FUNDAMENTALS

CS062

DATA STRUCTURES AND ADVANCED PROGRAMMING

4: The Catch-All Java Lecture

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Lecture 4: The Catch-All Java Lecture

- Packages
- JavaDoc
- Exceptions
- Assertions
- Text I/O
- Java GUIs
- Graphics
- Events

What is a package?

- A grouping of related classes and interfaces that provides access protection and name space management.
- e.g., `java.lang` for fundamental classes or `java.io` for classes related to reading input and writing output.
- Packages correspond to folders/directories.
- Lower-case names.
- `package whatevername;` at top of file.
- `import graphics.*;` for including all classes/interfaces.
- or `import graphics.Circle;` for more specific access.

https://docs.oracle.com/javase/tutorial/java/package/packages.html

Access modifiers

Modifier	Class	Package	Subclass	World
`public`	Y	Y	Y	Y
`protected`	Y	Y	Y	N
No modifier	Y	Y	N	N
`private`	Y	N	N	N

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Java Documentation Generation System

- Reads JavaDoc comments and gives HTML pages
- JavaDoc comment = description written in HTML + tags
- Enclosed in /** */
- Must precede class, variable, constructor or method declaration
- For class:
  - **@author** author name – classes and interfaces
  - **@version** date - classes and interfaces
- For method:
  - **@param** param name and description – methods and constructors
  - **@return** value returned, if any – methods
  - **@throws** description of any exceptions thrown - methods

https://www.oracle.com/technetwork/articles/java/index-137868.html

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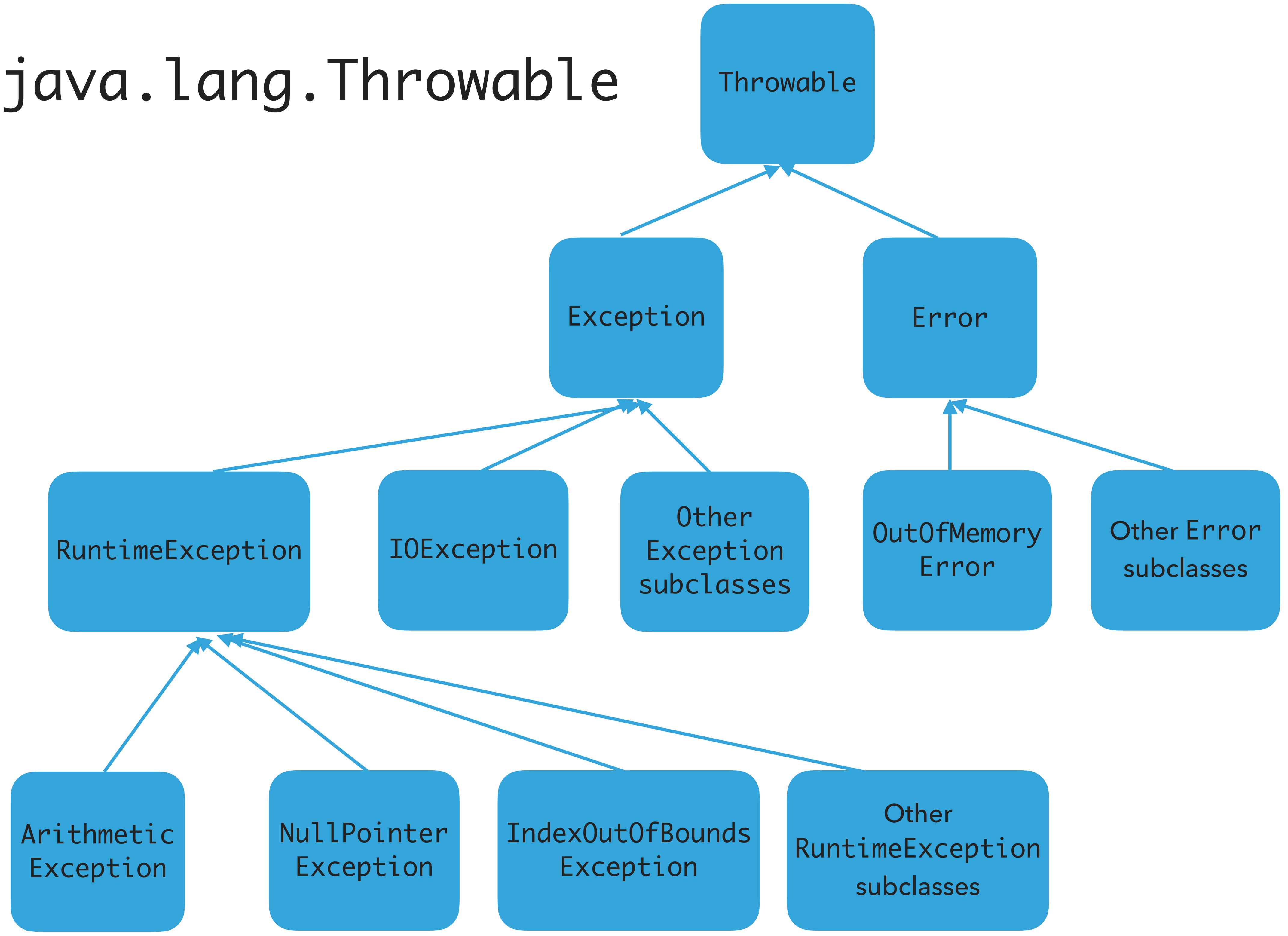
Exceptions are exceptional or unwanted events

- That is operations that disrupt the normal flow of the program.
    - E.g., divide a number by zero, run out of memory, ask for a file that does not exist, etc.
- When an error occurs within a method, the method throws an exception object that contains its name, type, and state of program.
- The runtime system looks for something to handle the exception among the call stack, the list of methods called (in reverse order) by `main` to reach the error.
- The exception handler catches the exception. If no appropriate handler, the program terminates.

