UNIVERSITY OF WASHINGTON

Building Java Programs

Supplement 3G:
Graphics

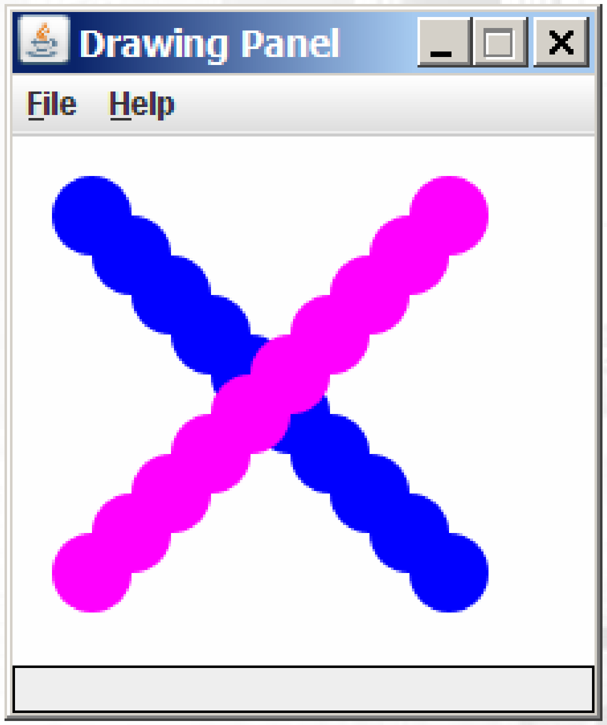
Lecture outline

Lecture 8

- **Drawing 2D graphics**
  - `DrawingPanel` **and** `Graphics` **objects**
  - **drawing and filling shapes**
  - **coordinate system**
  - **colors**
  - **drawing with loops**
  - **drawing with parameterized methods**
  - **basic animation**

Graphical objects

- We will draw graphics on the screen by interacting with three classes of objects:
  - `DrawingPanel`: A window on the screen.
    - This is not part of Java; it is provided by the instructor.
  - `Graphics`: A "pen" that can draw shapes and lines onto a window.
  - `Color`: The colors that indicate what color to draw our shapes.



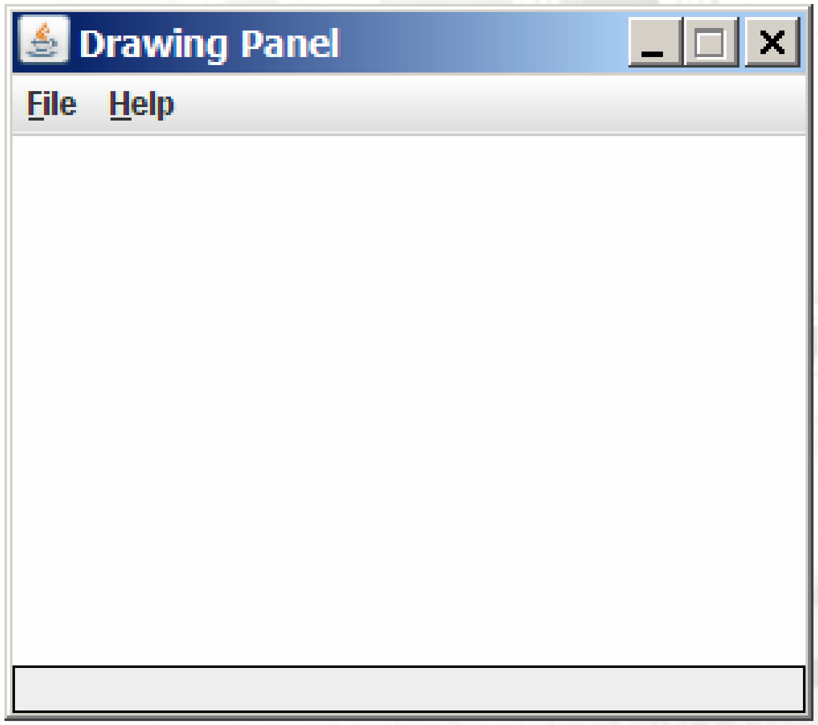
DrawingPanel

- To create a window, construct a `DrawingPanel` object:

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

Example:

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



- The window has nothing on it.
  - But we can draw shapes and lines on it using another object of a class named `Graphics`.

