Object-Oriented Programming

GUI Programming
Part 1

United International College

Outline

- AWT, Swing, JavaFX
- Frames
- Buttons
- Layout managers
- Colors and fonts
- Panels
- Simple input / output

Java and GUI Programming

- To this point, you have seen only how to write programs that take input from the keyboard, fuss with it, and then display the results on a console screen.
- Not what most users want. Modern programs don't work this way.
- This chapter starts you on the road to writing Java programs that use a graphical user interface (GUI)
  - Size and locate windows on the screen
  - Display text, images in a window
  - Receiving user input via mouse click or keyboard

Java and GUI Programming

Java has three different libraries for implementing Graphical User Interfaces:

1. AWT
   - Original Java GUI library (1996).
   - Only has basic GUI components.
   - Quickly replaced by Swing.
2. Swing
   - Main Java GUI library for a long time (1998).
   - Still uses a few basic AWT components.
   - Still used a lot today.
   - Will still be part of Java until at least 2026.

Java and GUI Programming

3. JavaFX
   - Newest GUI library (2008)
   - Can use XML and graphical GUI builder to design GUI layout with the mouse, no coding.
   - Can use CSS to specify visual style.
   - Built-in animations.
   - Better event handling than Swing.
   - Not very successful compared to Swing…
   - Not part of Java SE 11!
   - Slowly dying?

So we will use Swing.

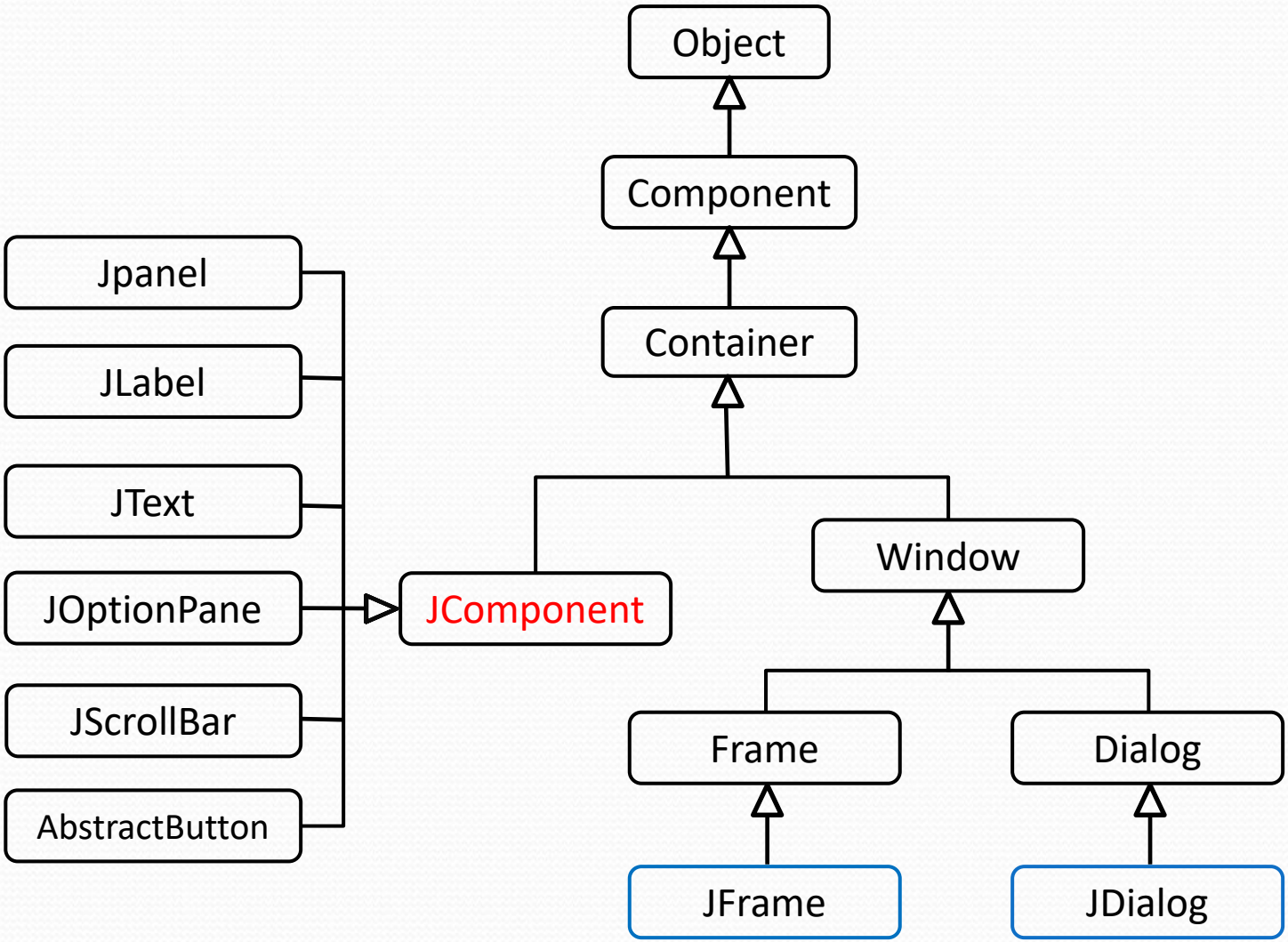
Java and GUI Programming

- Every user interface considers the following three main aspects –
  - UI Elements – These are the core visual elements the user eventually sees and interacts with.
  - Layouts – They define how UI elements should be organized on the screen and provide a final look and feel to the GUI .
  - Behavior – These are the events which occur when the user interacts with UI elements.

