Building Java Programs

Graphics

Reading: Supplement 3G

Lecture outline

- drawing 2D graphics
  - `DrawingPanel` and `Graphics` objects
  - drawing and filling shapes
  - coordinate system
  - colors

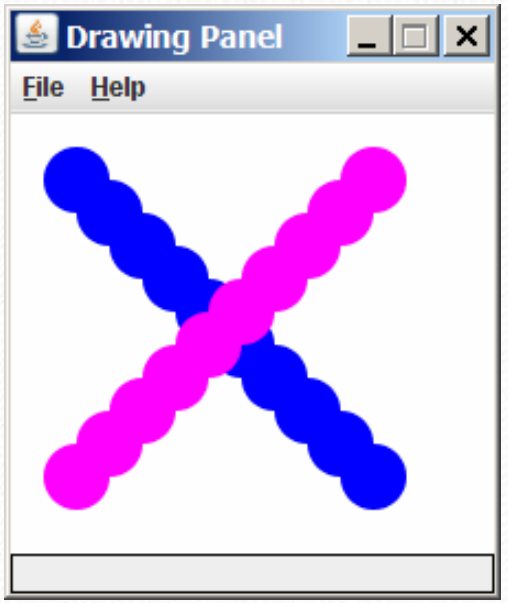
  - drawing with loops
  - drawing with parameterized methods

  - advanced topics: custom colors, polygons, animation

Graphical objects

- We will draw graphics using these kinds of *objects*:
  - `DrawingPanel`: A window on the screen.
    - Not part of Java; provided by the authors.
  - `Graphics`: A "pen" to draw shapes/lines on a window.
  - `Color`: Colors in which to draw shapes.

- **object:** An entity that contains data and behavior.
  - data: Variables inside the object.
  - behavior: Methods inside the object.



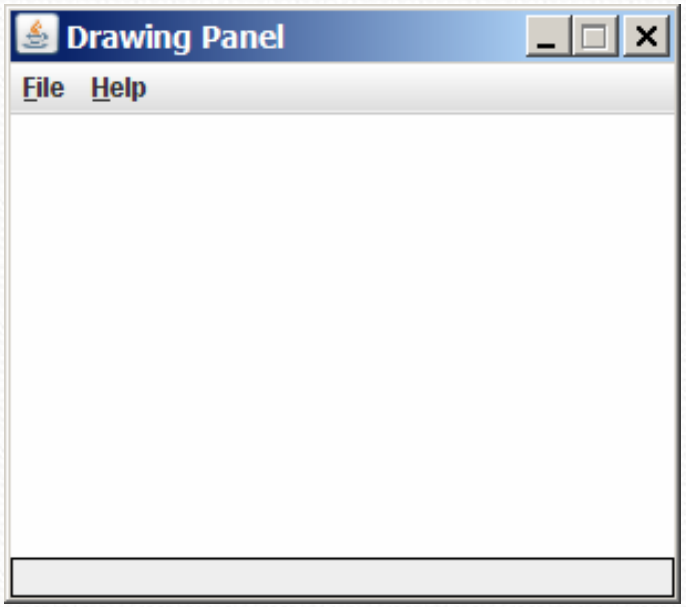
DrawingPanel

- To create a window:

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

Example:

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



- The window has nothing on it.
  - We can draw shapes and lines on it using another object of type `Graphics`.

