Methods and Scope with Tracing and Debugging

Lecture 11

CS106A, Summer 2019
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Announcements

- Honor Code Reminder

Honor Code

- Do **not look at assignment solutions that are not your own**.
  - Online or another student's.
- Do **not share solutions with other students**.
- If you discuss strategies (NOT SOLUTIONS), **you must indicate assistance you have received**.
  - You do not need to do this if the person is a CS106 staff member.
- You **can only reuse work in certain, limited situations**.
- If you have questions about honor code, please ask the instructors.

Plan for Today

- Review: Null, Events, Instance Variables
- Pass by Reference vs. Pass by Value
- Types of Errors
- Eclipse Debugger
- Practice!

Review: Accessing the Canvas

- It is possible to determine what, if anything, is at the canvas at a particular point.
- The method:

```
GObject getElementAt(double x, double y);
```

  returns which object is at the given location on the canvas.

- The return type is `GObject`, since we don't know what specific type (`GRect`, `GOval`, etc.) is really there.
- If no object is present, the special value `null` is returned.

Review: Null

`null` is a special variable value that objects can have that means "nothing". Primitives cannot be null.

If a method returns an object, it can return `null` to signify "nothing". (just say `return null;`)

```
// may be a GObject, or null if nothing at (x, y)
GObject maybeAnObject = getElementAt(x, y);
```

Objects have the value `null` before being initialized.

```
GOval circle;   // initially null
```

Review: Null

You can check if something is `null` using `==` and `!=`

```
// may be a GObject, or null if nothing at (x, y)
GObject maybeAnObject = getElementAt(x, y);
if (maybeAnObject != null) {
    // do something with maybeAnObject
} else {
    // null – nothing at that location
}
```

Review: Null

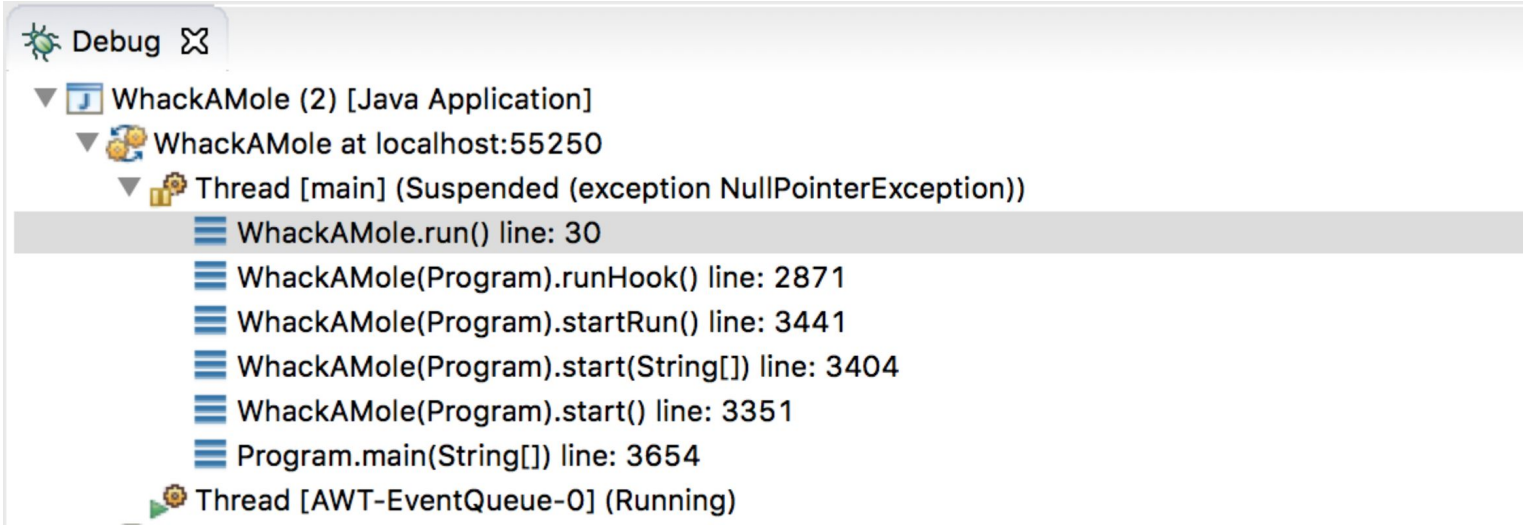
Calling methods on an object that is `null` will crash your program!

```
// may be a GObject, or null if nothing at (x, y)
GObject maybeAnObject = getElementAt(x, y);
if (maybeAnObject != null) {
    int x = maybeAnObject.getX();  // OK
} else {
    int x = maybeAnObject.getX();  // CRASH!
}
```

Review: Null

Calling methods on an object that is `null` will crash your program!

⇒ Throws a `NullPointerException`



Review: Events

- An ***event*** is some external stimulus that your program can respond to.

- Common events include:
  - Mouse motion / clicking.
  - Keyboard buttons pressed.
  - Timers expiring.
  - Network data available.

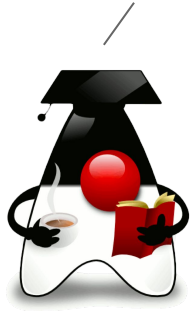
Review: Events

```
public void run() {
    // Java runs this when program launches
}

public void mouseClicked(MouseEvent event) {
    // Java runs this when mouse is clicked
}

public void mouseMoved(MouseEvent event) {
    // Java runs this when mouse is moved
}
```

To **respond** to events, your program must write methods to **handle** those events.



Review: Types of Mouse Events

- There are many different types of mouse events!
- Each takes the form:

```
public void eventMethodName(MouseEvent e) { ...
```

Method	Description
mouseMoved	mouse cursor moves
mouseDragged	mouse cursor moves while button is held down
mousePressed	mouse button is pressed down
mouseReleased	mouse button is lifted up
mouseClicked	mouse button is pressed and then released
mouseEntered	mouse cursor enters your program's window
mouseExited	mouse cursor leaves your program's window

Review: MouseEvent Objects

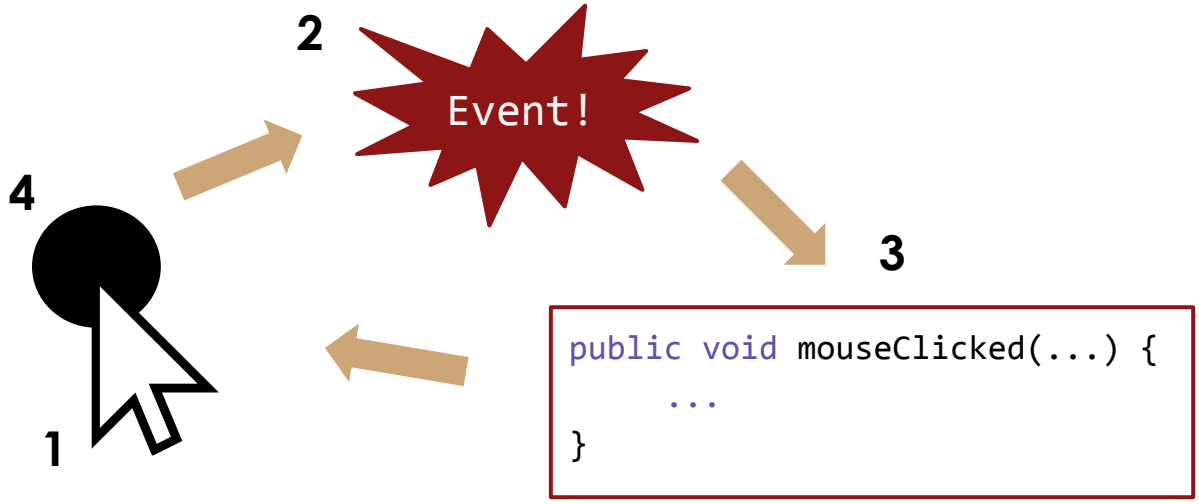
```
public void mouseClicked(MouseEvent e) { ...
```