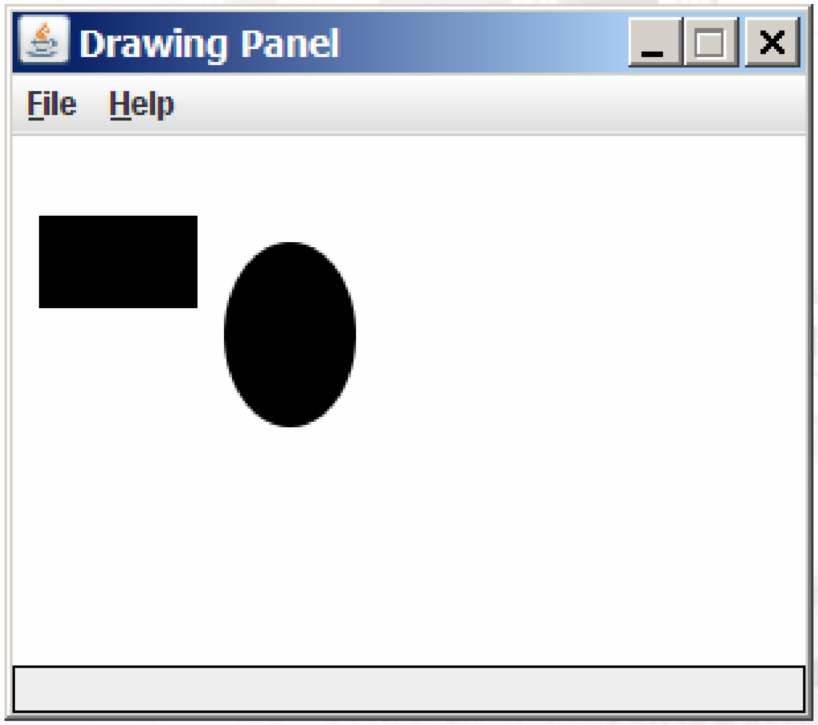
Graphics

- 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 the `getGraphics` method on your `DrawingPanel`.
  - Example:

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

- Once you have the `Graphics` object, draw shapes by calling its methods.
  - Example:

```
g.fillRect(10, 30, 60, 35);
g.fillOval(80, 40, 50, 70);
```



Graphics methods

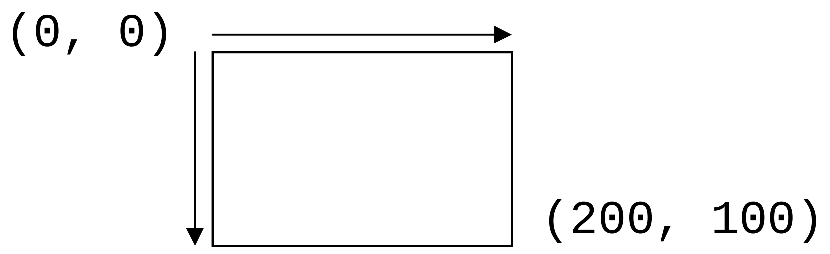
Method name	**Description**
`drawLine(`*x1*, *y1*, *x2*, *y2*`)`	line between points (*x1*, *y1*), (*x2*, *y2*)
`drawOval(`*x*, *y*, *width*, *height*`)`	draws outline of largest oval that fits in a box of size *width* * *height* with top-left corner at (*x*, *y*)
`drawRect(`*x*, *y*, *width*, *height*`)`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

Coordinate system

- Each (x, y) position on the `DrawingPanel` is represented by a *pixel* (picture element).