https://docs.oracle.com/javase/tutorial/essential/exceptions/definition.html

java.lang.Throwable



https://docs.oracle.com/javase/7/docs/api/java/lang/Throwable.html

Three major types of exception classes

- `Error`: rare internal system errors that an application cannot recover from.
  - Typically not caught and program has to terminate.
  - e.g., `java.lang.OutOfMemoryError` or `java.lang.StackOverflowError`
- `Exception`: errors caused by program and external circumstances.
  - Can be caught and handled.
  - e.g., `java.io.Exception`
- `RuntimeException`: programming errors that can occur in any Java method.
  - Method not required to declare that it throws any of the exception.
  - e.g., `java.lang.IndexOutOfBoundsException`, `java.lang.NullPointerException`, `java.lang.ArithmeticException`
- Unchecked exceptions: `Error` and `RuntimeException` and subclasses.
- `Checked exceptions`: All other exceptions - programmer has to check and deal with them.

https://docs.oracle.com/javase/7/docs/api/java/lang/Throwable.html

Handling exceptions

- Three operations:
  - Declaring an exception
  - Throwing an exception
  - Catching an exception

```
method1(){
    try {
          method2();
    } catch (Exception e) {
             System.err.println(e.getMessage());
    }
}
method2() throws Exception{
    if(some error) {
        throw new Exception();
    }
}
```

CATCH EXCEPTION

DECLARE EXCEPTION

THROW EXCEPTION

https://docs.oracle.com/javase/tutorial/essential/exceptions/catch.html

Declaring exceptions

- Every method must state the types of *checked* exceptions it might throw in the method header so that the caller of the method is informed of the exception.
    - System errors and runtime exceptions can happen to any code, therefore Java does not require explicit declaration of unchecked exceptions.
- `public void exceptionalMethod() throws IOException{`
- `throws`: the method might throw an exception. Can also throw multiple exceptions, separated by comma.

https://docs.oracle.com/javase/specs/jls/se7/html/jls-8.html#jls-8.4.6

Throwing exceptions

- If an error is detected, then the program can throw an exception.
    - e.g., you have asked for age and the user gave you a string. You can throw an `IllegalArgumentException`.
- `throw new IllegalArgumentException(“Wrong argument”);`
    - The argument in the constructor is called the exception message. You can access it by invoking `getMessage()`.
- `throws` FOR DECLARING AN EXCEPTION, `throw` TO THROW AN EXCEPTION

https://docs.oracle.com/javase/tutorial/essential/exceptions/throwing.html

Catching exceptions

- An exception can be caught and handled in a try-catch block.

```
method(){
    try {
         statements; //statements that could thrown exception
    } catch (Exception1 e1) {
            //handle e1;
    }
    catch (Exception2 e2) {
            //handle e2;
    }
}
```

- If no exception is thrown, then the catch blocks are skipped.
- If an exception is thrown, the execution of the try block ends at the responsible statement.
- The order of catch blocks is important. A compile error will result if a catch block for a superclass type appears before a catch block for a subclass. E.g., catch(Exception ex) followed by catch(RuntimeException ex) won't compile.
- If a method declares a checked exception (e.g., `void p1() throws IOException`) and you invoke it, you have to enclose it in a try catch block or declare to throw the exception in the calling method (e.g., `try{ p1();} catch (IOException e){…}`.

https://docs.oracle.com/javase/specs/jls/se7/html/jls-8.html#jls-8.4.6

finally block

- Used when you want to execute some code regardless of whether an exception occurs or is caught

```
method(){
    try {
         statements; //statements that could thrown exception
    } catch (Exception1 e) {
            //handle e; catch is optional.
    }
    finally{
            //statements that are executed no matter what;
    }
}
```

- The `finally` block will execute no matter what. Even after a `return`.

https://docs.oracle.com/javase/tutorial/essential/exceptions/declaring.html

EXCEPTIONS

```java
/**
 * Illustrates try,catch, finally blocks
 * @author https://docs.oracle.com/javase/tutorial/essential/exceptions/putItTogether.html
 *
 */
import java.io.*;
import java.util.List;
import java.util.ArrayList;

public class ListOfNumbers {
	// Note: This class will not compile yet.

	private List<Integer> list;
	private static final int SIZE = 10;

	public ListOfNumbers() {
		list = new ArrayList<Integer>(SIZE);
		for (int i = 0; i < SIZE; i++) {
			list.add(new Integer(i));
		}
	}

	public void writeList() {
		PrintWriter out = null;

		try {
			System.out.println("Entering" + " try statement");

			out = new PrintWriter(new FileWriter("OutFile.txt"));
			for (int i = 0; i < SIZE; i++) {
				out.println("Value at: " + i + " = " + list.get(i));
			}
		} catch (IndexOutOfBoundsException e) {
			System.err.println("Caught IndexOutOfBoundsException: " + e.getMessage());

		} catch (IOException e) {
			System.err.println("Caught IOException: " + e.getMessage());

		} finally {
			if (out != null) {
				System.out.println("Closing PrintWriter");
				out.close();
			} else {
				System.out.println("PrintWriter not open");
			}
		}
	}

}
```

Practice Time

- 1. Is there anything wrong with this exception handler?

```
try {

} catch (Exception e) {

} catch (ArithmeticException a) {

}
```

Answers

- 1. The ordering matters! The second handler can never be reached and the code won't compile.

https://docs.oracle.com/javase/tutorial/essential/exceptions/QandE/answers.html

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Pre and post conditions

- Pre-condition: Specification of what must be true for method to work properly.
- Post-condition: Specification of what must be true at end of method if precondition held before execution.

