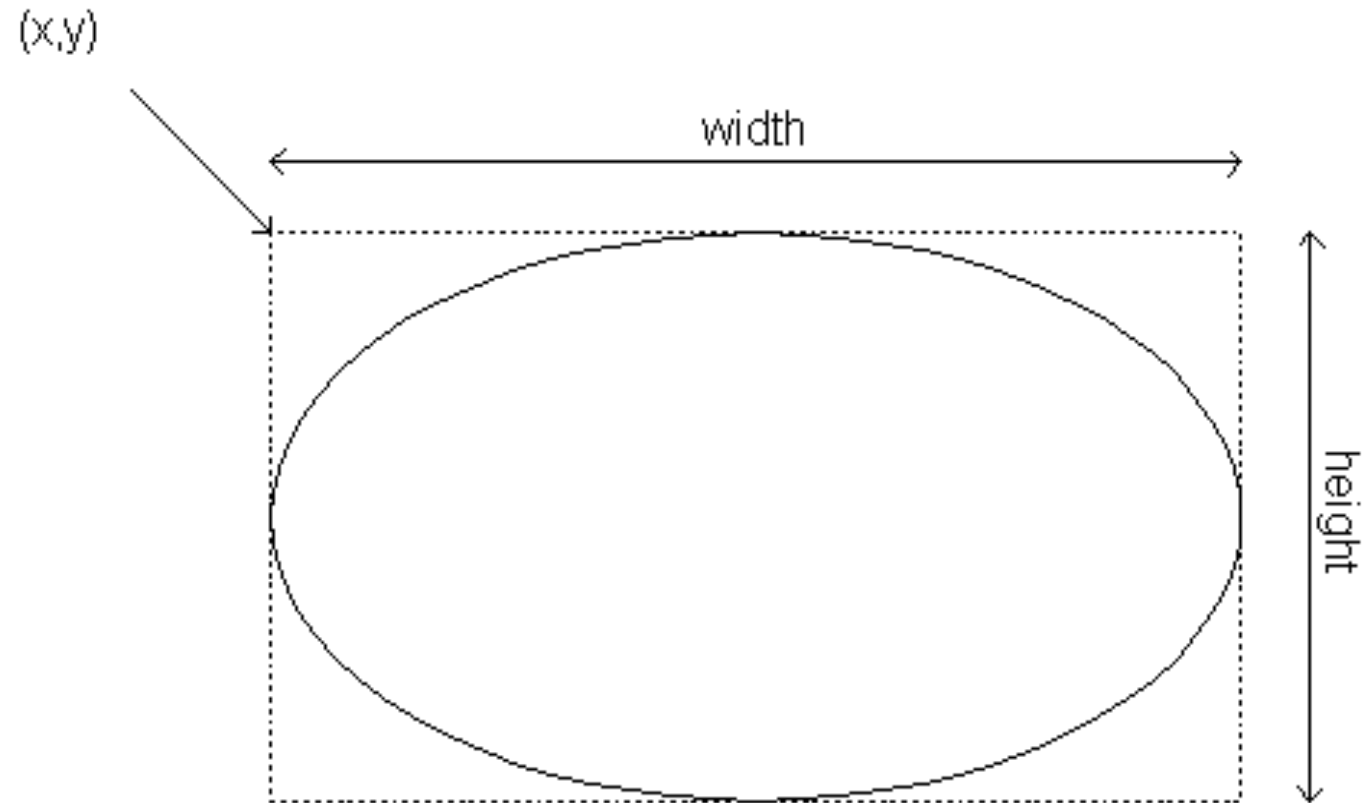
- Class `Point2D.Double` with constructor:
 - `Point2D.Double(double x, double y)`
- Class `Line2D.Double` with constructors:
 - `Line2D.Double(double X1, double Y1, double X2, double Y2)`
 - `Line2D.Double(Point2D p1, Point2D p2)`

Notice that we use Double for the pixels instead of integers



Graphical classes: Double version

- Class `Ellipse2D.Double` with constructor:
 - `Ellipse2D.Double(double x, double y, double width, double height)`



Graphical classes

- More about two-dimensional geometric objects:
 - <https://docs.oracle.com/javase/8/docs/api/index.html?java/awt/geom/package-summary.html>
- The official Javadocs page is the single most important URL you will see in your Java education

Graphical Applications

CLASSES COLOR, BASICSTROKE AND FONT

Class Color

- By default, all shapes are drawn in black;
- To change the color, apply the method `setColor` on `g2` parameter with the actual parameter an object of the class `Color`;
- The constructor of the class `Color` is:
 - `Color(float red, float green, float blue)`
where `red` is the intensity of the red color, `green` is the intensity of the green color, and `blue` is the intensity of the blue color. `red`, `green`, and `blue` are `float` in the range `[0.0, 1.0]`.
- There are predefined colors: `Color.black`, `Color.GREEN`, etc.
- Example: `g2.setColor(Color.red) ;`

Class BasicStroke

- To draw thicker lines, supply a different stroke object to **Graphics2D g2** parameter:
 - **g2.setStroke(new BasicStroke(4.0F)) ;**



Drawing Strings

- To draw a string use method `drawString` of the class `Graphics2D`:

```
g2.drawString(String s, float x, float y);
```

where `s` is the string to be drawn, and `x` and `y` are the `x` and `y` coordinates of the base point.

- Example: `g2.drawString("Applet", 50, 100);`





```
import java.awt.Graphics;
import java.awt.Graphics2D;
import javax.swing.JComponent;
import java.awt.Rectangle;
import javax.swing.JFrame;
import java.awt.Font;
import java.awt.Color;

public class SincereText extends JComponent
{
    public void paintComponent(Graphics g)
    {
        Graphics2D g2 = (Graphics2D) g;

        final int posSquareX = 10;
        final int posSquareY = 50;

        // Construct a square and draw it
        Rectangle box = new Rectangle(posSquareX, posSquareY, 150, 90);
        g2.draw(box);

        // Construct a String and draw it
        Font myFont = new Font("Arial", Font.ITALIC, 30);
        g2.setFont(myFont);
        g2.setColor(Color.ORANGE);
        g2.drawString("I love ICS2", posSquareX, posSquareY+60);
    }

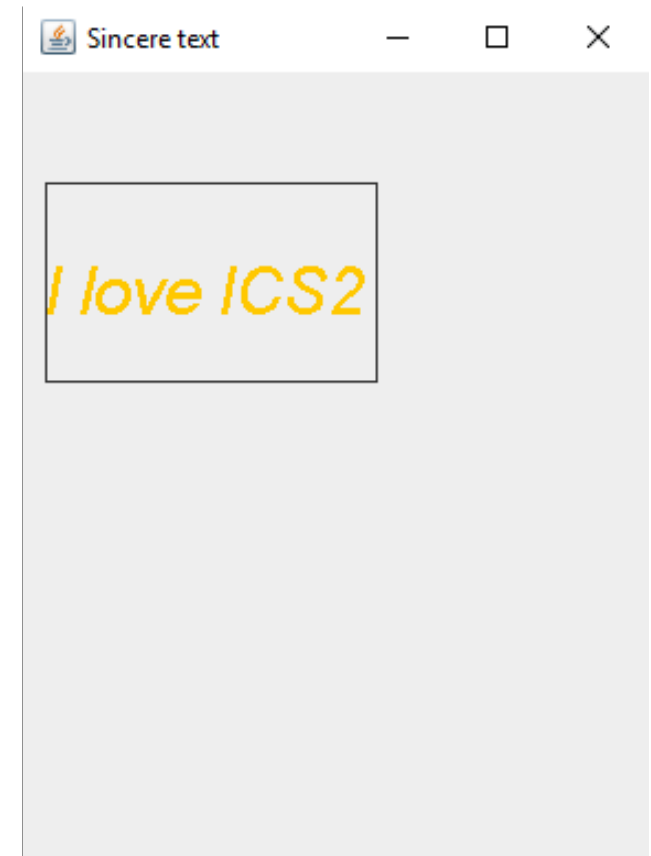
    public static void main(String[] args)
    {
        JFrame frame = new JFrame();

        final int FRAME_WIDTH = 300;
        final int FRAME_HEIGHT = 400;

        frame.setSize(FRAME_WIDTH, FRAME_HEIGHT);
        frame.setTitle("Sincere text");
        frame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);

        SincereText component = new SincereText();

        frame.add(component);
        frame.setVisible(true);
    }
}
```

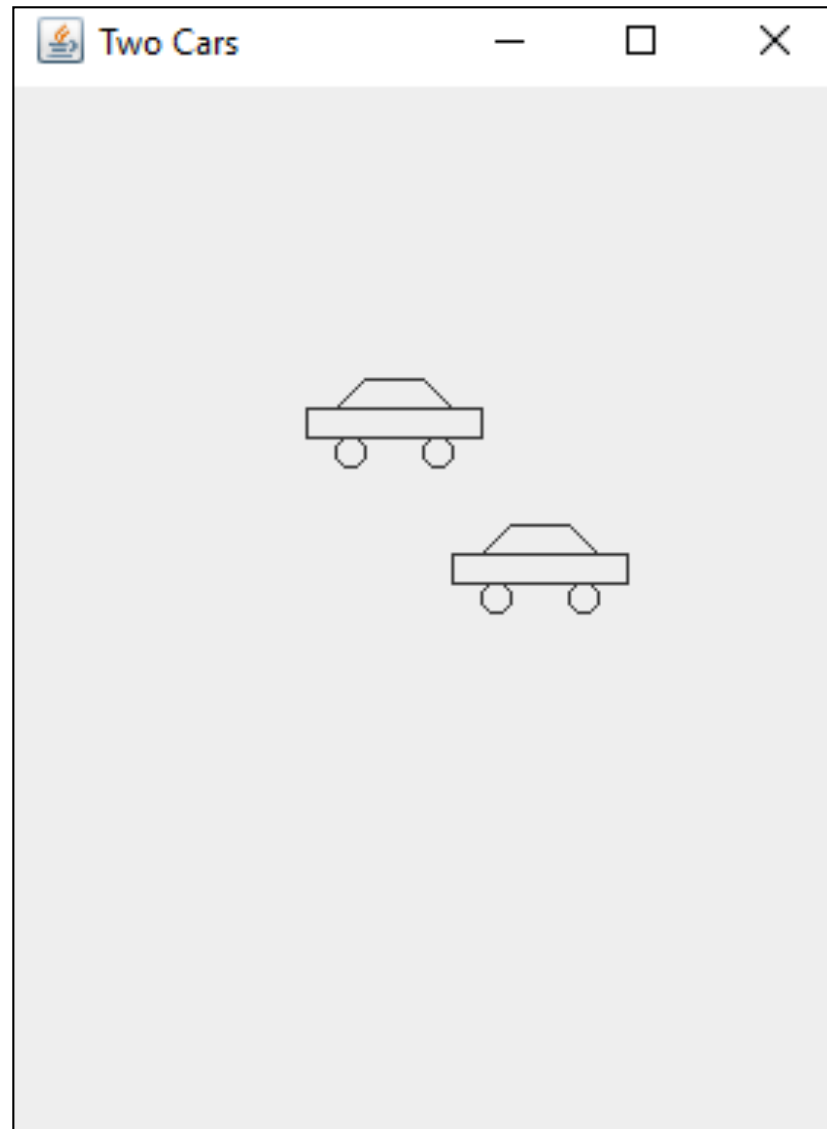


Graphical Applications

CAR EXAMPLE



Frame with two cars



Important

- To let Visual Studio Code know where to find the required files (we will be using three classes for this example):
 - Create a *package*. We need to add the following statement at the beginning of each class involved (**being the package name the same as the folder containing the files**)
`package Car;`

