

Graphics

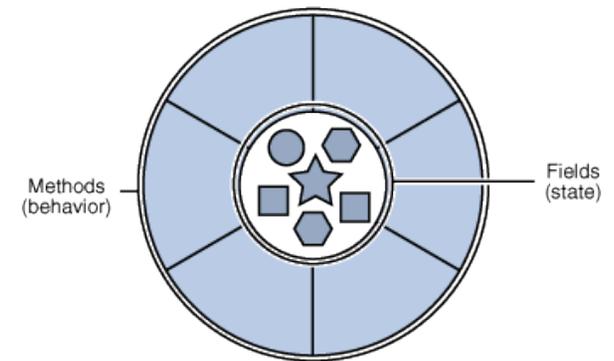
Subset of the Supplement Lesson slides from: Building Java Programs, Chapter 3 Graphics
by Stuart Reges and Marty Stepp (<http://www.buildingjavaprograms.com/>)

Classes and objects

- **class:** A program entity that represents either:
 1. A program / module, or
 2. A type of objects.
 - A class is a blueprint or template for constructing objects.
 - Example: The `DrawingPanel` class (type) is a template for creating many `DrawingPanel` objects (windows).
 - Java has 1000s of classes. Later (Ch.8) we will write our own.
- **object:** An entity that combines data and behavior.
 - **object-oriented programming (OOP):** Programs that perform their behavior as interactions between objects.

Objects

- **object:** An entity that contains data and behavior.
 - *data:* variables inside the object
 - *behavior:* methods inside the object
 - You interact with the methods; the data is hidden in the object.



- Constructing (creating) an object:
Type **objectName** = new **Type** (**parameters**) ;
- Calling an object's method:
objectName . **methodName** (**parameters**) ;

Blueprint analogy

iPod blueprint/factory

state:

current song
volume
battery life

behavior:

power on/off
change station/song
change volume
choose random song



creates

iPod #1

state:

song = "1,000,000 Miles"
volume = 17
battery life = 2.5 hrs

behavior:

power on/off
change station/song
change volume
choose random song



iPod #2

state:

song = "Letting You"
volume = 9
battery life = 3.41 hrs

behavior:

power on/off
change station/song
change volume
choose random song



iPod #3

state:

song = "Discipline"
volume = 24
battery life = 1.8 hrs

behavior:

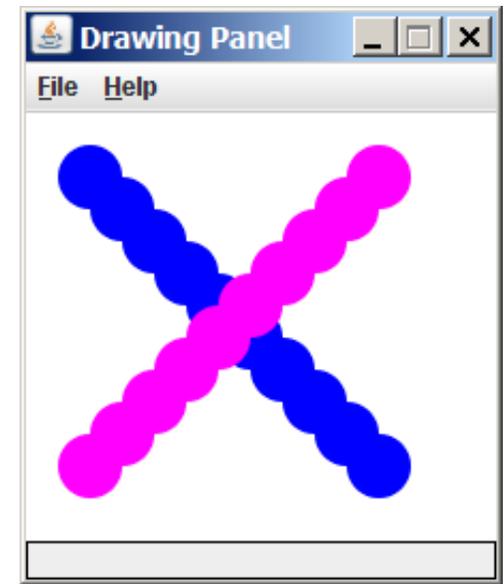
power on/off
change station/song
change volume
choose random song



Graphical objects

We will draw graphics in Java using 3 kinds of objects:

- `DrawingPanel`: A window on the screen.
 - Not part of Java; provided by the authors. See class web site.
- `Graphics`: A "pen" to draw shapes and lines on a window.
- `Color`: Colors in which to draw shapes.