- A `MouseEvent` contains information about the event that just occurred:

Method	Description
`e.getX()`	the *x*-coordinate of mouse cursor in the window
`e.getY()`	the *y*-coordinate of mouse cursor in the window

Review: Events

1. User performs some action, like moving / clicking the mouse.
2. This causes an event to occur!
3. Java executes a particular method to handle the event.
4. That method's code updates the screen appearance in some way



Review: Instance Variables

1. Variables exist until their inner-most control block ends.
2. If a variable is *defined outside all methods*, its inner-most control block is the entire program!
3. We call these variables ***instance variables***.

```
private type name;     // declared outside any method!
```

```
private GRect square = null;

public void run() {
    square = new GRect(...);
    GRect localSquare = new GRect(...);
}
```

Review: Instance Variables + Events

Often you need instance variables to pass information between the run method and the mouse event methods.

```
/* Instance variable for the square to be tracked */
private GRect square = null;

public void run() {
     square = makeSquare();
     addSquareToCenter();
}

public void mouseMoved(MouseEvent e) {
     double x = e.getX() - SQUARE_SIZE / 2.0;
     double y = e.getY() - SQUARE_SIZE / 2.0;
     square.setLocation(x, y);
}
```

Review: The Importance of Style

- It is considered extremely poor style to use instance variables unnecessarily:

Do not use instance variables where local variables, parameters, and return values suffice.

- Use *local variables* for temporary information.
- Use *parameters* to communicate data into a method.
- Use *return values* to communicate data out of a method.

Speaking of Parameters...

Pass by *Reference* vs. **Pass by *Value***

Pass by Reference vs Value

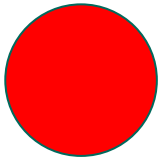
Pass by Reference

Objects are passed by **reference.**

A few examples:

`GRect`

`GImage`



`GOval`

Pass by Value

Primitives are passed by **value**.

A few examples:

`int`

`char`

`double`

`boolean`

Pass by Reference vs Value

What does this mean?

Let's Look at a Program!

Pass by Reference vs Value

What does this mean?

If something is passed by ***reference***, it ***can*** be altered simply by passing it into a method.

If something is passed by ***value***, it ***cannot*** be altered simply by passing it into a method.

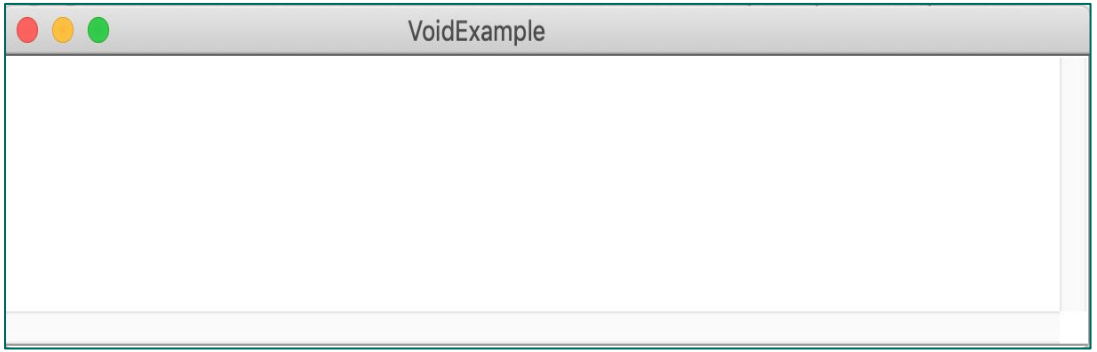
What Happened?

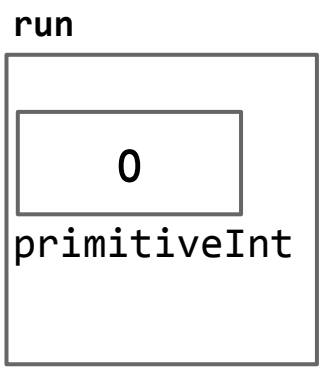
What Happened: Primitive

```
public void run(){
     int primitiveInt = 0;
     changeInt(primitiveInt);
     GLabel intLabel = new GLabel("primitiveInt: " + primitiveInt, 0, 50);
     add(intLabel);

     ...

}
```





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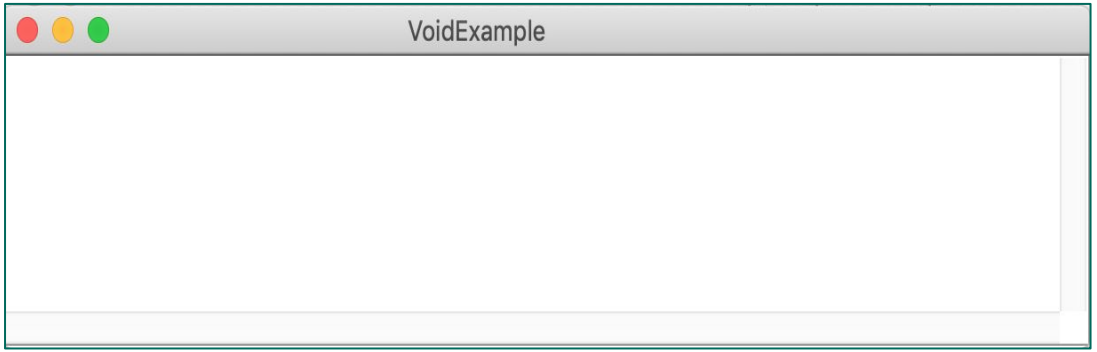

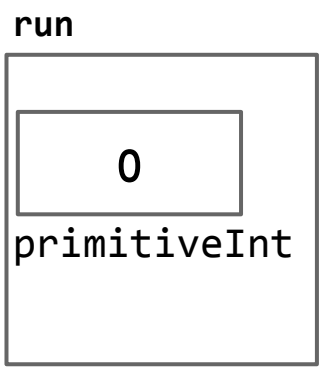

What Happened: Primitive

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         primitiveInt += 10;
    }

