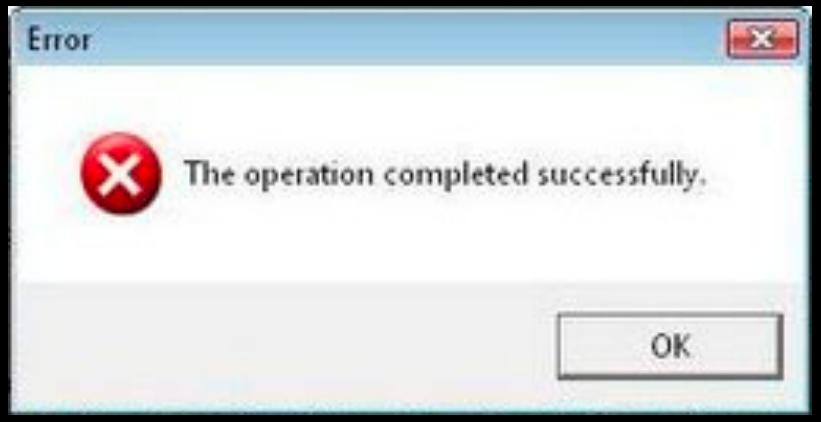

LELAND STANFORD JUNIOR UNIVERSITY
DIE LUFT DER FREIHEIT WEHT
1891
SPACE RANGER
LIGHTYEAR

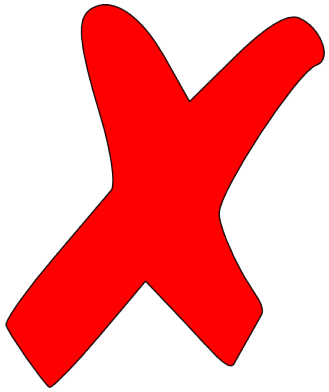
Graphics

Errors



What kind of bugs did you find in your code?

Reusing Variables



```
16    public void run() {
17        int counter = 0;
18        for (int i = 0; i < 10; i++) {
19            int counter = counter + 1;
20        }
21
22    }
```

Duplicate variable age

You only need to tell Java the type of a variable once.

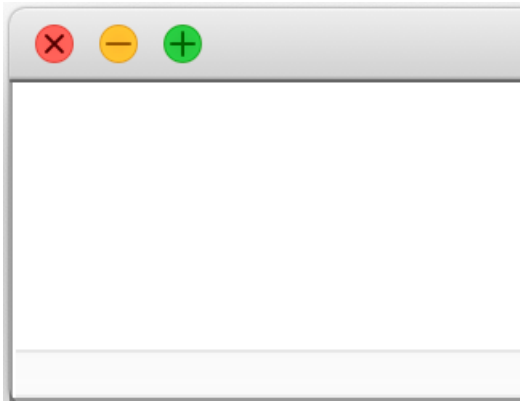
```
16    public void run() {
17        int counter = 0;
18        for (int i = 0; i < 10; i++) {
19            counter = counter + 1;
20        }
21
22    }
23
```

Updating Variable Values

"equals"
=

(1) Evaluate right hand side
(2) Store result in variable on left hand side

```
int year = 2019;
int prevYear = year;
year = year + 1;
println(prevYear + " " + year);
println(prevYear + year);
```



year

2019

prevYear

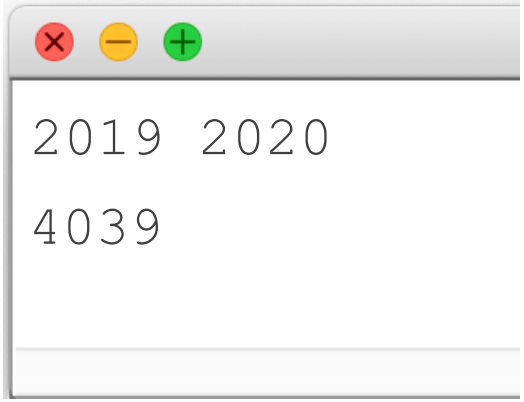
2019

Updating Variable Values

"equals"
=

(1) Evaluate right hand side
(2) Store result in variable on left hand side

```
int year = 2019;
int prevYear = year;
year = year + 1;
println(prevYear + " " + year);
println(prevYear + year);
```



year	prevYear
2020	2019

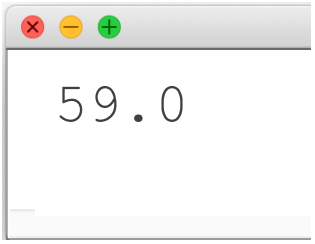
Updating Variable Values

"equals"
=

(1) Evaluate right hand side
(2) Store result in variable on left hand side

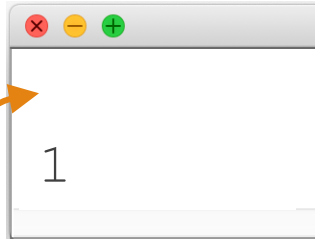
```
double seconds = 60;
seconds--;
println(seconds);
```

```
seconds = seconds – 1;
```




```
int total = 15;
total /= 10;
println();
println(total);
```

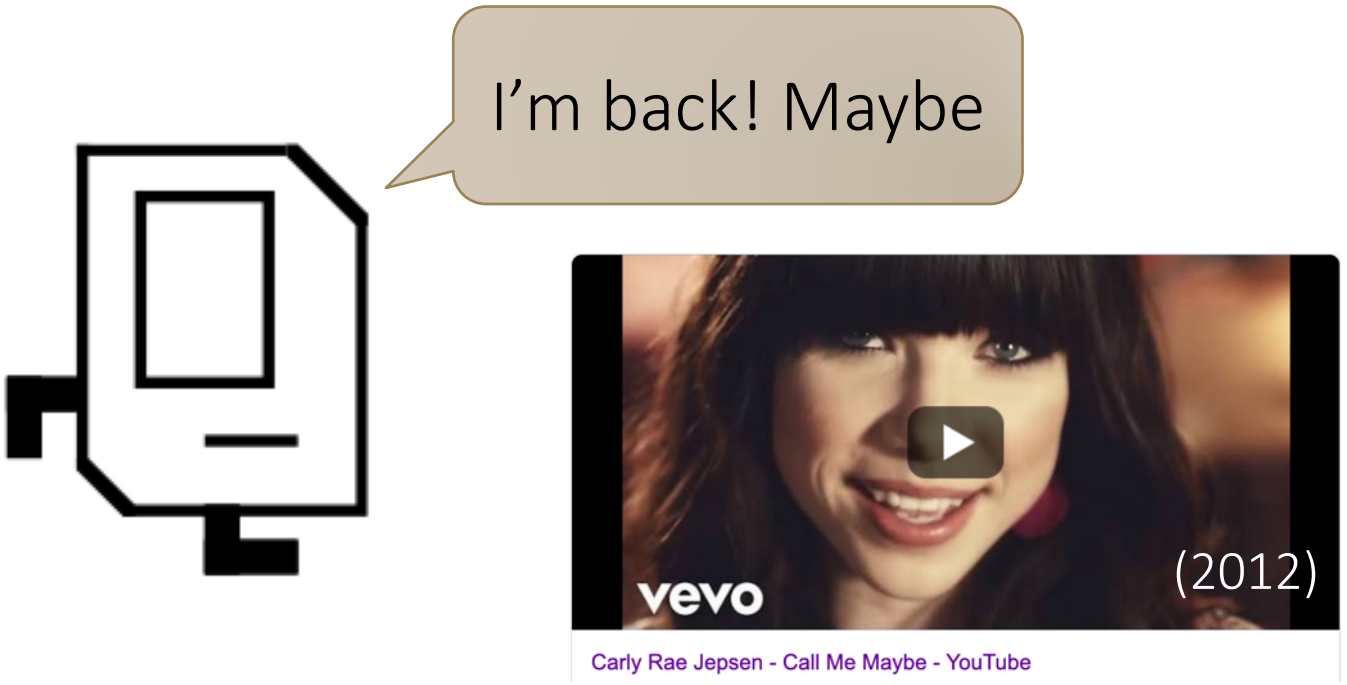
```
total = total / 10;
```




```
int age;
age = age + 1;
```

The local variable age may not have been initialized

We Called Karel, Maybe



Looping Beepers

How many beepers did Karel put down?


```
for (int i = 0; i < 5; i++) {
  for (int j = 0; j < 4; j++) {
    for (int k = 0; k < 3; k++) {
      putBeeper();
    }
  }
}
```

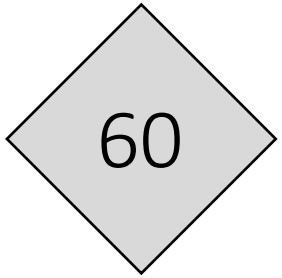
60

```
for (int i = 0; i < 3; i++) {
  int countdown = 10;
  while (countdown > 0) {
    countdown -= 2;
    putBeeper();
  }
}
```

Looping Beepers

How many beepers did Karel put down?


```
for (int i = 0; i < 5; i++) {
  for (int j = 0; j < 4; j++) {
    3 x 
  }
}
```

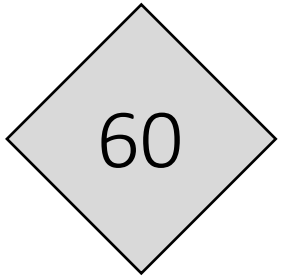



```
for (int i = 0; i < 3; i++) {
  int countdown = 10;
  while (countdown > 0) {
    countdown -= 2;
    putBeeper();
  }
}
```

Looping Beepers

How many beepers did Karel put down?

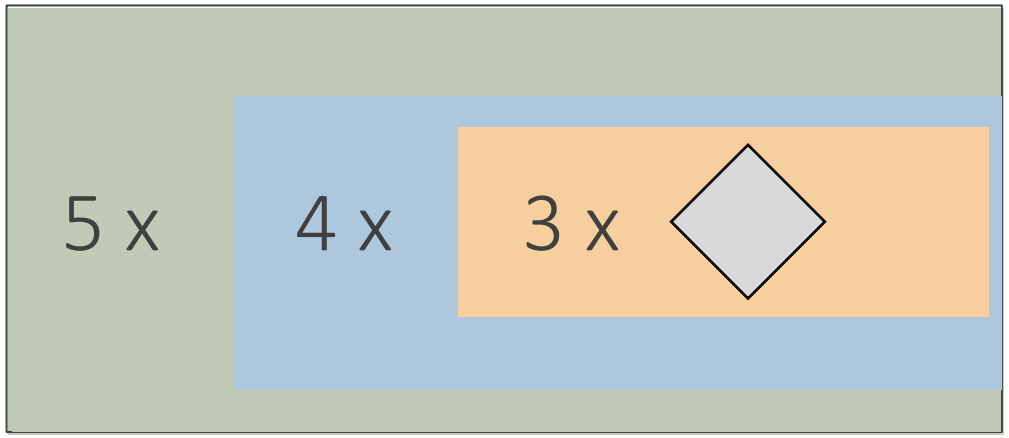

```
for (int i = 0; i < 5; i++) {
                4 x    3 x
}
```

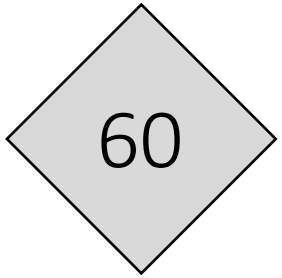



```
for (int i = 0; i < 3; i++) {
  int countdown = 10;
  while (countdown > 0) {
    countdown -= 2;
    putBeeper();
  }
}
```

Looping Beepers

How many beepers
did Karel put down?






```
for (int i = 0; i < 3; i++) {
  int countdown = 10;
  while (countdown > 0) {
    countdown -= 2;
    putBeeper();
  }
}
```