DrawingPanel



"Canvas" objects that represents windows/drawing surfaces

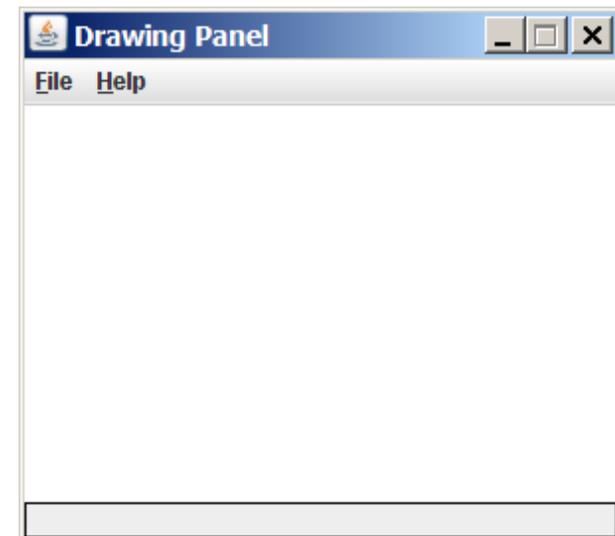
- To create a window:

```
DrawingPanel name = new DrawingPanel(width, height) ;
```

Example:

```
DrawingPanel panel = new DrawingPanel(300, 200) ;
```

- The window has nothing on it.
 - We draw shapes / lines on it with another object of type `Graphics`.



Graphics



"Pen" or "paint brush" objects to draw lines and shapes

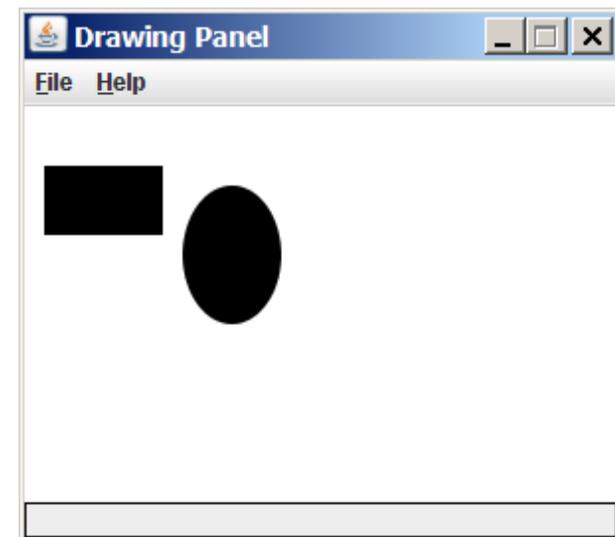
- Access it by calling `getGraphics` on your `DrawingPanel`.

```
Graphics g = panel.getGraphics();
```

- Draw shapes by calling methods on the `Graphics` object.

```
g.fillRect(10, 30, 60, 35);
```

```
g.fillOval(80, 40, 50, 70);
```



Java class libraries, import

- **Java class libraries:** Classes included with Java's JDK.
 - organized into groups named *packages*
 - To use a package, put an *import declaration* in your program:

```
// put this at the very top of your program
import packageName.*;
```

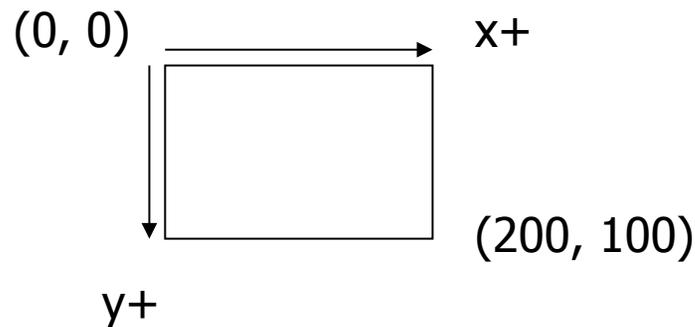
- `Graphics` belongs to a package named `java.awt`

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

- To use `Graphics`, you must place the above line at the very top of your program, before the `public class` header.