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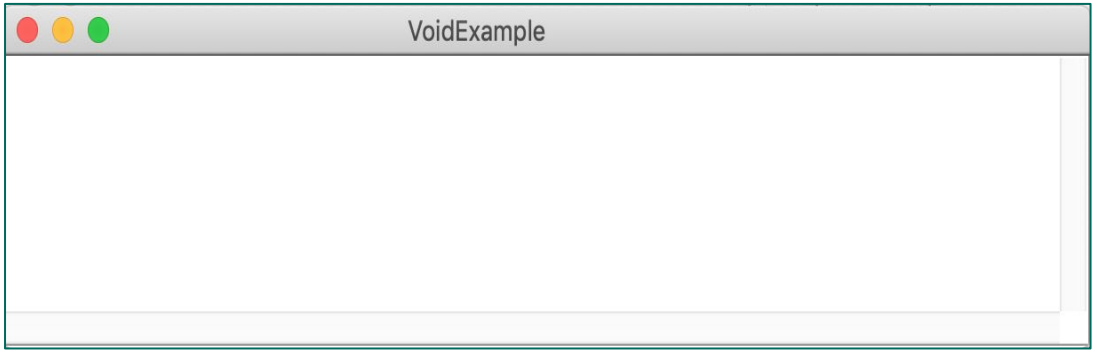
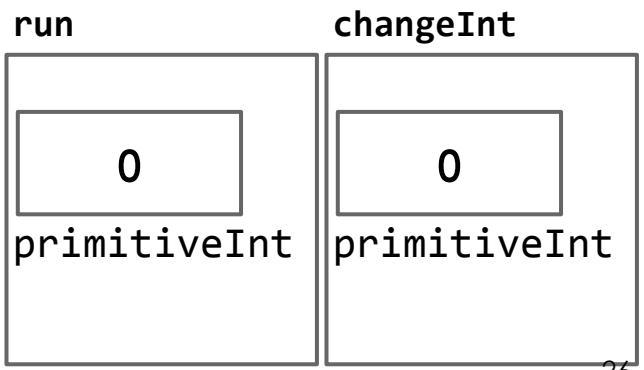
```





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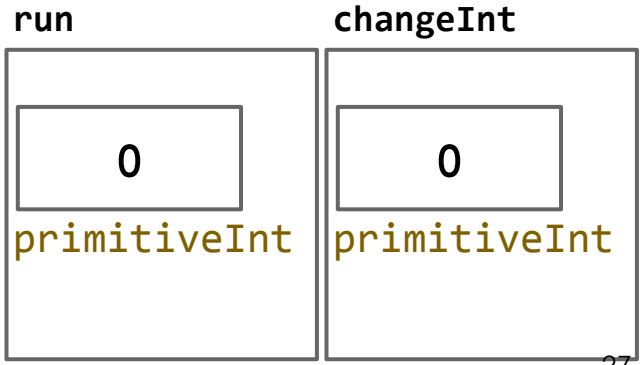

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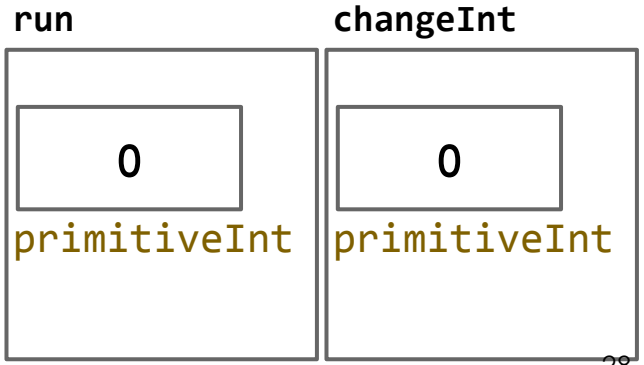

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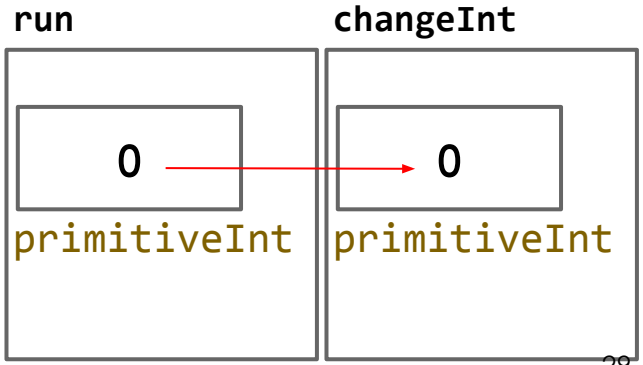

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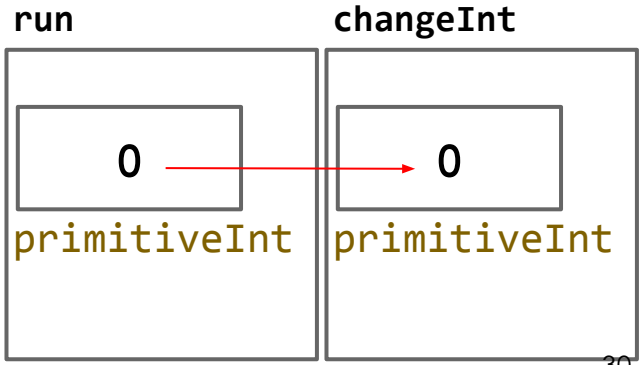
The `primitiveInt` inside of **changeInt** copied the value of the `primitiveInt` inside of **run**.