`public class CarComponent extends Jcomponent { ... }`
 - **Open the folder directly from Visual Studio Code**

CarViewer Class

```
import javax.swing.JFrame;

public class CarViewer {
    public static void main(String[] args) {
        JFrame frame = new JFrame();
        frame.setSize(300, 400);
        frame.setTitle("Two Cars");
        frame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
        CarComponent component = new CarComponent();
        frame.add(component);
        frame.setVisible(true);
    }
}
```

CarComponent Class

```
import javax.swing.JComponent;
import java.awt.Graphics;
import java.awt.Graphics2D;

public class CarComponent extends JComponent {
    public void paintComponent(Graphics g) {
        Graphics2D g2 = (Graphics2D) g;
        Car car1 = new Car(100, 100);
        Car car2 = new Car(150, 150);
        car1.drawMe(g2);
        car2.drawMe(g2);
    }
}
```

Car Class

```
public class Car {  
    public Car(double x, double y) {  
        xLeft = x;  
        yTop = y;  
    }  
    public void drawMe(Graphics2D g2) {  
        Rectangle2D.Double body = new Rectangle2D.Double(xLeft, yTop + 10, 60, 10);  
        Ellipse2D.Double frontTire = new Ellipse2D.Double(xLeft + 10, yTop + 20, 10, 10);  
        Ellipse2D.Double rearTire = new Ellipse2D.Double(xLeft + 40, yTop + 20, 10, 10);  
        Point2D.Double r1 = new Point2D.Double(xLeft + 10, yTop + 10);  
        Point2D.Double r2 = new Point2D.Double(xLeft + 20, yTop);  
        Point2D.Double r3 = new Point2D.Double(xLeft + 40, yTop);  
        Point2D.Double r4 = new Point2D.Double(xLeft + 50, yTop + 10);  
        Line2D.Double frontWindshield = new Line2D.Double(r1, r2);  
        Line2D.Double roofTop = new Line2D.Double(r2, r3);  
        Line2D.Double rearWindshield = new Line2D.Double(r3, r4);  
        g2.draw(body);  
        g2.draw(frontTire);  
        g2.draw(rearTire);  
        g2.draw(frontWindshield);  
        g2.draw(roofTop);  
        g2.draw(rearWindshield);  
    }  
    private double xLeft;  
    private double yTop; }  
}
```

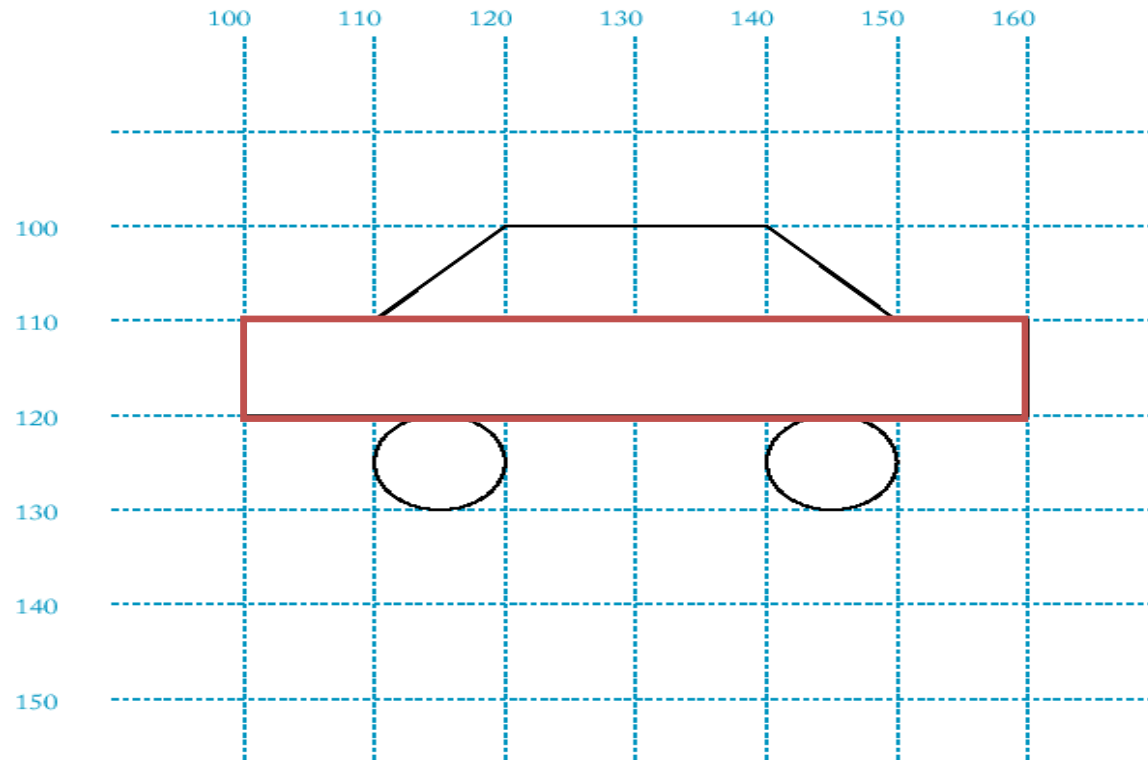
Car Class

- Note that the drawMe method does not draw the parts at absolute locations
 - It uses offsets from the base x and y coordinates
 - This is a small example of how working with graphics requires a large amount of algebra
- The drawMe method is large
- We will take a look at what the parts do step-by-step in the next few slides

Car Class

`xLeft = 100;`

`yTop = 100;`

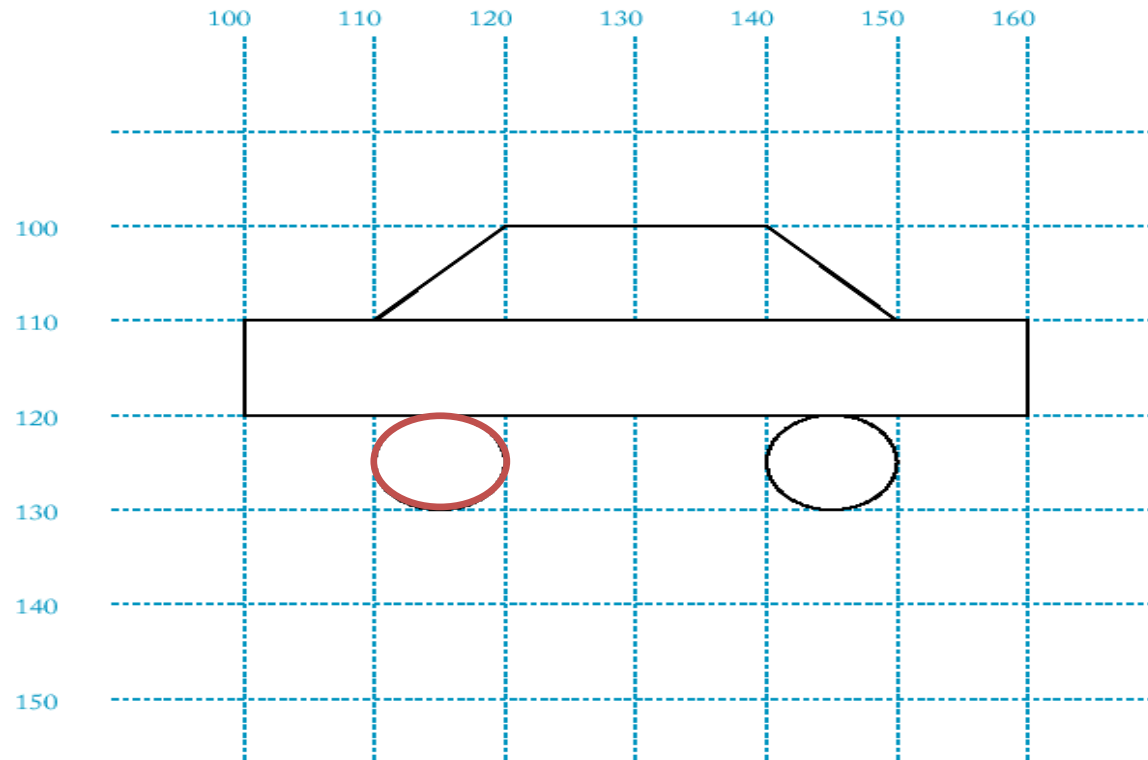


```
public void drawMe(Graphics2D g2) {  
    Rectangle2D.Double body = new Rectangle2D.Double(xLeft, yTop + 10, 60, 10);  
    ...  
}
```

