Building Java Programs

Graphics

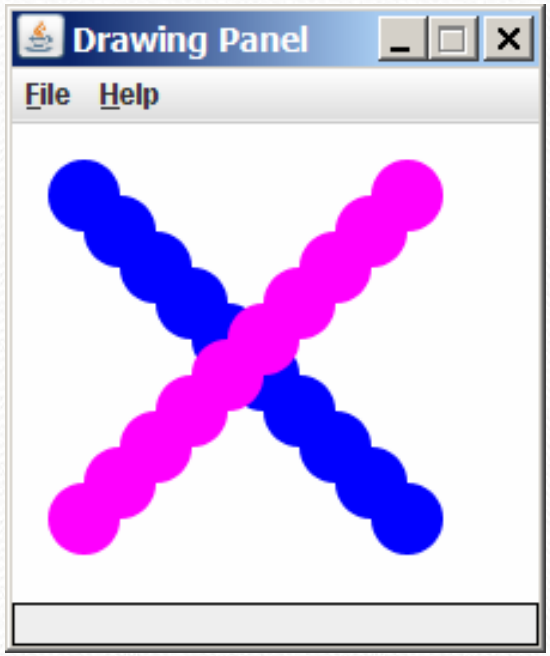
reading: Supplement 3G

videos: Ch. 3G #1-2

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.
- `Graphics`: A "pen" to draw shapes/lines on a window.
- `Color`: Colors in which to draw shapes.



Objects (briefly)

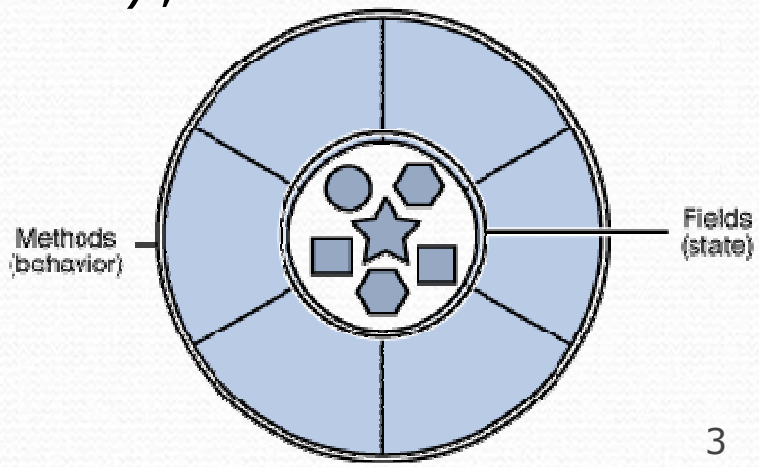
- **object:** An entity that contains data and behavior.
  - *data*: Variables inside the object.
  - *behavior*: Methods inside the object.
    - You interact with the methods; the data is hidden in the object.

- Constructing (creating) an object:

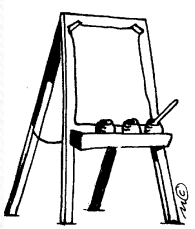
```
type objectName = new type(parameters);
```

- Calling an object's method:

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



DrawingPanel



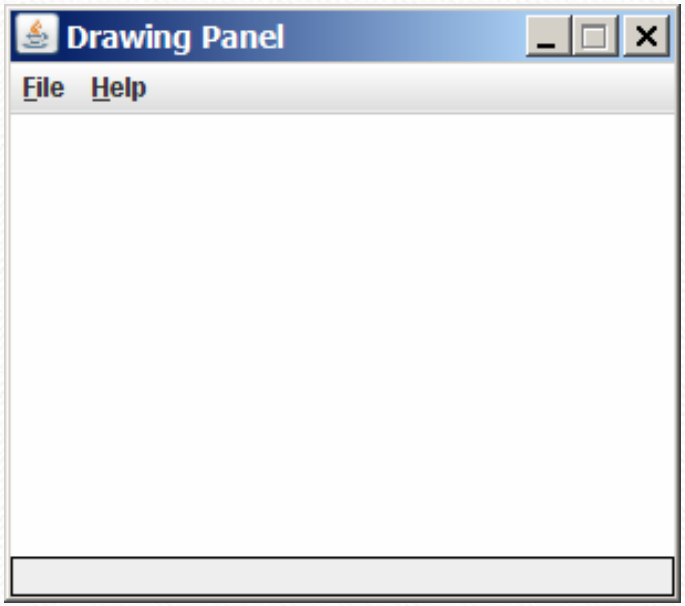
"Canvas" objects that represents windows/drawing surfaces