They are stored in different locations in the computer's memory. One just copied the **value** of the other variable.



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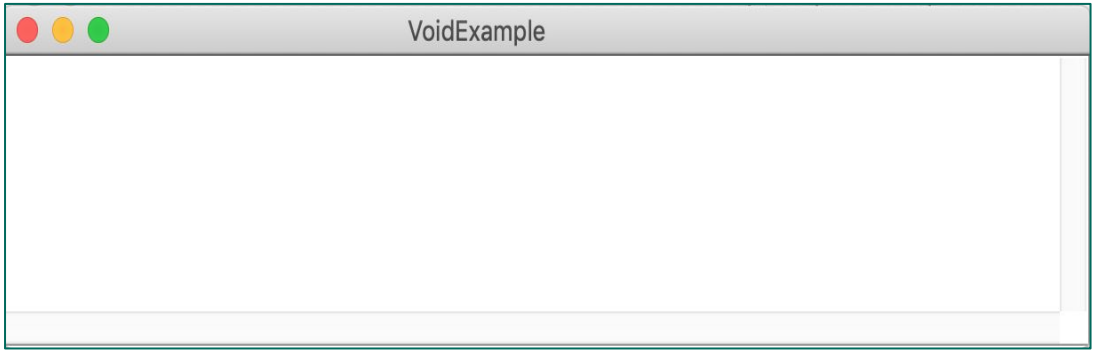

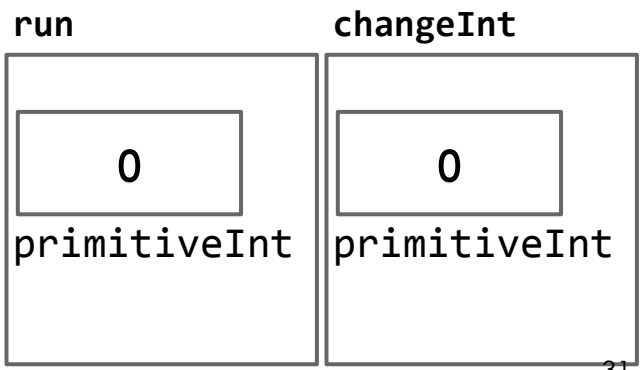

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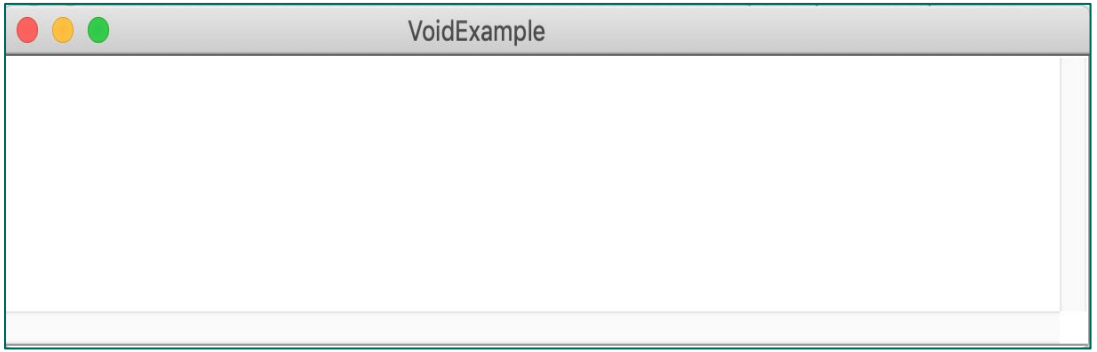

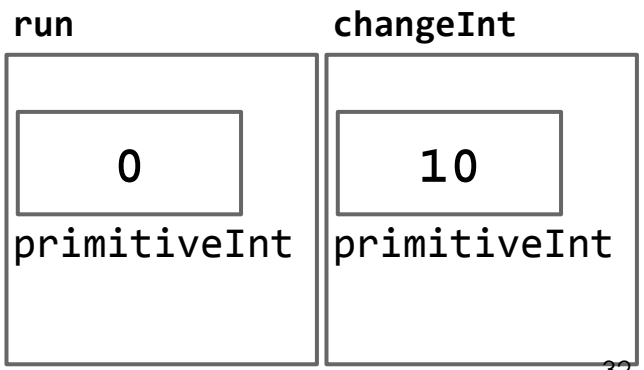

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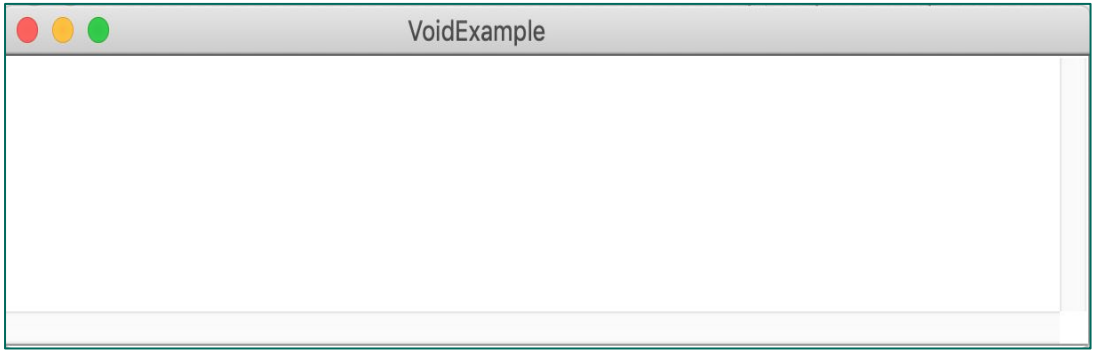

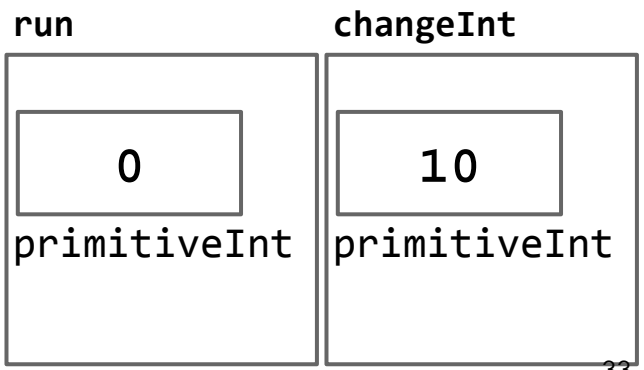