Car Class

`xLeft = 100;`

`yTop = 100;`



```
public void drawMe(Graphics2D g2) { ...
```

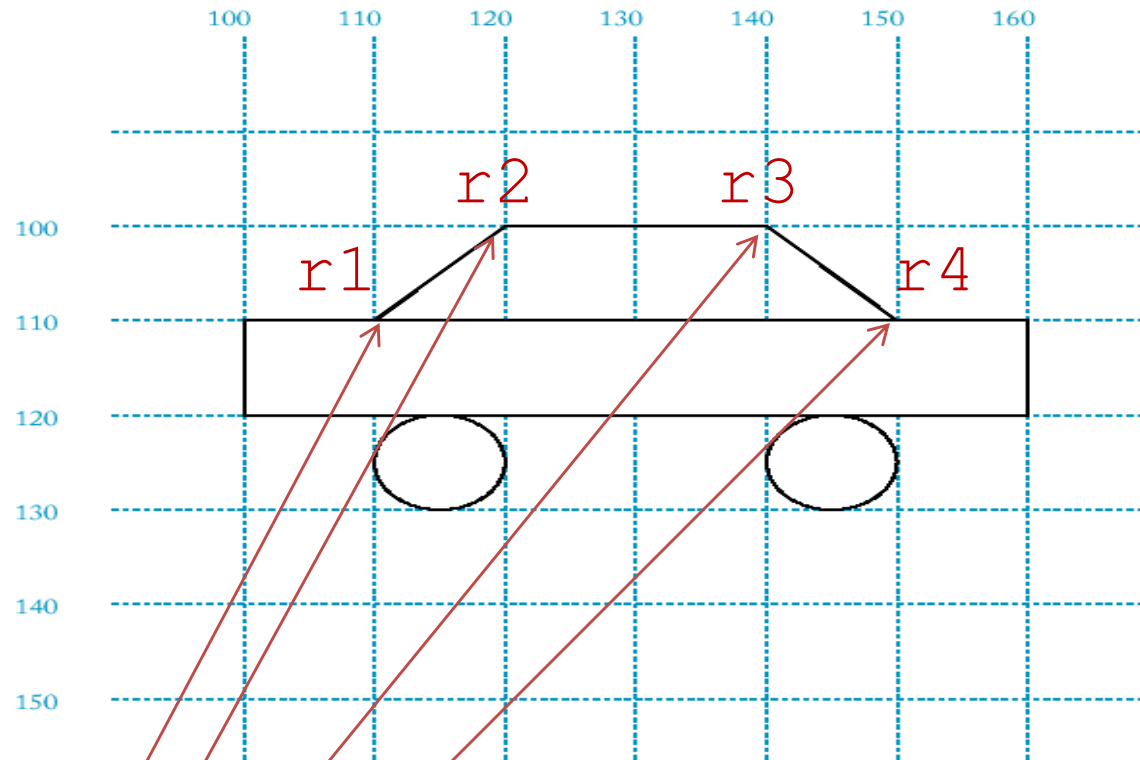
```
    Ellipse2D.Double frontTire = new Ellipse2D.Double(xLeft + 10, yTop + 20, 10, 10);
```

```
    ...
```

```
}
```

Car Class

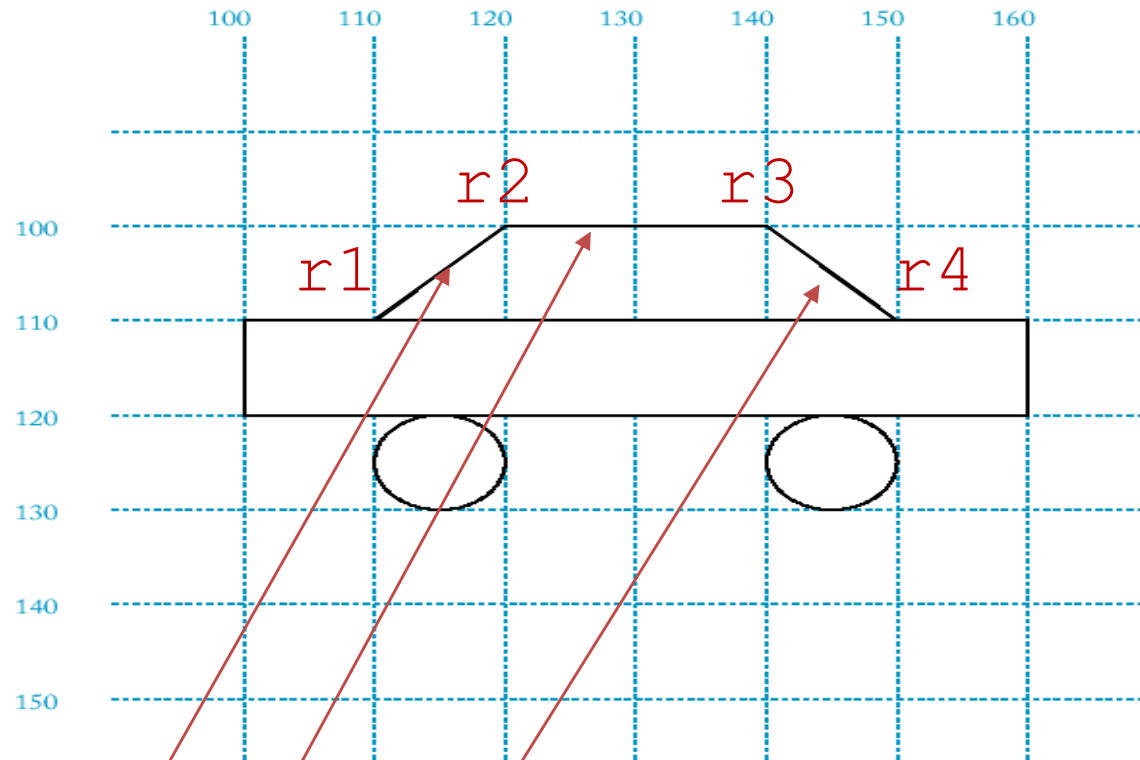
`xLeft = 100;`
`yTop = 100;`



```
public void drawMe(Graphics2D g2) { ...  
    Point2D.Double r1 = new Point2D.Double(xLeft + 10, yTop + 10);  
    Point2D.Double r2 = new Point2D.Double(xLeft + 20, yTop);  
    Point2D.Double r3 = new Point2D.Double(xLeft + 40, yTop);  
    Point2D.Double r4 = new Point2D.Double(xLeft + 50, yTop + 10); ... }
```

Car Class

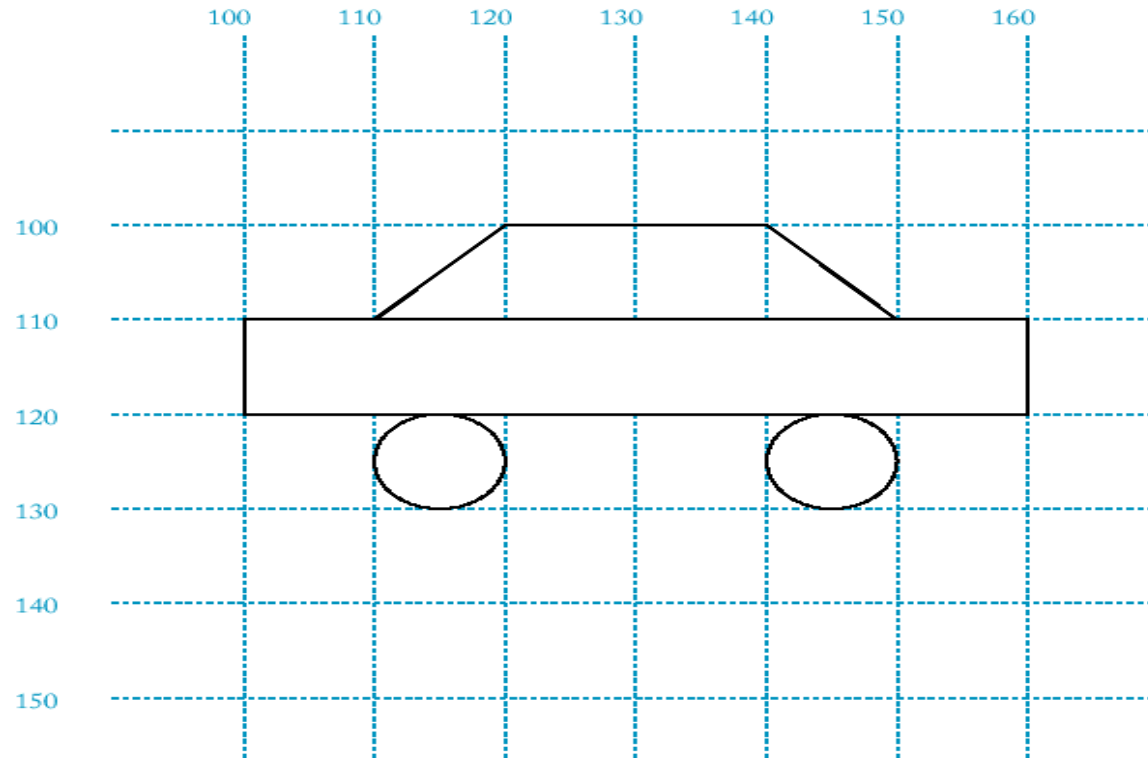
`xLeft = 100,`
`yTop = 100;`



```
public void drawMe(Graphics2D g2) { ...  
    Line2D.Double frontWindshield = new Line2D.Double(r1, r2);  
    Line2D.Double roofTop = new Line2D.Double(r2, r3);  
    Line2D.Double rearWindshield = new Line2D.Double(r3, r4);  
    ... }
```

Car Class

```
xLeft = 100;  
yTop = 100;
```



```
public void drawMe(Graphics2D g2) { ...  
    g2.draw(body);  
    g2.draw(frontTire);  
    g2.draw(rearTire);  
    g2.draw(frontWindshield);  
    g2.draw(roofTop);  
    g2.draw(rearWindshield);  
    ... }
```