https://docs.oracle.com/javase/8/docs/technotes/guides/language/assert.html

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I/O streams

- Input stream: a sequence of data into the program.
- Output stream: a sequence of data out of the program.
- Stream sources and destinations include disk files, keyboard, peripherals, memory arrays, other programs, etc.
- Data stored in variables, objects and data structures are temporary and lost when the program terminates. Streams allow us to save them in files, e.g., on disk or CD (!)
- Streams can support different kinds of data: bytes, principles, characters, objects, etc.

https://docs.oracle.com/javase/tutorial/essential/io/streams.html

Files

- Every file is placed in a directory in the file system.
- Absolute file name: the file name with its complete path and drive letter.
    - e.g., on Windows: `C:\apapoutsaki\somefile.txt`
    - On Mac/Unix: `/home/apapoutsaki.somefile.txt`
- `File`: contains methods for obtaining file properties, renaming, and deleting files. Not for reading/writing!
- CAUTION: DIRECTORY SEPARATOR IN WINDOWS IS \, WHICH IS SPECIAL CHARACTER IN JAVA. SHOULD BE "\\" INSTEAD.

TEXT I/O

```java
/**
 * Demonstrates File class and its operations.
 * @author https://liveexample.pearsoncmg.com/html/TestFileClass.html
 *
 */

import java.io.File;
import java.util.Date;

public class TestFile {
  public static void main(String[] args) {
    File file = new File("some.text");
    System.out.println("Does it exist? " + file.exists());
    System.out.println("The file has " + file.length() + " bytes");
    System.out.println("Can it be read? " + file.canRead());
    System.out.println("Can it be written? " + file.canWrite());
    System.out.println("Is it a directory? " + file.isDirectory());
    System.out.println("Is it a file? " + file.isFile());
    System.out.println("Is it absolute? " + file.isAbsolute());
    System.out.println("Is it hidden? " + file.isHidden());
    System.out.println("Absolute path is " + file.getAbsolutePath());
    System.out.println("Last modified on " + new Date(file.lastModified()));
  }
}
```

Writing data to a text file

- `PrintWriter output = new PrintWriter(new File(“filename”));`
- New file will be created. If already exists, discard.
- Invoking the constructor may throw an I/O Exception…
- `output.print` and `output.println` work with Strings, and primitives.
- Always close a stream!

TEXT I/O

```java
/**
 * Demonstrates how to write to text file.
 * @author https://liveexample.pearsoncmg.com/html/WriteData.html
 *
 */

import java.io.File;
import java.io.IOException;
import java.io.PrintWriter;

public class WriteData {
    public static void main(String[] args) {

        PrintWriter output = null;
        try {
            output = new PrintWriter(new File("addresses.txt"));
            // Write formatted output to the file
            output.print("Alexandra Papoutsaki ");
            output.println(222);
            output.print("Tom Yeh ");
            output.println(128);

        } catch (IOException e) {
            System.err.println(e.getMessage());
        } finally {
            if (output != null)
                output.close();
        }
    }
}
```

Reading data from a text file

- `java.util.Scanner` reads Strings and primitives.
- Breaks input into tokens, demoted by whitespaces.
- To read from keyboard: `Scanner input = new Scanner(System.in);`
- To read from file: `Scanner input = new Scanner(new File("filename"));`
- Need to close stream as before.
- `hasNext()` tells us if there are more tokens in the stream. `next()` returns one token at a time.
  - Variations of next are `nextLine()`, `nextByte()`, `nextShort()`, etc.

TEXT I/O

```java
/**
 * Demonstrates how to read data from a text file.
 * @author https://liveexample.pearsoncmg.com/html/ReadData.html
 *
 */

import java.io.File;
import java.io.IOException;
import java.util.Scanner;

public class ReadData {
    public static void main(String[] args) {

        Scanner input = null;
        // Create a Scanner for the file
        try {
            input = new Scanner(new File("addresses.txt"));

            // Read data from a file
            while (input.hasNext()) {
                String firstName = input.next();
                String lastName = input.next();
                int room = input.nextInt();
                System.out.println(firstName + " " + lastName + " " + room);
            }
        } catch (IOException e) {
            System.err.println(e.getMessage());
        } finally {
            if (input != null)
                input.close();
        }

    }
}
```