Java and GUI Programming

- There are two types of UI elements:
  - Components: elementary UI entities, such as button, label and textField.
  - Containers: hold components in a specific layout. A container can also hold sub-containers. E.g., frame and panel.
- In a GUI program, a component must be kept in a container. You need to identify a container to hold the components.
  - Every container has a method called **`add(Component c)`**

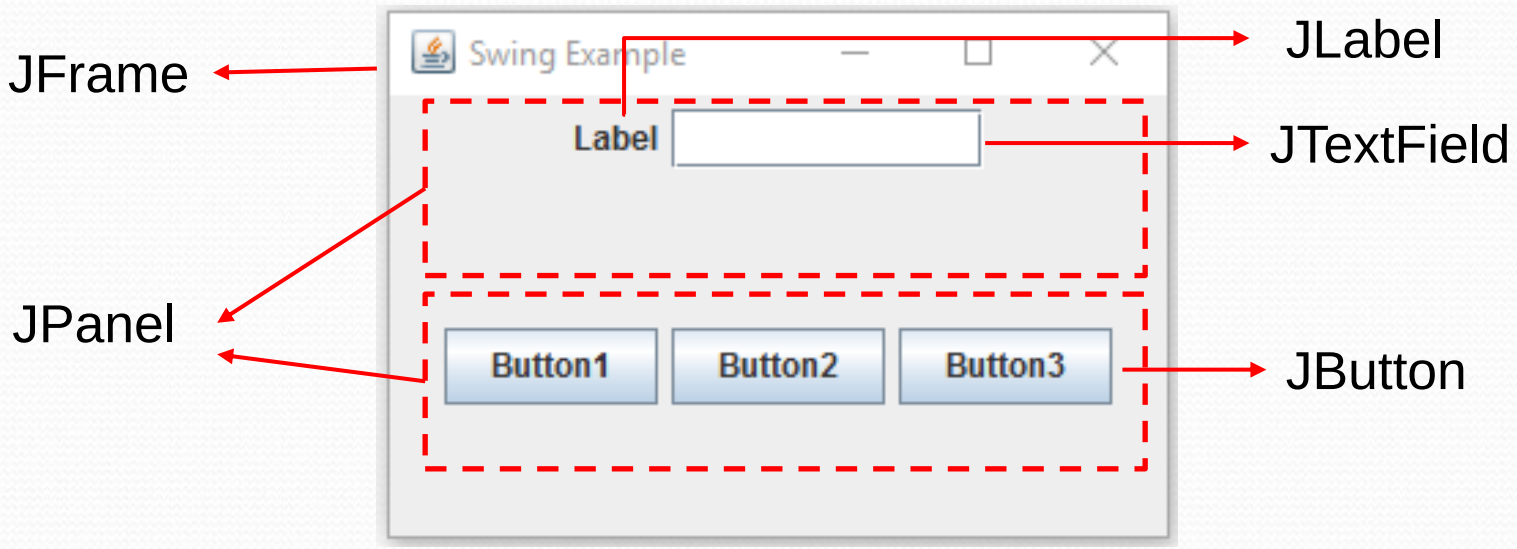
Inheritance Hierarchy of Swing Class



SWING UI Elements

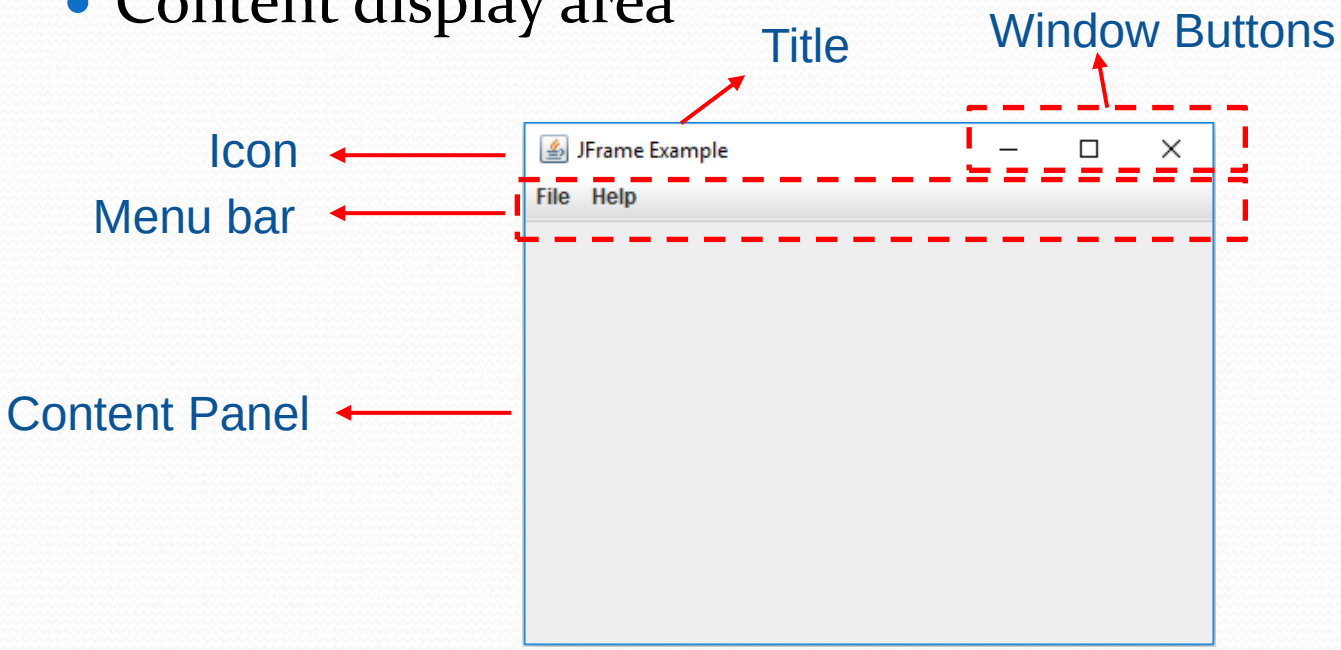
- Following is the list of commonly used controls while designing GUI using SWING
  - JLabel
  - JButton
  - JTextField
  - JTextArea
  - JOptionPane
  - JFileChooser
  - …