Coordinate system

- Each (x, y) position is a *pixel* ("picture element").
- Position $(0, 0)$ is at the window's top-left corner.
 - x increases rightward and the y increases downward.
- The rectangle from $(0, 0)$ to $(200, 100)$ looks like this:



Graphics methods

| Method name | Description |
|--|--|
| <code>g.drawLine(x1, y1, x2, y2) ;</code> | line between points $(x1, y1)$, $(x2, y2)$ |
| <code>g.drawOval(x, y, width, height) ;</code> | outline largest oval that fits in a box of size $width * height$ with top-left at (x, y) |
| <code>g.drawRect(x, y, width, height) ;</code> | outline of rectangle of size $width * height$ with top-left at (x, y) |
| <code>g.drawString(text, x, y) ;</code> | text with bottom-left at (x, y) |
| <code>g.fillOval(x, y, width, height) ;</code> | fill largest oval that fits in a box of size $width * height$ with top-left at (x, y) |
| <code>g.fillRect(x, y, width, height) ;</code> | fill rectangle of size $width * height$ with top-left at (x, y) |
| <code>g.setColor(Color) ;</code> | set Graphics to paint any following shapes in the given color |

Color



- Specified as predefined `Color` class constants:

`Color`.**CONSTANT_NAME**

where **CONSTANT_NAME** is one of:

`BLACK,` `BLUE,` `CYAN,` `DARK_GRAY,` `GRAY,`
`GREEN,` `LIGHT_GRAY,` `MAGENTA,` `ORANGE,`
`PINK,` `RED,` `WHITE,` `YELLOW`

- Or create one using Red-Green-Blue (RGB) values of 0-255

```
Color name = new Color(red, green, blue);
```

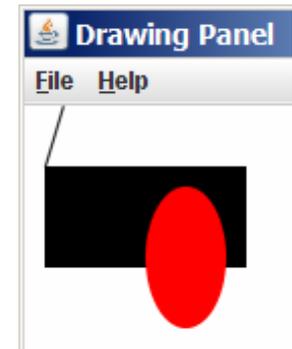
– Example:

```
Color brown = new Color(192, 128, 64);
```

Using colors

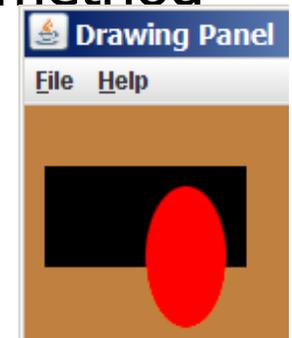
- Pass a `Color` to Graphics object's `setColor` method
 - Subsequent shapes will be drawn in the new color.

```
g.setColor(Color.BLACK);  
g.fillRect(10, 30, 100, 50);  
g.drawLine(20, 0, 10, 30);  
g.setColor(Color.RED);  
g.fillOval(60, 40, 40, 70);
```



- Pass a color to `DrawingPanel`'s `setBackground` method
 - The overall window background color will change.

```
Color brown = new Color(192, 128, 64);  
panel.setBackground(brown);
```



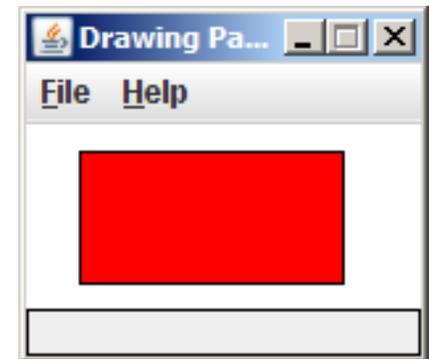
Outlined shapes

- To draw a colored shape with an outline, first *fill* it, then *draw* the same shape in the outline color.

```
import java.awt.*; // so I can use Graphics
public class OutlineExample {
    public static void main(String[] args) {
        DrawingPanel panel = new DrawingPanel(150, 70);
        Graphics g = panel.getGraphics();

        // inner red fill
        g.setColor(Color.RED);
        g.fillRect(20, 10, 100, 50);

        // black outline
        g.setColor(Color.BLACK);
        g.drawRect(20, 10, 100, 50);
    }
}
```

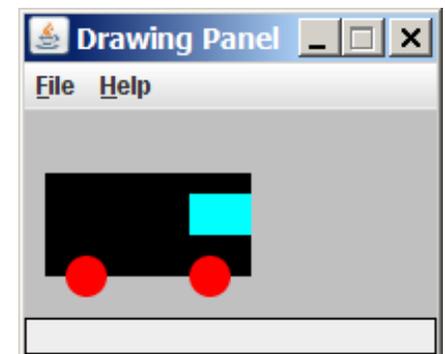


Superimposing shapes

- When ≥ 2 shapes occupy the same pixels, the last drawn "wins."

