Topic 8
graphics

"What makes the situation worse is that the highest level CS course I've ever taken is cs4, and quotes from the graphics group startup readme like '*these paths are abstracted as being the result of a topological sort on the graph of ordering dependencies for the entries*' make me lose consciousness in my chair and bleed from the nose."

-mgrimes, Graphics problem report 134

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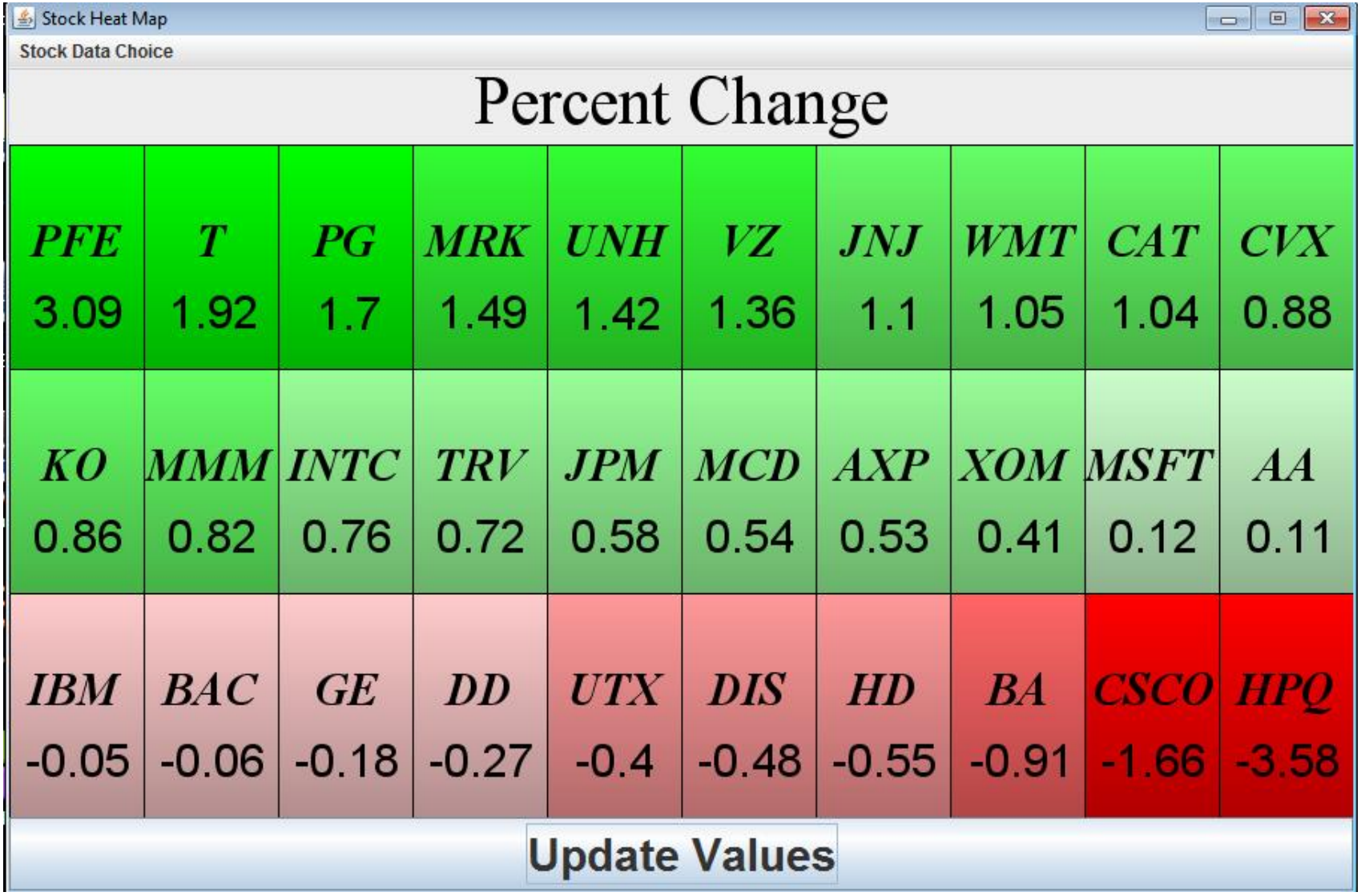
Based on slides bu Marty Stepp and Stuart Reges from http://www.buildingjavaprograms.com/