- To create a window:

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

Example:

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



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

Graphics

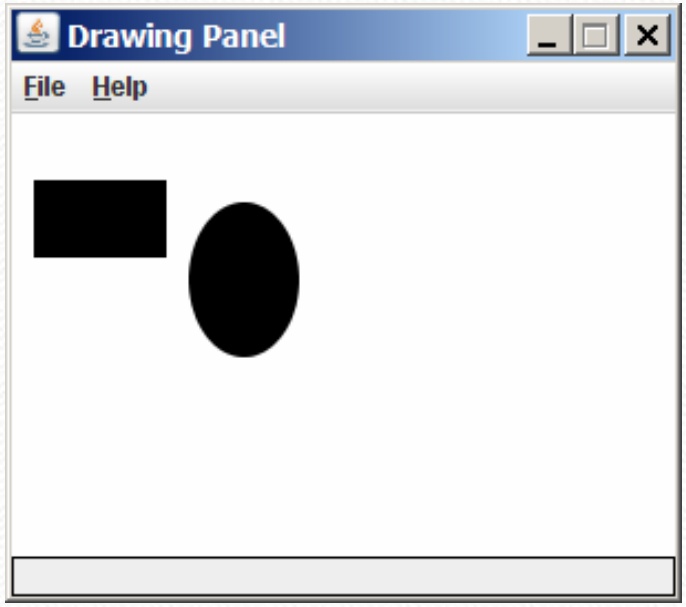
"Pen" objects that can draw lines and shapes

- 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.

- Syntax:

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

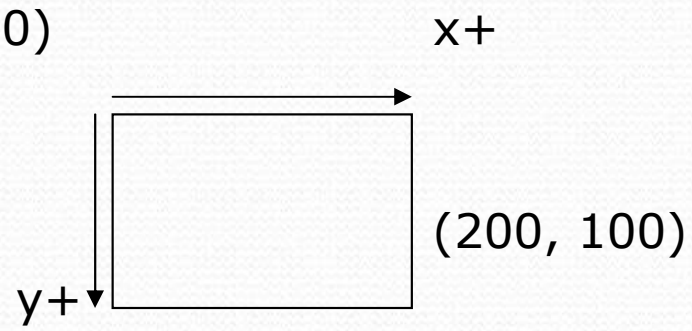
- `Graphics` is in a package named `java.awt`

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

  - In order 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").
- (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

- Create one using Red-Green-Blue (RGB) values from 0-255

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

  - Example:

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

- Or use a predefined `Color` class constant (more common)

```
Color.CONSTANT_NAME
```

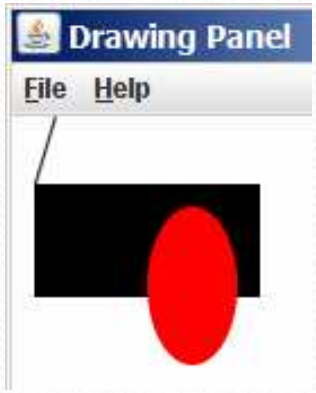
  where **CONSTANT_NAME** is one of:

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

Using Colors

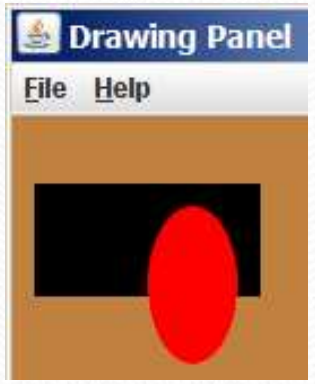
- Pass a `Color` to `Graphics` object's `setColor` method
  - Subsequent shapes will be drawn in the new color.

```
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.

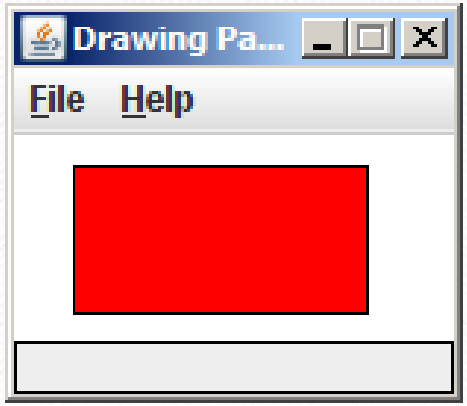
```
Color brown = new Color(192, 128, 64);
panel.setBackground(brown);
```



Outlined shapes

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

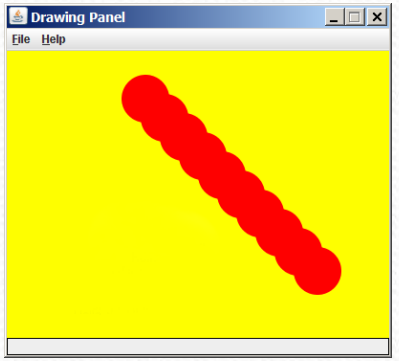
```
import java.awt.*;  // so I can use Graphics

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);
    }
}
```



Drawing with loops

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

```
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);
}
```



- Nested loops are okay as well:

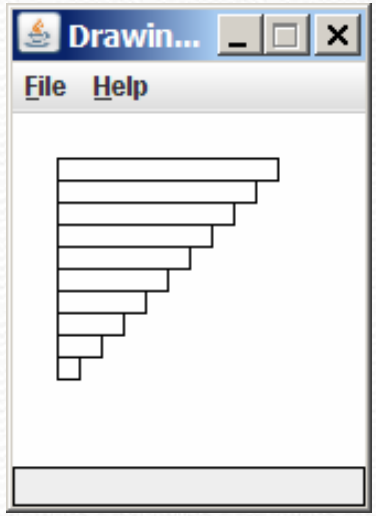
```
DrawingPanel panel = new DrawingPanel(250, 250);
Graphics g = panel.getGraphics();
g.setColor(Color.BLUE);

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

Loops that begin at 0

- 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:

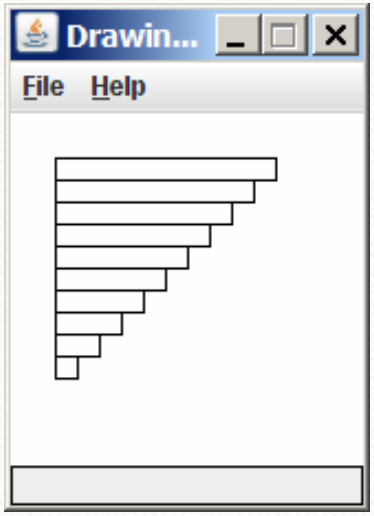
```
DrawingPanel panel = new DrawingPanel(160, 160);
Graphics g = panel.getGraphics();

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



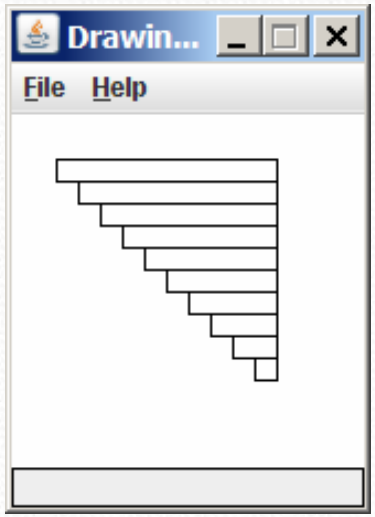
Drawing w/ loops questions

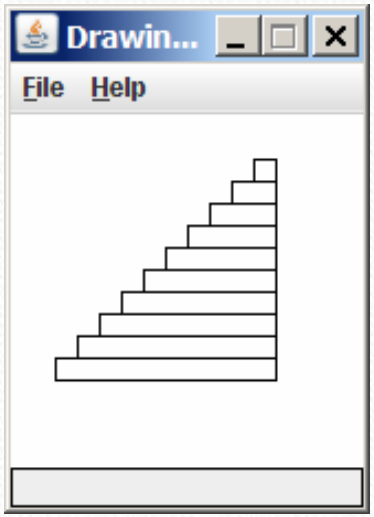
- Code from previous slide:

```
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.