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

```
public class Car {  
    public static void main(String[] args) {  
        DrawingPanel panel = new DrawingPanel(200, 100);  
        panel.setBackground(Color.LIGHT_GRAY);  
        Graphics g = panel.getGraphics();  
  
        g.setColor(Color.BLACK);  
        g.fillRect(10, 30, 100, 50);  
  
        g.setColor(Color.RED);  
        g.fillOval(20, 70, 20, 20);  
        g.fillOval(80, 70, 20, 20);  
  
        g.setColor(Color.CYAN);  
        g.fillRect(80, 40, 30, 20);  
    }  
}
```



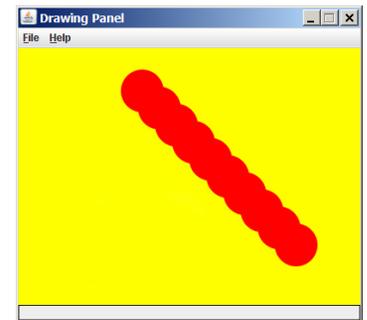


Graphics with Loops!

Drawing with loops

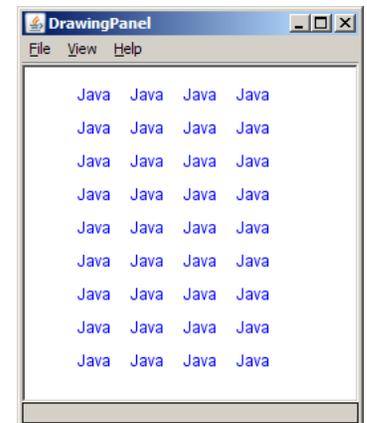
- The x, y, w, h expressions can use the loop counter variable:

```
panel.setBackground(Color.YELLOW);
g.setColor(Color.RED);
for (int i = 1; i <= 10; i++) {
    //           x           y           w           h
    g.fillOval(100 + 20 * i, 5 + 20 * i, 50, 50);
}
```



- Nested loops can be used with graphics:

```
g.setColor(Color.BLUE);
for (int x = 1; x <= 4; x++) {
    for (int y = 1; y <= 9; y++) {
        g.drawString("Java", x * 40, y * 25);
    }
}
```

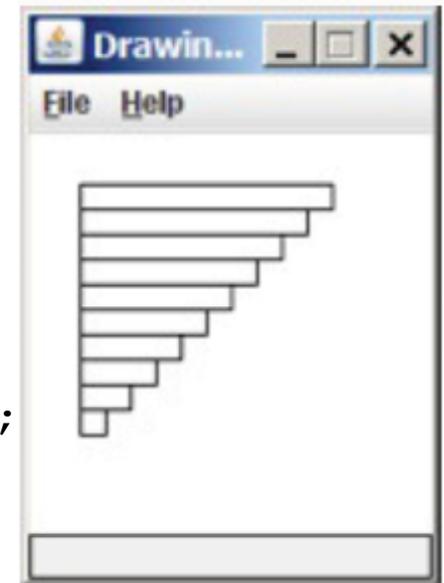


Zero-based loops

Beginning at 0 and using < can make coordinates easier.