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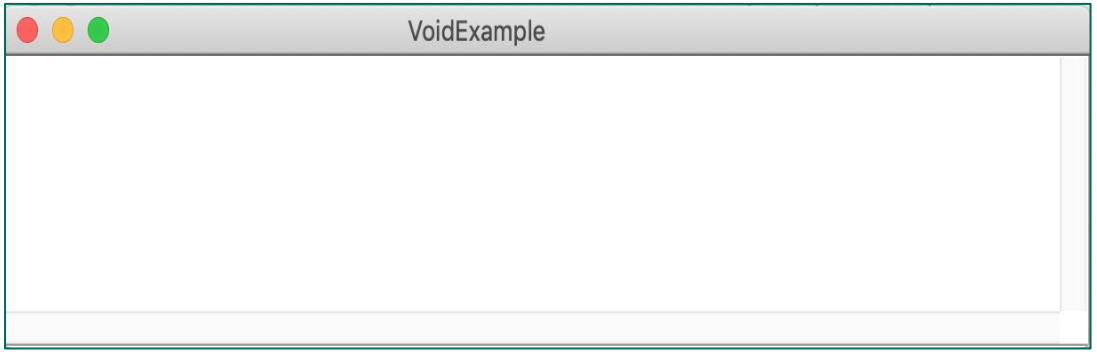

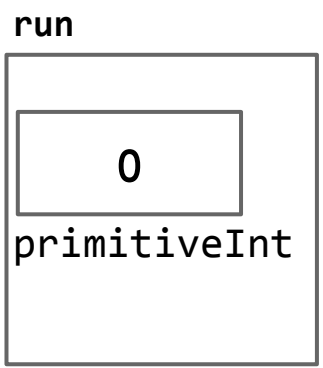

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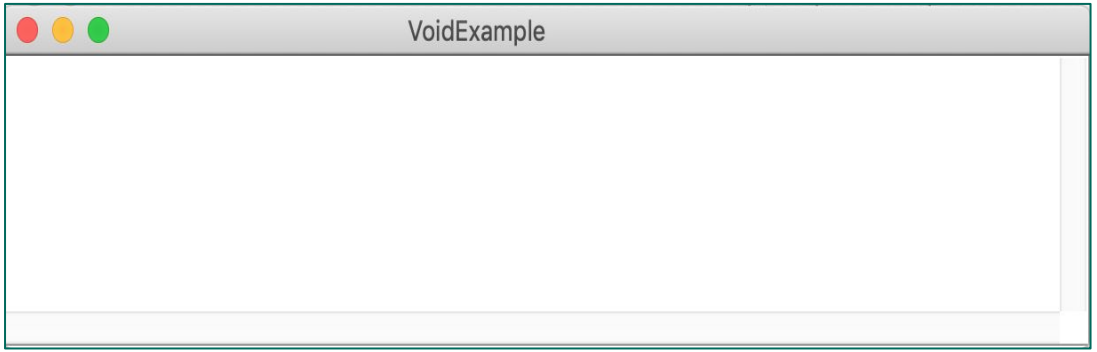

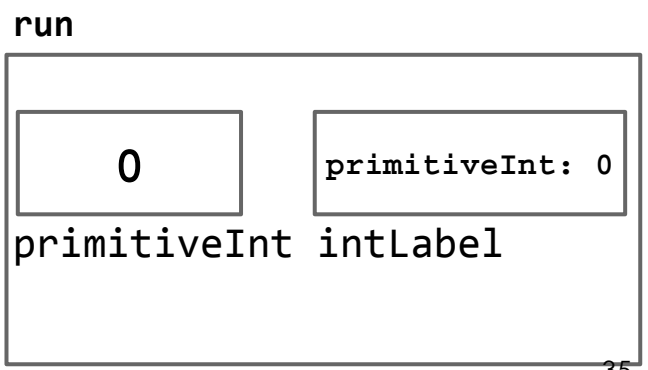

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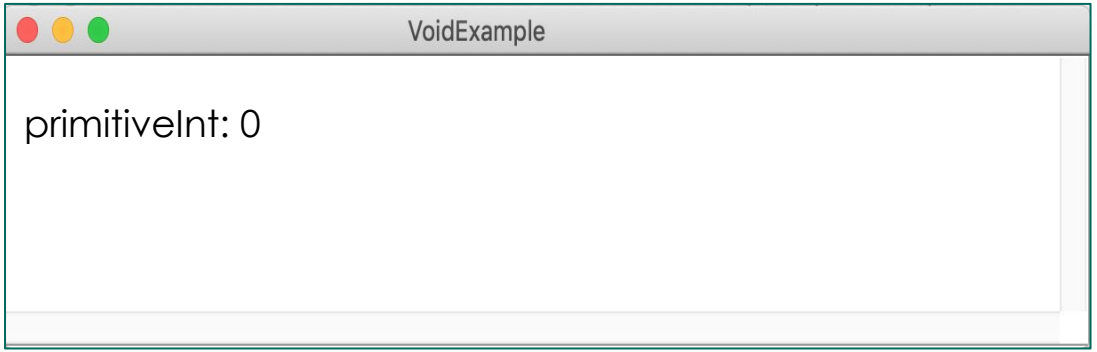

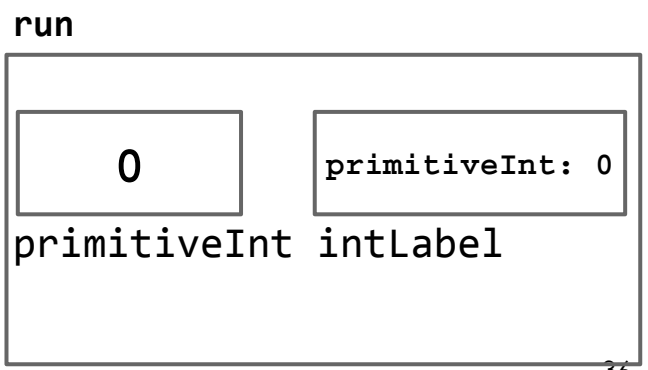

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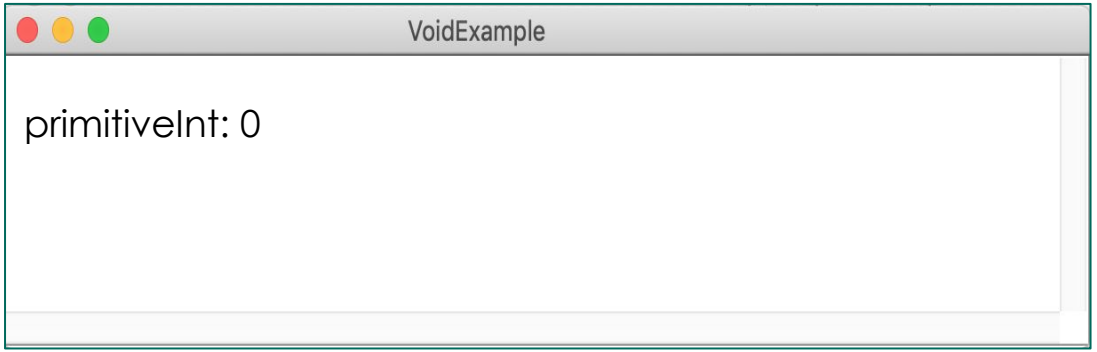
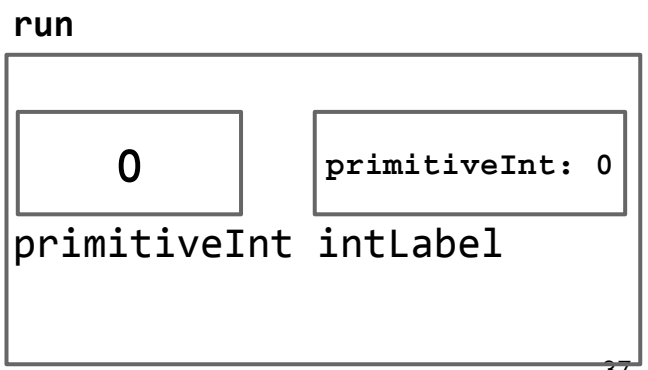
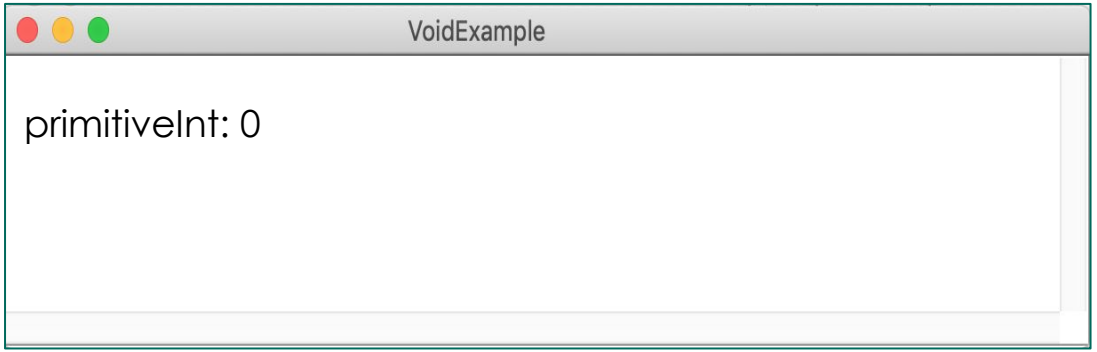




What Happened: Object