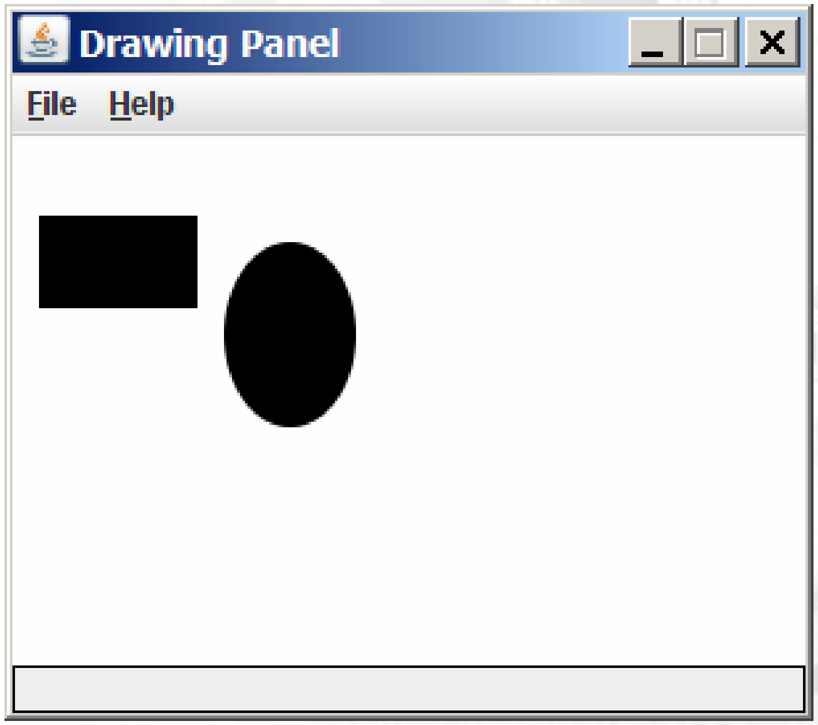
- The origin (0, 0) is at the window's top-left corner.
  - x increases rightward and the y increases downward
  - The y is reversed from what you may expect.

- For example, the rectangle from (0, 0) to (200, 100) looks like this:



A complete program

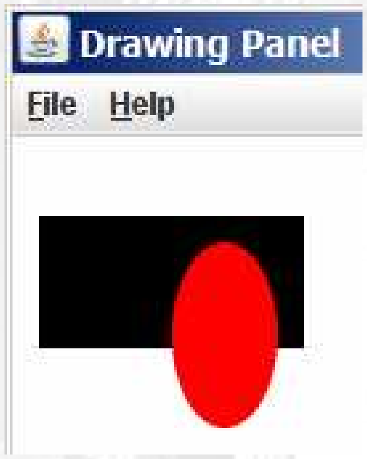
```
import java.awt.*;

public class DrawingExample1 {
    public static void main(String[] args) {
        DrawingPanel panel = new DrawingPanel(300, 200);
        Graphics g = panel.getGraphics();
        g.fillRect(10, 30, 60, 35);
        g.fillOval(80, 40, 50, 70);
    }
}
```



Colors

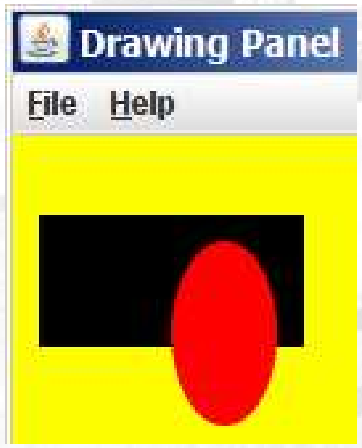
- Colors are specified by constants in the `Color` class named: `BLACK`, `BLUE`, `CYAN`, `DARK_GRAY`, `GRAY`, `GREEN`, `LIGHT_GRAY`, `MAGENTA`, `ORANGE`, `PINK`, `RED`, `WHITE`, and `YELLOW`
  - Pass these to the `Graphics` object's `setColor` method.
  - Example:

```
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`:
  - Example:

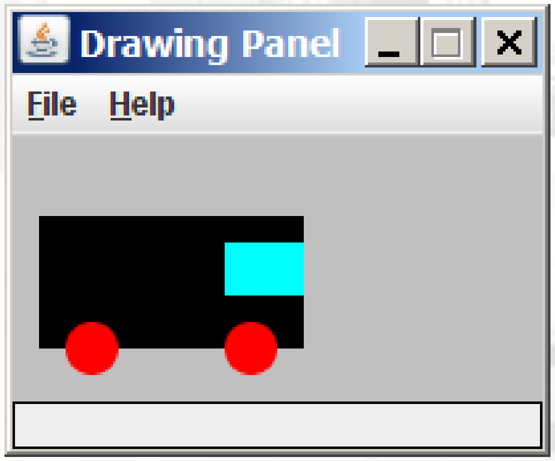
```
panel.setBackground(Color.YELLOW);
```



Superimposing shapes

Drawing one shape on top of another causes the last shape to appear on top of the previous one(s).