CarComponent Class

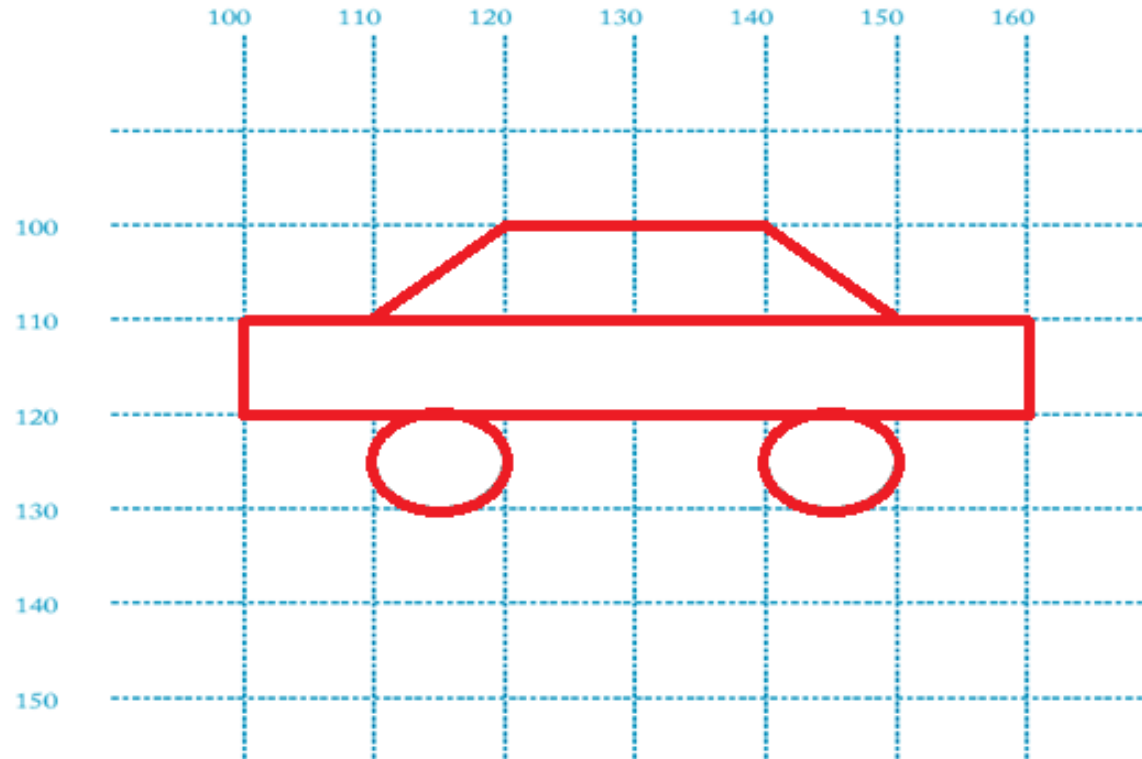
```
import javax.swing.JComponent;
import java.awt.Graphics;
import java.awt.Graphics2D;

public class CarComponent extends JComponent {
    public void paintComponent(Graphics g) {
        Graphics2D g2 = (Graphics2D) g;
        Car car1 = new Car(100, 100);
        Car car2 = new Car(150, 150);
        car1.drawMe(g2);
        car2.drawMe(g2);
    }
}
```

Exercise to practise: implement a method “translate” (as in the example of the two rectangles) to draw two cars instead of create them

“Tuning” your car

```
xLeft = 100;  
yTop = 100;
```



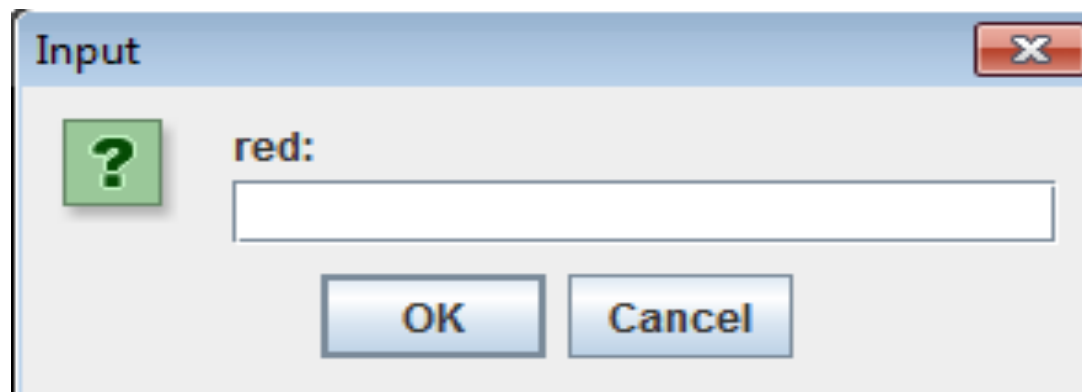
```
public void drawMe(Graphics2D g2) { ...  
    g2.setStroke(new BasicStroke(2));  
    g2.setColor(Color.RED);  
    g2.draw(body);  
    g2.draw(frontTire);  
    ...  
}
```

<https://docs.oracle.com/javase/7/docs/api/java/awt/Graphics2D.html>

READING INPUT

Reading input in windows

- `String input = JOptionPane.showInputDialog(prompt)`
- Convert strings to numbers if necessary:
`int count = Integer.parseInt(input);`
- Conversion throws an exception if user doesn't supply a number
- Add `import java.swing.JOptionPane;`

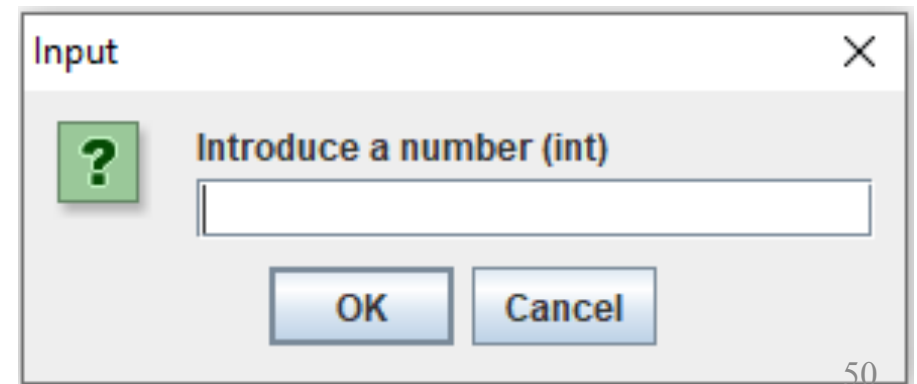




Reading input in windows

```
import javax.swing.JOptionPane;

class ReadingInput {
    public static void main(String[] args) {
        String input = JOptionPane.showInputDialog("Introduce a number (int)");
        int count = Integer.parseInt(input);
        [...]
        System.out.print("The number introduced is " + count);
    }
}
```





Reading input in windows

- This is a pretty simple way to interact with the computer
- The user will
 1. See the window pop up
 2. Type in an integer
 3. Hit return
- The computer will
 1. Display the window
 2. Wait for the user to type something in and hit return
 3. Store that value in a variable



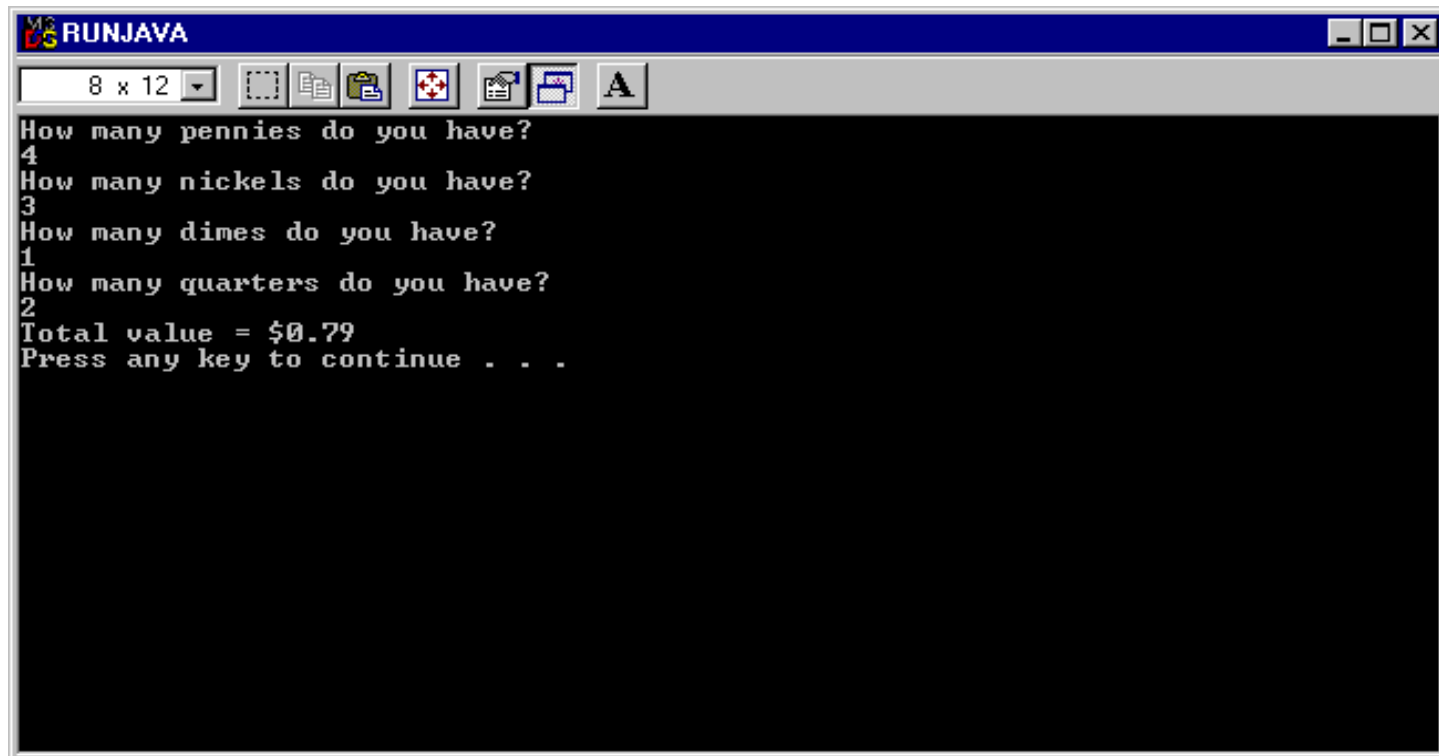
Reading input in windows

- Most current GUIs have many buttons, text fields, and so on, any of which the user could interact with at any time
- In order to do something like this first we have to look at Java's event-handling model