Containers and Components



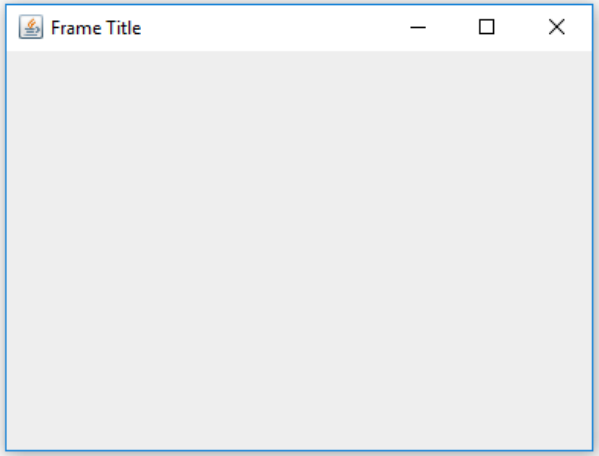
Frames

- A **`JFrame`** is a commonly used top-level container.
- Provides the "main window" for your GUI application
  - Title bar, contains an icon, a title, the minimize, maximize and close buttons
  - Optional menu bar
  - Content display area



Frames

```
import javax.swing.JFrame;
public class EmptyWindow {
    public static void main(String[] args) {
        // A JFrame is a top-level window with a title and a border.
        JFrame f = new JFrame("Frame Title");
        f.setSize(400, 300);
        // Closing the window terminates the program.  Do not forget
        // this otherwise the program might keep running even after
        // the window is closed!
        f.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
        // Make the window visible to the user.
        f.setVisible(true);
        // The window is empty!
    }
}
```



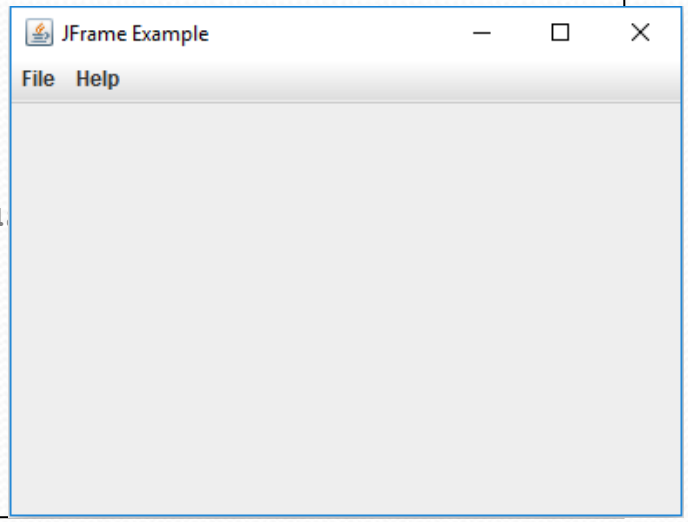
Frames

- To write a GUI program, we typically start with a subclass extending from **`javax.swing.Jframe`** to inherit from the main window:

```
public class MyFrame extends JFrame {
    public MyFrame() {…}
    // methods

     public static void main (String[] args)
    {
        new MyFrame();
    }
}
```

```
import javax.swing.*;
public class MyWindow extends JFrame {
    public MyWindow()
    {
        this.setTitle("JFrame Example");
        this.setSize(400, 300);
        this.setLocation(600,300);
        this.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
        JMenuBar menuBar = new JMenuBar(); // Window menu bar
        JMenu menuF= new JMenu("File");
        JMenuItem item1 = new JMenuItem("Open");
        JMenuItem item2 = new JMenuItem("Save As");
        menuF.add(item1);
        menuF.add(item2);
        JMenu menuH= new JMenu("Help");
        menuBar.add(menuF);
        menuBar.add(menuH);
        this.setJMenuBar(menuBar);
        // Make the window visible to the u
        this.setVisible(true);}
    public static void main(String[] args)
        new MyWindow();
    }
}
```



MyWindow.java

Buttons

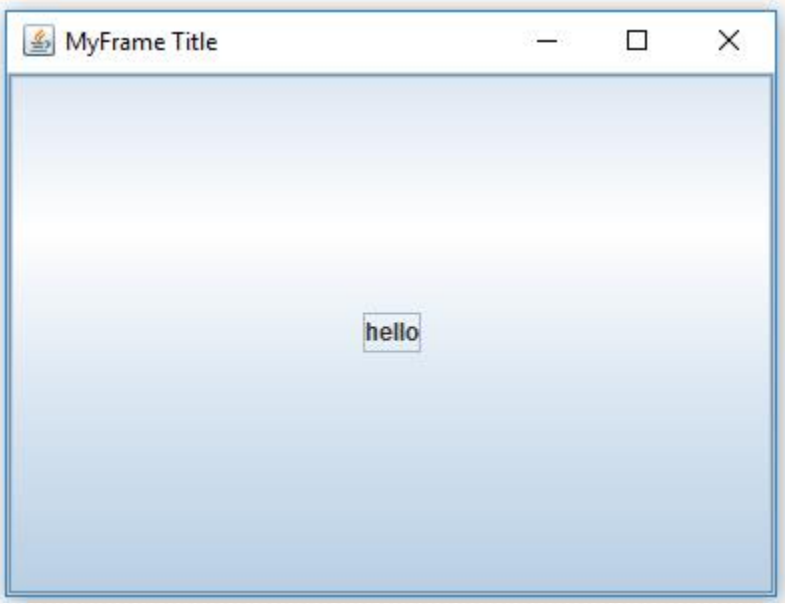
A **JButton** is a Swing object representing one button.

```
import javax.swing.JButton;
import javax.swing.JFrame;
public class MyFrameButton extends JFrame {
    public MyFrameButton() {
        this.setTitle("MyFrame Title");
        this.setSize(400, 300);
        this.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
        // Create a button with the text "hello".
        JButton b = new JButton("hello");
        // Add the button to the frame.
        this.add(b);
        // Always make the frame visible *after* adding all the components
        // (like buttons) otherwise the components will not be visible in
        // the frame.
        this.setVisible(true);
    }
}
```