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GUIs

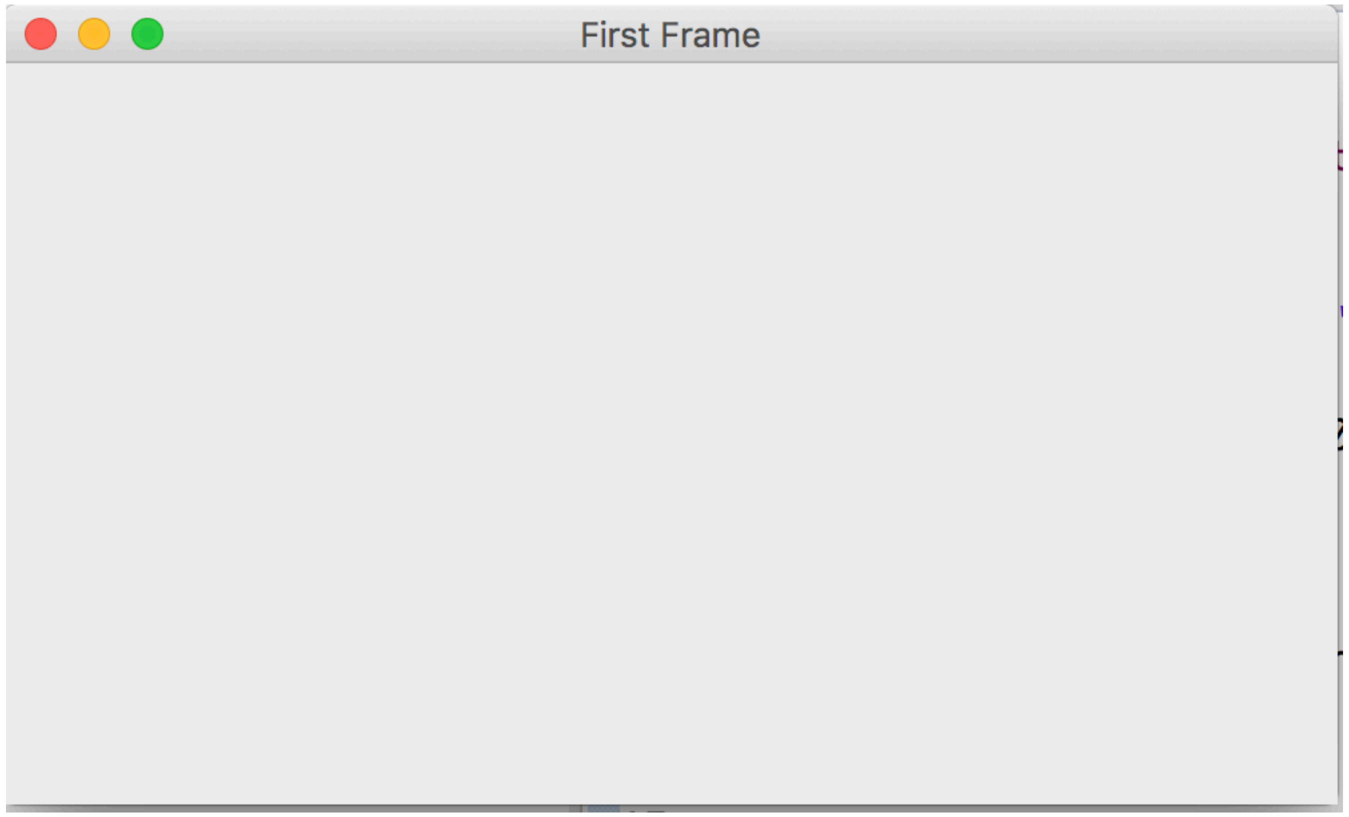
- AWT: The Abstract Windowing Toolkit is found in the package `java.awt`
  - Heavyweight components.
  - Implemented with native code written for that particular computer.
  - The AWT library was written in six weeks!
- Swing: Java 1.2 extended AWT with the `javax.swing` package.
  - Lightweight components.
  - Written in Java.

`JFrame`

- `javax.swing.JFrame` inherits from `java.awt.Frame`
- The outermost container in an application.
- To display a window in Java:
  - Create a class that extends `JFrame`.
  - Set the size.
  - Set the location.
  - Set it visible.

JFrame

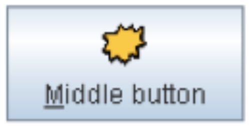
```
import javax.swing.JFrame;

public class MyFirstGUI extends JFrame {

    public MyFirstGUI() {
        super("First Frame");
        setSize(500, 300);
        setLocation(100, 100);
        setVisible(true);
    }

    public static void main(String[] args) {
        MyFirstGUI mfgui = new MyFirstGUI();
    }

}
```



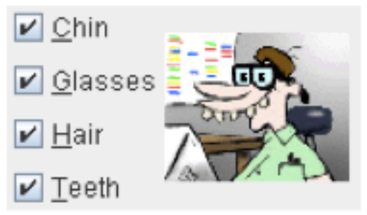
Closing a GUI

- The default operation of the quit button is to set the visibility to false. The program does not terminate!
- `setDefaultCloseOperation` can be used to control this behavior.
- `mfgui.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);`
- More options (hide, do nothing, etc).