- Example: Draw ten stacked rectangles starting at (20, 20), height 10, width starting at 100 and decreasing by 10 each time:

```
DrawingPanel panel = new DrawingPanel(160, 160);  
Graphics g = panel.getGraphics();  
for (int i = 0; i < 10; i++) {  
    g.drawRect(20, 20 + 10 * i, 100 - 10 * i, 10);  
}  
                x,          y,          width,          height
```

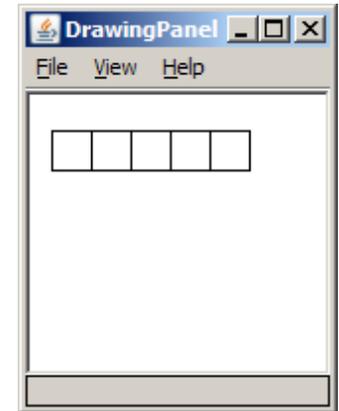


Zero-based loops

- Beginning at 0 and using `<` can make coordinates easier.

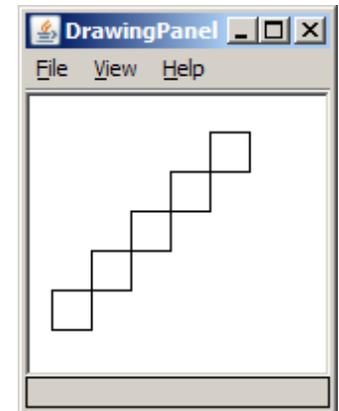
```
DrawingPanel panel = new DrawingPanel(150, 140);  
Graphics g = panel.getGraphics();
```

```
// horizontal line of 5 20x20 rectangles starting  
// at (11, 18); x increases by 20 each time  
for (int i = 0; i < 5; i++) {  
    g.drawRect(11 + 20 * i, 18, 20, 20);  
}
```



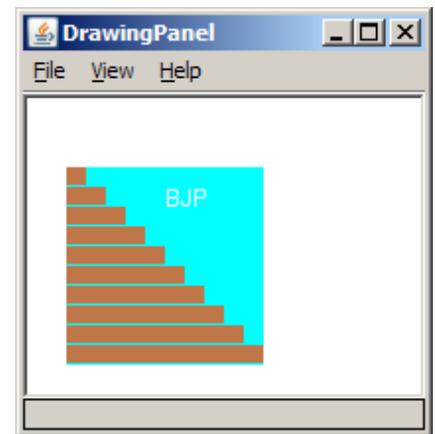
- Exercise: Write a variation of the above program that draws the output at right.
 - The bottom-left rectangle is at (11, 98).

```
for (int i = 0; i < 5; i++) {  
    g.drawRect(11 + 20 * i, 98 - 20 * i, 20, 20);  
}
```



Java book figure

- Write a program that draws the following figure:
 - drawing panel is size 200x150
 - book is at (20, 35), size 100x100
 - cyan background
 - white "BJP" text at position (70, 55)
 - stairs are in color (red=191, green=118, blue=73)
 - each stair is 9px tall
 - 1st stair is 10px wide
 - 2nd stair is 20px wide ...
 - stairs are 10px apart (1 blank pixel between)



Java book solution

```
// Draws a Building Java Programs textbook with DrawingPanel.
import java.awt.*;

public class Book {
    public static void main(String[] args) {
        DrawingPanel panel = new DrawingPanel(200, 150);
        panel.setBackground(Color.WHITE);
        Graphics g = panel.getGraphics();

        g.setColor(Color.CYAN);           // cyan background
        g.fillRect(20, 35, 100, 100);

        g.setColor(Color.WHITE);         // white "bjp" text
        g.drawString("BJP", 70, 55);

        g.setColor(new Color(191, 118, 73));
        for (int i = 0; i < 10; i++) {    // orange "bricks"
            g.fillRect(20, 35 + 10 * i, 10 + 10 * i, 9);
        }
    }
}
```