```
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);
    }
}
```



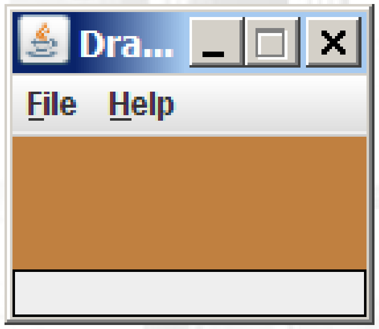
Custom colors

It is also legal to construct a `Color` object of your own.

- Colors are specified by three numbers (`int`s from 0 to 255) representing the amount of red, green, and blue.
  - Computers use red-green-blue or "RGB" as the primary colors to represent color information.

- Example:

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



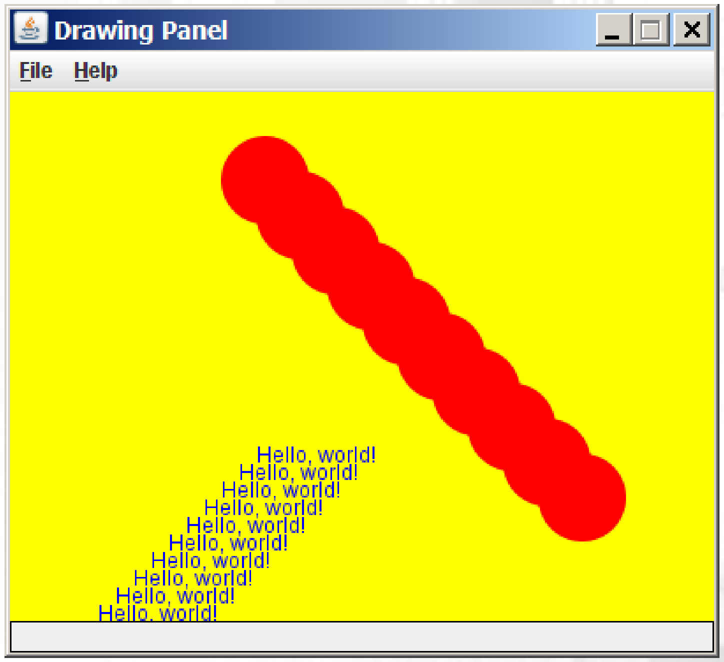
- or:

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

Drawing with loops

- We can draw many repetitions of the same item at different x/y positions with `for` loops.
  - The x or y expression contains the loop counter, `i`, so that in each pass of the loop, when `i` changes, so does x or y.

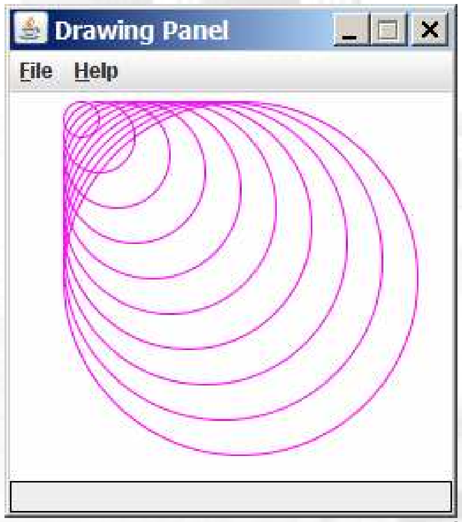
```
DrawingPanel panel = new DrawingPanel(400, 300);
panel.setBackground(Color.YELLOW);
Graphics g = panel.getGraphics();

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

g.setColor(Color.BLUE);
for (int i = 1; i <= 10; i++) {
    g.drawString("Hello, world!",
         150 - 10 * i, 200 + 10 * i);
}
```



Loops to change shape's size

A for loop can also vary a shape's size:

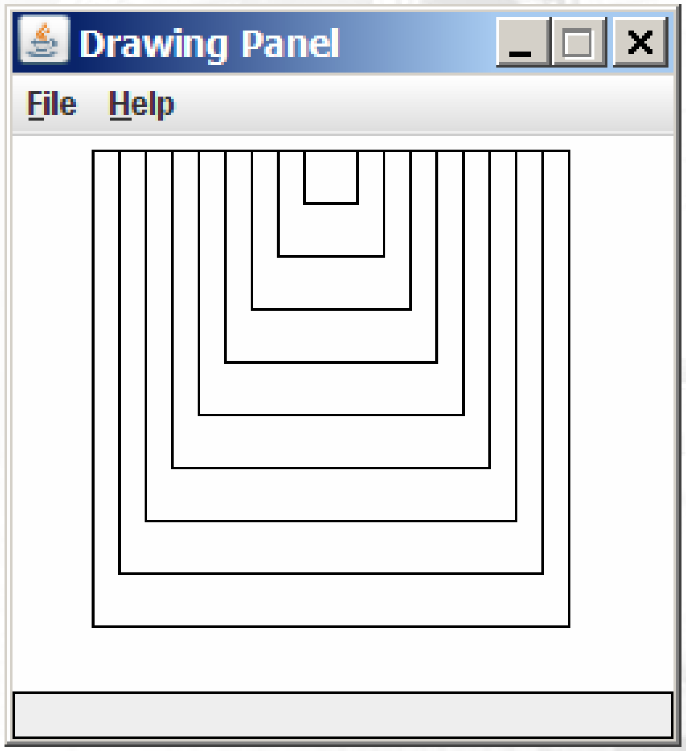
```
import java.awt.*;