Buttons

A **JButton** is a Swing object representing one button.

```
public class TestFrameButton {
    public static void main(String[] args)
    {
        new MyFrameButton();
    }
}
```



Buttons

- A button is a graphical component:

  A Visual Guide to Swing Components (MIT web site)

- Components needs to be:
  1. Created using **`new`**.
  2. Added to a component container.
- A frame is one possible kind of component container (more component containers later).
- Problems:
  - The button takes all the space in the window: we can solve this problem using a layout manager.
  - The button does nothing: we can solve this problem using an event handler (next week).

Layout Managers

- Layout managers are special Swing objects that automatically determine for you the size and position of components (like buttons) inside a component container (like a frame).
- Many layout managers available in Swing:

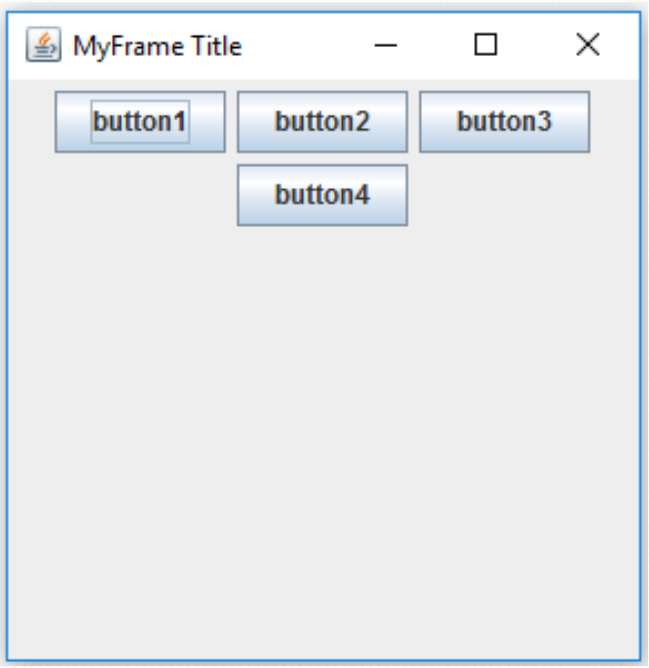
  A Visual Guide to Layout Managers (Oracle web site)
- Most important ones are:
  - **`BorderLayout`**: maximum of 5 components in 5 areas.
  - **`FlowLayout`**: components next to each other, going to the next line if necessary.
  - **`GridLayout`**: grid of components.

Layout Managers

```
import java.awt.FlowLayout;
import javax.swing.JButton;
import javax.swing.JFrame;
public class MyFrameLayout extends JFrame {
    public MyFrameLayout() {
        this.setTitle("MyFrame Title");
        this.setSize(300, 300);
        this.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
        // A flow layout manager lays out components in a single row,
        // going to the next row when the current row is full.
        // Possible arguments for the constructor are: FlowLayout.CENTER
        // (default), FlowLayout.LEFT, FlowLayout.RIGHT.
        FlowLayout fl = new FlowLayout();
        // Set the layout manager for the frame.
        this.setLayout(fl);
        for (int i = 1; i <=4 ; i++) {
            JButton b = new JButton("button"+i);
            this.add(b);
        }
        this.setVisible(true);
    }
}
```

Layout Managers

```
public class TestFrame {
    public static void main(String[] args)
    {
        new MyFrameLayout();
    }
}
```



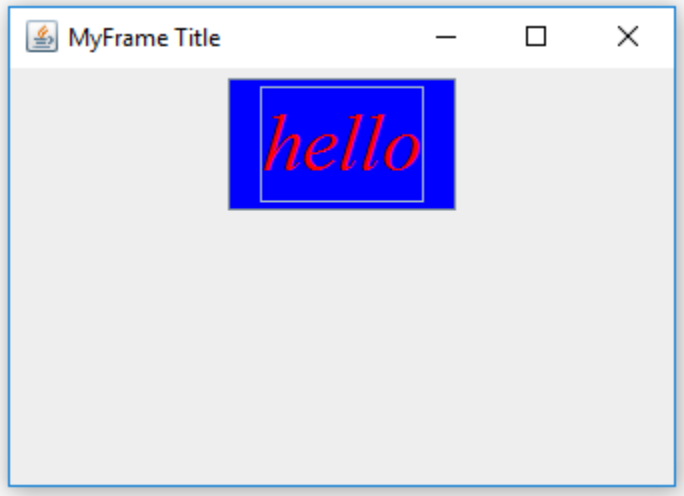
Colors and fonts

All Swing components have:

- A background color.
- A foreground color.
- A font.

What these exactly mean depends on the type of component!