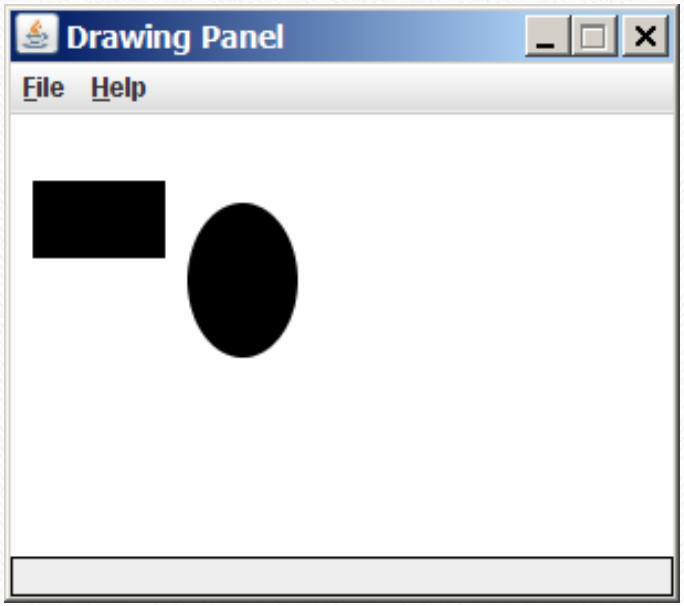
Graphics

- Shapes are drawn using an object of class `Graphics`.
  - You must place an import declaration in your program:
    `import java.awt.*;`
  - 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);
```

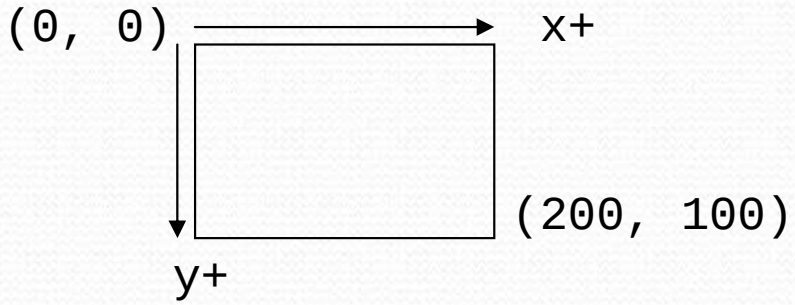


Graphics methods

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

Coordinate system

- Each (x, y) position is a *pixel* ("picture element").
- (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:



Colors

- Colors are specified by `Color` class constants named:
  `BLACK`, `BLUE`, `CYAN`, `DARK_GRAY`, `GRAY`, `GREEN`, `LIGHT_GRAY`, `MAGENTA`, `ORANGE`, `PINK`, `RED`, `WHITE`, `YELLOW`
  - Pass to `Graphics` object's `setColor` method:

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

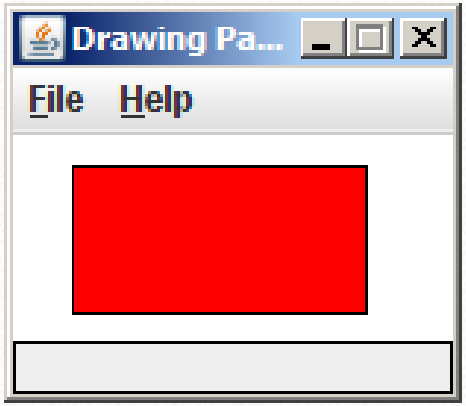
- The background color can be set by calling `setBackground` on the `DrawingPanel`:

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

Outlined shapes

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

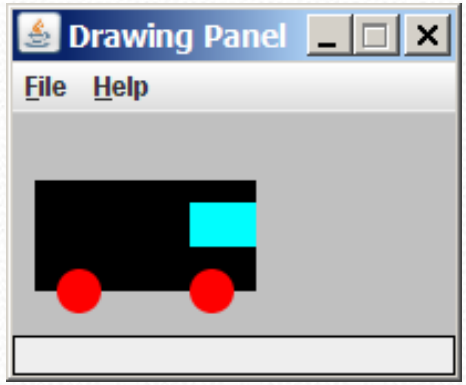
```
import java.awt.*;  // so I can use Graphics

public class DrawOutline {
    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 two shapes occupy the same pixels, the last one drawn is seen.

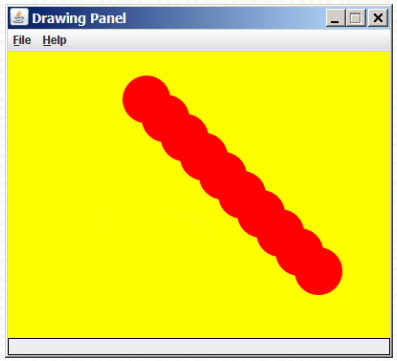
```
import java.awt.*;

public class DrawCar {
    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);
    }
}
```



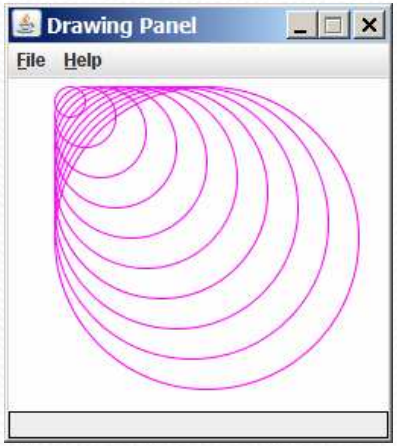
Drawing with loops

- The *x*, *y*, *w*, *h* expression can contain the loop counter, `i`.

```
DrawingPanel panel = new DrawingPanel(400, 300);
panel.setBackground(Color.YELLOW);
Graphics g = panel.getGraphics();

g.setColor(Color.RED);
for (int i = 1; i <= 10; i++) {
    g.fillOval(100 + 20 * i, 5 + 20 * i, 50, 50);
}
```




```
DrawingPanel panel = new DrawingPanel(250, 220);
Graphics g = panel.getGraphics();
g.setColor(Color.MAGENTA);
for (int i = 1; i <= 10; i++) {
    g.drawOval(30, 5, 20 * i, 20 * i);
}
```

