Programming graphics

- Need a window – `javax.swing.JFrame`
  - Several essential steps to use (necessary "plumbing"):
    - Set the size – width and height in pixels
    - Set a title (optional), and a close operation
    - Make it visible
  - See EmptyFrameViewer.java (p. 59)
- Add `javax.swing.JComponents` to window
  - Draw shapes, colors, … on these components
- That's all there is to it!
  - Except for the painstaking labor, of course

Drawing rectangles for example

- Define class that `extends JComponent`
  - Or a subclass like `JPanel` for additional features
- Implement `paintComponent` method
  - Use `Graphics` object passed to this method
    - Actually a `Graphics2D` object since Java 1.2
  - Then let that object draw `Rectangle` objects
  - See RectangleComponent.java (p. 61)
- Add the component to a frame for viewing
  - e.g., RectangleViewer.java

`java.awt.Graphics2D`

- Is a subclass of `java.awt.Graphics`
  - So cast is allowed; and `Graphics` methods inherited
  - If don't cast, must use primitive drawing methods:
    - e.g., `drawRect(int, int, int, int)`, `fillOval(int, int, int, int)`, …
    - i.e., not object-oriented – so lots of work to use/reuse
- But `Graphics2D` can do a *lot* more stuff
  - e.g., `draw(java.awt.Shape)` draws any `Shape`, including `Rectangle`, `Ellipse2D`, `Polygon`, …
  - `fill(Shape)` draws and fills `Shape` with current color

Drawing more complex shapes

- Text example (p. 114-116) – Car.java
  - Acts like a `Car` that can draw itself
  - `Car` constructor sets `x` and `y` locations
  - Includes `draw(Graphics2D g2)` method
    - Lets `Graphics2D` object draw lines, ellipses, rectangles
- A class like CarComponent.java just uses it:

```
Car myCar = new Car(x, y);
myCar.draw(g2); // passes reference to graphics object
```

- Still need a view window, like CarViewer.java

C o l o r

- *Current* color applies to text, lines, and fills:

```
g2.setColor(Color.RED);
g2.draw(…); // draws … in red
g2.setColor(Color.BLUE);
g2.fill(…); // fills … with blue
```

- Custom colors available:
  - Can set by `float` values in range `0.0F` to `1.0F`:

```
Color gb = new Color(0.0F, 0.7F, 1.0F);
g2.setColor(gb);
```

  - Or by `int` values in range `0` to `255`:

```
Color bg = new Color(0, 255, 175);
```

Rendering text with `Graphics2D`

- Actually necessary to "draw" the text at a specified location on the Graphics object
  - `g.drawString(aString, x, y)` – uses current rendering context (e.g., color), and current text attributes (e.g., font)
- Font: a *face* name, a *style*, and a point *size*

```
Font f =
new Font("Serif", Font.BOLD, 24);
g2.setFont(f); // sets font for g2
```

Applets – an alternate approach

- A way to run a program – but *not an application*
  - No `main` method necessary
- Need a subclass of Applet (or JApplet)
  - So: `class __ extends Applet` (or `extends JApplet`)
- Most web browsers know how to create a new applet, and how to use certain Applet methods
  - So, applets must be embedded in an html page
  - And, to be useful, they must include at least one of the methods the browser invokes (e.g., `paint`)

"Running" an Applet

- The applet is started by the web browser as soon as the web page (html file) is visited
- The html file (stands for hypertext markup language) — must have an applet tag in it:

```
<applet code=AppletClassName.class
        width=### height=###>
</applet> <!-- needs a closing tag too -->
```

- The browser works in a certain order:
  - Creates a new applet object – includes a window, a Graphics object, lots of `class Applet` methods
  - Invokes (1) `init` – once, (2) `start` – first & return visits, (3) `paint` – first & every need to paint (also `stop`, `destroy`)

Implementing a "simple" applet

- `import javax.swing.JApplet;` // mandatory
  - Also usually Graphics and Graphics2D and others
- Declare a class that extends JApplet:
  `public class RectangleApplet extends JApplet`
- Implement `paint` method (at least)
  - Same procedures as `paintComponent` for components
- Create an html file to load the applet in a web browser or the `appletviewer` (provided with JDK)
- See RectangleApplet.java (p. 63) and related html files (p. 64)

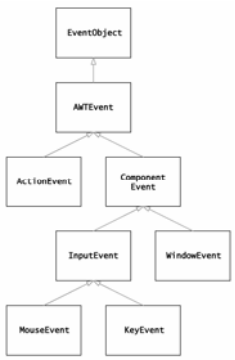
Images

- Images are not drawings
  - You don't draw them, you show them
  - But `Graphics` method is called `drawImage` anyway
- `Image` is an abstract class
  - Generally, create instance by loading from file or URL
  - Can also create/edit by classes in java.awt.image
- Applets know how to get images (ImageApplet)
  - Applications use `Toolkit` to get (demo)

```
Toolkit.getDefaultToolkit().getImage("javacup.gif");
```