Colors and fonts




```
import java.awt.Color;
import java.awt.FlowLayout;
import java.awt.Font;
import javax.swing.JButton;
import javax.swing.JFrame;
public class MyFrameCF extends JFrame {
    public MyFrameCF() {
        this.setTitle("MyFrame Title");
        this.setSize(400, 300);
        this.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
        FlowLayout fl = new FlowLayout();
        this.setLayout(fl);
        JButton b = new JButton("hello");
        b.setBackground(Color.BLUE);
        b.setForeground(new Color(255, 0, 0)); // red (RGB decimal values).
        // Font: name, style (Font.PLAIN, Font.ITALIC, Font.BOLD),
        // size (in pixels).
        b.setFont(new Font(Font.SERIF, Font.ITALIC, 40));
        this.add(b);
        this.setVisible(true);
    }
}
```

Panels

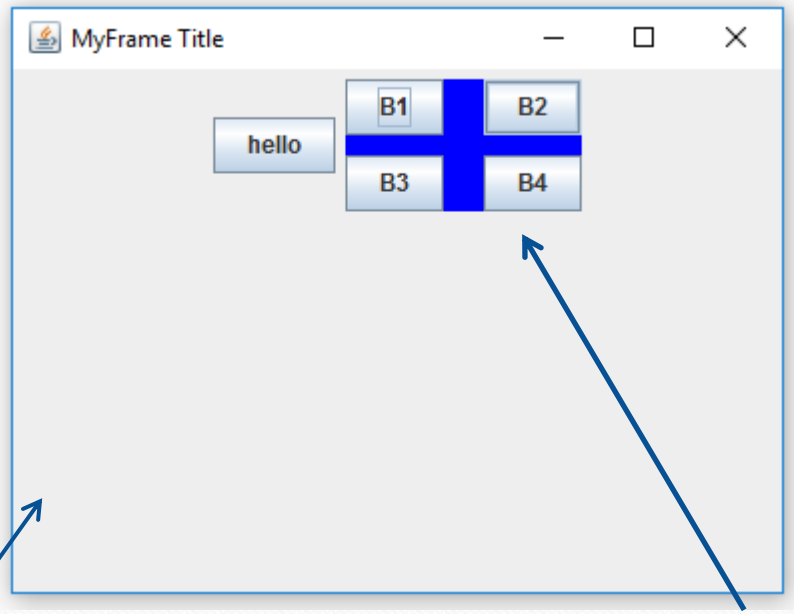
- A panel is a Swing object which is both:
  - a component (you can add it to a frame)
  - a component container (you can add components to it, including other panels)

  at the same time!
- A panel can have its own layout manager, independently of the frame or of other panels.
- Panels are very useful for grouping components and hierarchically organizing GUIs into multiple separate areas, even when you resize the frame!

Panels

```
import java.awt.*;
import javax.swing.*;
public class MyFramePanel extends JFrame {
    public MyFramePanel() {
        this.setTitle("MyFrame Title");
        this.setSize(400, 300);
        this.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
        this.setLayout(new FlowLayout()); // Layout manager for the frame.
        this.add(new JButton("hello"));   // Add button to the frame.
        JPanel p = new JPanel();
        p.setBackground(Color.BLUE);
        this.add(p);                      // Add panel to the frame.
        // Layout manager for the panel.
        // 2 rows, 2 columns, 20 pixels hgap, 10 pixels vgap.
        p.setLayout(new GridLayout(2, 2, 20, 10));
        // Create four buttons and add them to the panel (not the frame).
        // The four buttons always stay together even when you resize.
        for(int i = 0; i < 4; i++) {
            p.add(new JButton("B" + (i + 1)));
        }
        this.setVisible(true);
    }
}
```

Panels



Frame (grey) with FlowLayout, one button, and one panel.

Panel (blue) with GridLayout and four buttons

Painting GUI Components

- In Java, components are rendered on screen in a process known as painting. Although this is usually handled automatically, there are occasions when you need to trigger repainting, or modify the default painting for a component.
- Painting is triggered when a GUI element is launched or altered in anyway
  - Frame to be visible, resize, etc.
  - An item is selected, a button is clicked, etc.
- When a paint request is triggered, the **`paintComponent`** is invoked.
- You can call the **`repaint`** method to invoke the **`paintComponent`** method indirectly.

Painting GUI Components

To draw on a component:

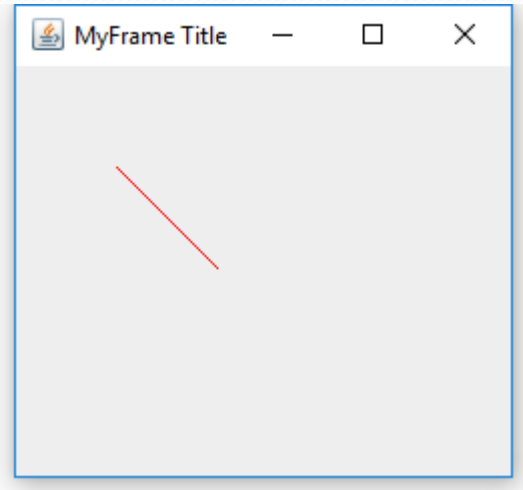
- Create your own JComponent subclass.
- Override the `paintComponent(Graphics g)` method:
  - Always call `super.paintComponent(g)` first .
    - If you forget this, the component might not be cleaned properly before you draw on it.
  - Use the methods of the graphics object `g` given by Swing as argument to your `paintComponent` method to draw on the component: `setColor`, `drawLine`, etc.