CS324E, Graphics and Visualization Examples - Heat Map



Random Art

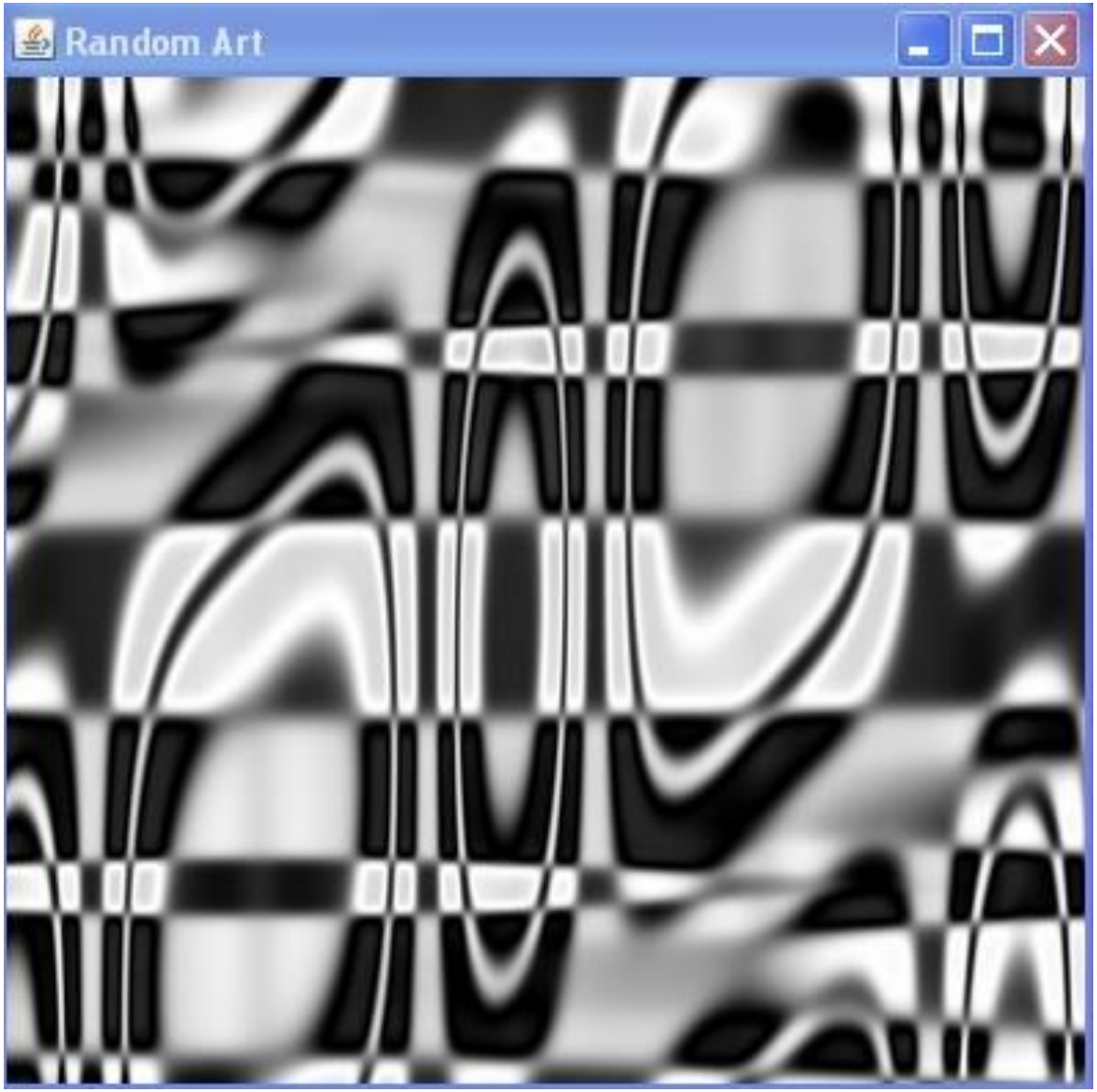