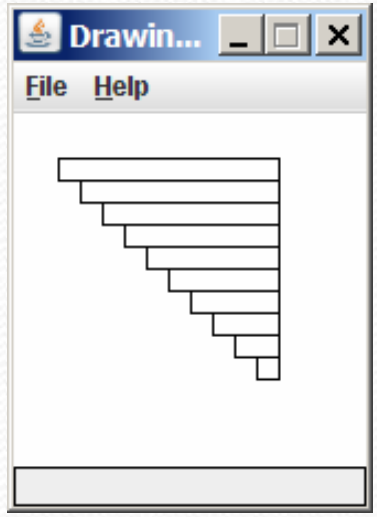




Drawing w/ loops answers

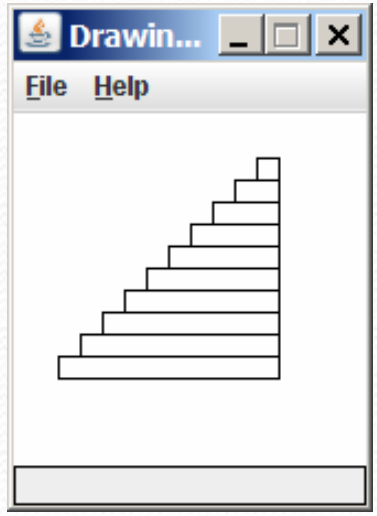
- Solution #1:

```
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:

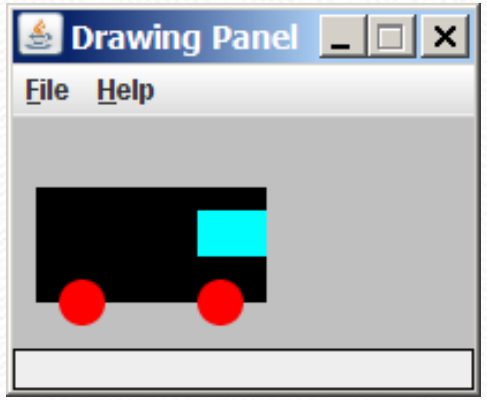
```
Graphics g = panel.getGraphics();
for (int i = 0; i < 10; i++) {
    g.drawRect(110 - 10 * i, 20 + 10 * i,
               10 + 10 * i, 10);
}
```



Superimposing shapes

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

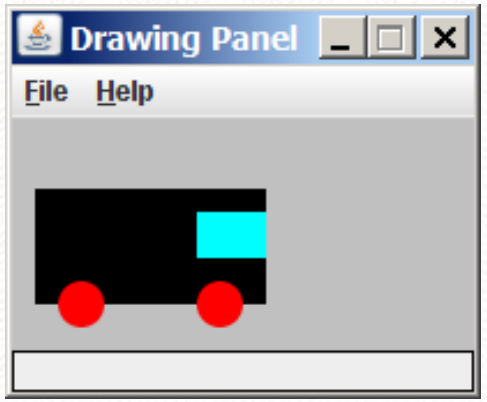
```
import java.awt.*;

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);
    }
}
```



Drawing with methods

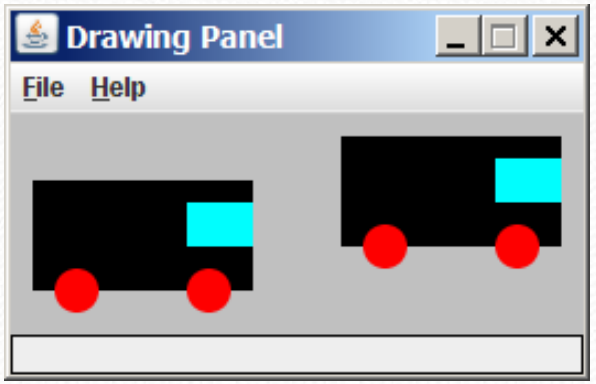
- To draw in multiple methods, you must pass `Graphics g`.