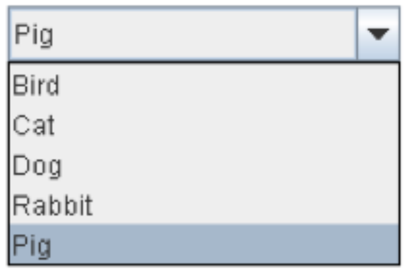
Basic components



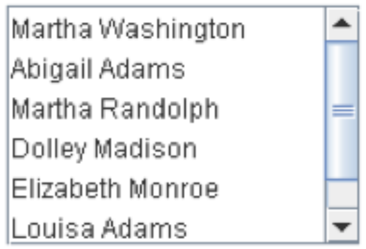
JButton



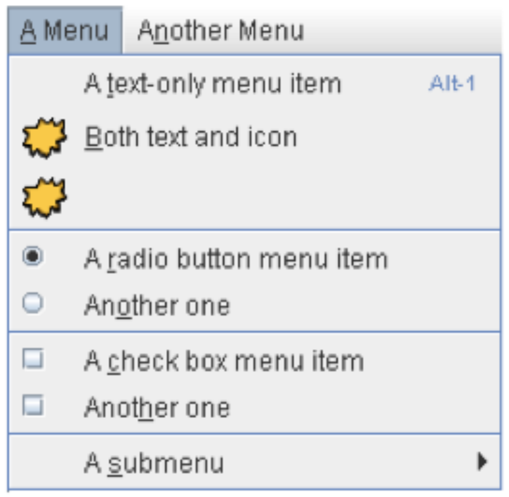
JCheckBox



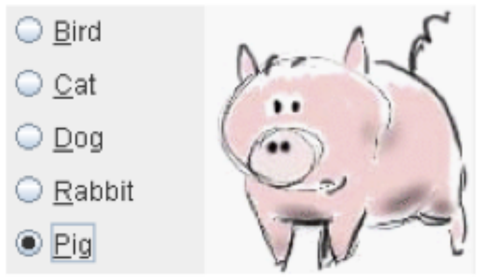
JComboBox



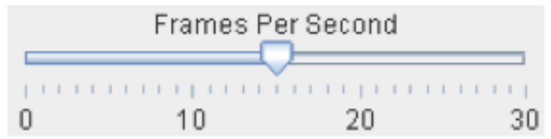
JList



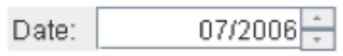
JMenu



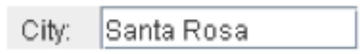
JRadioButton



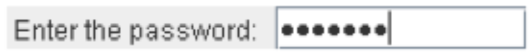
JSlider


Date: 07/2006

JSpinner

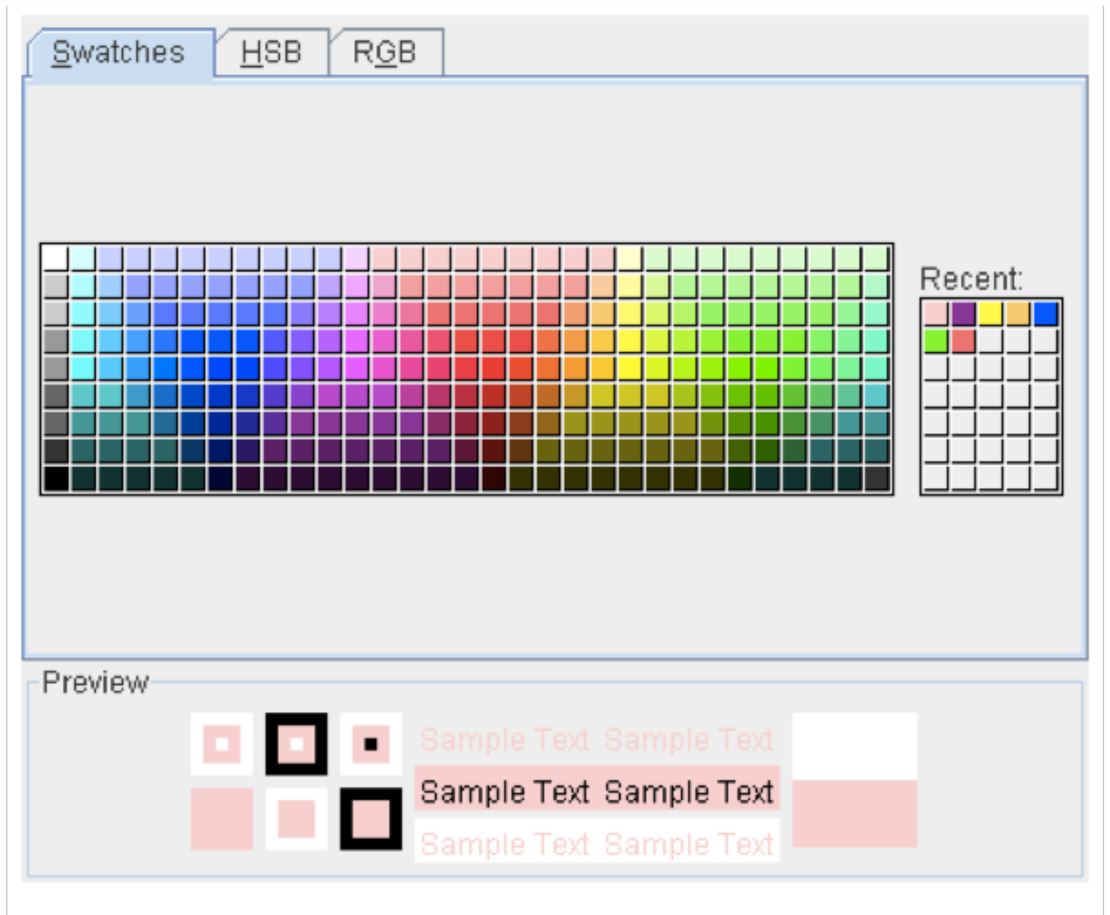

City: Santa Rosa

JTextField

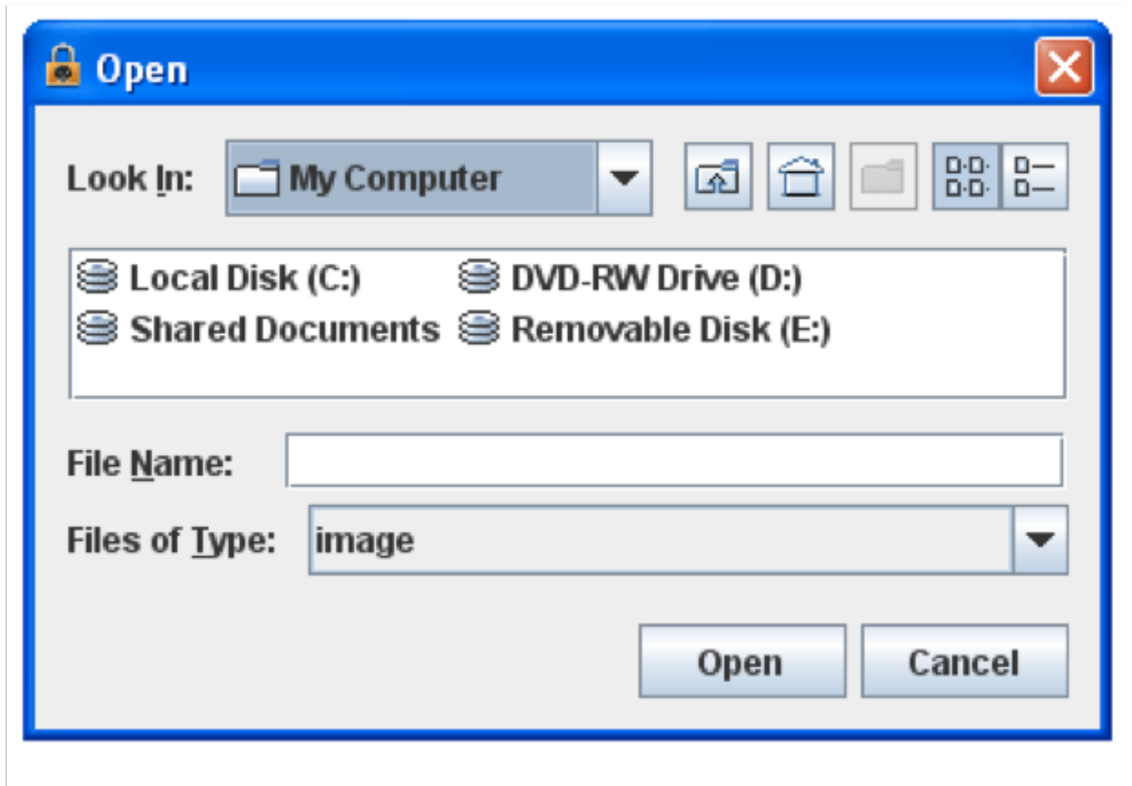

Enter the password: •••••••

JPasswordField

Interactive displays



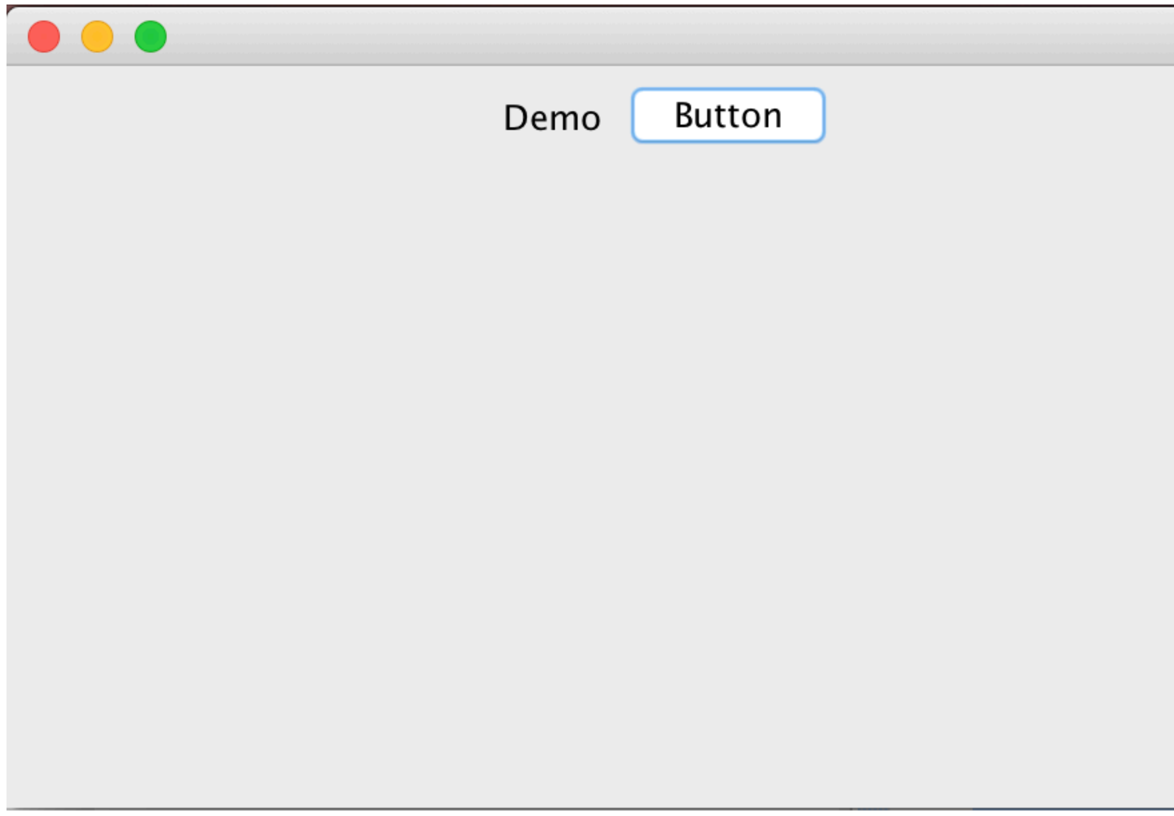
JColorChooser



JFileChooser

Adding JComponents to JFrame

```
import java.awt.Container;
import java.awt.FlowLayout;
import javax.swing.JButton;
import javax.swing.JFrame;
import javax.swing.JLabel;
import javax.swing.JPanel;

public class GUIDemo extends JFrame {
    public GUIDemo() {
        // Container cp = getContentPane();
        // cp.setLayout(new FlowLayout());
        // cp.add(new JLabel("Demo"));
        // cp.add(new JButton("Button"));
        JPanel mainPanel = new JPanel(new FlowLayout());
        mainPanel.add(new JLabel("Demo"));
        mainPanel.add(new JButton("Button"));
        setContentPane(mainPanel);
        setSize(500, 300);
        setVisible(true);
    }

    public static void main(String[] args) {
        GUIDemo gd = new GUIDemo();
        gd.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
    }
}
```



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Java Graphics

- Create arbitrary objects you want to draw:
  - `Rectangle2D.Double`, `Line.Double`, etc.
  - Constructors take x, y coordinates and dimensions, but don't actually draw items.
- All drawing takes place in `paint` method using a "graphics content".
- Triggered implicitly by uncovering window or explicitly by calling the `repaint` method.
  - Adds repaint event to draw queue and eventually draws it.