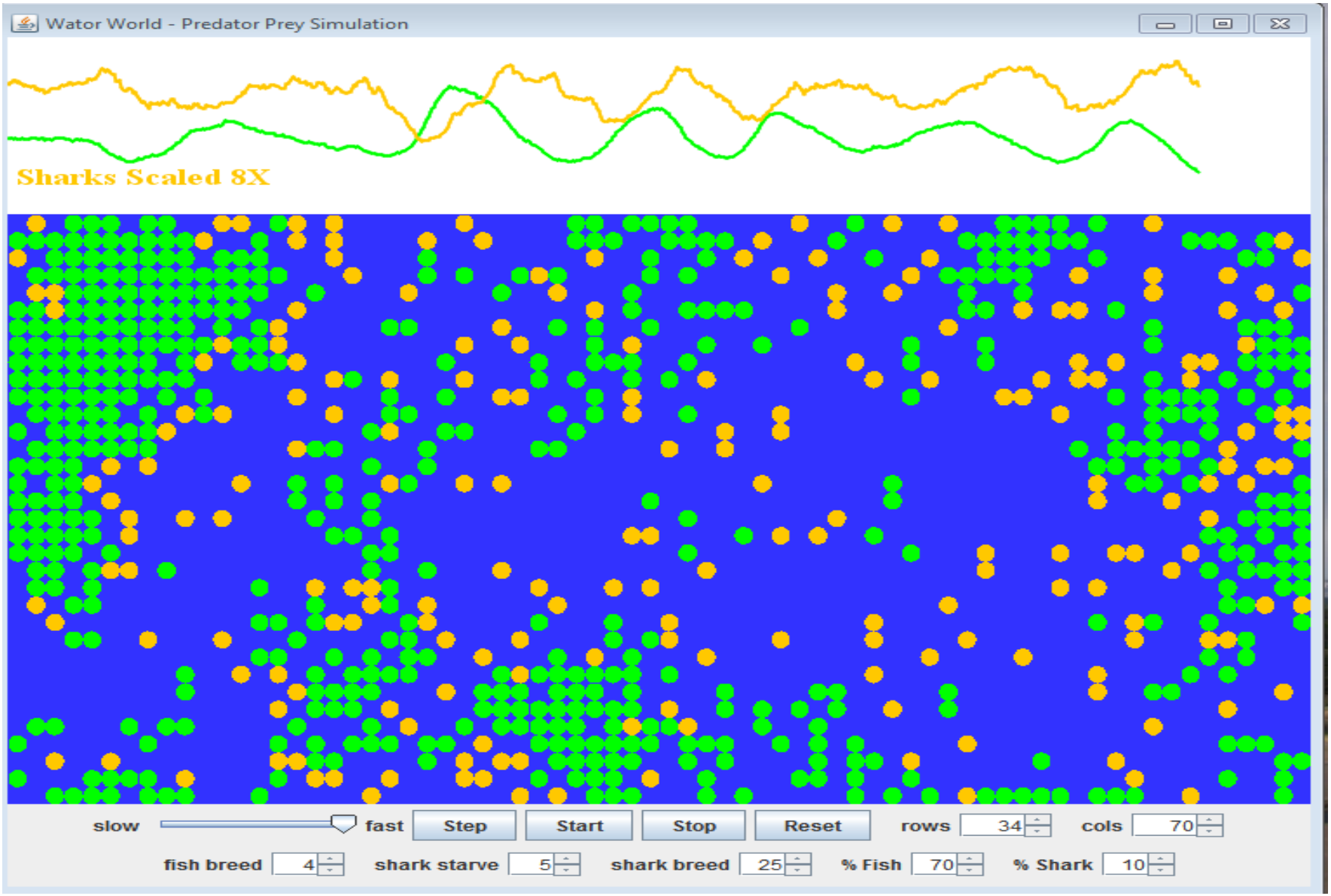
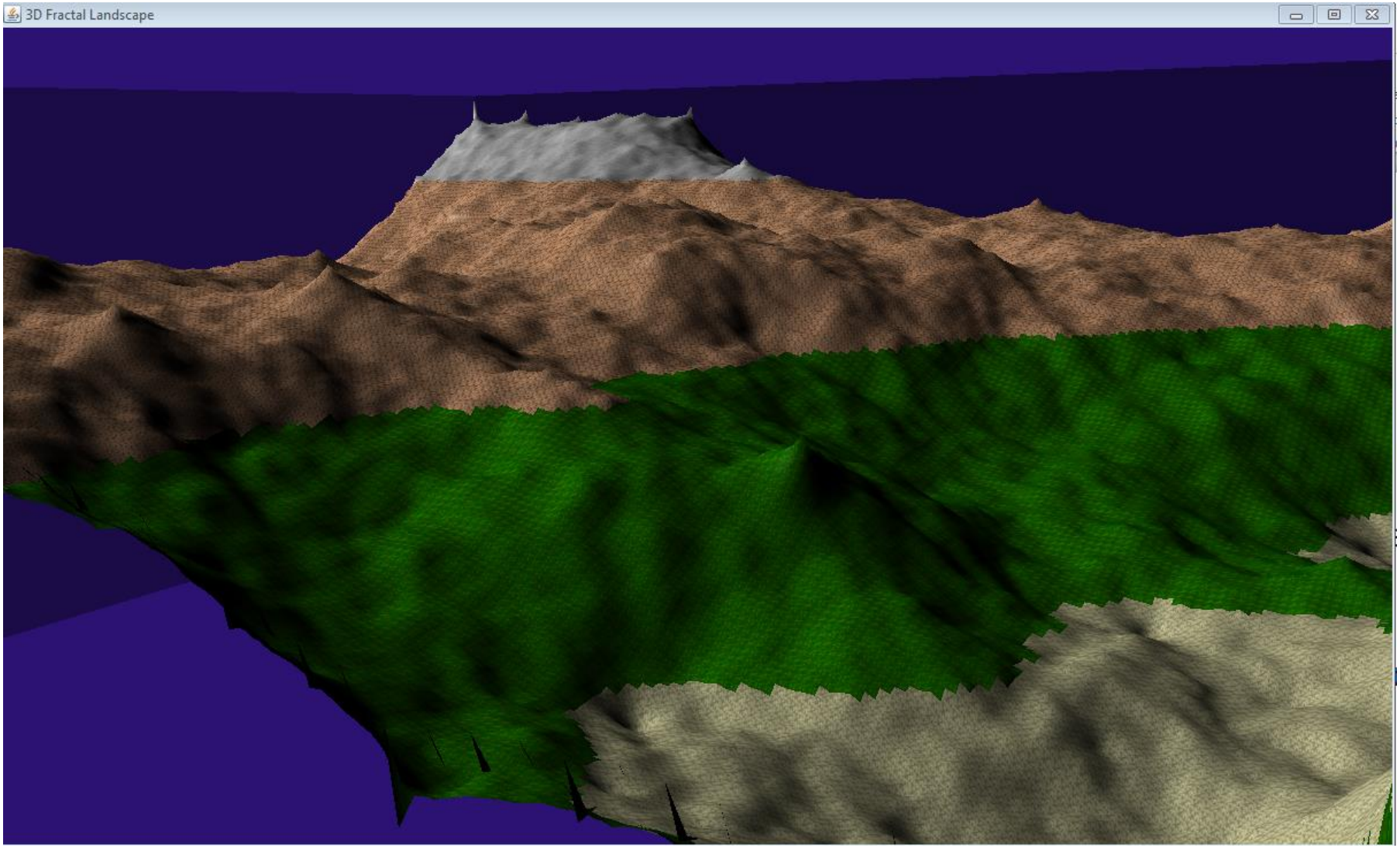