EVENT-HANDLING MODEL

Program control

- In console-based applications user input is under the control of the program: i.e., the program will ask the user for input in a specific order.



```

RUNJAVA
8 x 12
How many pennies do you have?
4
How many nickels do you have?
3
How many dimes do you have?
1
How many quarters do you have?
2
Total value = $0.79
Press any key to continue . . .

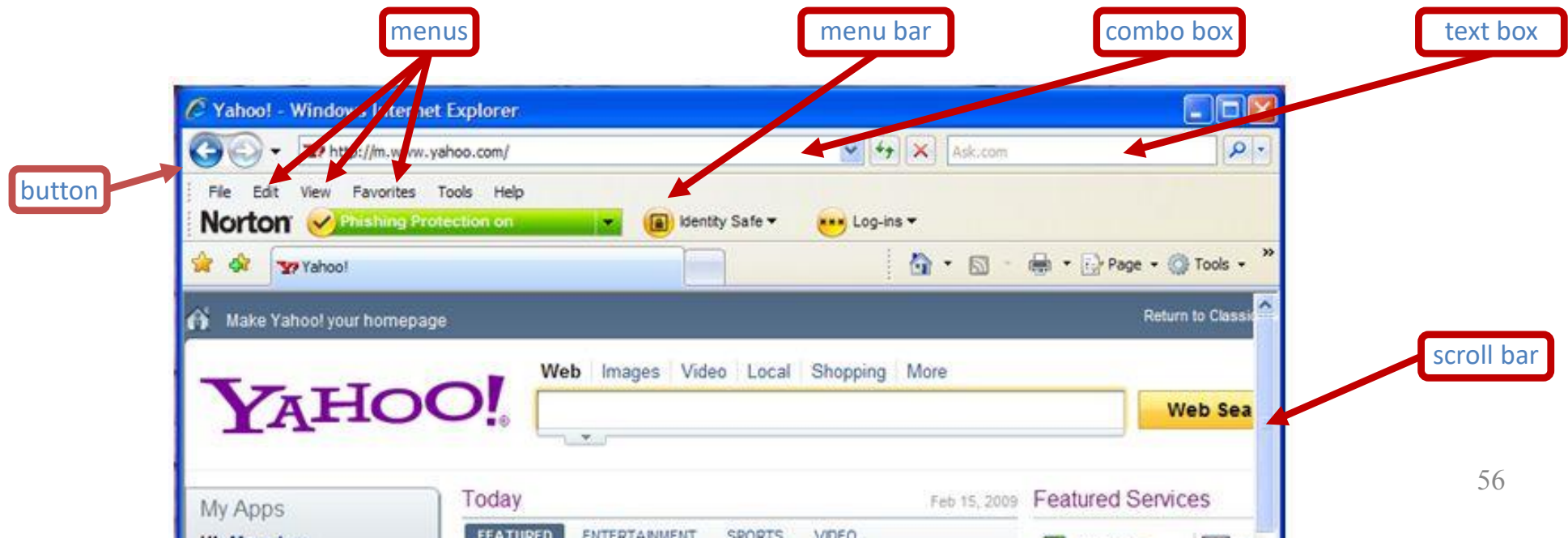
```

Program control

- In a console application, when input is requested from the user, the entire program stops and waits for the user to type something
 - Known as synchronous input
- The user can type whatever they want, but there is no way for the user to choose what to do
 - For example, the user cannot skip a prompt and go on the the next one, or go back to a previous one

User control

- In programs with a modern graphical user interface (GUI) the user is in control:
 - The user can use both the mouse and keyboard
 - The user can manipulate many parts of the GUI in any desired order (click buttons, pull down menus, scroll bars *etc.*).



User control

The image shows a Spotify web interface with several user control elements highlighted by blue arrows and labels:

- menus**: Points to the left sidebar menu containing Home, Search, Your Library, Create Playlist, and Liked Songs.
- menu bar**: Points to the top navigation bar containing Home, Search, Your Library, Create Playlist, and Liked Songs.
- text box**: Points to the search bar in the top navigation bar.
- scroll bar**: Points to the vertical scrollbar on the right side of the main content area.
- button**: Points to the play/pause button in the main content area.
- combo box**: Points to the user profile dropdown menu in the top right corner.

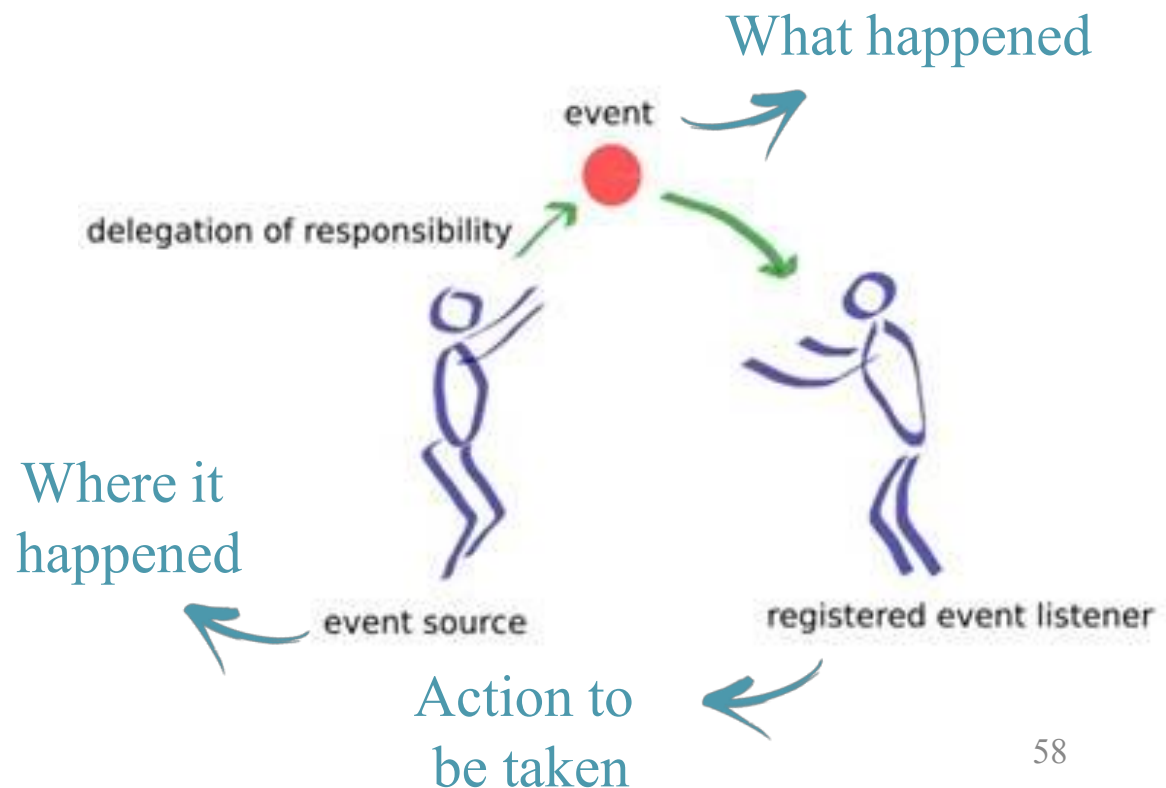
The main content area displays a playlist titled "Classic British Rock" by Kyutae, featuring songs like "Day Tripper - Remastered 2009" by The Beatles, "Killer Queen - Remastered 2011" by Queen, "Whole Lotta Love - 1990 Remaster" by Led Zeppelin, "(I Can't Get No) Satisfaction - Mono Version" by The Rolling Stones, "Smoke on the Water" by Deep Purple, and "Comfortably Numb" by The Wall.

#	TITLE	ALBUM	DATE ADDED	
1	Day Tripper - Remastered 2009 The Beatles	The Beatles 1962 - 1966 (Remastered)	Jan 1, 2020	2:50
2	Killer Queen - Remastered 2011 Queen	Sheer Heart Attack (Deluxe Edition 2011 Remaster)	Jan 1, 2020	3:00
3	Whole Lotta Love - 1990 Remaster Led Zeppelin	Led Zeppelin II (1994 Remaster)	Jan 1, 2020	5:34
4	(I Can't Get No) Satisfaction - Mono Version The Rolling Stones	Hot Rocks (1964-1971)	Jan 1, 2020	3:43
5	Smoke on the Water Deep Purple	Machine Head	Jan 1, 2020	5:42
6	Comfortably Numb The Wall	The Wall	Jan 1, 2020	6:22

The bottom of the interface shows the currently playing song, "Bohemian Rhapsody" by Queen, with a progress bar and playback controls.

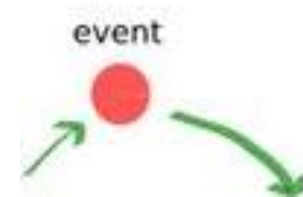
Event-handling model

- The Graphical User Interface (GUI) in Java is based on the event-handling model;
- The event-handling model is based on:
 - Events;
 - Event sources;
 - Event listeners.



Events

- The Java window manager sends a program an event notification when:
 - the user types characters;
 - the user uses the mouse inside one of the program's windows;
- The window manager generates a huge number of events:
 - *e.g.* whenever the mouse moves a tiny interval over a window a *mouse move* event is generated;
 - Most programs have no interest in many of these events.



Event sources

- The event source is the GUI component that generates a particular event:
 - button -> click events
 - menu item -> menu selection event
 - scrollbar -> scrollbar adjustment event
- Once you have determined the event source, you attach one or more listeners to it.



event source

Event listeners

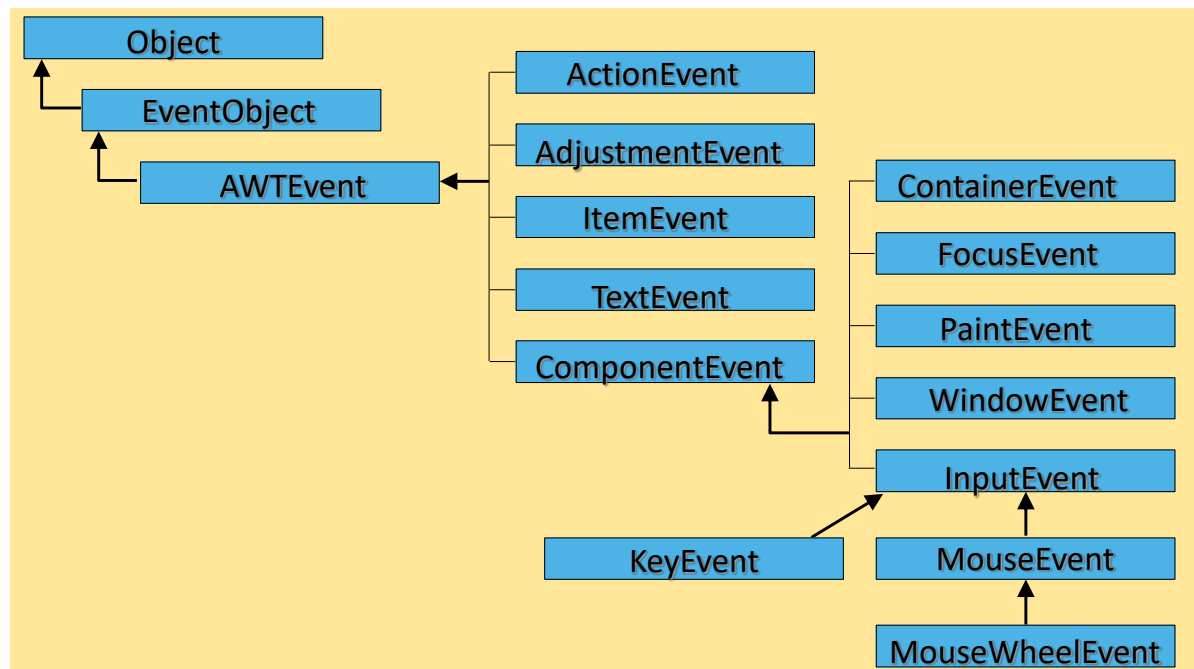
- To avoid unnecessary events, a program indicates events it likes to receive;
- This is done by installing event listeners;
- Different listeners are used to listen for and respond to different kinds of events.