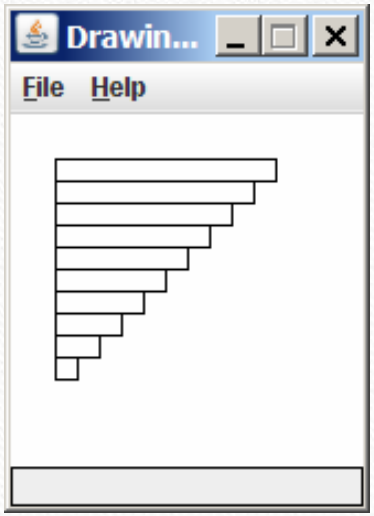


Loops that begin at 0

- Beginning a loop at 0 and using < can make coordinates easier to compute.

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

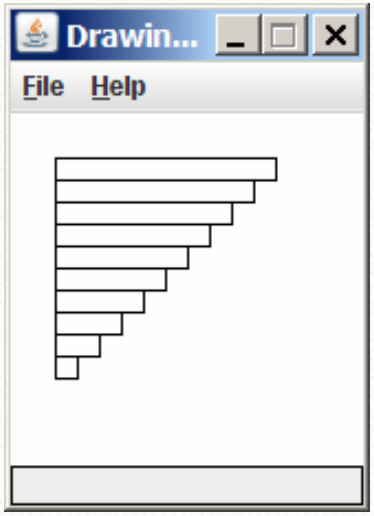
```
DrawingPanel panel = new DrawingPanel(160, 160);
Graphics g = panel.getGraphics();

for (int i = 0; i < 10; i++) {
    g.drawRect(20, 20 + 10 * i,
               100 - 10 * i, 10);
}
```



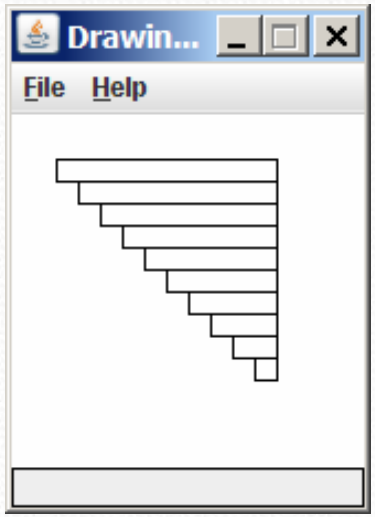
Drawing w/ loops questions

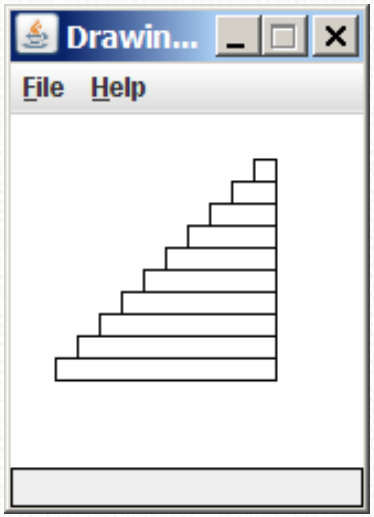
- Code from previous slide:

```
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);
}
```



- Write variations of the above program that draw the figures at right as output.

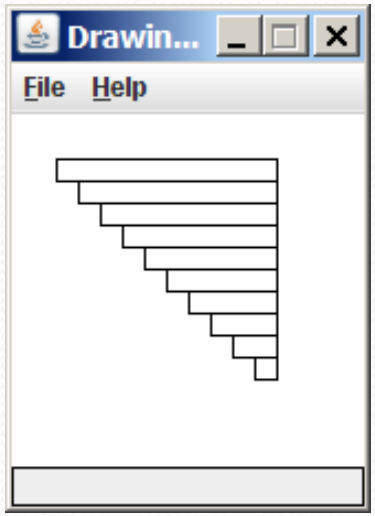




Drawing w/ loops answers

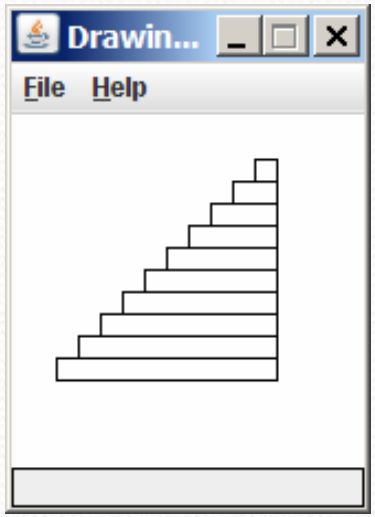
- Solution #1:

```
Graphics g = panel.getGraphics();
for (int i = 0; i < 10; i++) {
    g.drawRect(20 + 10 * i, 20 + 10 * i,
               100 - 10 * i, 10);
}
```