Image Manipulation

Simulation and Visualization
WatorWorld

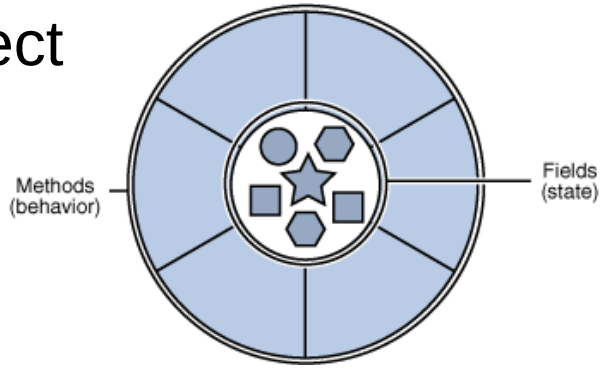


Fractal 3D Landscape



Objects (briefly)

- **object:** An entity that contains data and behavior.
  - *data*: variables inside the object
  - *behavior*: methods called on object
    - You interact with the methods; the data is hidden in the object.
    - A **class** is a data type.



- Constructing (creating) an object:

```
Type objectName = new Type(parameters);
```

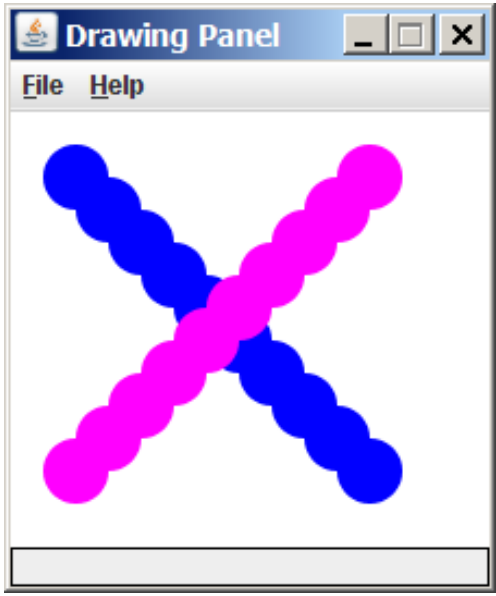
- Calling an object's method:

```
objectName.methodName(parameters);
```

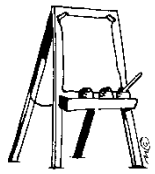
Graphical objects

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

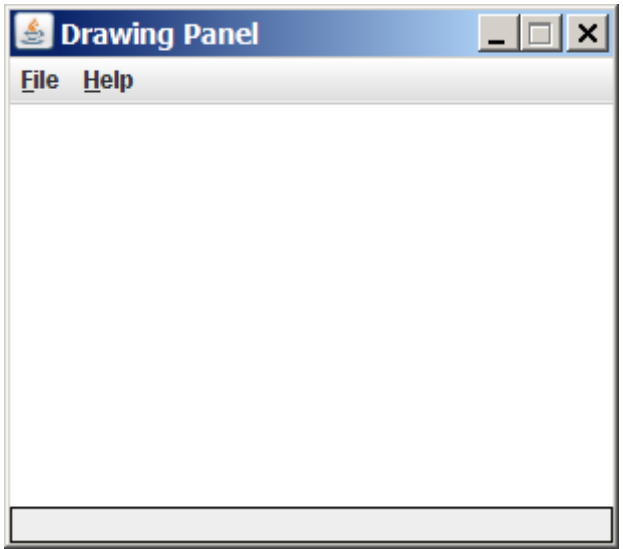
- To create a window:

```
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

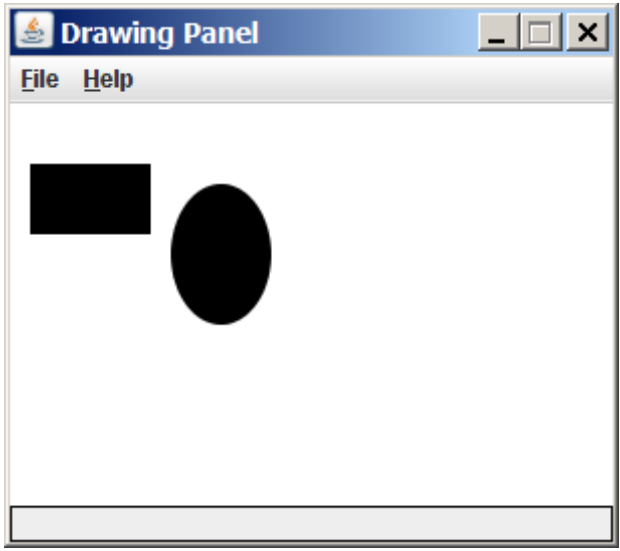
"Pen" or "paint brush" objects to draw lines and shapes

- 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.ClassName;
```

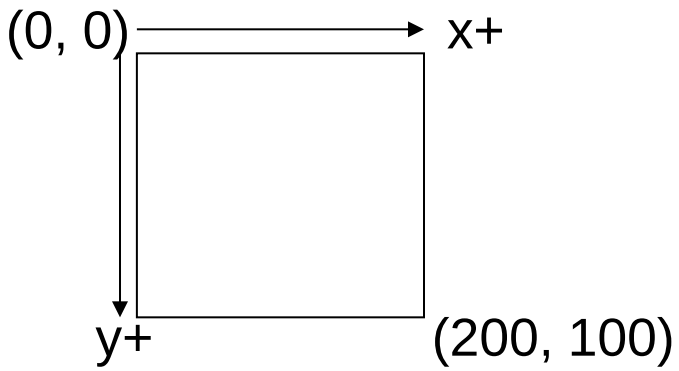
- `Graphics` belongs to a package named `java.awt`

```
import java.awt.Graphics;
```

  - 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
`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

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);
  Color burntOrange = new Color(191, 87, 0);
  ```

Color pickers

List of Colors

Clicker Question

- How many rectangles appear on the DrawingPanel when the following code is run?