registered event listener

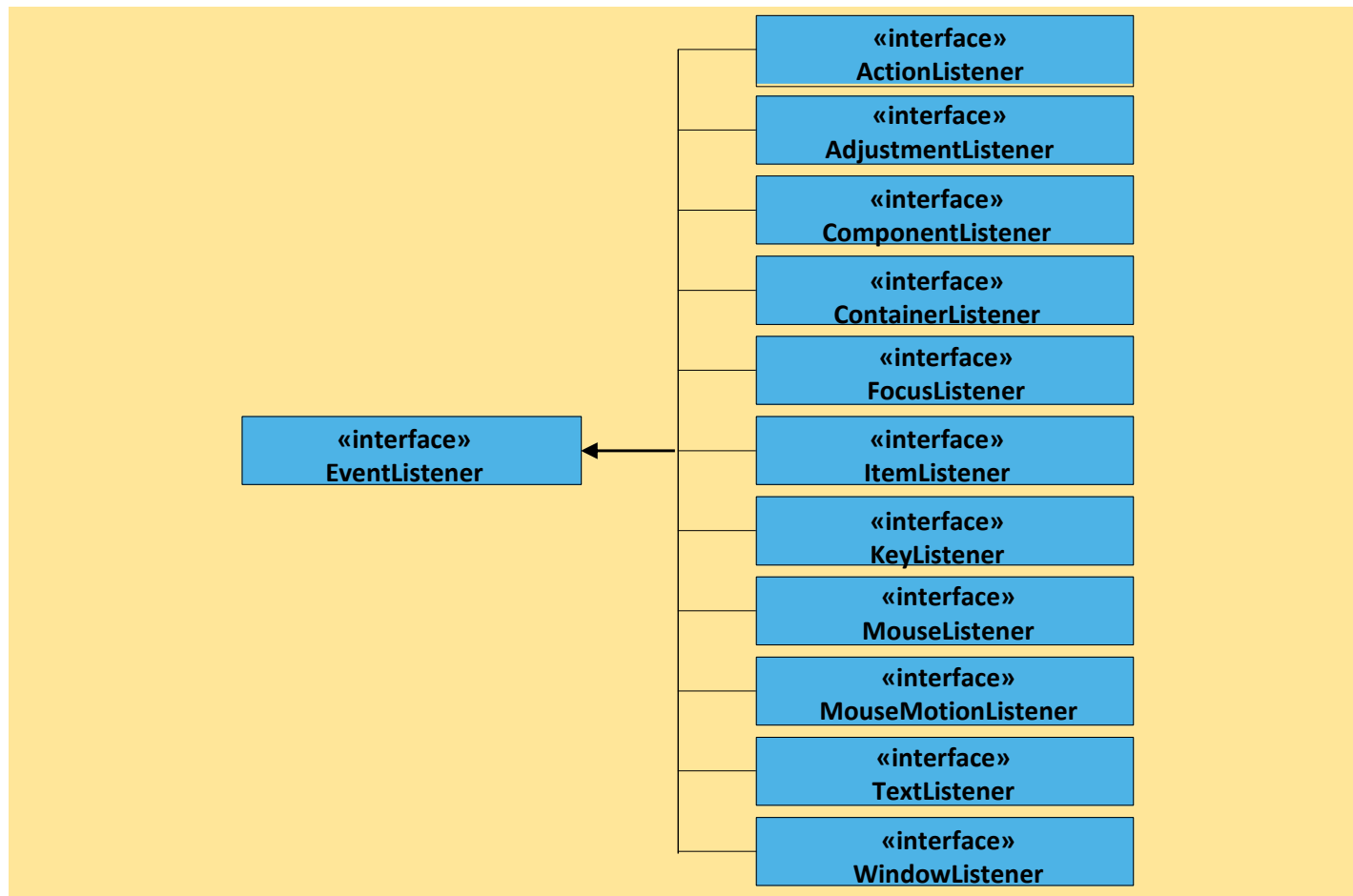
Events

- Events are represented as standard classes in Java;
- Each event object has type, name, source, and additional relevant information;
- Event objects are provided by Java window manager;



Event listeners

- Event listeners are implemented in Java as classes;
- An event-listener class indicates the type **T** of events it listens by implementing a listener interface **T**;



Event sources & event-handling model

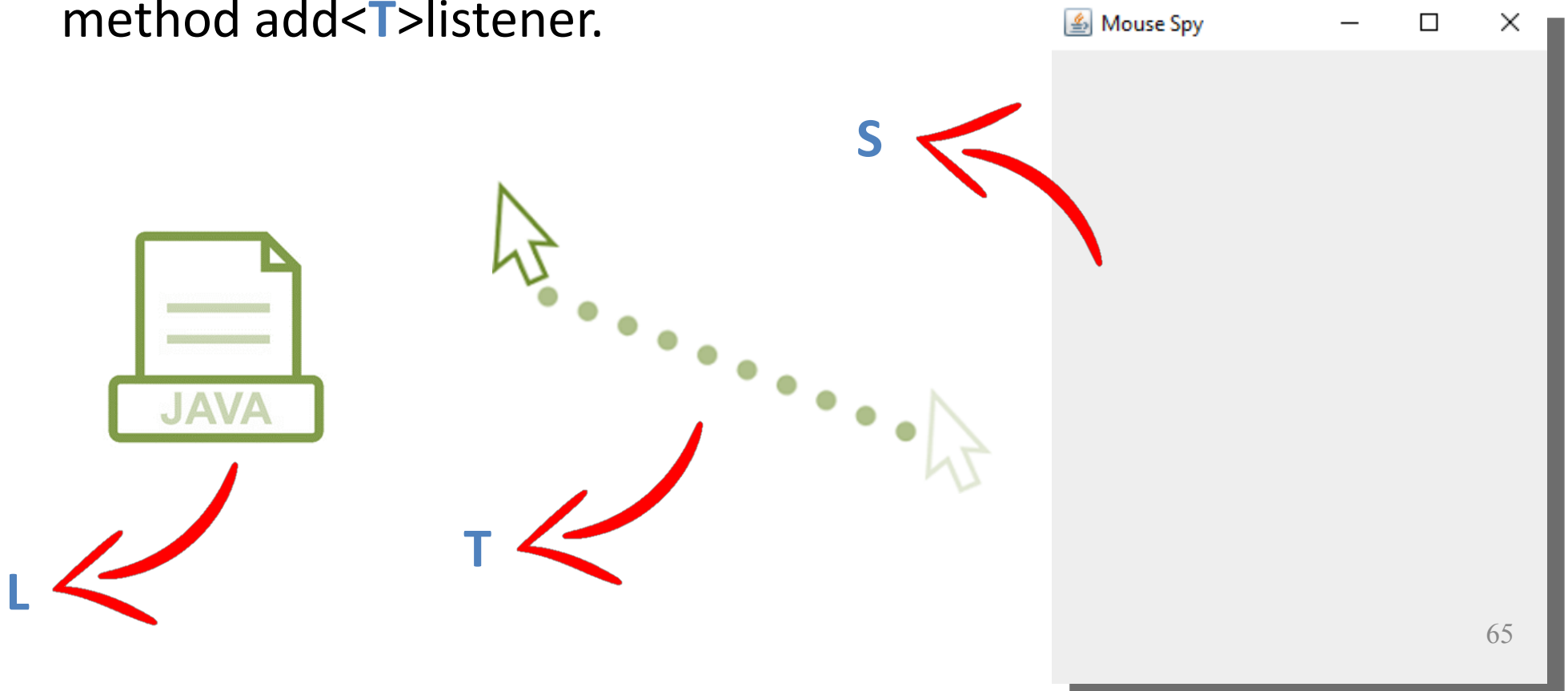
- Assume that we have:
 - an event-source object **S** that generates events of type **T**;
 - an event listener **L** for events of type **T**;
- Then, we add **L** to listen events from **T** generated in **S** using a method `add<T>listener`.
- In this case the Java window manager uses the loop:

while (true)

- » wait for next event;
- » determine event type **T**, and generate an object **E** with type event **T** ;
- » determine GUI source object **S** where event occurred;
- » call appropriate method of the listener **L** added to **S** with factual parameter the object **E**.

Event sources & event-handling model

- Assume that we have:
 - an event-source object **S** that generates events of type **T**;
 - an event listener **L** for events of type **T**;
- Then, we add **L** to listen events from **T** generated in **S** using a method `add<T>listener`.