```
public void run(){
     ...

     GRect objectRect = new GRect(100, 100);
     objectRect.setFilled(true);
     objectRect.setColor(Color.BLUE);
     add(objectRect, 100, 100);
     changeRect(objectRect);
}
```



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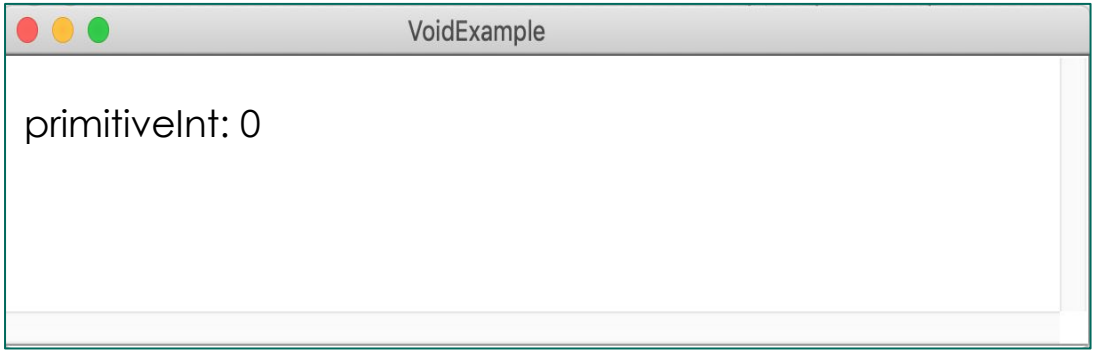

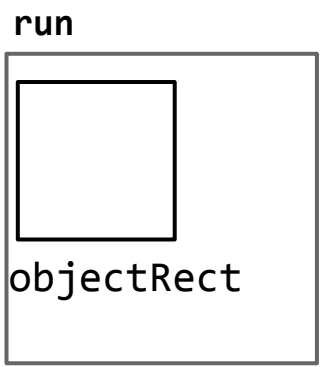

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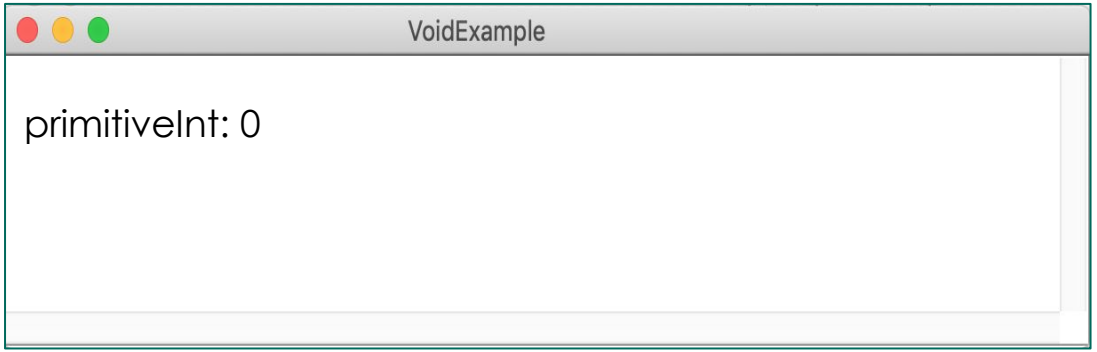

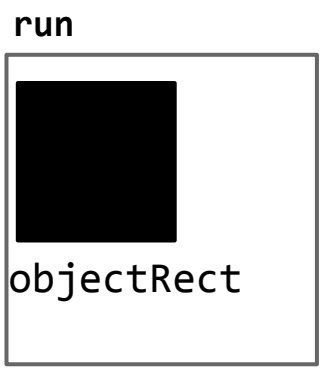

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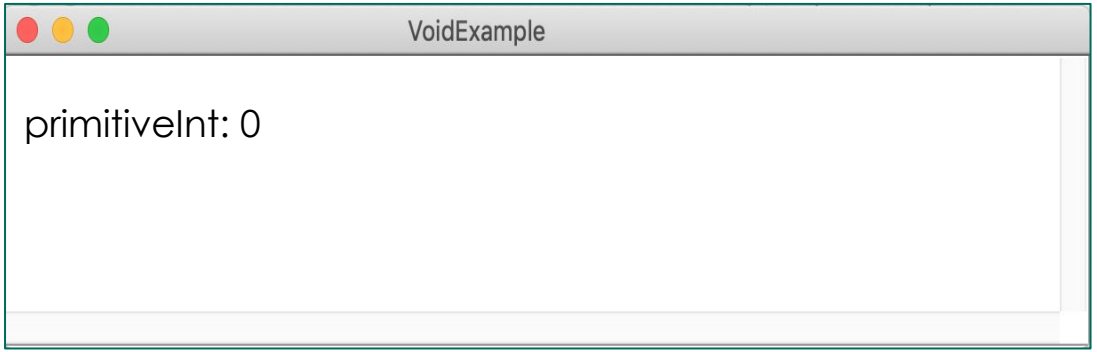

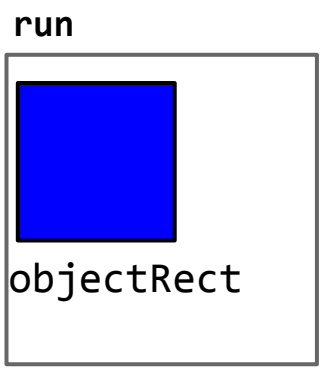

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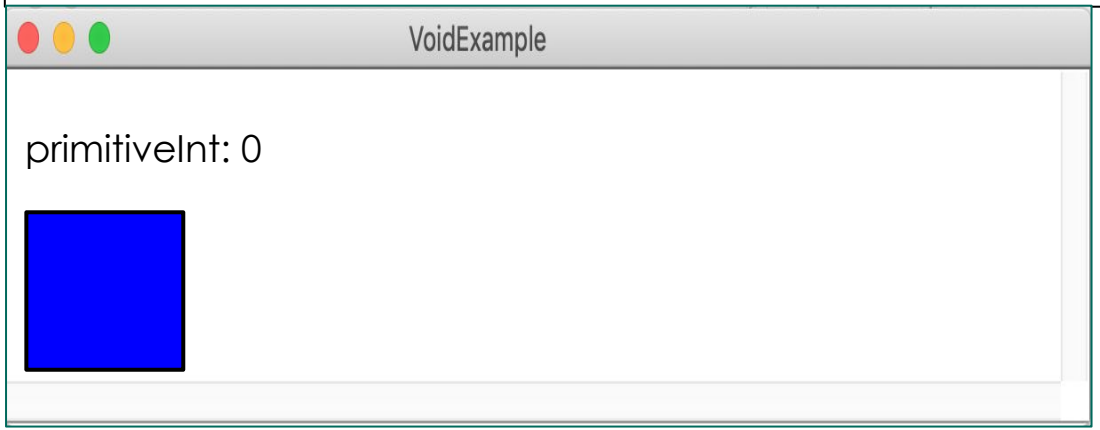

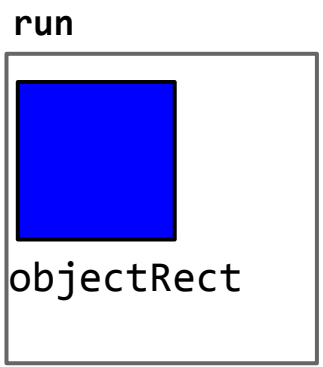

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      changeRect(objectRect);
}
```