Looping Beepers

How many beepers did Karel put down?


```
for (int i = 0; i < 5; i++) {
  for (int j = 0; j < 4; j++) {
    for (int k = 0; k < 3; k++) {
      putBeeper();
    }
  }
}
```

60

```
for (int i = 0; i < 3; i++) {
  int countdown = 10;
  while (countdown > 0) {
    countdown -= 2;
    putBeeper();
  }
}
```

15

Countdown:
10,8,6,4,2,~~0~~

Looping Beepers

How many beepers did Karel put down?


```
for (int i = 0; i < 5; i++) {
  for (int j = 0; j < 4; j++) {
    for (int k = 0; k < 3; k++) {
      putBeeper();
    }
  }
}
```

60

```
for (int i = 0; i < 3; i++) {
  int countdown = 10;
  while (countdown > 0) {
    countdown -= 2;
    putBeeper();
  }
}
```

15

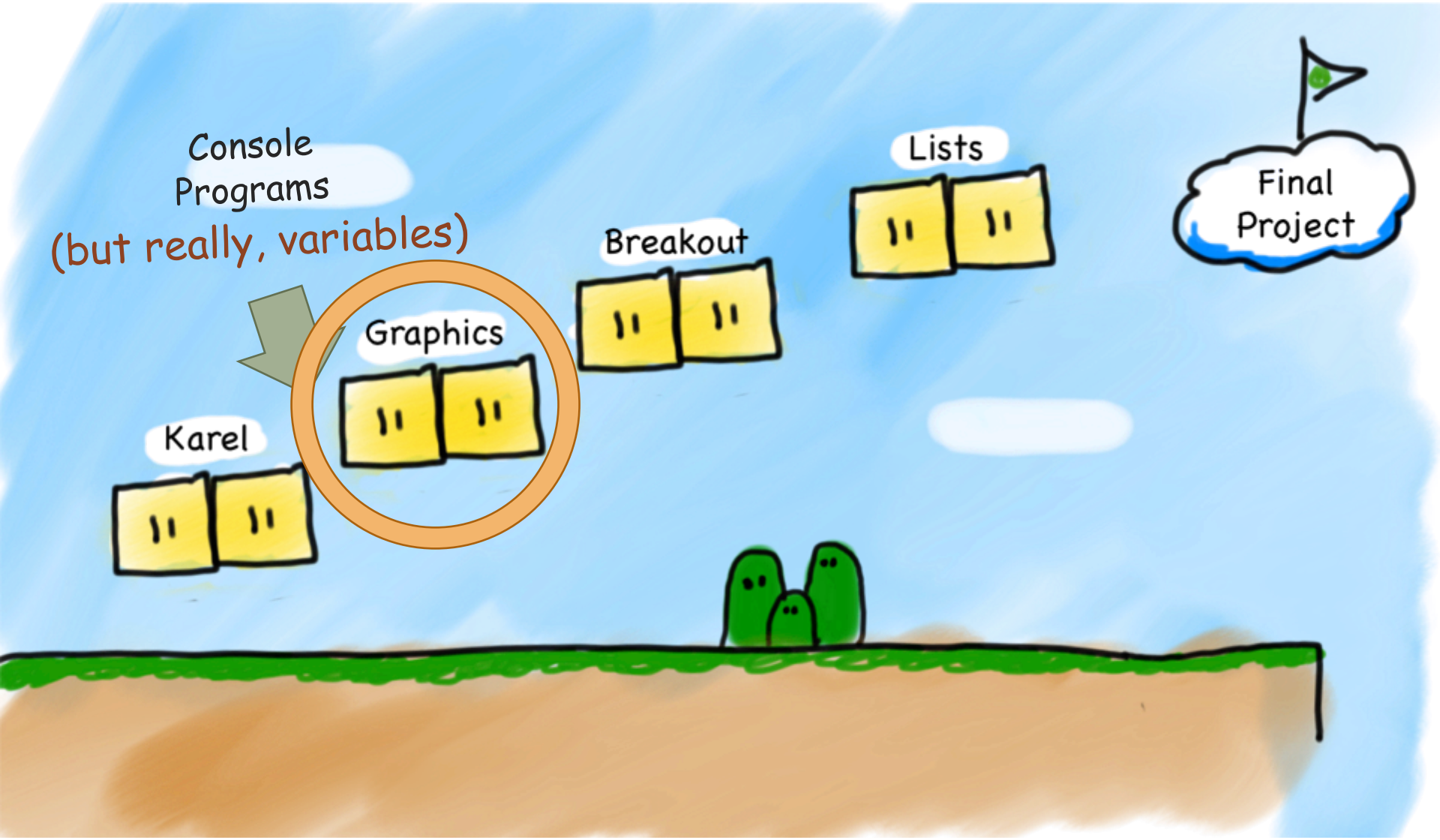
3 x

Countdown:

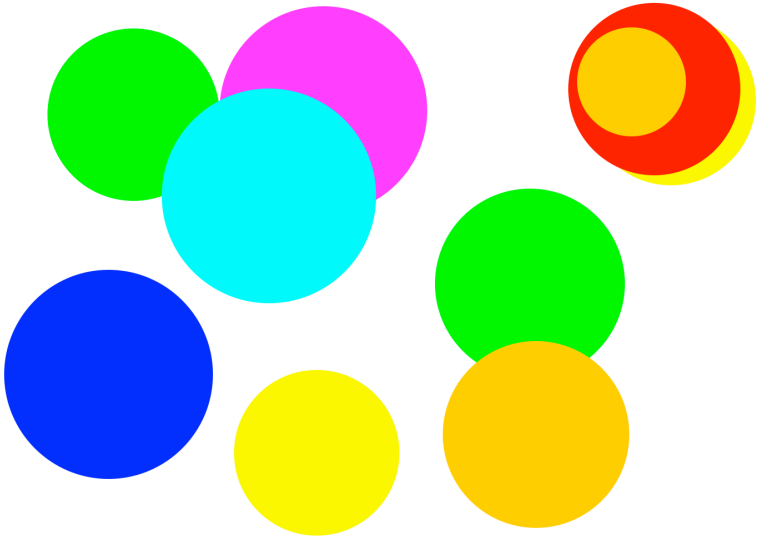
10,8,6,4,2,0

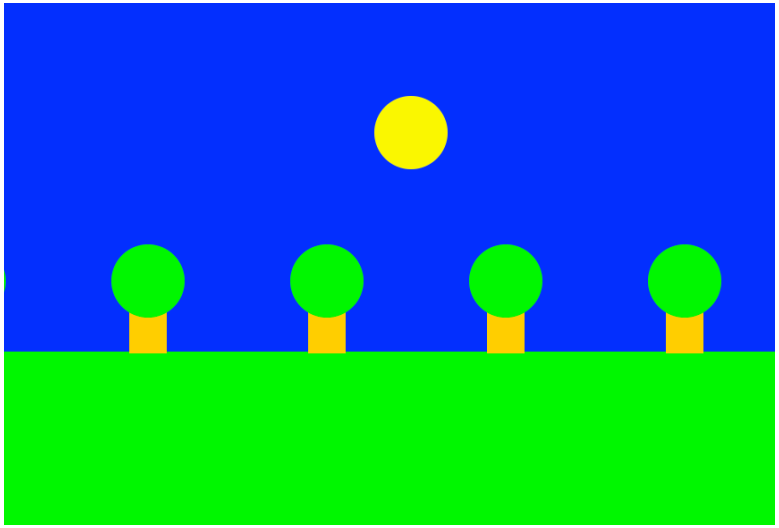
Programming takes practice.

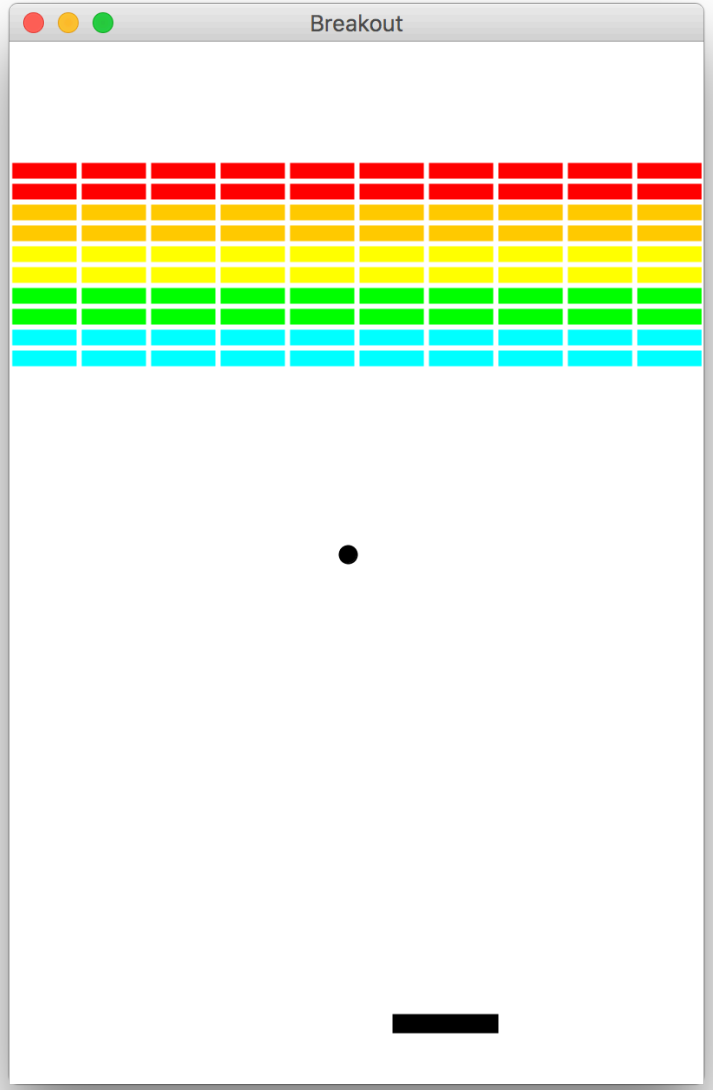
Our Second Step



Beyond Console Programs





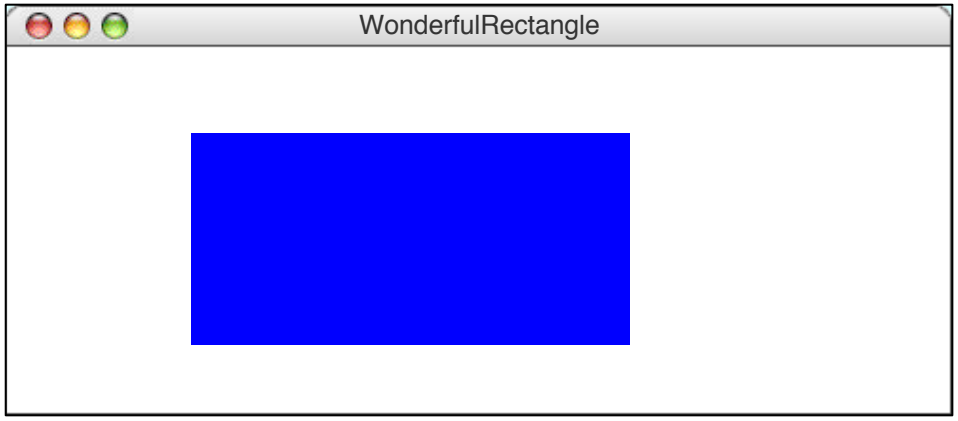


GRect

GRect is a variable that stores a rectangle.