- Solution #2:

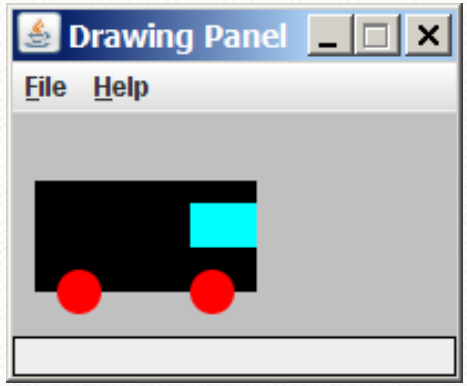
```
Graphics g = panel.getGraphics();
for (int i = 0; i < 10; i++) {
    g.drawRect(110 - 10 * i, 20 + 10 * i,
               10 + 10 * i, 10);
}
```



Drawing with methods

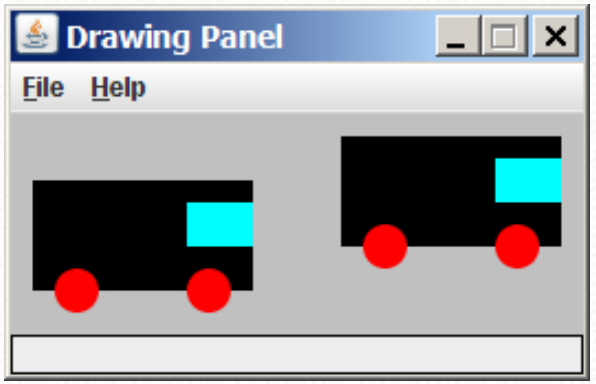
- To draw in multiple methods, you must pass `Graphics g`.

```
import java.awt.*;

public class DrawCar1 {
    public static void main(String[] args) {
        DrawingPanel panel = new DrawingPanel(200, 100);
        panel.setBackground(Color.LIGHT_GRAY);
        Graphics g = panel.getGraphics();
        drawCar(g);
    }

    public static void drawCar(Graphics g) {
        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);
    }
}
```



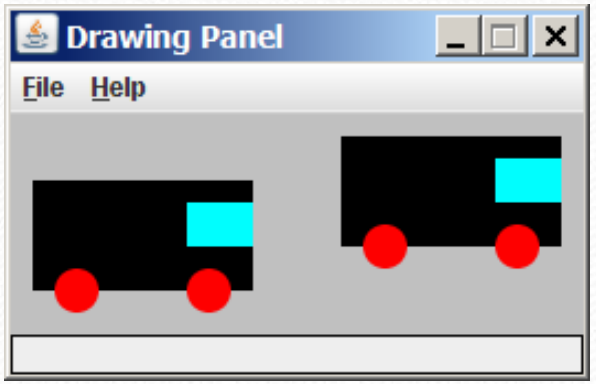
Parameterized figures

- Modify the car-drawing method so that it can draw many cars, such as in the following image.
  - Top-left corners: (10, 30), (150, 10)
  - Hint: We must modify our `drawCar` method to accept x/y coordinates as parameters.