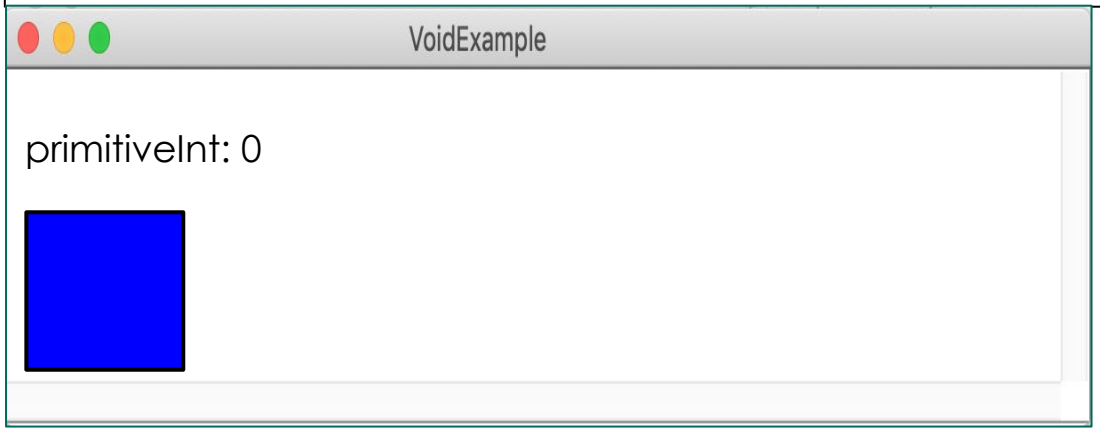

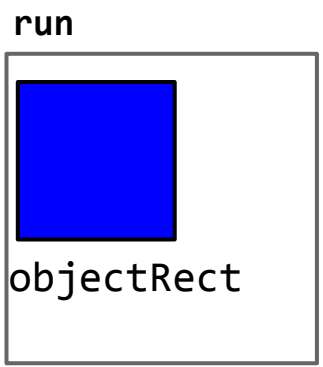

What Happened: Object

```
public void run(){
    changeRect(objectRect);
}

private void changeRect(GRect objectRect){
    objectRect.setFilled(false);
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}
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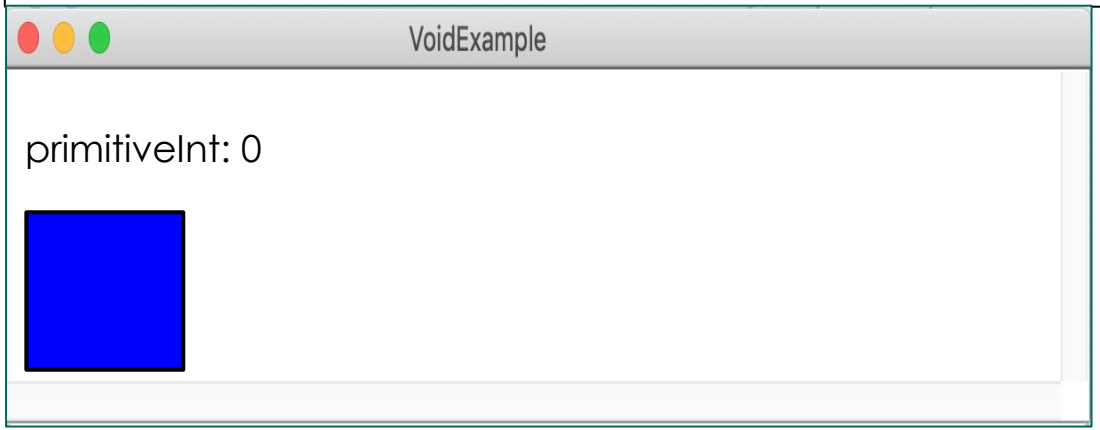

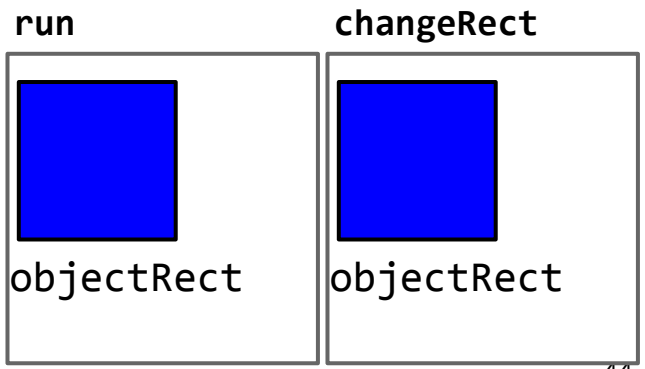

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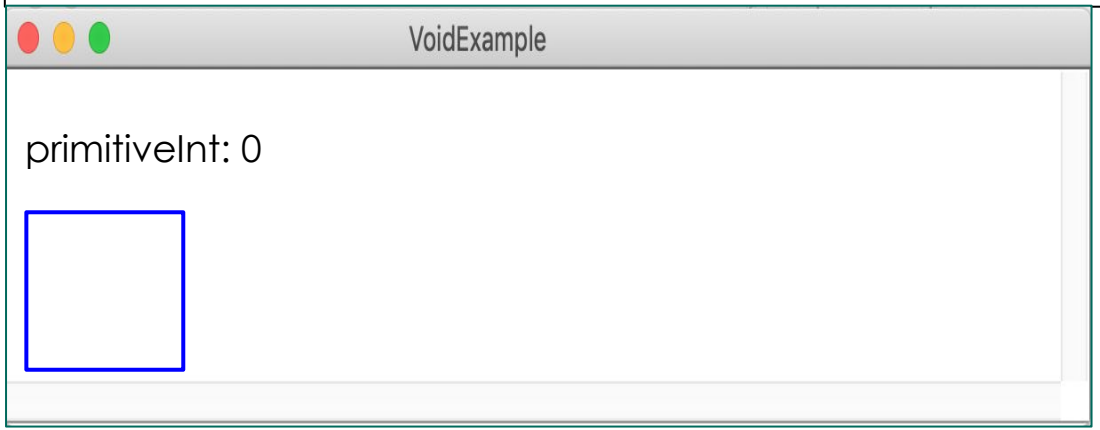

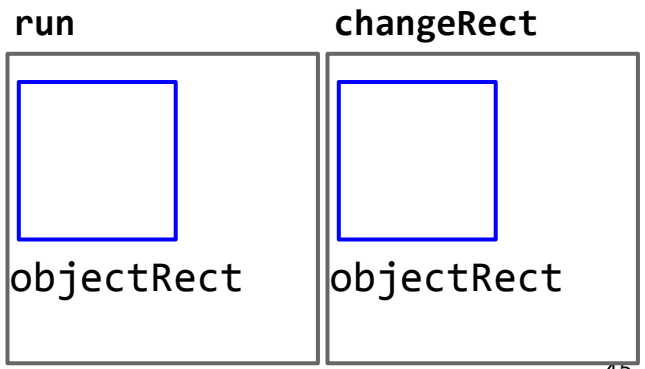

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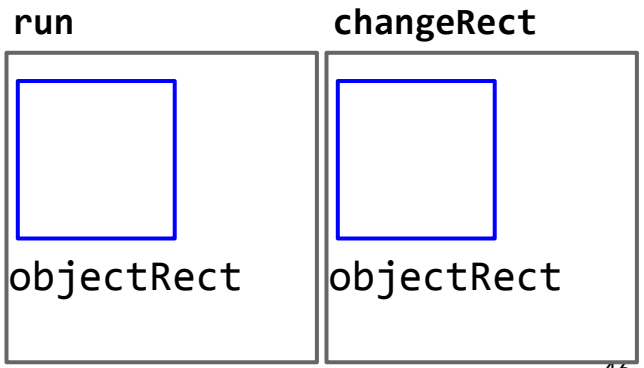
! ! !



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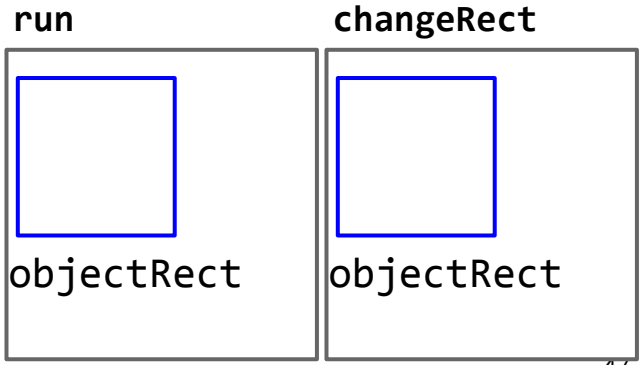

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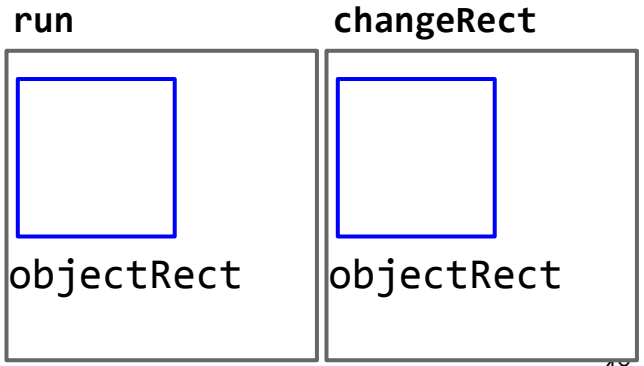
Unlike a primitive variable, it wasn't the **value** that was copied here.



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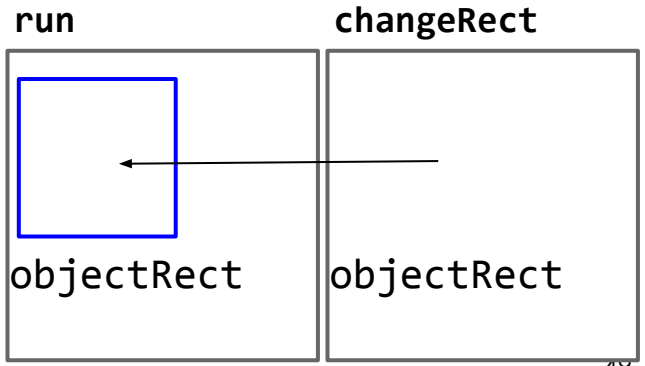
Unlike a primitive variable, it wasn't the **value** that was copied here.

Our changeRect `objectRect` variable **kept track of the location in memory** where our run `objectRect` was stored.



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        objectRect.setColor(Color.GREEN);
    }
    add(objectRect, 100, 100);
    changeRect(objectRect);
}
```
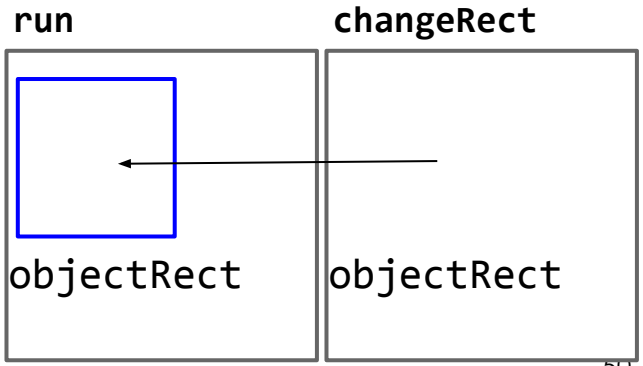