public class DrawCircles {
    public static void main(String[] args) {
        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);
        }
    }
}
```



A loop that varies both

- The loop in this program affects both the size and shape of the figures being drawn.
  - Each pass of the loop, the square drawn becomes 20 pixels smaller in size, and shifts 10 pixels to the right.

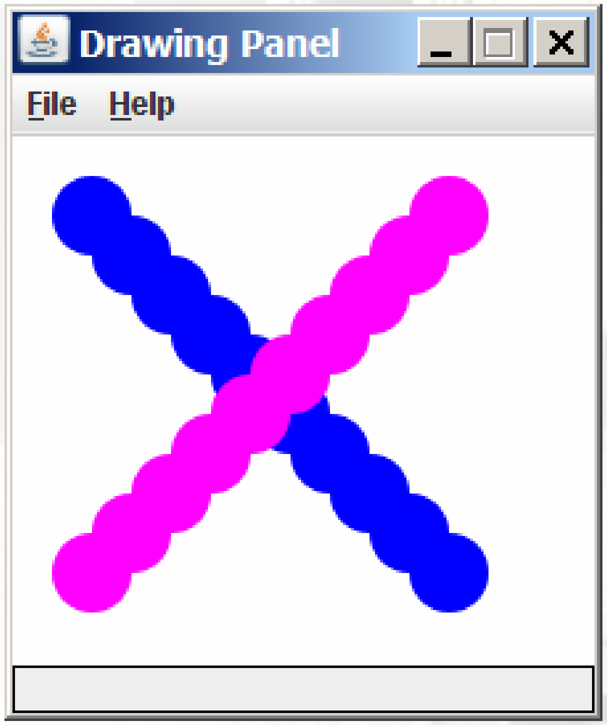
```
DrawingPanel panel = new DrawingPanel(250, 200);
Graphics g = panel.getGraphics();
for (int i = 1; i <= 10; i++) {
    g.drawRect(20 + 10 * i, 5,
        200 - 20 * i, 200 - 20 * i);
}
```



Drawing example 2

What sort of figure does the following code draw?

```
import java.awt.*;

public class DrawingExample2 {
   public static final int NUM_CIRCLES = 10;

   public static void main(String[] args) {
      DrawingPanel panel = new DrawingPanel(220, 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);
      }