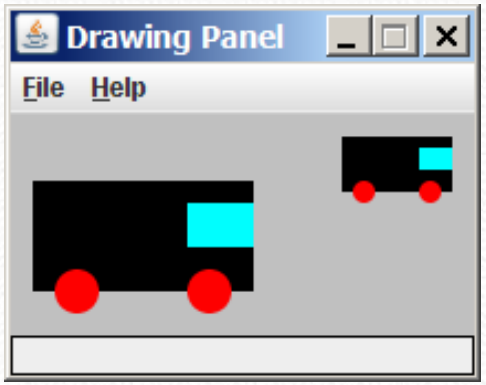
Parameterized answer

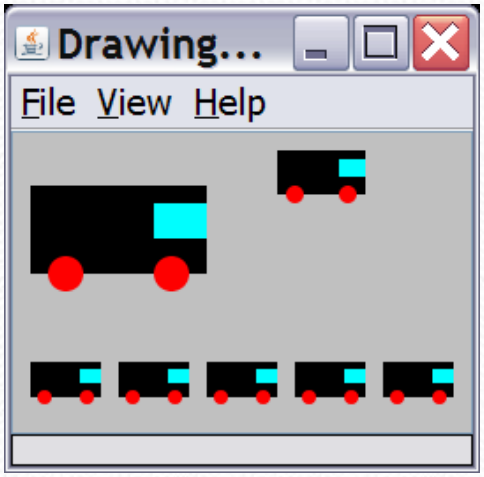
```
import java.awt.*;

public class DrawCar2 {
    public static void main(String[] args) {
        DrawingPanel panel = new DrawingPanel(260, 100);
        panel.setBackground(Color.LIGHT_GRAY);
        Graphics g = panel.getGraphics();
        drawCar(g, 10, 30);
        drawCar(g, 150, 10);
    }

    public static void drawCar(Graphics g, int x, int y) {
        g.setColor(Color.BLACK);
        g.fillRect(x, y, 100, 50);

        g.setColor(Color.RED);
        g.fillOval(x + 10, y + 40, 20, 20);
        g.fillOval(x + 70, y + 40, 20, 20);

        g.setColor(Color.CYAN);
        g.fillRect(x + 70, y + 10, 30, 20);
    }
}
```



Drawing parameter question

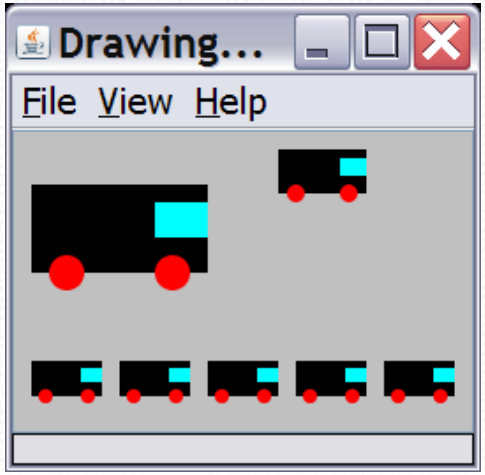
- Modify `drawCar` to allow the car to be drawn at any size.
  - Existing car: size 100. Second car: (150, 10), size 50.
- Once you have this working, use a `for` loop with your method to draw a line of cars, like the picture at right.
  - Start at (10, 130), each size 40, separated by 50px.





Drawing parameter answer

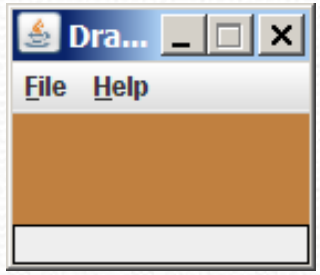
```
import java.awt.*;

public class DrawCar3 {
    public static void main(String[] args) {
        DrawingPanel panel = new DrawingPanel(210, 100);
        panel.setBackground(Color.LIGHT_GRAY);

        Graphics g = panel.getGraphics();
        drawCar(g, 10, 30, 100);
        drawCar(g, 150, 10, 50);
        for (int i = 0; i < 5; i++) {
            drawCar(g, 10 + i * 50, 130, 40);
        }
    }

    public static void drawCar(Graphics g, int x, int y, int size) {
        g.setColor(Color.BLACK);
        g.fillRect(x, y, size, size / 2);

        g.setColor(Color.RED);
        g.fillOval(x + size / 10, y + 2 * size / 5,
                   size / 5, size / 5);
        g.fillOval(x + 7 * size / 10, y + 2 * size / 5,
                   size / 5, size / 5);

        g.setColor(Color.CYAN);
        g.fillRect(x + 7 * size / 10, y + size / 10,
                   3 * size / 10, size / 5);
    }
}
```



Custom colors

- You can construct custom `Color` objects.
  - Pass 3 numbers from 0-255 for red, green, and blue.

```
DrawingPanel panel = new DrawingPanel(80, 50);
Color brown = new Color(192, 128, 64);
panel.setBackground(brown);
```



  - or:

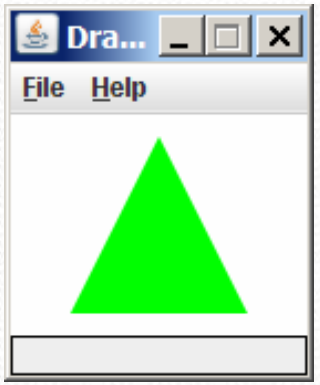
```
DrawingPanel panel = new DrawingPanel(80, 50);
panel.setBackground(new Color(192, 128, 64));
```

Drawing polygons

- `Polygon` objects 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);
```



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 <= NUM_CIRCLES; 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.