As an example, the following `run` method displays a rectangle

```
public class WonderfulRect extends GraphicsProgram {
    public void run() {
        GRect rect = new GRect(220, 120);
        rect.setFilled(true);
        rect.setColor(Color.BLUE);
        add(rect, 50, 50);
    }
}
```



GRect

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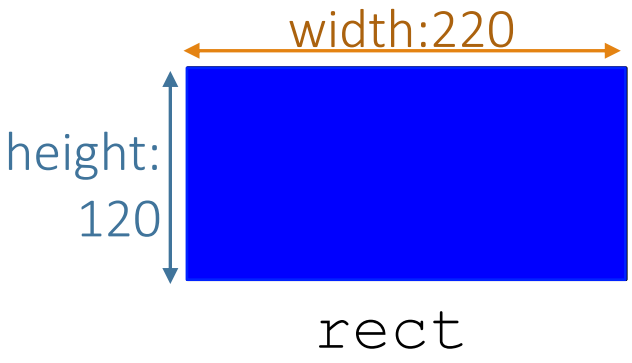
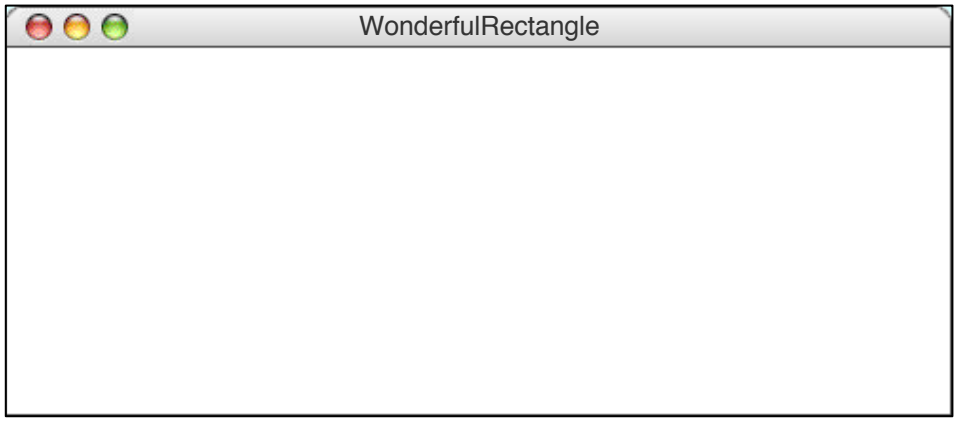
As an example, the following `run` method displays a rectangle

```
public class WonderfulRect extends GraphicsProgram {
    public void run() {
        GRect rect = new GRect(220, 120);
        rect.setFilled(true);
        rect.setColor(Color.BLUE);
        add(rect, 50, 50);
    }
}
```





GRect

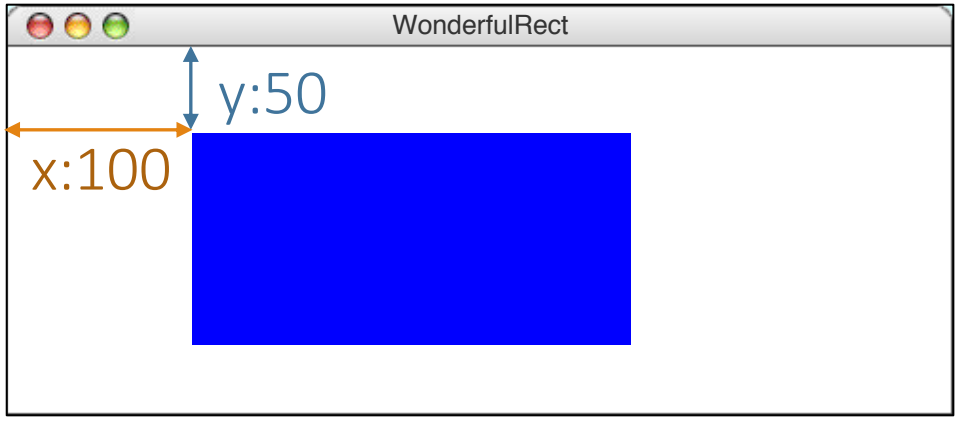
GRect is a variable that stores a rectangle.

As an example, the following `run` method displays a rectangle

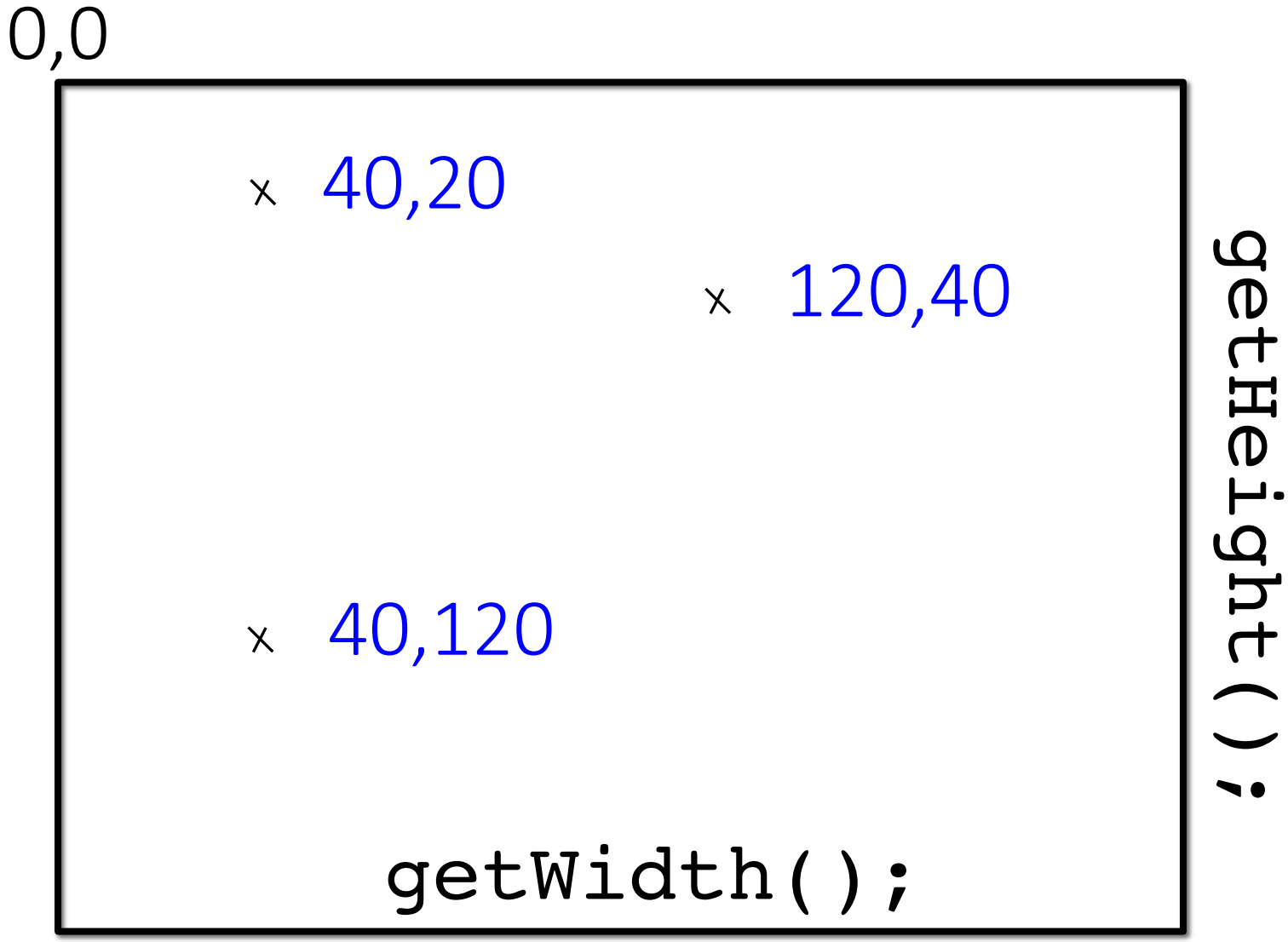
```
public class WonderfulRect extends GraphicsProgram {
    public void run() {
        GRect rect = new GRect(200, 200);
        rect.setFilled(true);
        rect.setColor(Color.BLUE);
        add(rect, 100, 50);
    }
}
```

⚠ You must call `add()` to display things!

Coordinates for a rectangle are the top left corner.



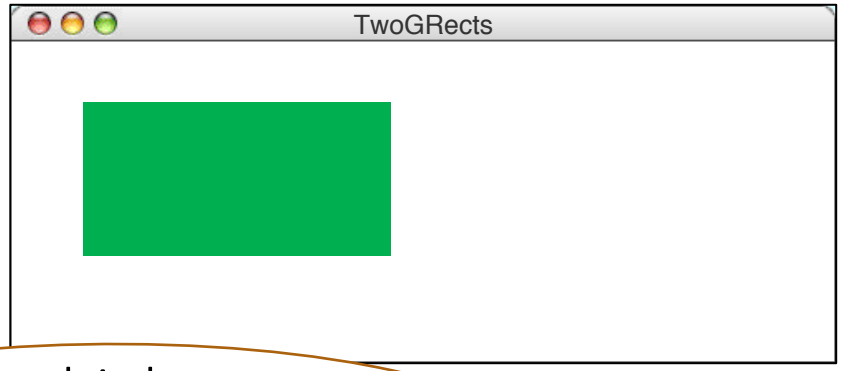
Graphics Coordinates



The Graphics *Canvas*

Two GRects

```
GRect rect = new GRect(100, 100);
rect.setFilled(true);
rect.setColor(Color.BLUE);
add(rect, 50, 50);
rect.setColor(Color.GREEN);
add(rect, 150, 50);
```



⚠ multiple `add()` commands just move things around!

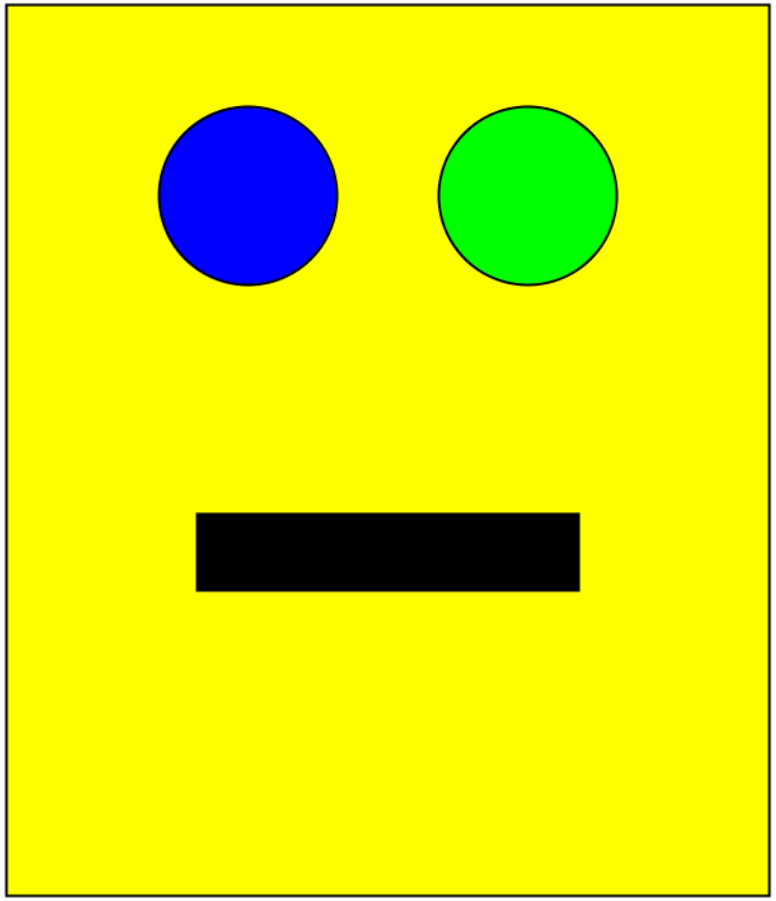
```
GRect rectB = new GRect(100, 100);
rectB.setFilled(true);
rectB.setColor(Color.BLUE);
add(rectB, 50, 50);

GRect rectG = new GRect(100, 100);
rectG.setFilled(true);
rectG.setColor(Color.GREEN);
add(rectG, 150, 50);
```

This draws two separate rectangles.