      g.setColor(Color.MAGENTA);
      for (int i = 1; i <= NUM_CIRCLES; i++) {
         g.fillOval(15 * (NUM_CIRCLES
                + 1 - i), 15 * i, 30, 30);
      }
   }
}
```

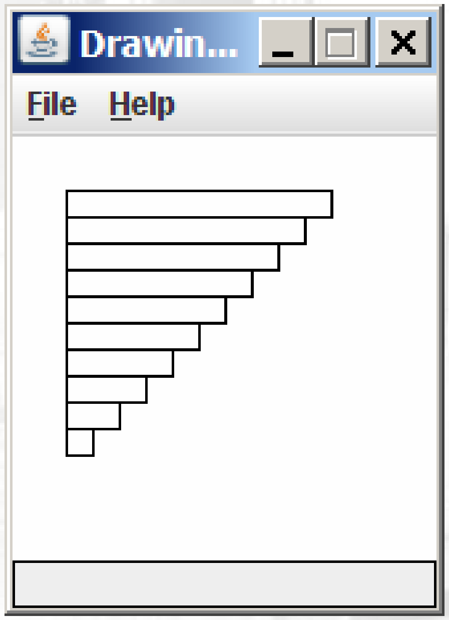


Loops that begin at 0

- Often when working with graphics (and with loops in general), we begin our loop count at 0 and use < instead of <=.
  - A loop that repeats from 0 to < 10 still repeats 10 times, just like a loop that repeats from 1 to <= 10.
  - But when the loop counter variable `i` is used to set the figure's coordinates, often starting `i` at 0 gives us the coordinates we want.

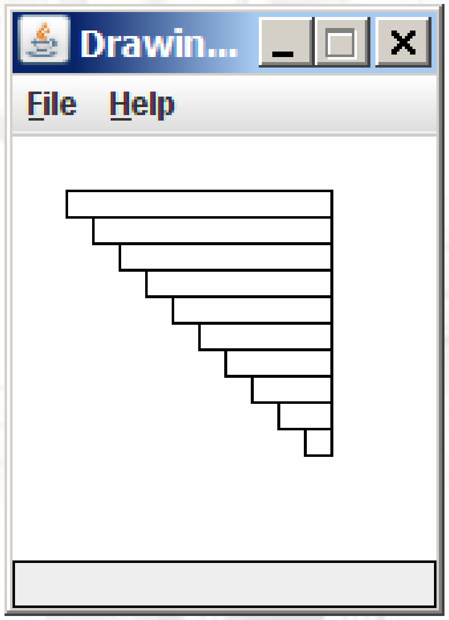
- Example: Draw ten stacked rectangles starting at (20, 20), height 10, with widths that start at 100 and decrease by 10 each time:

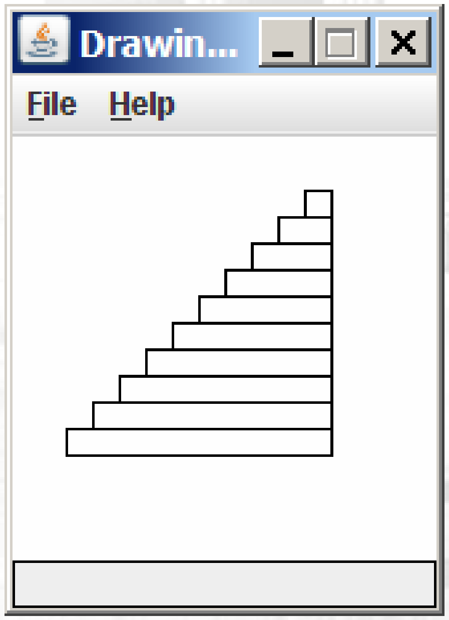
```
DrawingPanel panel = new DrawingPanel(160, 160);
Graphics g = panel.getGraphics();

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



Drawing w/ loops questions

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

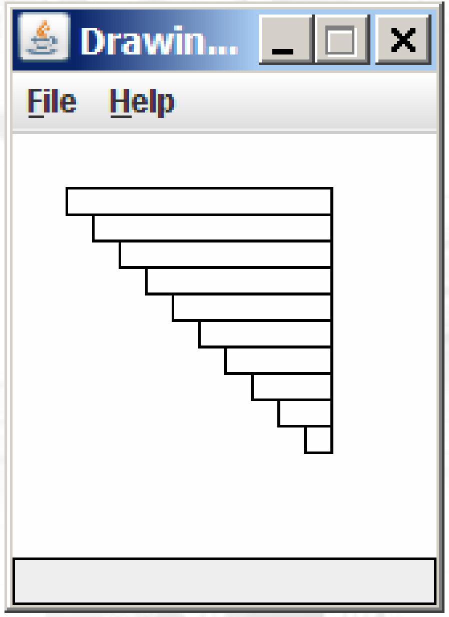




Drawing w/ loops answers

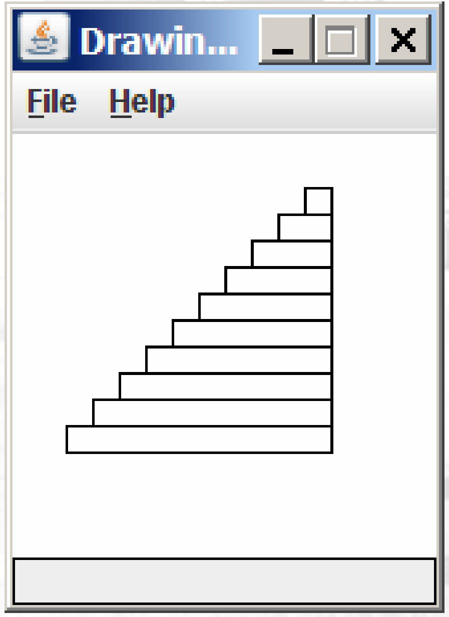
- Solution #1:

```
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:

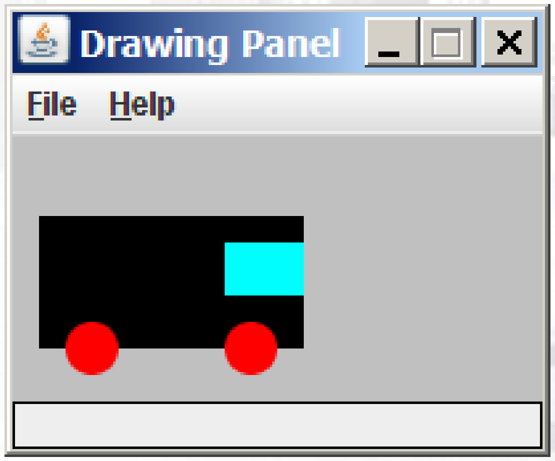
```
Graphics g = panel.getGraphics();