Example: MouseSpyViewer

- The mouse is a source of events
- There are too many to mention, but we will look at
 - when a mouse button has been clicked
 - when a mouse button has been pressed on a component
 - when a mouse button has been released on a component
 - when the mouse enters a component
 - when the mouse exits a component
- First we will need a component for the mouse to interact with
- Then we will write a listener that will receive the events so they can be processed

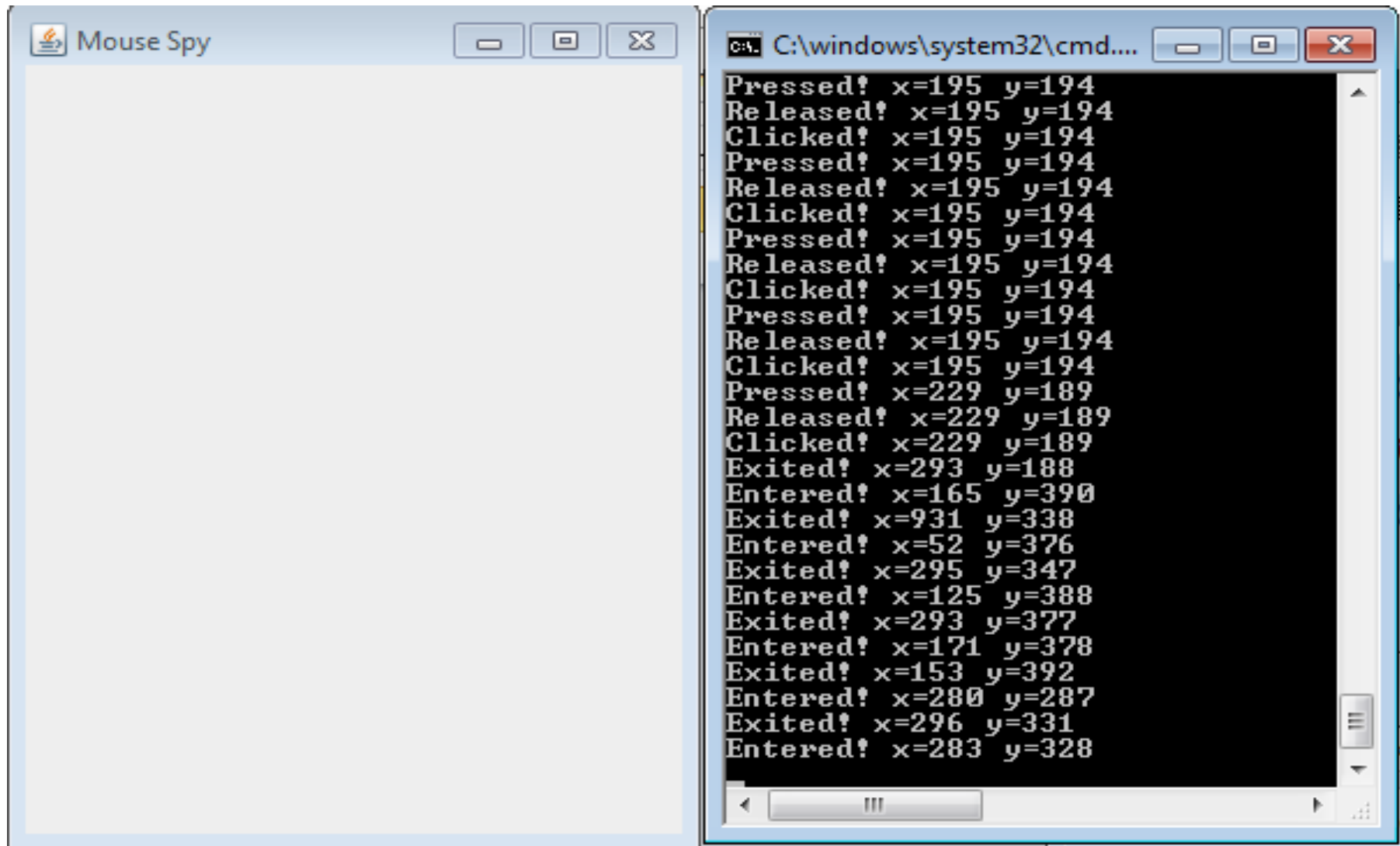
Example: MouseSpyViewer

Write an application that prints in the console window the X and Y coordinates of the dot pointed at by the computer mouse. In this case:

- The event class is the standard **MouseEvent** class;
- The event source is an object of some frame class (**MouseSpyViewer**);
- The listener class (**MouseSpy**) implements the standard **MouseListener** interface.



Example: MouseSpyViewer



The MouseSpy Class

```
import java.awt.event.*;
```

```
class MouseSpy implements MouseListener
```

```
{    public void mousePressed(MouseEvent event)
    { System.out.println("Pressed! x=" + event.getX() + " y=" + event.getY()); }
```

```
    public void mouseReleased(MouseEvent event)
    { System.out.println("Released! x=" + event.getX() + " y=" + event.getY()); }
```

```
    public void mouseClicked(MouseEvent event)
    { System.out.println("Clicked! x=" + event.getX() + " y=" + event.getY()); }
```

```
    public void mouseEntered(MouseEvent event)
    { System.out.println("Entered! x=" + event.getX() + " y=" + event.getY()); }
```

```
    public void mouseExited(MouseEvent event)
    { System.out.println("Exited! x=" + event.getX() + " y=" + event.getY()); }
}
```

The MouseSpyViewer Class

```
import javax.swing.*;

public class MouseSpyViewer extends JFrame {
    public MouseSpyViewer() {
        MouseSpy listener = new MouseSpy();
        addMouseListener(listener);
    }

    public static void main(String[] args) {
        MouseSpyViewer frame = new MouseSpyViewer();
        frame.setSize(300, 400);
        frame.setTitle("Mouse Spy");
        frame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
        frame.setVisible(true);
    }
}
```

INNER CLASSES IN LISTENERS

Inner classes

[...] This is a class that is declared within another class. - Java: A Beginner's Guide, Eighth Edition

But WHY???!!!

- Java does not permit multiple inheritances
- Useful when using adapters (more later)

Interesting link:

http://www.fredosaurus.com/notes-java/GUI/events/inner_class_listener.html

The use of inner classes in listeners

- Class inside another class
- Inner class can access variables and methods of the outer class

```
public class ButtonFrame extends JFrame
{
    private JButton button;
    private JLabel label;

    class ClickListener implements ActionListener
    {
        public void actionPerformed(ActionEvent e)
        {
            // We can modify label from the inner class
            label.setText("Button clicked");
        }
    }
}
```

The use of inner classes in listeners

```
class MyClass {  
    public MyClass() {  
        // begin inner class  
        class MyListener implements ListenerInterface {  
            public void eventOccured(EventClass event)  
            {  
                // event actions go here!  
            }  
        } // end inner class  
        MyListener listener = new MyListener();  
        anEventSource.addListener(listener);  
    } // Outer class methods and variables  
} // end outer class
```

[Interlude: *extends* vs *implements*]

extends

A keyword available in Java programming language that allows a class to use the features of an already existing class

A class can extend one superclass

An interface can extend one or more interfaces

Associated with inheritance

implements

A keyword available in Java programming language that allows a class to provide definitions to the abstract methods of an interface

Class can implement one or more interfaces

An interface cannot implement another interface

Associated with abstraction

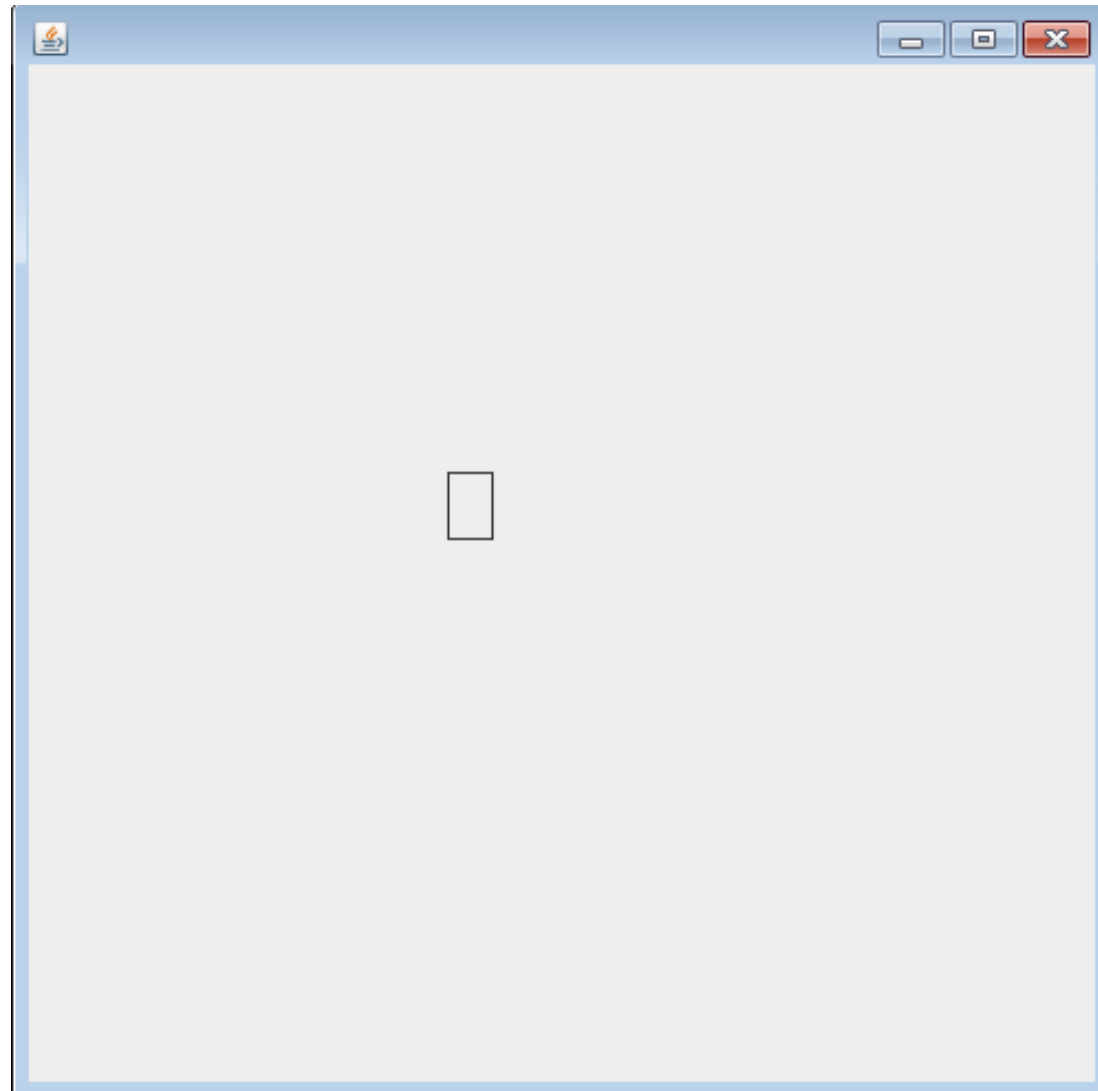
Example: Mouse Frame

Write an application that moves a rectangle to the mouse press position. In this case:

- The event class is the standard **MouseEvent** class;
- The event source is an object of some component class (**MouseComponent**);
- The listener class (an inner class **MousePressListener**) implements the standard **MouseListener** interface.