```
import java.awt.*;

public class Car2 {
    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);
    }
}
```



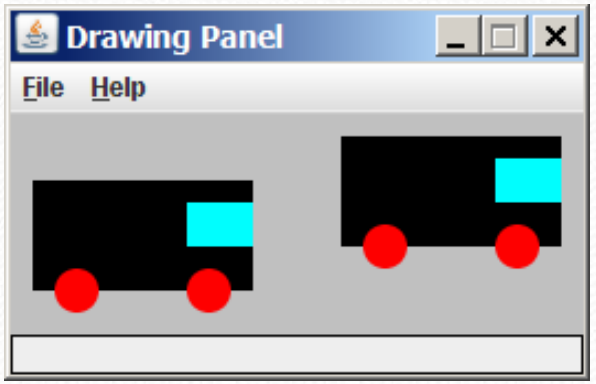
Parameterized figures

- Modify the car-drawing method so that it can draw cars at different positions, as in the following image.
  - Top-left corners: (10, 30), (150, 10)



Parameterized answer

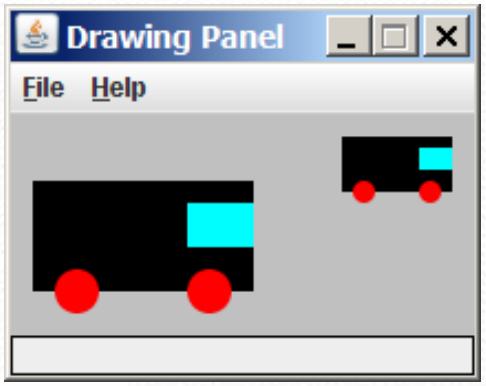
```
import java.awt.*;

public class Car3 {
    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);
    }
}
```

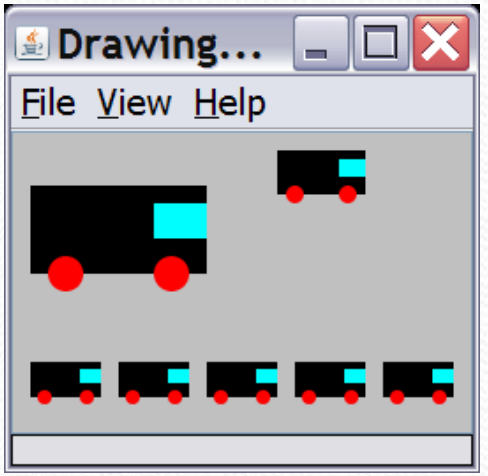


Drawing parameter question

- Modify `drawCar` to allow the car to be drawn at any size.
  - Existing car: size 100
  - Second car: size 50, top/left at (150, 10)

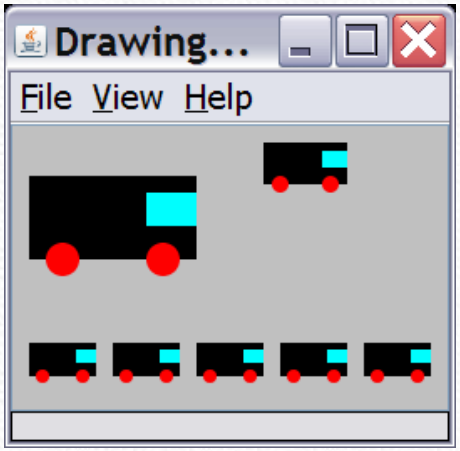
- Then use a `for` loop to draw a line of cars.
  - Start at (10, 130), each car size 40, separated by 50px.





Drawing parameter answer

```
import java.awt.*;
public class Car4 {
    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);
    }
}
```



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);
```

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.