Events

- Signals from the outside
  - Usually user initiates:
    - Mouse click, button push, menu-select, enter text, …
  - Not always: TimerTester.java
- Each event has a type – a class in `java.awt.event`
  - So each event is an object
  - Created *almost constantly* (by Java window manager)



Event sources

- Technically: can be any external signal
  - Including from a different program or system
    - e.g., a "client" applet contacting a web "server"
  - In a GUI, focus is on user signals
- Java `Components` generate the events
  - Each component generates different event types, e.g.:
    - Panels (inc. Applets) → `MouseEvents`
    - Textfields and buttons → `ActionEvents`
    - Windows → `WindowEvents`
    - Keyboard → `KeyEvents`
  - Components *inform* a list of `Listeners` about events

Listeners

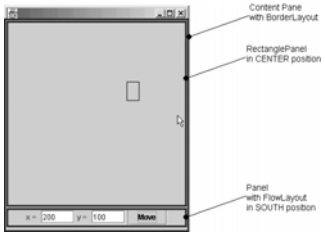
- Objects that components tell about events
  - Must have methods a component can invoke
    - i.e., *implements* one of the `Listener` interfaces
  - Must be added to a component's listener list
- Different listeners apply to different messages
  - `ActionListener` – `actionPerformed`
    - e.g., ClickListener (with ButtonTester.java)
  - `MouseListener` – `mouseClicked`, `mouseEntered`, …
    - e.g., MouseSpy demo (from 1st edition of textbook)
- Note: also can extend `Adapter` class instead of implement listeners directly – saves busywork ☺

Inner class listeners

- Can access private instance variables of outer class
  - Stores implicit reference to outer class object
  - So can often "handle" events more easily
    - e.g., RectangleComponentViewer.java
- Notice they can access `final` local variables too
  - Another example: TimerTester2.java
  - *Must* be final so no ambiguity about value
  - For example, no opportunity for variable to go out of scope while object exists

Laying out GUI components

- Depends on layout manager
  - Defaults:
    - JFrame: `BorderLayout`
    - JPanel: `FlowLayout`
  - Others:
    - `GridLayout`
    - `GridBagLayout`
- Can set new, and even make custom



Choosing a layout manager

- e.g., a grid layout for calculator buttons:

```
panel.setLayout( new
  GridLayout(4,3) );
panel.add(button7);
panel.add(button8);
panel.add(button9);
panel.add(button4);
...
```

- e.g., CS10Display.java

Text components

- `JLabel` – not for user input, just display
- `JTextField` – for one row of text
  - new JTextField(), or (int columns)
  - getText(), setText(String), setFont(Font), setEditable(boolean), … (mostly inherited)
  - ActionEvent on <enter>
- `JTextArea` – for multiple rows of text
  - new JTextArea(), or (int rows, int columns)
  - Same methods inherited from JTextComponent
  - Generates no events, so usually use with a button

Choices

- Choice objects generate `ActionEvents`
- Handlers for `JCheckBox` and `JRadioButton`: use `boolean` method `isSelected()`
  - Note: put radio buttons in a `ButtonGroup` – so just one can be selected at a time
  - For same reason – should visually group them in a panel with a border, like `EtchedBorder`
- For `JComboBox`: use `getSelectedItem()`
  - Note: returns `Object` – usually cast to `String`
- e.g., ChoiceFrame.java (see FontViewer.java, pp. 794-798)

Menus

- Steps to implement `swing` menus:
  - 1. Add a menu bar to a `JFrame`

```
JMenuBar bar = new JMenuBar();
setJMenuBar(bar);
```

  - 2. Add menus to the menu bar

```
JMenu fileMenu = new JMenu("File");
bar.add(fileMenu);
```

  - 3. Add menu items to the menus, & listeners to items

```
JMenuItem openItem = new JMenuItem("Open");
fileMenu.add(openItem);
openItem.addActionListener(listener);
```

- e.g., MenuFrame.java (see FontViewer2.java, pp. 803-7)

Sliders, and more `swinging`

- Note - good text section 18.4, pp. 808-814: should read while browsing API on web
  - About how to "discover" `swing` features/usage
    - Focuses on `JSlider` – generates `ChangeEvents`, so `addChangeListener(listener)`, where listener implements `stateChanged` method
    - Requires `javax.swing.event` for "change" events
  - e.g., SliderFrame.java (see ColorViewerFrame.java, pp. 812-814)
- Explore `swing` as needed, or even just for fun
  - Buy a book, or look at API classes starting with "`J`"
  - Or just run the SwingSet demo from the JDK