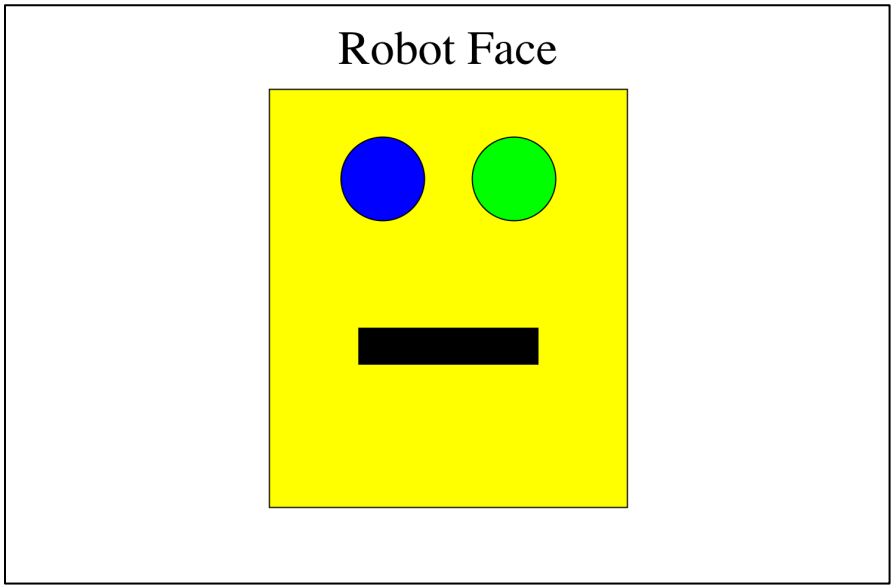
Questions?

Karel's Grandpa

Robot Face

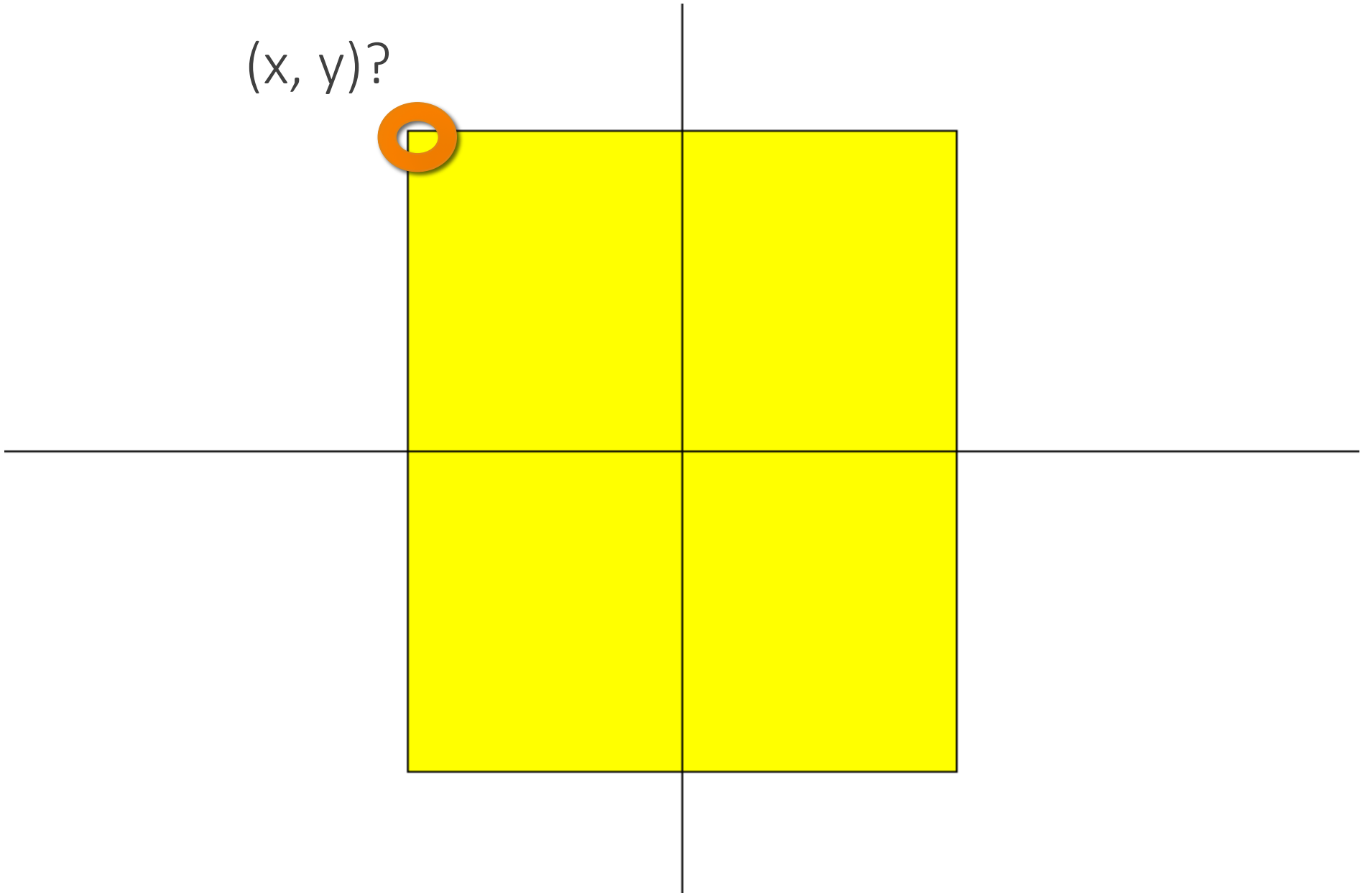


Karel's Grandpa

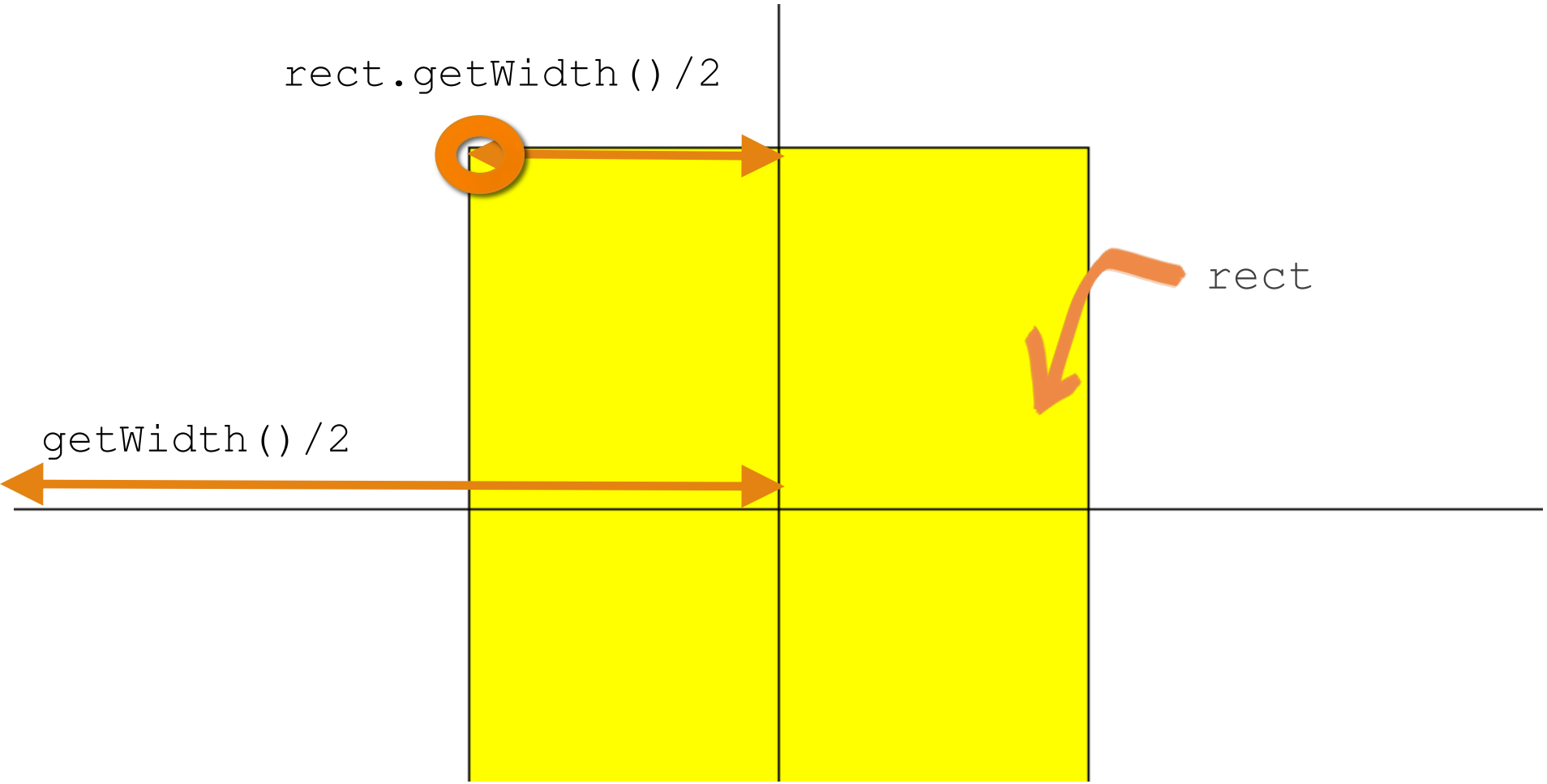



```
public void run() {
    drawHead();
    drawMouth();
    drawLabel();
    drawEyes();
}
```

drawHead()



drawHead()