```
DrawingPanel p1 = new DrawingPanel(200, 200);
Graphics gr = new Graphics();
for(int i = 0; i < 5; i++) {
     gr.drawRect(i * 25, i * 20, 20, 50);
}
```

A. 5 B. 6 C. 20

D. None due to syntax error

E. None due to runtime error

Clicker Question

- What named color is closest to the Color object created by this code?

```
Color mc = new Color(255, 255, 255);
```

A. Black

B. Brown

C. Gray

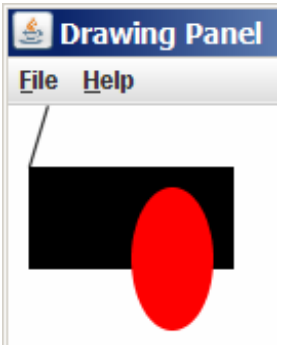
D. Orange

E. White

Using colors

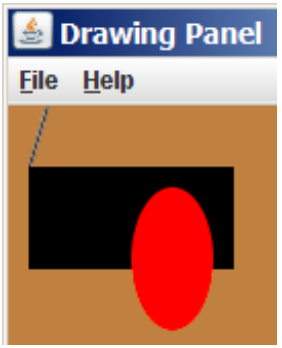
- Pass a `Color` to `Graphics` object's `setColor` method
  - Subsequent shapes will be drawn in the new color.

```
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.

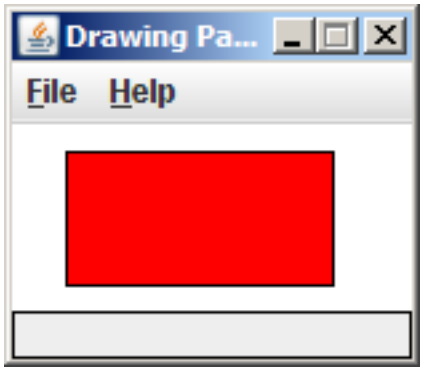
```
Color brown = new Color(192, 128, 64);
panel.setBackground(brown);
```



Outlined shapes

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

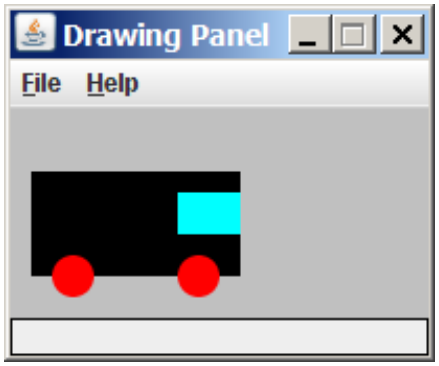
```
import java.awt.Graphics;  // so I can use Graphics
import java.awt.Color;

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."

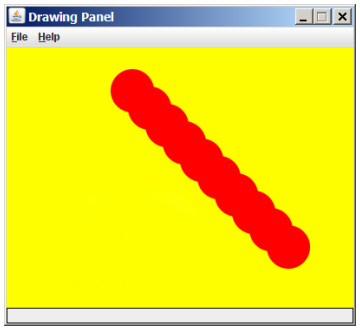
```
import java.awt.Graphics;
import java.awt.Color;


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);
    }
}
```



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);
}
```



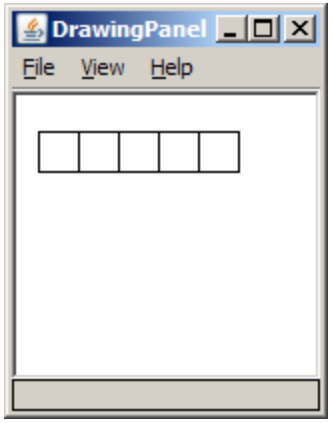
- Nested loops can be used with graphics:

```
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 calculating 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);
}
```