Graphics context

- All drawing is done in `paint` method of component.
- `public void paint (Graphics g)`
- `g` is a graphics context provided by the system.
- "pen" that does the drawing.
- You call `repaint()` not `paint()`.
- Need to import classes from `java.awt.*`, `java.geom.*`, `javax.swing.*`
- See `MyGraphicsDemo`.

General graphics applications

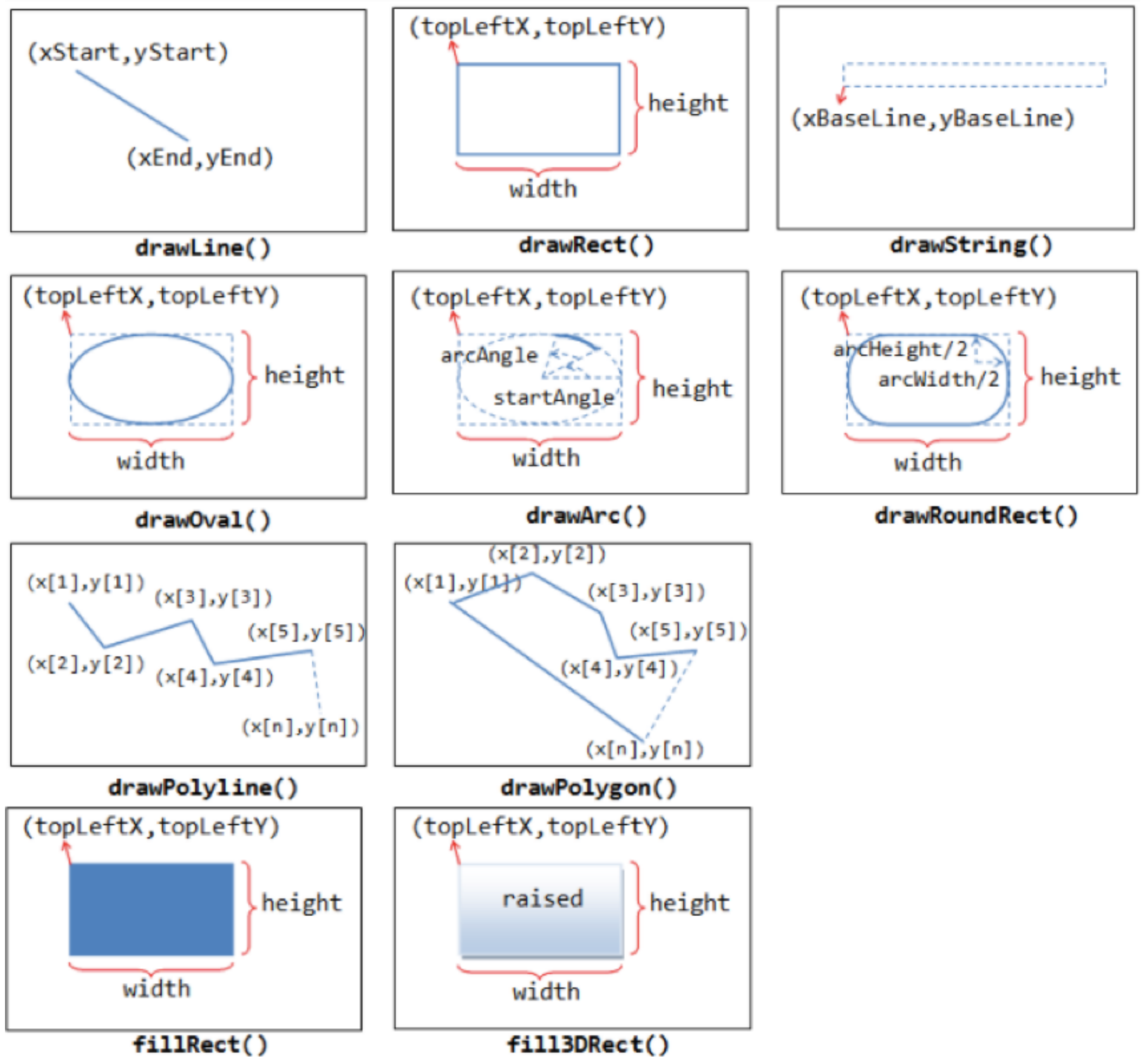
- Create an extension of component (`JPanel` or `JFrame`) and implement `paint` method in subclass.
- At start of `paint()` method cast `g` to `Graphics2D`.
- Call `repaint()` every time you want the component to be redrawn.