Practice

- Create some graphics using shapes and loops

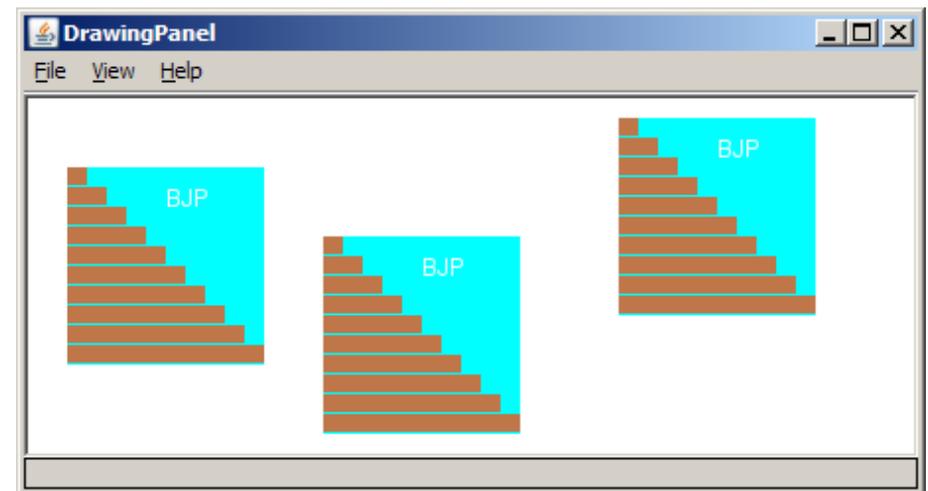


Graphics Methods & adding Parameters

Alternative Presentation

Multiple Java books

- Modify the Java book program so that it can draw books at different *positions* as shown below.
 - book top/left positions: (20, 35), (150, 70), (300, 10)
 - drawing panel's new size: 450x180



Multiple books solution

- To draw in a method, you must pass `Graphics g` to it.

```
// Draws many BJP textbooks using parameters.
```

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

```
public class Book2 {
```

```
    public static void main(String[] args) {
```

```
        DrawingPanel panel = new DrawingPanel(450, 180);
```

```
        panel.setBackground(Color.WHITE);
```

```
        Graphics g = panel.getGraphics();
```

```
        // draw three books at different locations
```

```
        drawBook(g, 20, 35);
```

```
        drawBook(g, 150, 70);
```

```
        drawBook(g, 300, 10);
```

```
    }
```

```
    ...
```

Multiple books, cont'd.

...

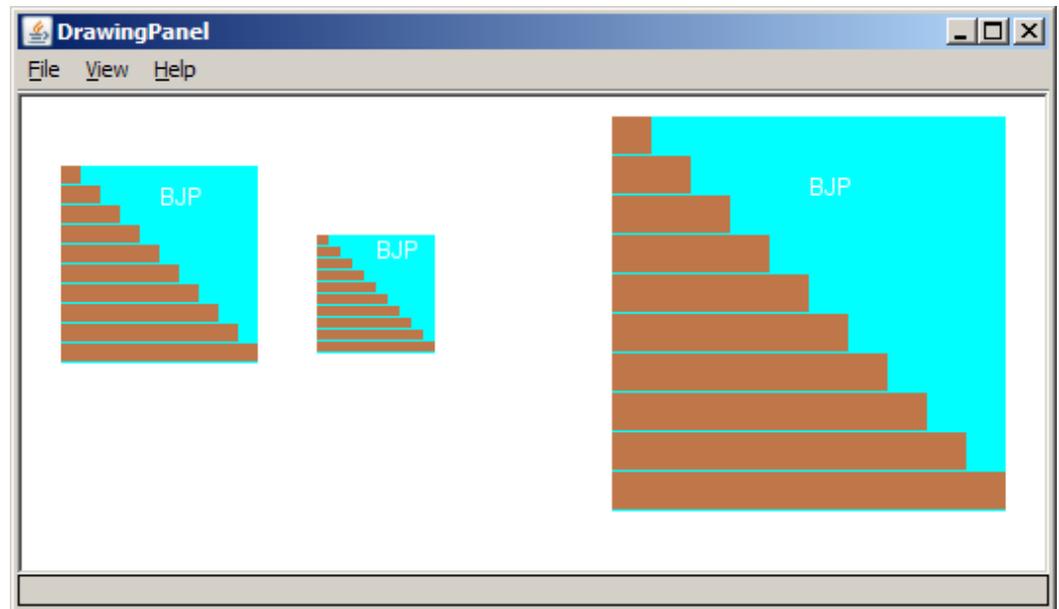
```
// Draws a BJP textbook at the given x/y position.
public static void drawBook(Graphics g, int x, int y) {
    g.setColor(Color.CYAN);           // cyan background
    g.fillRect(x, y, 100, 100);

    g.setColor(Color.WHITE);          // white "bjp" text
    g.drawString("BJP", x + 50, y + 20);

    g.setColor(new Color(191, 118, 73));
    for (int i = 0; i < 10; i++) {    // orange "bricks"
        g.fillRect(x, y + 10 * i, 10 * (i + 1), 9);
    }
}
}
```