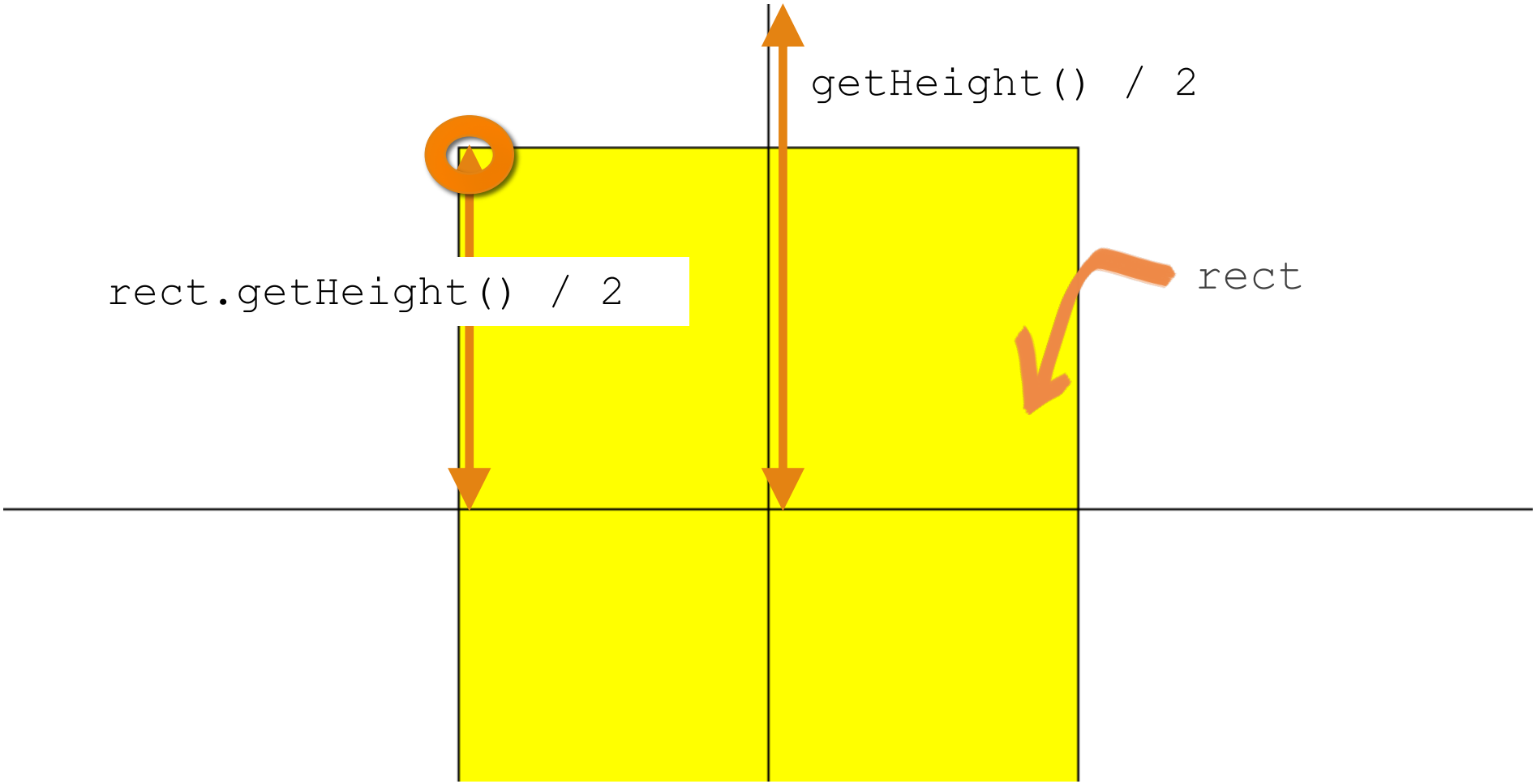



```
double headX = getWidth()/2 - rect.getWidth()/2;
```

or

```
double headX = (getWidth() - rect.getWidth())/2;
```

drawHead()

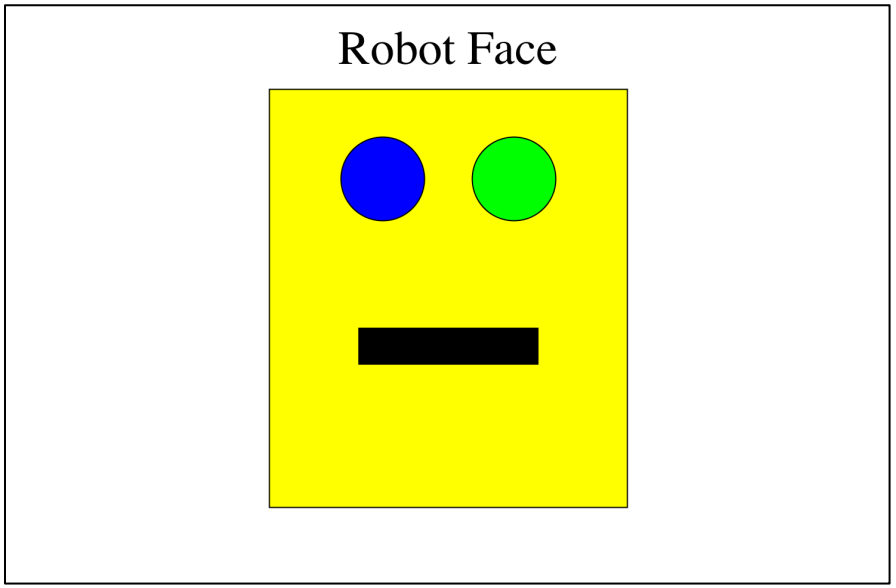



```
double headY = getHeight()/2 - rect.getHeight()/2;
```

or

```
double headY = (getHeight() - rect.getHeight())/2;
```

Karel's Grandpa




```
public void run() {
    drawHead();
    drawMouth();
    drawLabel();
    drawEyes();
}
```

Constants

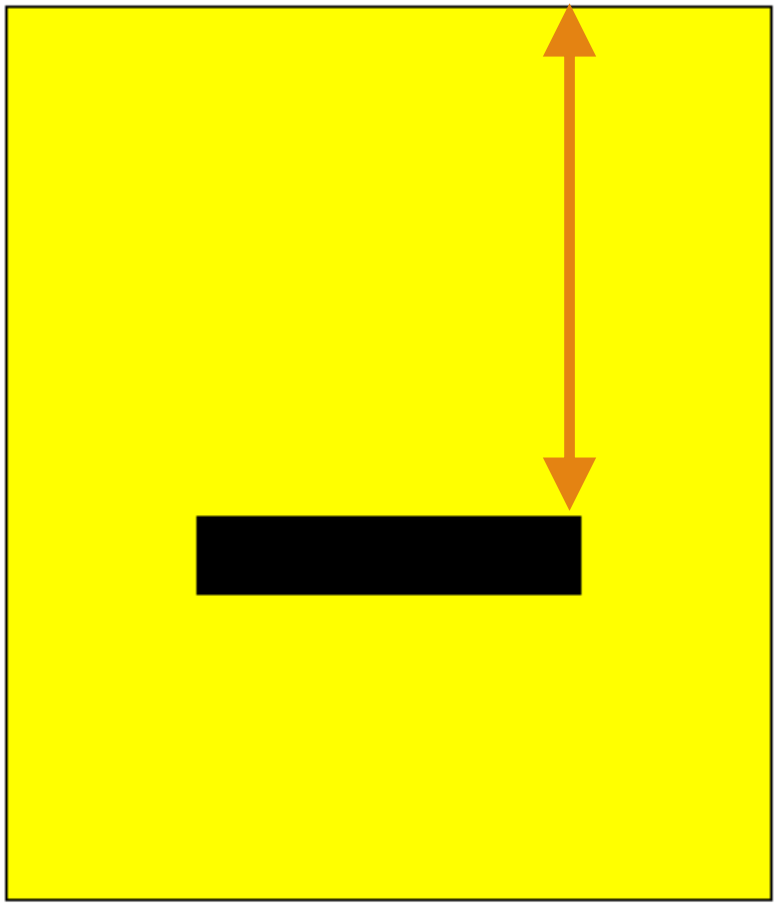
Once *constants* are defined, they cannot be changed anywhere.

Constants might have a lot of syntax, but they are easy to use.

```
public class RobotFace extends GraphicsProgram {

    /* The distance from the top of the head
     * to the top of the mouth */
    private static final int MOUTH_Y_OFFSET = 200;

    public void run() {
        drawHead();
        drawMouth();
        drawLabel();
        drawEyes();
    }
}
```

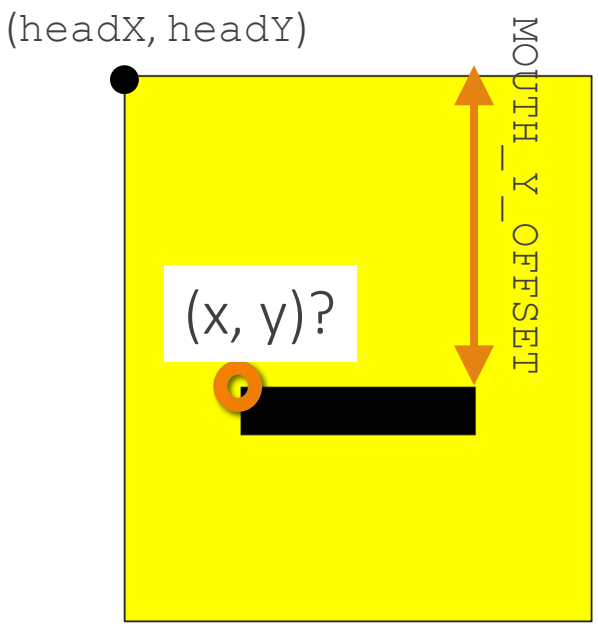
drawMouth()

```
/* The distance from the top of the head to the top of the mouth */
private static final int MOUTH_Y_OFFSET = 200;
```



drawMouth()

```
public class RobotFace extends GraphicsProgram {

    private static final int MOUTH_Y_OFFSET = 200;
    ... // more constants, hidden

    private void drawMouth() {
        double headX = ...;
        double headY = ...;

        double mouthX = ...
        double mouthY = ????????

        GRect mouth = new GRect(
              mouthX, mouthY,
              MOUTH_WIDTH, MOUTH_HEIGHT);

        ?????????
        ?????????
    }
    ... // more code
}
```

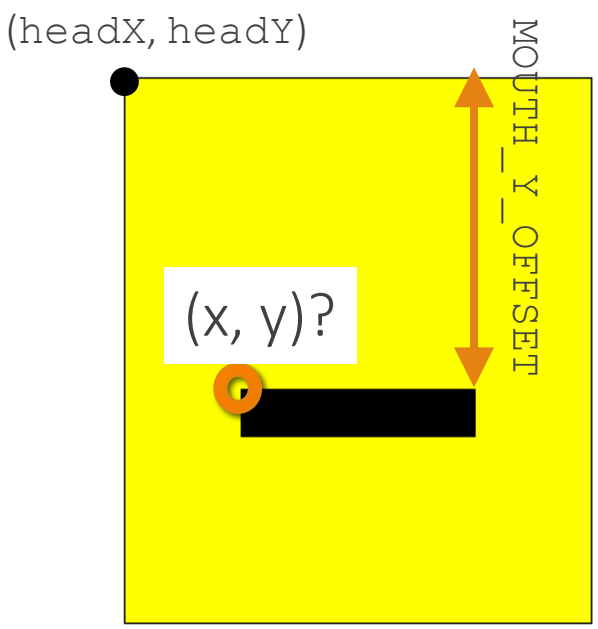


(1) Calculate `mouthY`

(2) Add the black filled in mouth to canvas

drawMouth()

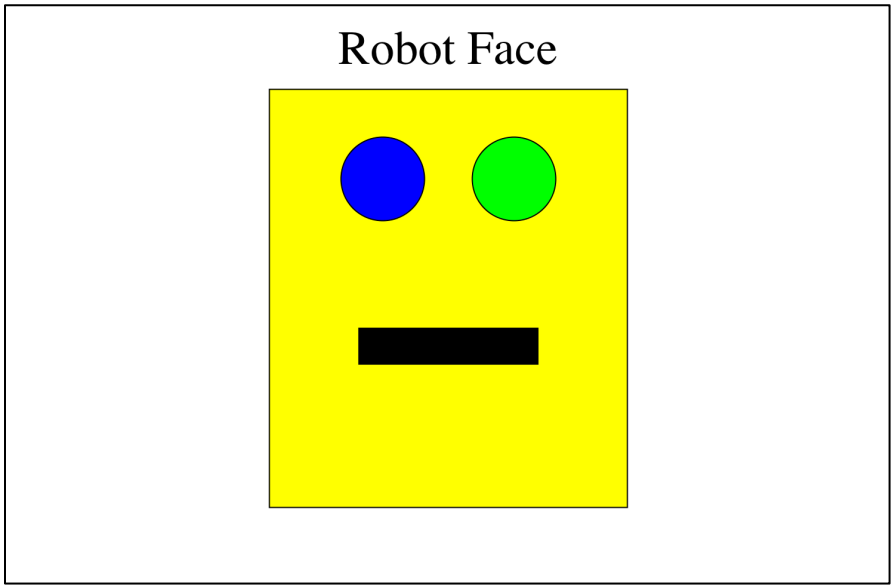
```
public class RobotFace extends GraphicsProgram {

    private static final int MOUTH_Y_OFFSET = 200;
    ... // more constants, hidden

    private void drawMouth() {
        double headX = ...;
        double headY = ...;

        double mouthX = ...
        double mouthY = headY + MOUTH_Y_OFFSET;

        GRect mouth = new GRect(
              mouthX, mouthY,
              MOUTH_WIDTH, MOUTH_HEIGHT);

        mouth.setFilled(true);
        add(mouth);
    }
    ... // more code
}
```



(1) Calculate `mouthY`

(2) Add the black filled in mouth to canvas

Karel's Grandpa




```
public void run() {
✓    drawHead();
✓    drawMouth();
     drawLabel();
     drawEyes();
}
```

GLabel

A variable that represents text.