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



Drawing with methods

- It is possible to draw graphics in different static methods.
  - Since you'll need to send commands to the Graphics g to draw the figure, you should pass Graphics g as a parameter.

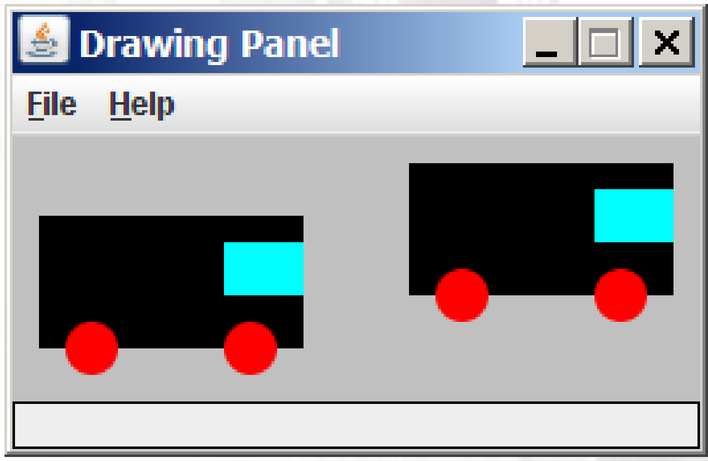
```
import java.awt.*;

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

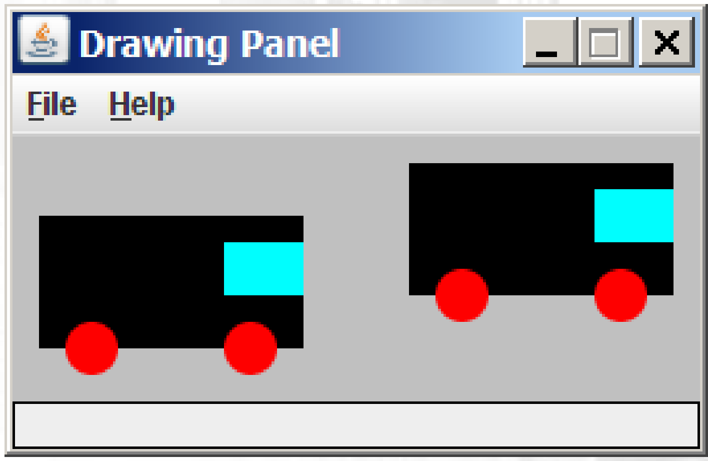
- If you want to draw the same figure many times, write a method to draw that figure and accept the x/y position as parameters.
  - Adjust the x/y coordinates of your drawing commands to take into account the parameters.

- Exercise:
  Modify the previous car-drawing method to work at any location, so that it can produce an image such as the following:
  - One car's top-left corner is at (10, 30).
  - The other car's top-left corner is at (150, 10).



Drawing parameters solution

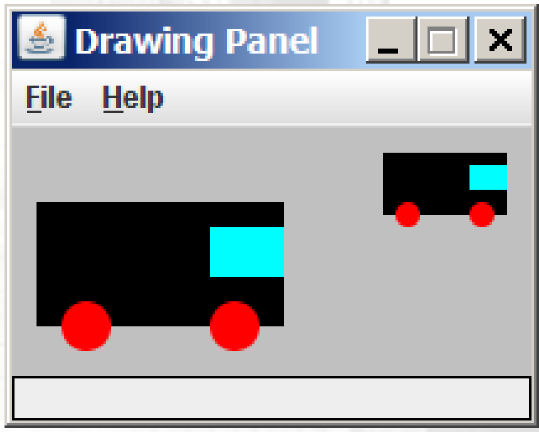
```
import java.awt.*;

public class DrawingWithParameters {
    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