Resizable Java books

- Modify the Java book program so that it can draw books at different *sizes* as shown below.
 - book sizes: 100x100, 60x60, 200x200
 - drawing panel's new size: 520x240



Resizable books solution

```
// Draws many sized BJP textbooks using parameters.
import java.awt.*;

public class Book3 {
    public static void main(String[] args) {
        DrawingPanel panel = new DrawingPanel(520, 240);
        panel.setBackground(Color.WHITE);
        Graphics g = panel.getGraphics();

        // draw three books at different locations/sizes
        drawBook(g, 20, 35, 100);
        drawBook(g, 150, 70, 60);
        drawBook(g, 300, 10, 200);
    }

    ...
}
```

Resizable solution, cont'd.

...

```
// Draws a book of the given size at the given position.
public static void drawBook(Graphics g, int x, int y, int size) {
    g.setColor(Color.CYAN);           // cyan background
    g.fillRect(x, y, size, size);

    g.setColor(Color.WHITE);          // white "bjp" text
    g.drawString("BJP", x + size/2, y + size/5);

    g.setColor(new Color(191, 118, 73));
    for (int i = 0; i < 10; i++) {    // orange "bricks"
        g.fillRect(x,                 // x
                  y + size/10 * i,    // y
                  size/10 * (i + 1),  // width
                  size/10 - 1);       // height
    }
}
}
```

Polygon

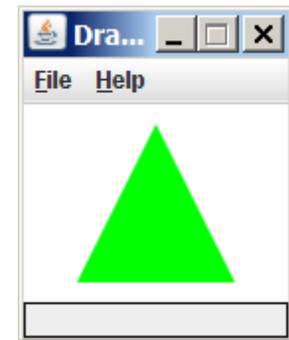
Objects that represent arbitrary shapes

- Add points to a `Polygon` using its `addPoint(x, y)` method.

- Example:

```
DrawingPanel p = new DrawingPanel(100, 100);  
Graphics g = p.getGraphics();  
g.setColor(Color.GREEN);
```

```
Polygon poly = new Polygon();  
poly.addPoint(10, 90);  
poly.addPoint(50, 10);  
poly.addPoint(90, 90);  
g.fillPolygon(poly);
```



DrawingPanel methods

- **panel.clear()** ;
Erases any shapes that are drawn on the drawing panel.
- **panel.setWidth(width)** ;
panel.setHeight(height) ;
panel.setSize(width, height) ;
Changes the drawing panel's size to the given value(s).
- **panel.save(filename)** ;
Saves the image on the panel to the given file (String).
- **panel.sleep(ms)** ;
Pauses the drawing for the given number of milliseconds.

Animation with `sleep`

- `DrawingPanel`'s `sleep` method pauses your program for a given number of milliseconds.
- You can use `sleep` to create simple animations.

```
DrawingPanel panel = new DrawingPanel(250, 200);  
Graphics g = panel.getGraphics();
```

```
g.setColor(Color.BLUE);  
for (int i = 1; i <= 10; i++) {  
    g.fillOval(15 * i, 15 * i, 30, 30);  
    panel.sleep(500);  
}
```

- Try adding `sleep` commands to loops in past exercises in this chapter and watch the panel draw itself piece by piece.