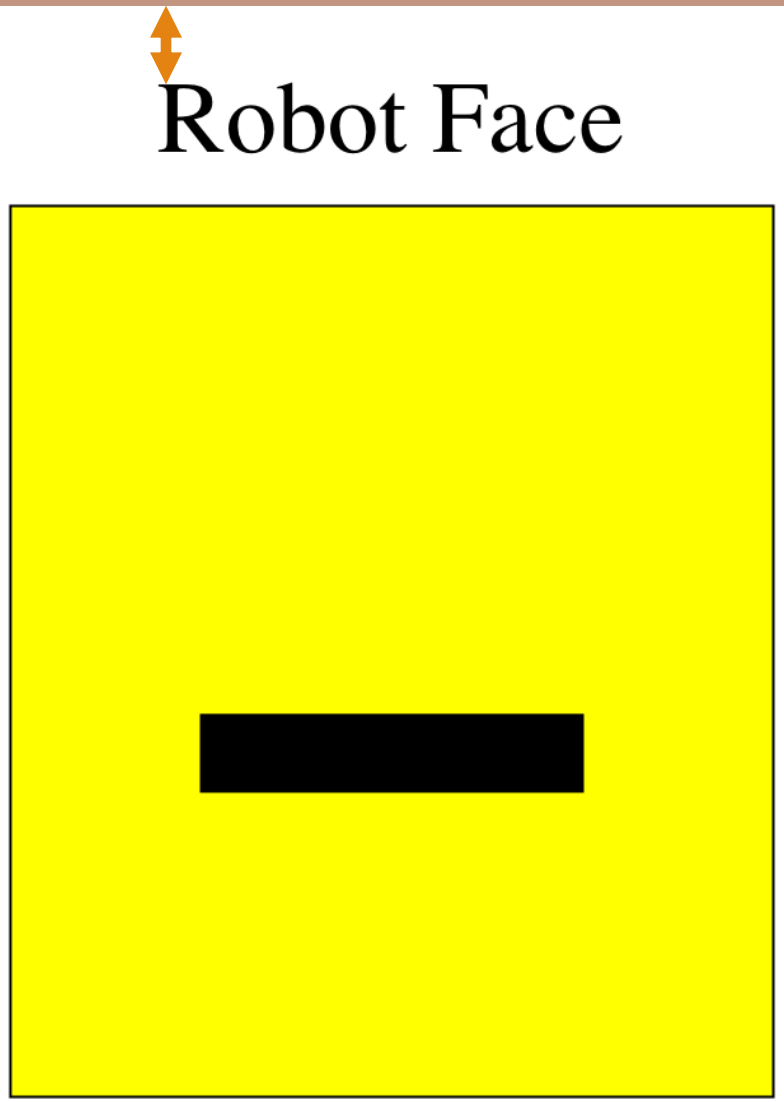
```
public class HelloProgram extends GraphicsProgram {
   public void run() {
      GLabel label = new GLabel(
            "hello, world", 100, 75);
      label.setFont("SansSerif-36");
      label.setColor(Color.RED);
      add(label);
   }
}
```

GLabel

A variable that represents text.

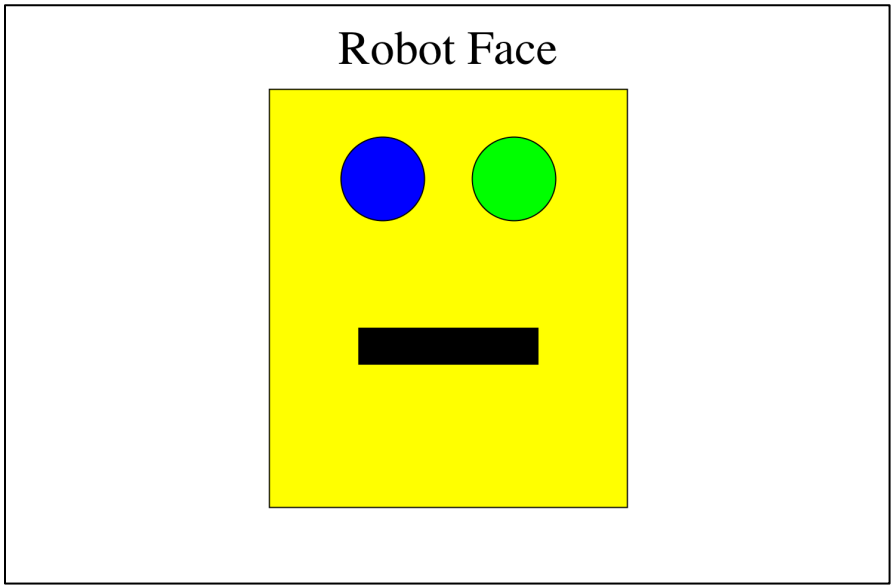
```
public class HelloProgram extends GraphicsProgram {
    public void run() {
        GLabel label = new GLabel(
                "hello, world", 100, 75);
        label.setFont("SansSerif-36");
        label.setColor(Color.RED);
        add(label);
    }
}
```

drawLabel()




```
/* The distance from the top of the screen to the base of the label */
private static final int LABEL_Y = 50;
```

Karel's Grandpa



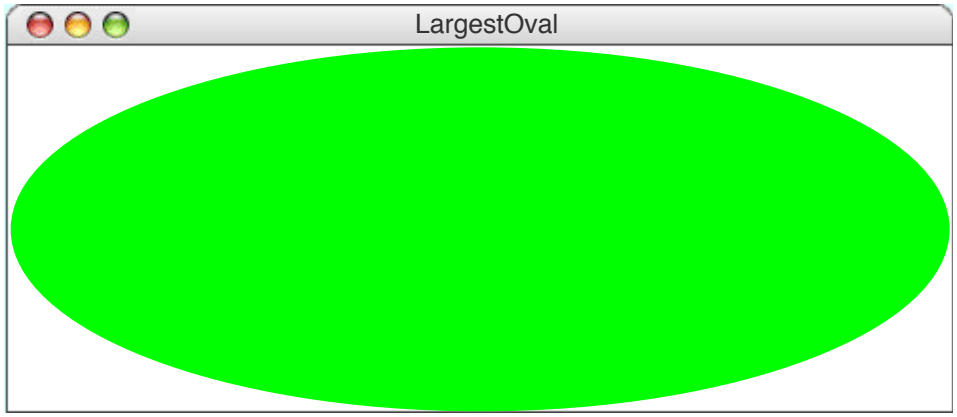

```
public void run() {
✓    drawHead();
✓    drawMouth();
✓    drawLabel();
     drawEyes();
}
```

GOval

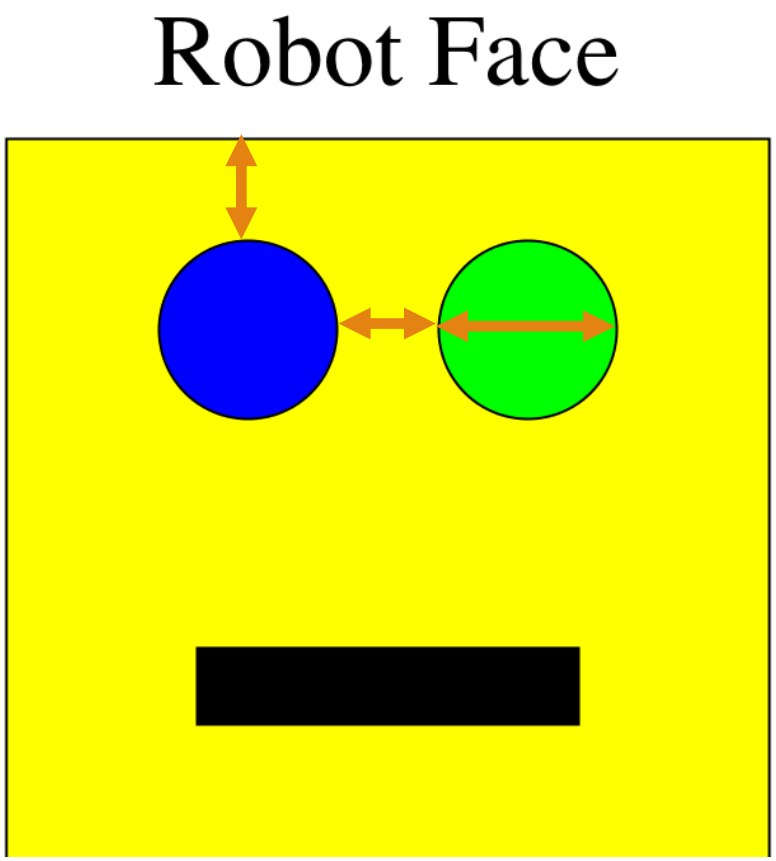
The `GOval` class represents an elliptical shape defined by the boundaries of its enclosing rectangle.

As an example, the following `run` method creates the largest oval that fits within the canvas:

```
public void run() {
    GOval oval = new GOval(getWidth(), getHeight());
    oval.setFilled(true);
    oval.setColor(Color.GREEN);
    add(oval, 0, 0);
}
```

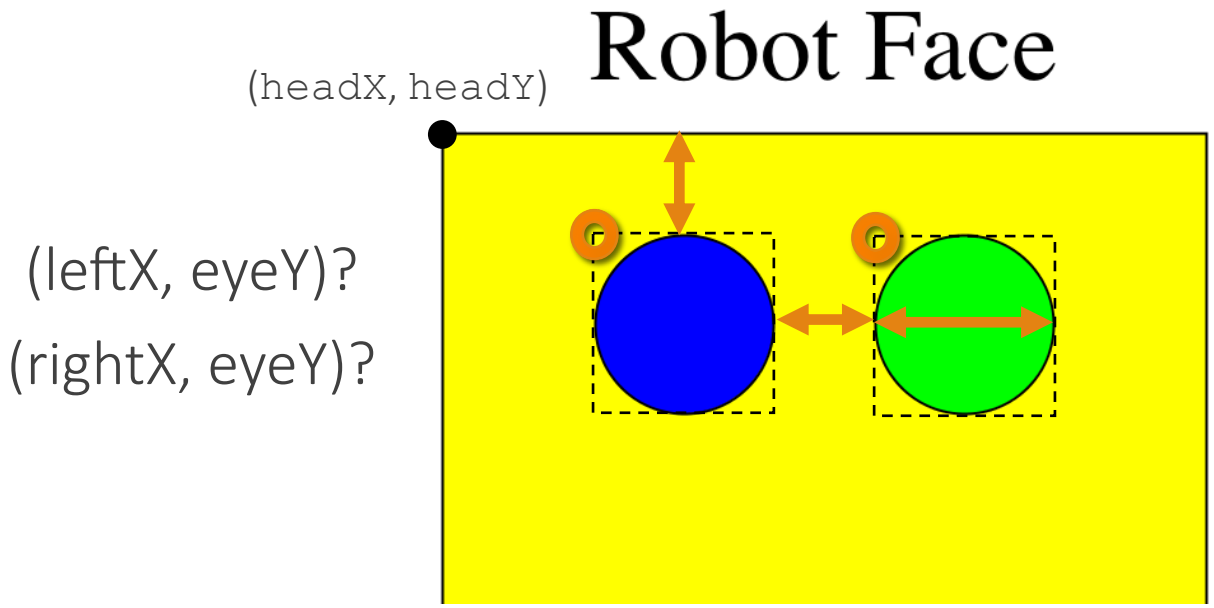


drawEyes()




```
/* The diameter of each eye*/
private static final int EYE_DIAMETER = 70;
/* The distance from the top of the head to the top of the eyes*/
private static final int EYE_Y_OFFSET = 40;
/* The distance in between the two eyes */
private static final int EYE_X_SEPARATION = 40;
```