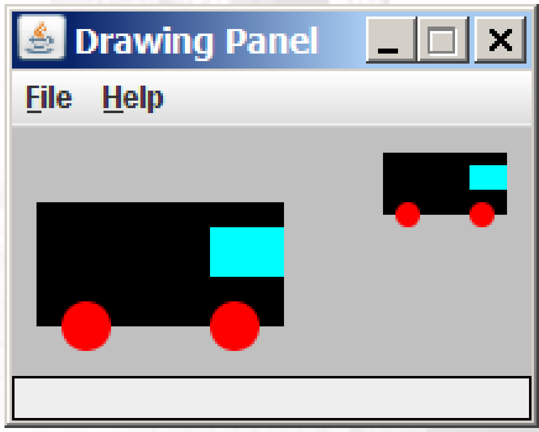
- Methods can accept any number of parameters to adjust the figure's appearance.

- Exercise:
  Write a new version of the `drawCar` method that also allows the cars to be drawn at any size, such as the following:



Drawing parameter solution

```
import java.awt.*;

public class DrawingWithParameters2 {
    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);
    }

    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);
    }
}
```



Animation with sleep

- `DrawingPanel` has a method named `sleep` that pauses your program for a given number of milliseconds.

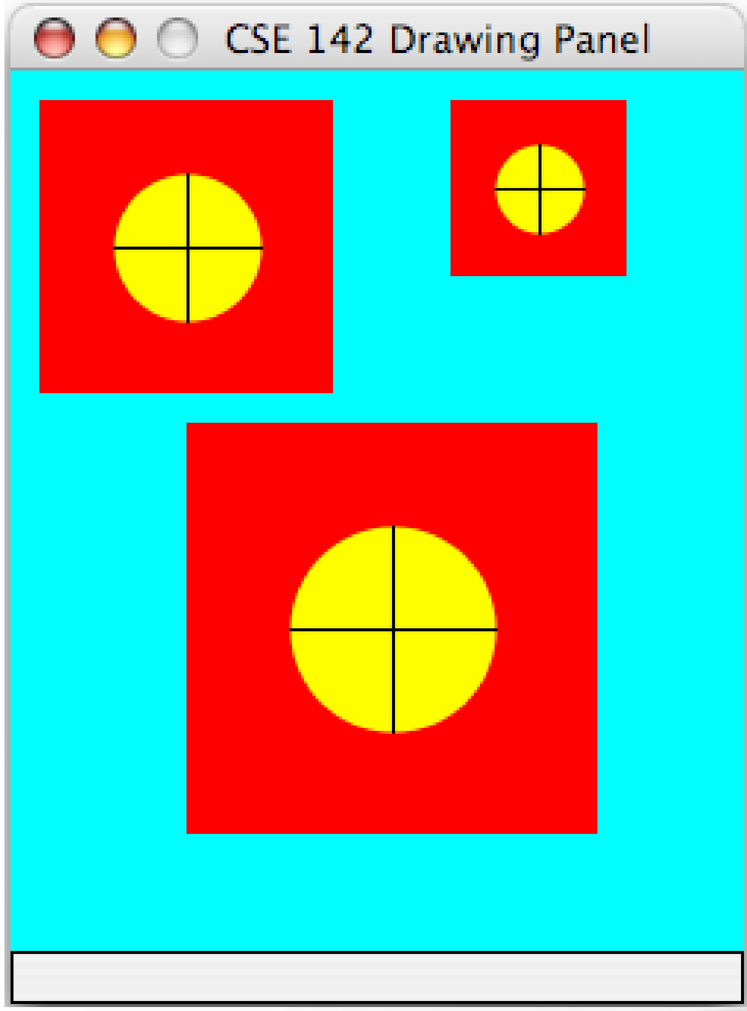
- You can use `sleep` to produce simple animations.

```
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!

Parameterized figure exercise

- Let's write a program together that will display the following figures on a drawing panel of size 300x400:
  - top-left figure:
    - overall size = 100
    - top-left corner = (10, 10)
    - inner rectangle and oval size = 50
    - inner top-left corner = (35, 35)
  - top-right figure:
    - overall size = 60
    - top-left corner = (150, 10)
    - inner rectangle and oval size = 30
    - inner top-left corner = (165, 25)
  - bottom figure:
    - overall size = 140
    - top-left corner = (60, 120)
    - inner rectangle and oval size = 70
    - inner top-left corner = (95, 155)


CSE 142 Drawing Panel