Geometric objects

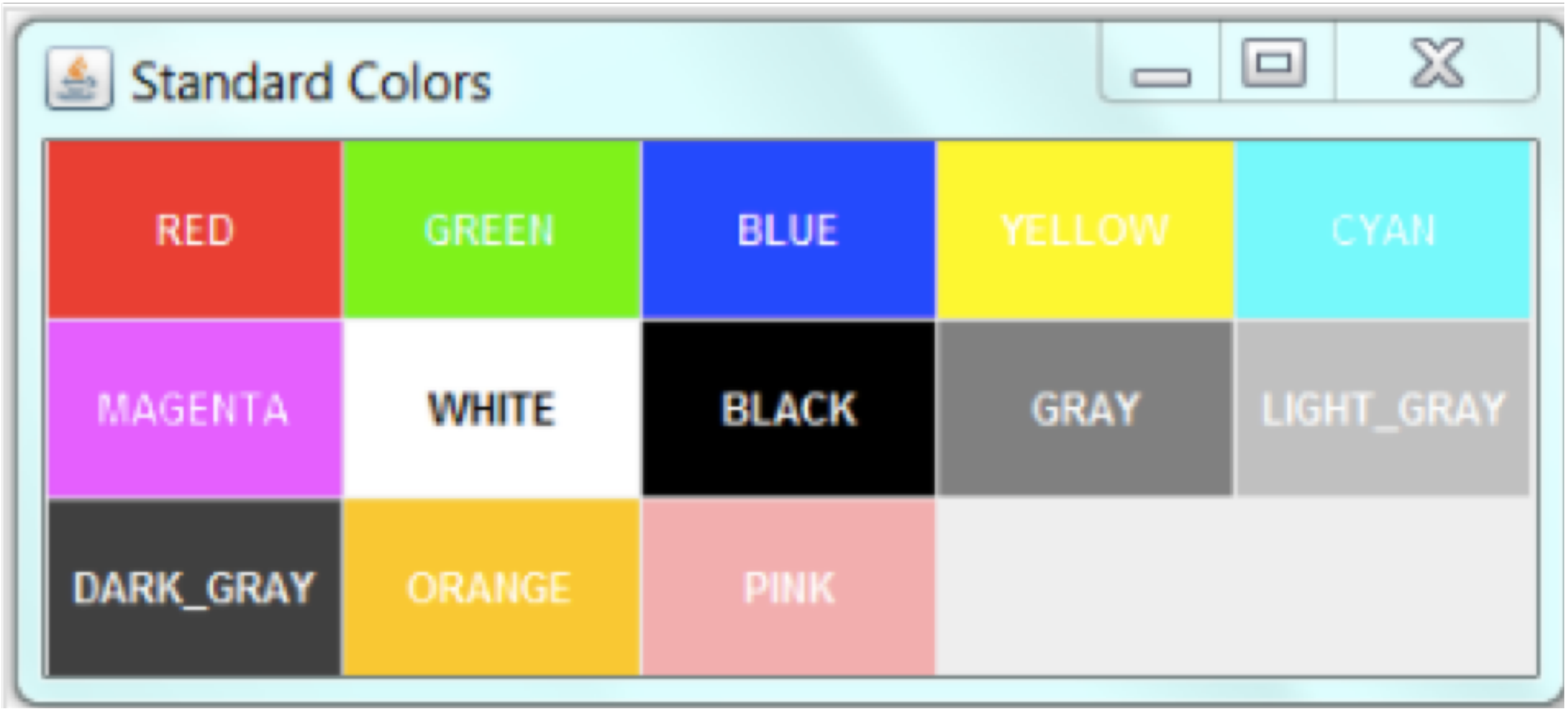
- Objects from classes `Rectangle2D.Double`, `Line2D.Double`, etc. from `java.awt.geom`
- Constructors take parameters x, y, width, height but don't draw object.
- `Rectangle2D.Double`
- `Ellipse2D.Double`
- `Arc2D.Double`
- etc.

Drawing

- `myObj.setFrame(x, y, width, height)`: moves and sets size of component
- `g2.draw(myObj)`: gives outline
- `g2.fill(myObj)`: gives filled version
- `g2.drawString(“a string”, x, y)`: draws string



java.awt.Color



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Action listeners

- Define what should be done when a user performs certain operations.
  - e.g., clicks a button, chooses a menu item, presses Enter, etc.
- The application should implement the ActionListener interface.
- An instance of the application should be registered as a listener on one or more components.
- Implement the `actionPerformed` method.

```
public class MultiButtonApp implements ActionListener {
    ...
        //where initialization occurs:
        button1.addActionListener(this);
        button2.addActionListener(this);

    ...
    public void actionPerformed(ActionEvent e) {
        if(e.getSource() == button1){
             //do something
        }
    }
}
```

https://docs.oracle.com/javase/tutorial/uiswing/events/actionlistener.html

Mouse listeners

- Define what should be done when a user enters a component, presses or releases one of the mouse buttons.
- The application should implement the [MouseListener] interface
  - Implement methods `mousePressed`, `mouseReleased`, mouseEntered, mouseExited, and `mouseClicked`.
- **Or** extend the [MouseAdapter] class
  - Which has default implementations of all of them.

```
public class MouseEventDemo ... implements MouseListener {
        //where initialization occurs:
        //Register for mouse events on blankArea and the panel.
        blankArea.addMouseListener(this);
        addMouseListener(this);
    ...

    public void mousePressed(MouseEvent e) {
       saySomething("Mouse pressed; # of clicks: "
                    + e.getClickCount(), e);
    }
```

https://docs.oracle.com/javase/tutorial/uiswing/events/mouselistener.html

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Readings:

- Oracle's guides:
  - JavaDoc: https://www.oracle.com/technetwork/articles/java/index-137868.html
  - Exceptions: https://docs.oracle.com/javase/tutorial/essential/exceptions/
  - Assertions: https://docs.oracle.com/javase/8/docs/technotes/guides/language/assert.html
  - I/O: https://docs.oracle.com/javase/tutorial/essential/io
  - Writing Event Listeners: https://docs.oracle.com/javase/tutorial/uiswing/events/index.html
- Java Graphics: https://github.com/pomonacs622021fa/Handouts/blob/master/graphics.md
- Programming with GUIs: https://github.com/pomonacs622021fa/Handouts/blob/main/JavaGUI.pdf
- Swing/GUI Cheat Sheet: https://github.com/pomonacs622021fa/Handouts/blob/master/swing.md
- Textbook:
  - Chapter 1.2 (Page 107)