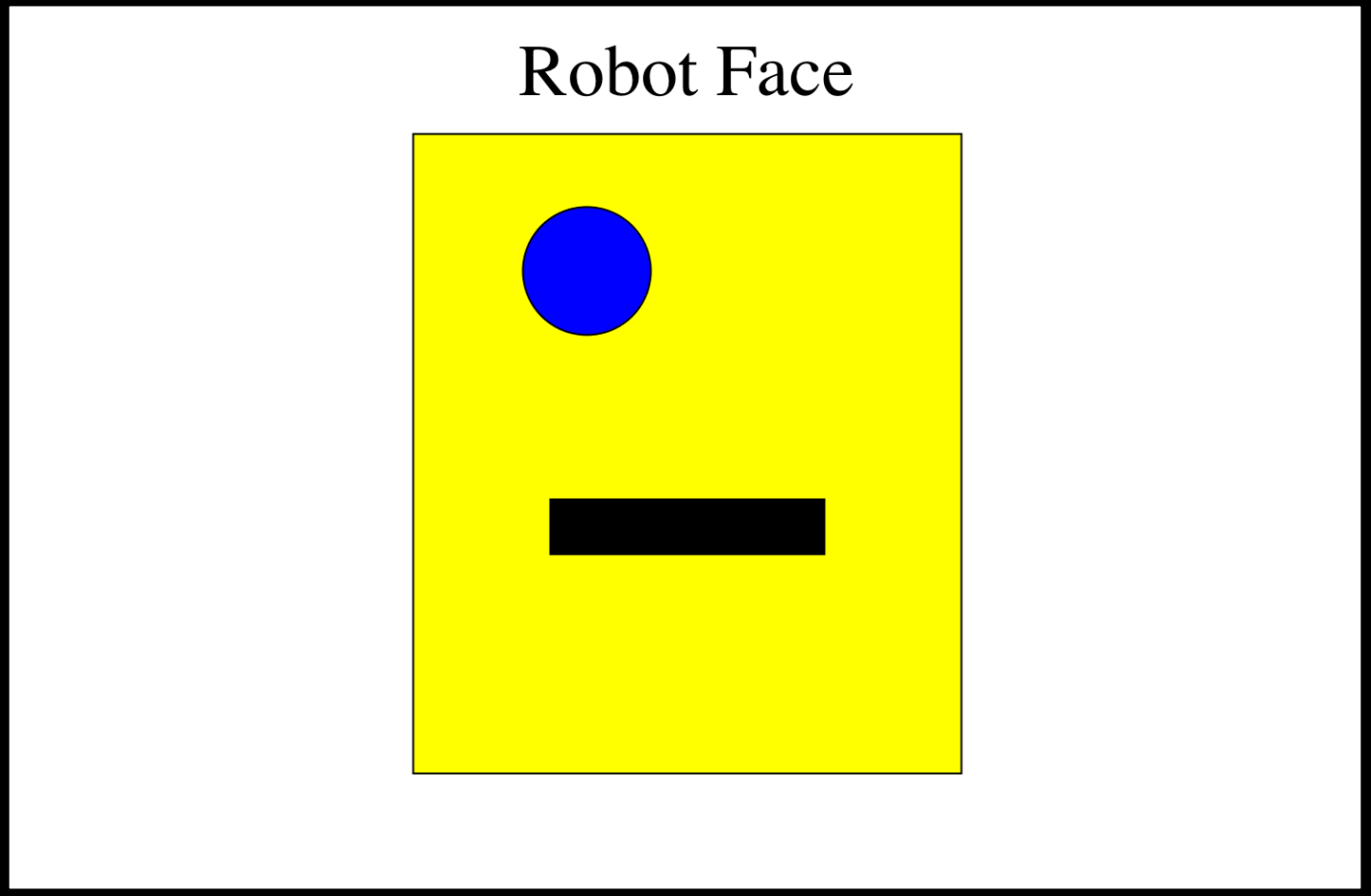
drawEyes()



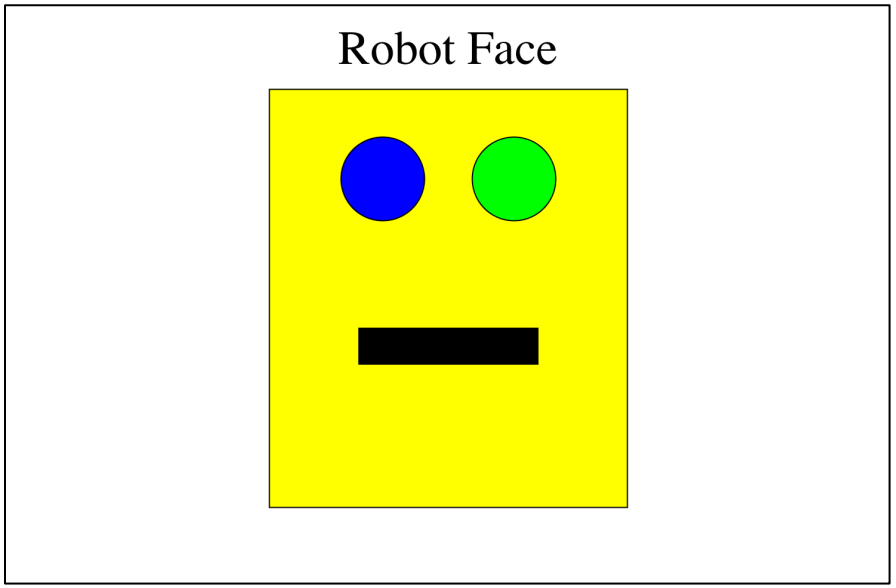

```
/* The diameter of each eye*/
private static final int EYE_DIAMETER = 70;
/* The distance from the top of the head to the top of the eyes*/
private static final int EYE_Y_OFFSET = 40;
/* The distance in between the two eyes */
private static final int EYE_X_SEPARATION = 40;

double eyeY = headY + EYE_Y_OFFSET;
double leftX = getWidth()/2 - EYE_X_SEPARATION/2 - EYE_DIAMETER;
double rightX = getWidth()/2 + EYE_X_SEPARATION/2;
```

drawEyes()

Programming time!

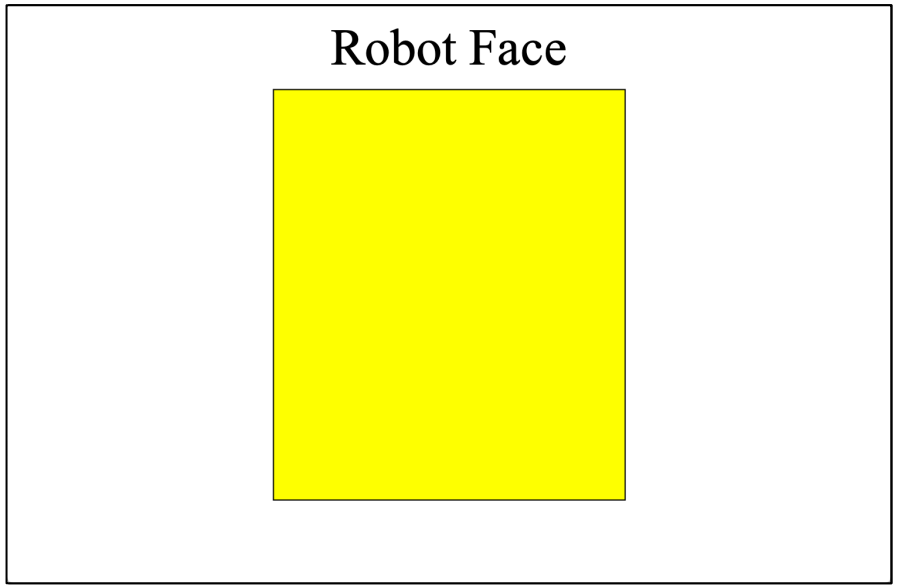


Karel's Grandpa




```
public void run() {
  ✓ drawHead();
  ✓ drawMouth();
  ✓ drawLabel();
  ✓ drawEyes();
}
```

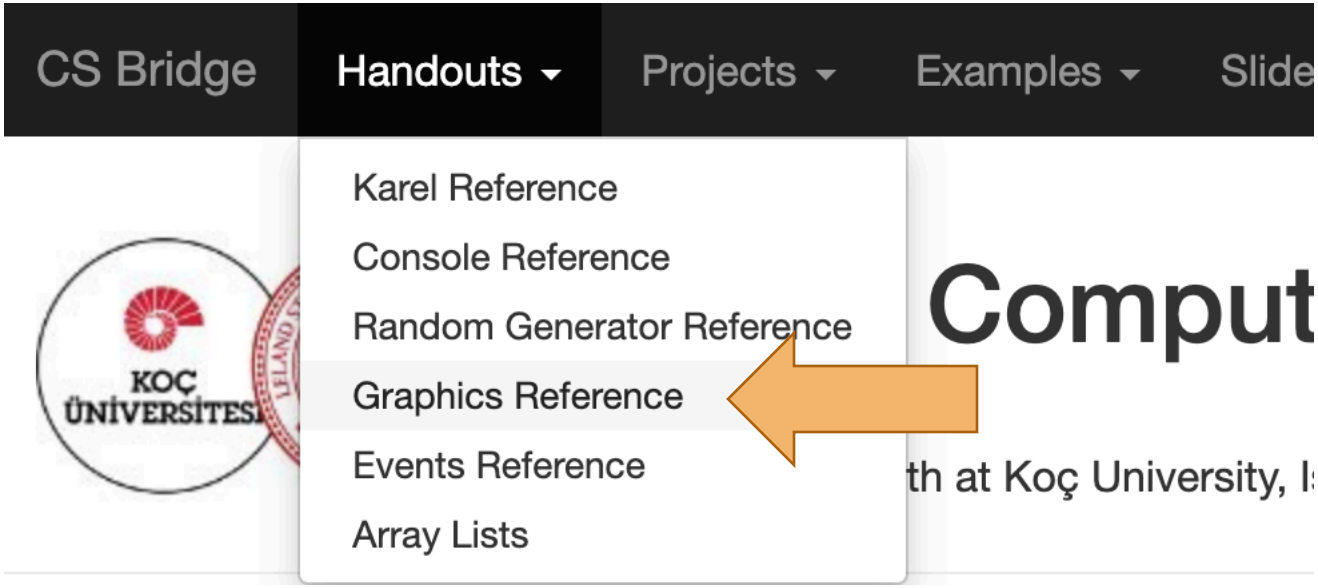
Not Karel's Grandpa




```
public void run() {
    drawMouth();
    drawLabel();
    drawEyes();
    drawHead();
}
```

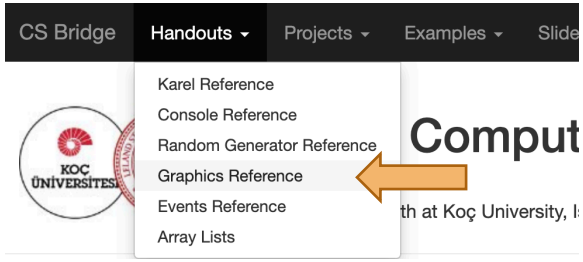
⚠ Order of `add()` matters!