Painting GUI Components

```
import java.awt.Color;
import java.awt.Graphics;
import javax.swing.JPanel;
public class MyPanel extends JPanel {
// The argument g is a Graphics object that lets you directly draw on
// the panel.  Swing automatically supplies g as argument to your
// method every time Swing needs to call your paintComponent method.
    @Override
    protected void paintComponent(Graphics g) {
        // We must clean the panel before drawing on it.
        super.paintComponent(g);
        // We use g to draw a red line on the clean panel.
        g.setColor(Color.RED);
        g.drawLine(50, 50, 100, 100);
    }
}
```

Painting GUI Components

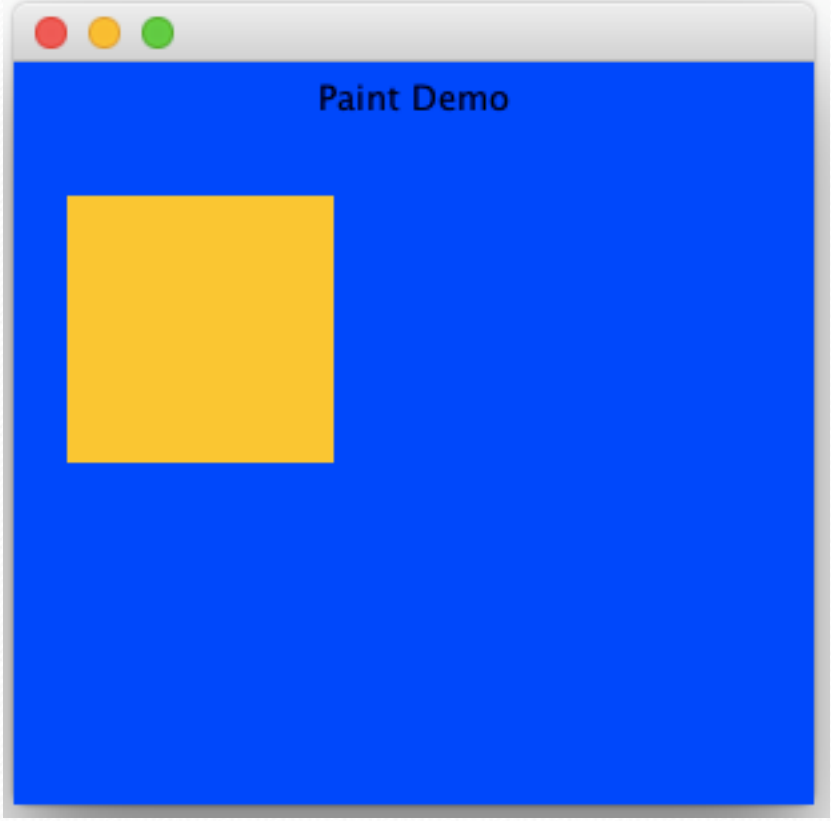
```
import javax.swing.JFrame;
public class MyFrame extends JFrame {
     public MyFrame() {
          this.setTitle("MyFrame Title");
          this.setSize(400, 300);
          this.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
          // No layout manager for the frame, so the panel will
          // use the full size of the frame.
          this.add(new MyPanel());
          this.setVisible(true);
     }
}
public class Test { // As before.
     public static void main(String[] args) {
          new MyFrame();
     }
}
```



Painting GUI Components

```
import javax.swing.*;
import java.awt.*;
public class MyDrawPanel extends JPanel {
    public MyDrawPanel() {
        JLabel label = new JLabel("Paint Demo");
        this.setBackground(Color.blue);
        this.add(label);
    }
    public void paintComponent(Graphics g) {
        super.paintComponent(g);  //call paintComponent of Jpanel
         g.setColor(Color.orange);
        g.fillRect(20, 50, 100, 100);
    }
    public static void main(String[] args) {
        JFrame frame = new JFrame();
        MyDrawPanel panel = new MyDrawPanel();
        frame.getContentPane().add(panel);
        frame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
        frame.setSize(300, 300);
        frame.setVisible(true);
    }
}
```

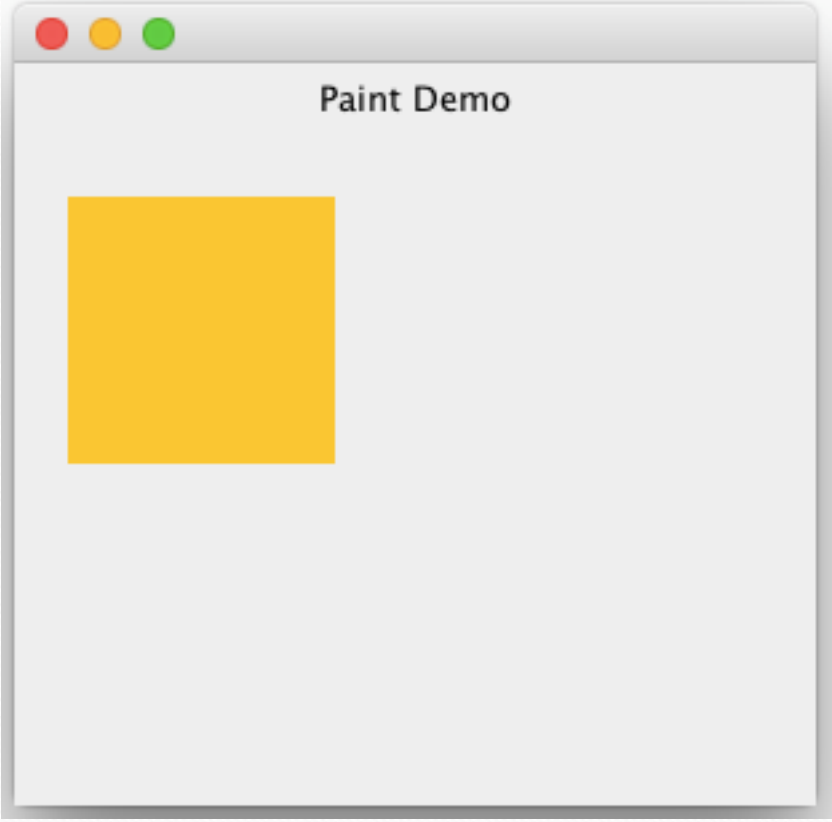
Painting GUI Components



Painting GUI Components

```
import …
public class MyDrawPanel extends JPanel {
    public MyDrawPanel() {
        JLabel label = new JLabel("Paint Demo");
        this.setBackground(Color.blue);
        this.add(label);
    }
    public void paintComponent(Graphics g) {
        //super.paintComponent(g); //no paintComponent of JPanel
        g.setColor(Color.orange);
        g.fillRect(20, 50, 100, 100);
    }
    public static void main(String[] args) {
        JFrame frame = new JFrame();
        MyDrawPanel panel = new MyDrawPanel();
        frame.getContentPane().add(panel);
        frame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
        frame.setSize(300, 300);
        frame.setVisible(true);
    }
}
```