Mouse Frame



Mouse Component

```
public class MouseComponent extends JComponent {
    private Rectangle box;
    public MouseComponent() {
        box = new Rectangle(100, 100, 20, 30);
        class MousePressListener implements MouseListener {
            public void mousePressed(MouseEvent event) {
                int x = event.getX();
                int y = event.getY();
                box.setLocation(x, y);
                repaint(); // repaints the component
            }
            public void mouseReleased(MouseEvent event) {}
            public void mouseClicked(MouseEvent event) {}
            public void mouseEntered(MouseEvent event) {}
            public void mouseExited(MouseEvent event) {}
        }
        MousePressListener listener = new MousePressListener();
        addMouseListener(listener);
    }
    public void paintComponent(Graphics g) {
        Graphics2D g2 = (Graphics2D) g;
        g2.draw(box);
    }
}
```

Mouse Frame

```
import javax.swing.JFrame;

public class MouseFrame {
    public static void main(String[] args) {
        MouseComponent comp = new MouseComponent();
        JFrame frame = new JFrame();
        frame.add(comp);
        frame.setSize(400, 400);
        frame.setVisible(true);
    }
}
```

MOUSE ADAPTER CLASS

Adapter Classes

- Adapter classes provide the default implementation of listener interfaces
- If you inherit the adapter class, you will not be forced to provide the implementation of all the methods of listener interfaces
- So it saves time/code

➤ *Revise interfaces in Lecture 2!*

<https://developer.classpath.org/doc/java/awt/event/MouseAdapter-source.html>



The MouseAdapter Class

- To avoid writing empty methods in your listeners, use the standard **MouseListener** class;
- This class implements the **MouseListener** interface, but all the methods are empty;
- Thus, when you extend your listener with the **MouseListener** class, you write only nonempty methods:

```
class MousePressListener extends MouseAdapter {  
    public void mousePressed(MouseEvent event) {  
        int x = event.getX();  
        int y = event.getY();  
        box.setLocation(x, y);  
        repaint(); // repaints the applet  
    }  
}
```

GUI COMPONENTS EXAMPLE



Graphical applications: an example

A graphical window with a title bar containing a Java logo and standard window controls (minimize, maximize, close). The window contains a label "Interest Rate:" followed by a text input field containing the value "10.0". To the right of the input field is a button labeled "Add Interest".

A graphical window with a title bar containing a Java logo and standard window controls (minimize, maximize, close). The window contains a list of numerical values, each on a new line: 1210.00, 1331.00, 1464.10, 1610.51, 1771.56, 1948.72, 2143.59, 2357.95, and 2593.74. The list is displayed in a monospaced font. The window has a vertical scrollbar on the right and a horizontal scrollbar at the bottom.

```
textArea.append(String.format("%.2f\n", account.getBalance()));
```

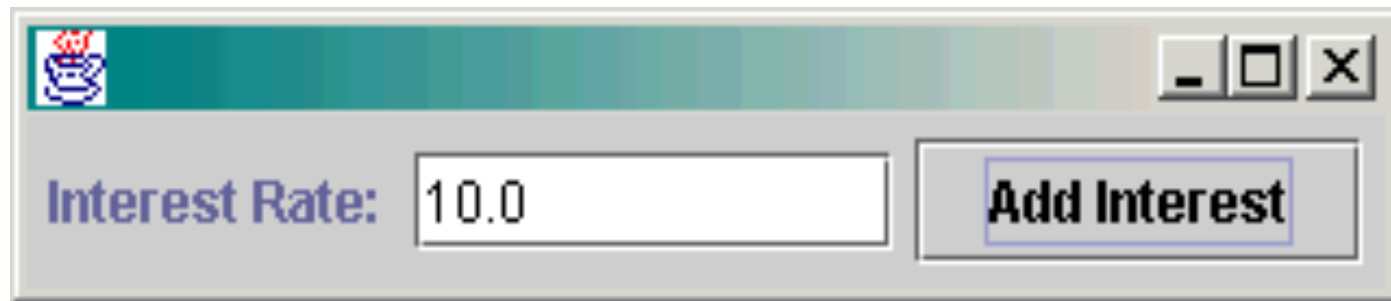
Classes for GUI components

- Use package `javax.swing`

- Class names for components start with **J**

```
JTextField rateField = new JTextField(10);  
JLabel xLabel = new JLabel("Interest Rate:  
");
```

```
JButton calButton = new  
JButton("AddInterest");
```



JPanel

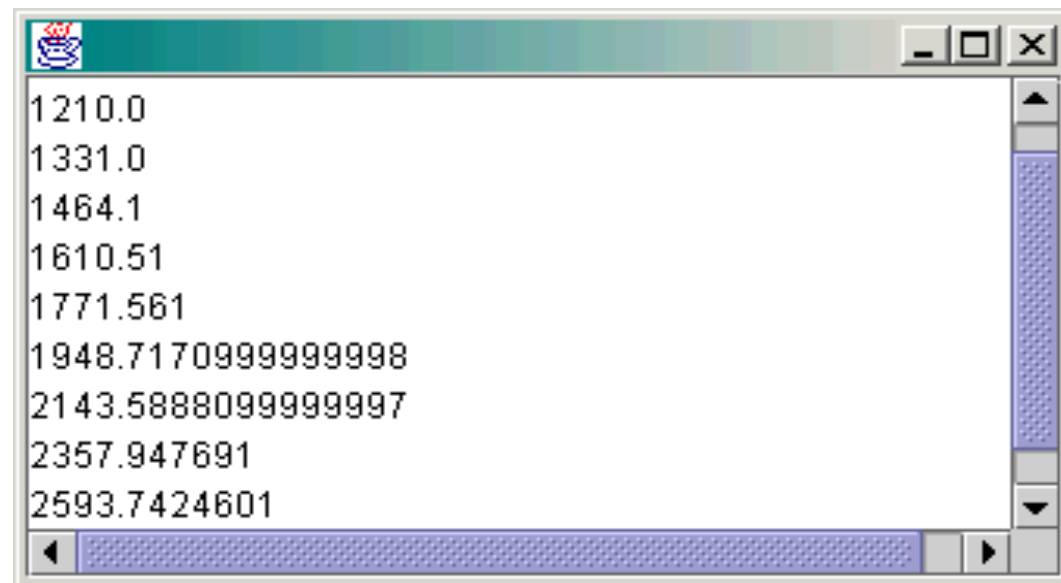
- Use package `javax.swing`
- JFrame: heavyweight container used as the top-level window
- JPanel: lightweight container generally used to organize/group Graphic user interface components
- JPanels are added on top of JFrame, whereas graphical user interface components are added on one or more JPanels.

```
JPanel controlPanel = new JPanel();  
JFrame controlFrame = new JFrame();  
controlFrame.add(controlPanel);
```

<https://www.educba.com/jpanel-vs-jframe/>

Text components

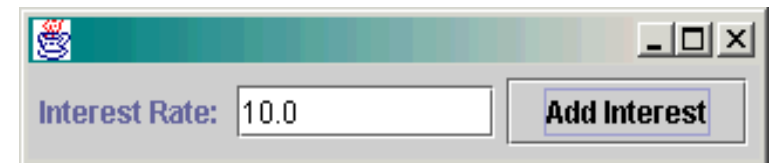
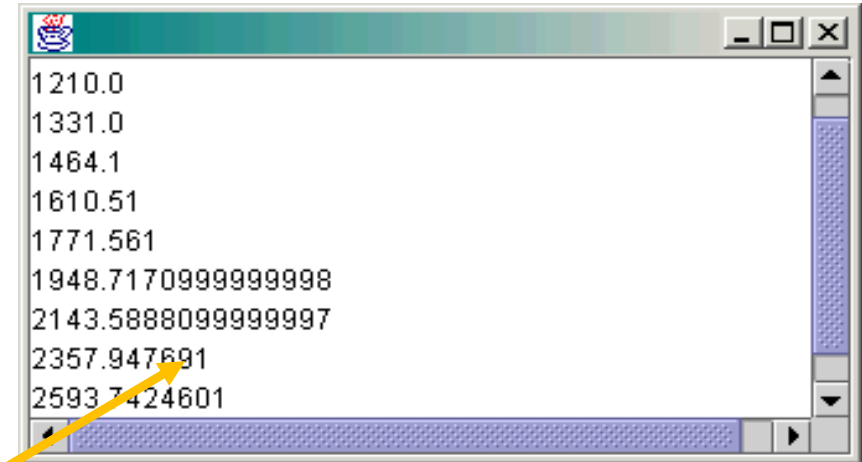
- To construct a text area use the `JTextArea` class ;
- To construct a text area with `n` rows and `m` columns use the constructor: `JTextArea (int n, int m)`
 - To append a string to a text area use the method `append(String str)` that appends the given text to the end of the text area.
- To (dis)allow the user to edit a text area use the methods: `setEditable(boolean flag)`
- To set the font of a text area use: `setFont(Font f)`
- To add scroll bars create a `JScrollPane` object with constructor parameter the reference of the `JTextArea` object.



```
import javax.swing.*;
import java.awt.event.*;
```

Text area example

```
public class TextAreaTest {
    public static void main(String[] args) {
        BankAccount account = new BankAccount(1000);
        JTextArea textArea = new JTextArea(10, 30);
        JScrollPane scrollPane = new JScrollPane(textArea);
        JFrame frame = new JFrame();
        frame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
        frame.add(scrollPane);
        frame.setSize(200, 100);
        frame.setVisible(true);
        JLabel rateLabel = new JLabel("Interest Rate: ");
        JTextField rateField = new JTextField(10);
        JButton calButton = new JButton("Add Interest");
        class CalculateListener implements ActionListener {
            public void actionPerformed(ActionEvent event) {
                double rate = Double.parseDouble(rateField.getText());
                account.deposit((account.getBalance()*rate/100));
                textArea.append(account.getBalance() + "\n");
            }
        }
        ActionListener listener = new CalculateListener();
        calButton.addActionListener(listener);
        JPanel controlPanel = new JPanel();
        controlPanel.add(rateLabel);
        controlPanel.add(rateField);
        controlPanel.add(calButton);
        JFrame controlFrame = new JFrame();
        controlFrame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
        controlFrame.add(controlPanel);
        controlFrame.setSize(220, 100);
        controlFrame.setVisible(true);
    }
}
```



Recommendation

- Get familiar with the use of Java documentation
 - Several constructors and (overloaded) methods are available per each component
 - You can learn a lot from it
 - It saves time!
- Practice: some examples (you may need Lecture 5)
 - https://personales.unican.es/corcuerp/java/Labs/LAB_18.htm
 - <https://www3.ntu.edu.sg/home/ehchua/programming/java/GraphicsExercises.html>

Learning goals

- Identify differences between console and *graphical application*
- Be able to configure and use *basic GUI components*
- Understand and be able to utilize commonly use *graphical classes*
- Understand and be able to implement the *event-handling model*
- Understand and be able to implement and use *inner classes*
- Implement *listener-based applications*
- Identify differences between *extends* and *implements*
- Identify the benefits of using *interfaces/adapters*
- Identify differences between *interfaces* and *adapters*