Graphics Methods Reference



Graphics Methods

`add(`*object*`)`	Adds the object to the canvas at the front of the stack
`add(`*object*`, x, y)`	Moves the object to (*x*, *y*) and then adds it to the canvas
`remove(`*object*`)`	Removes the object from the canvas
`removeAll()`	Removes all objects from the canvas
`getElementAt(`*x*`, `*y*`)`	Returns the frontmost object at (*x*, *y*), or `null` if none
`getWidth()`	Returns the width in pixels of the entire canvas
`getHeight()`	Returns the height in pixels of the entire canvas
`setBackground(`*c*`)`	Sets the background color of the canvas to *c*.
`pause(`*milliseconds*`)`	Pauses the program for the specified time in milliseconds
`waitForClick()`	Suspends the program until the user clicks the mouse



Reference Sheet

Constructors

`new GLabel(String text)` *or* **`new GLabel(String text, double x, double y)`**
Creates a new **`GLabel`** object; the second form sets its location as well.

`new GRect(double x, double y, double width, double height)`
Creates a new **`GRect`** object; the **`x`** and **`y`** parameters can be omitted and default to 0.

`new GOval(double x, double y, double width, double height)`
Creates a new **`GOval`** object; the **`x`** and **`y`** parameters can be omitted and default to 0.

`new GLine(double x1, double y1, double x2, double y2)`
Creates a new **`GLine`** object connecting (**`x1`**, **`y1`**) and (**`x2`**, **`y2`**).

Methods common to all graphical objects

`void setLocation(double x, double y)`
Sets the location of this object to the specified coordinates.

`void move(double dx, double dy)`
Moves the object using the displacements **`dx`** and **`dy`**.

`double getWidth()`
Returns the width of the object.

`double getHeight()`
Returns the height of the object.

`void setColor(Color c)`
Sets the color of the object.

Methods available for GRect and GOval only

`void setFilled(boolean fill)`
Sets whether this object is filled (**`true`** means filled, **`false`** means outlined).

`boolean isFilled()`
Returns **`true`** if the object is filled.

`void setFillColor(Color c)`
Sets the color used to fill this object. If the color is **`null`**, filling uses the color of the object.

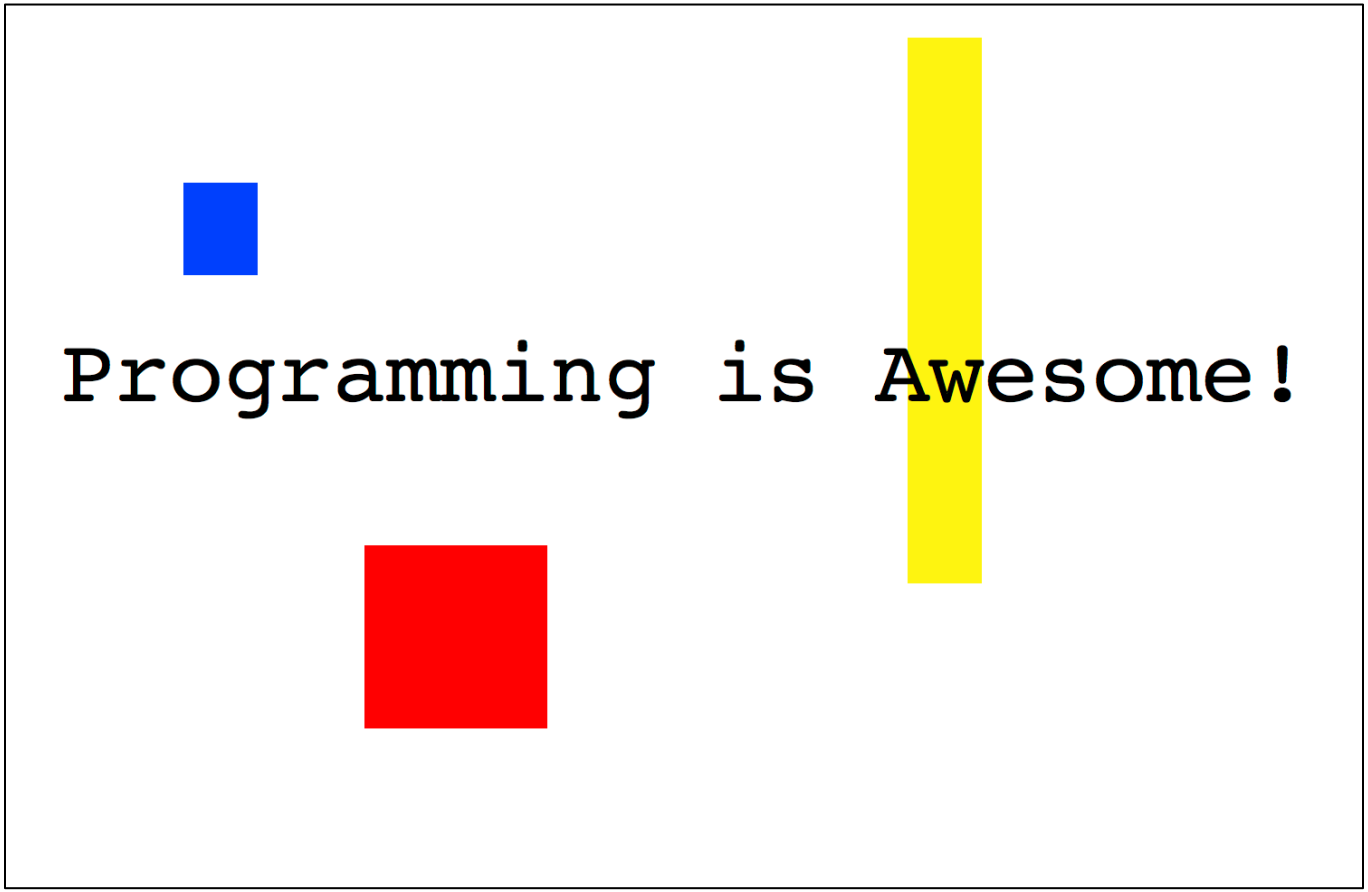
Methods available for GLabel only

`void setFont(String fontName)`
Sets the font, as described in Chapter 5.

`double getAscent()`
Returns the height above the text baseline.

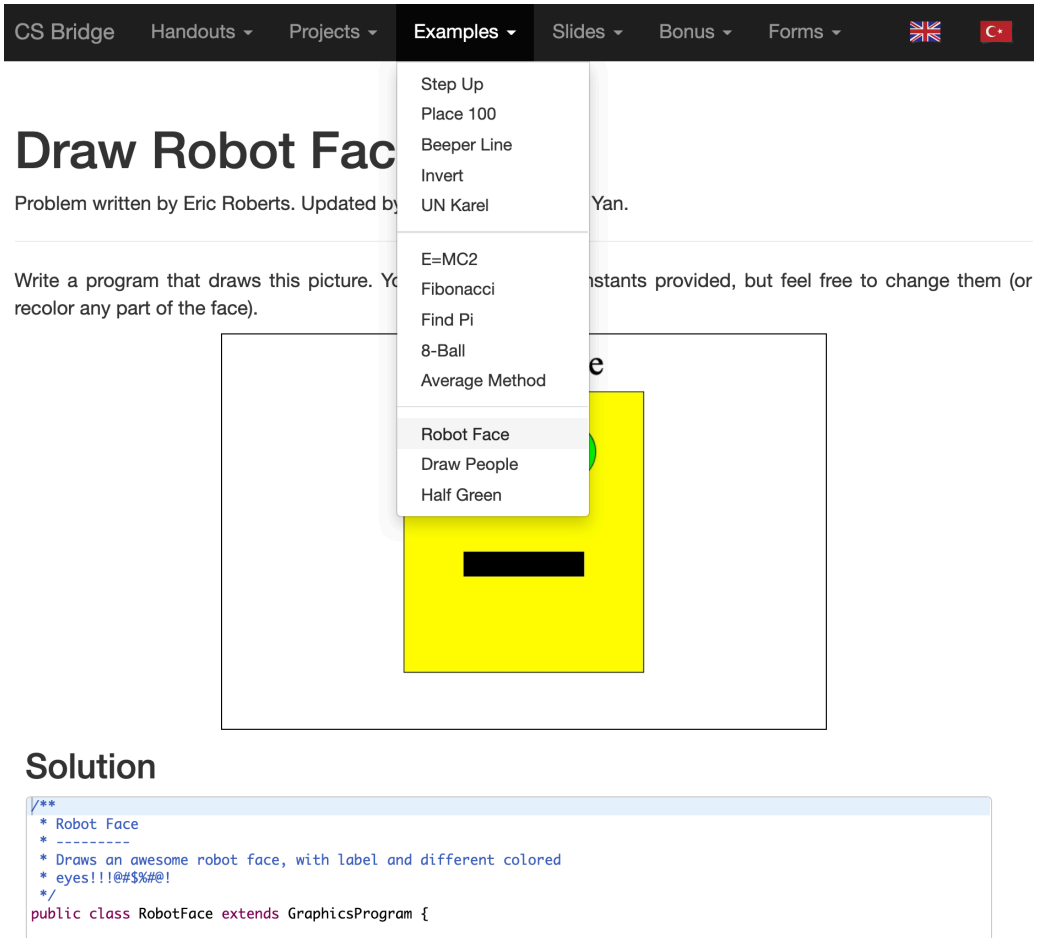
`double getDescent()`
Returns the height below the text baseline.

Time to Be Awesome



If you don't finish, you can keep working in the afternoon!

Karel's Grandpa



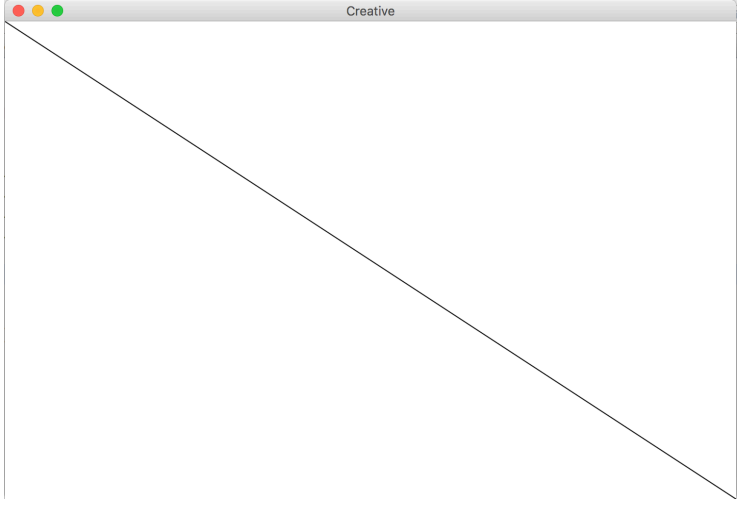
Read the solution code if you get stuck!

(bonus) GLine

The `GLine` class represents a line defined by a start point and an end point.

As an example, the following `run` method creates a diagonal line across the canvas:

```
public void run() {
    GLine line = new GLine(0,0, getWidth(), getHeight());
    add(line);
}
```



(bonus) Karel's Grandpa