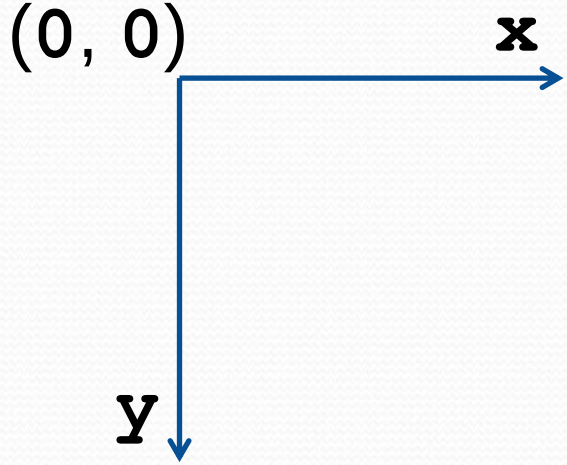
Painting GUI Components



Painting GUI Components

Warning:

- the location (`0`, `0`) is in the upper-left corner of the component!
- the horizontal **`x`** coordinate increases from left to right.
- the vertical **`y`** coordinate increases from top to bottom!

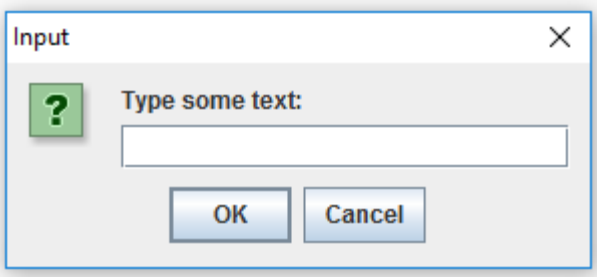


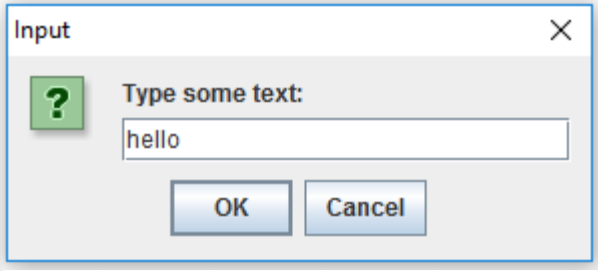
Simple input / output

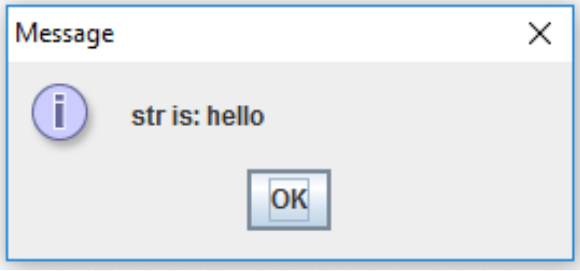
- `JOptionPane` makes it easy to pop up a standard dialog box that prompts users for a value or informs them of something
- Using a `JOptionPane`:
  - `showInputDialog` for input.
  - `showMessageDialog` for output.
  - `showConfirmDialog` for Yes / No / Cancel questions.
  - Some options for title and style.
  - Default options are good enough.

Simple input / output

```
import javax.swing.JOptionPane;
public class ShowInput {
    public static void main(String[] args) {
        // Input:
        // If the user clicks on "cancel" then str will be null.
        // If the user types something in the dialog and clicks
        // on "OK" then str will be what the user typed.
        String str = JOptionPane.showInputDialog("Type some text:");
        // Output:
        JOptionPane.showMessageDialog(null, "str is: " + str);
    }
}
```



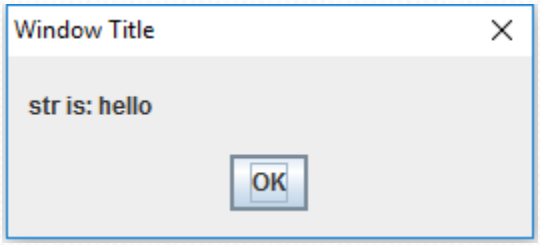


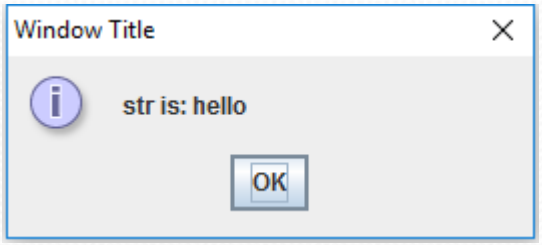


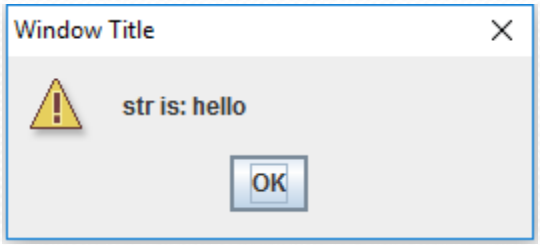
Simple input / output

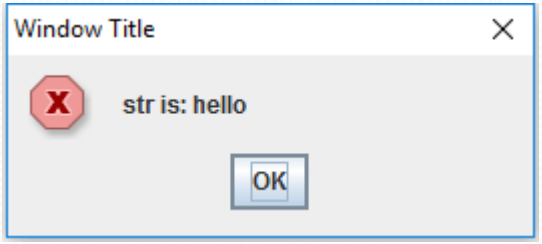
```
import javax.swing.JOptionPane;
public class TestIO {
    public static void main(String[] args) {
        // Input:
        String str = JOptionPane.showInputDialog(null, "Type some text:",
            "Window Title", JOptionPane.QUESTION_MESSAGE);
        // Output:
        JOptionPane.showMessageDialog(null, "str is: " + str, "Window Title",
            JOptionPane.PLAIN_MESSAGE);
        JOptionPane.showMessageDialog(null, "str is: " + str, "Window Title",
            JOptionPane.INFORMATION_MESSAGE);
        JOptionPane.showMessageDialog(null, "str is: " + str, "Window Title",
            JOptionPane.WARNING_MESSAGE);
        JOptionPane.showMessageDialog(null, "str is: " + str, "Window Title",
            JOptionPane.ERROR_MESSAGE);
    }
}
```

Simple input / output



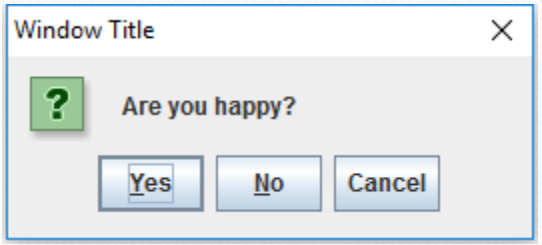


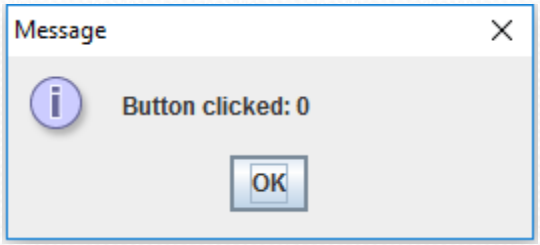




Simple input / output

```
import javax.swing.JOptionPane;
public class ShowConfirm {
    public static void main(String[] args) {
        // Show a yes / no / cancel dialog.  Styles are: YES_NO_OPTION,
        // YES_NO_CANCEL_OPTION, OK_CANCEL_OPTION, DEFAULT_OPTION (OK only).
        // The result is an integer indicating which button was clicked.
        int result = JOptionPane.showConfirmDialog(null, "Are you happy?",
            "Window Title", JOptionPane.YES_NO_CANCEL_OPTION);
        // Output:
        JOptionPane.showMessageDialog(null, "Button clicked: " + result);
    }
}
```





Event-Dispatching Thread

- In the previous examples, we invoke the constructor directly in the entry main() method to setup the GUI components.
- The constructor will be executed in the so-called "Main-Program" thread. This may cause multi-threading issues (such as unresponsive user-interface and deadlock).

```
public class MyFrame extends JFrame {
    public MyFrame() {…}
    // methods

     public static void main(String[] args)
    {
        new MyFrame();
    }
}
```

Event-Dispatching Thread

- Swing uses threads:
  - One main thread running the `main` method.
  - One event dispatch thread automatically taking care of graphical events (mouse clicks, etc.)
  - More threads if you create them…
- Most Swing components can only be used by one thread at a time.
- Since the event dispatch thread is already using the Swing components, all of your graphical code must be executed by the event dispatch thread too! No choice.

Event-Dispatching Thread

To execute graphical code on the event dispatch thread, you must:

1. Create a class that implements the **`Runnable`** interface for thread code with a **`public void run()`** method.
2. Put all your graphical code inside the **`run`** method.
3. Create an object from that class.
4. Give the object to the event dispatch thread using the **`javax.swing.SwingUtilities.invokeLater`** method.

Event-Dispatching Thread

```
import javax.swing.JFrame;
class MyThreadCode implements Runnable {
    @Override
    public void run() {
        JFrame f = new JFrame("Frame Title");
        f.setSize(400, 300);
        f.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
        f.setVisible(true);
    }
}
public class Test {
    public static void main(String[] args) {
        MyThreadCode m = new MyThreadCode();
        javax.swing.SwingUtilities.invokeLater(m);
    }
}
```

Event-Dispatching Thread

In practice it is easier to use an anonymous class:

```
import javax.swing.JFrame;
public class Test {
    public static void main(String[] args) {
        // The code inside the {} is the same code as before.  It is
        // the code of an anonymous class (no name) that implements
        // the same Runnable interface as before.
        javax.swing.SwingUtilities.invokeLater(new Runnable() {
            @Override
            public void run() {
                JFrame f = new JFrame("Frame Title");
                f.setSize(400, 300);
                f.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
                f.setVisible(true);
            }
        }); // End of anonymous class.
    }
}
```

Event-Dispatching Thread

It is even easier to create your own frame subclass:

```
import javax.swing.JFrame;
public class MyFrame extends JFrame {
    public MyFrame() {
        // We can use the setTitle method to set the title, or call
        // directly the constructor of the superclass JFrame with
        // the title: super("MyFrame Title");
        this.setTitle("MyFrame Title");
        this.setSize(400, 300);
        this.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
        this.setVisible(true);
    }
}
```

Event-Dispatching Thread

And then always use the same code to solve the event dispatch thread problem, with a simple anonymous class:

```
public class Test {
    public static void main(String[] args) {
        javax.swing.SwingUtilities.invokeLater(new Runnable()
{
            @Override
            public void run() {
                new MyFrame();
            }
        });
    }
}
```

Summary

- AWT, Swing, JavaFX
- Frames
- Buttons
- Layout managers
- Colors and fonts
- Panels
- Simple input / output