Basically, whenever we change our `changeRect` `objectRect` variable, we are actually changing our `run` `objectRect` variable.

The way we've programmed this, they are connected together.



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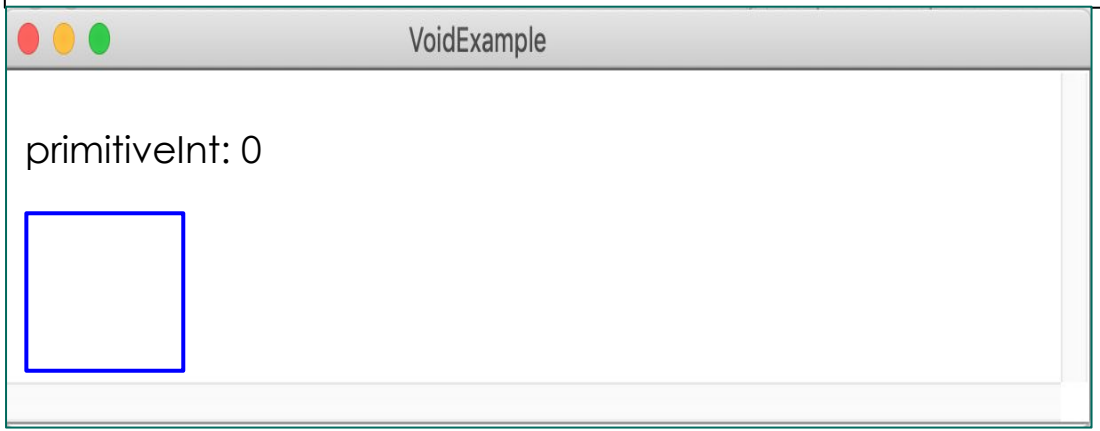

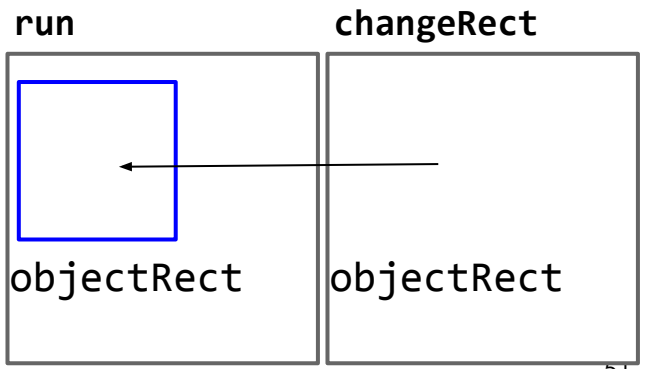

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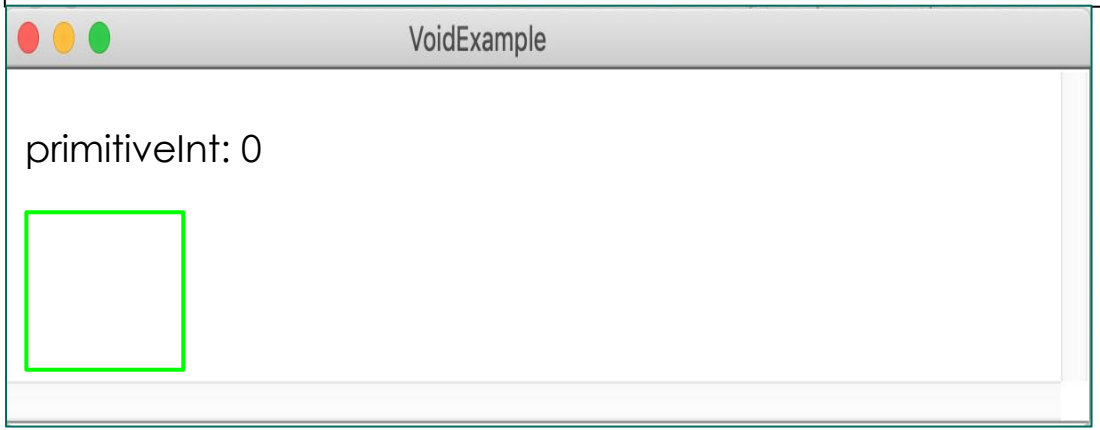

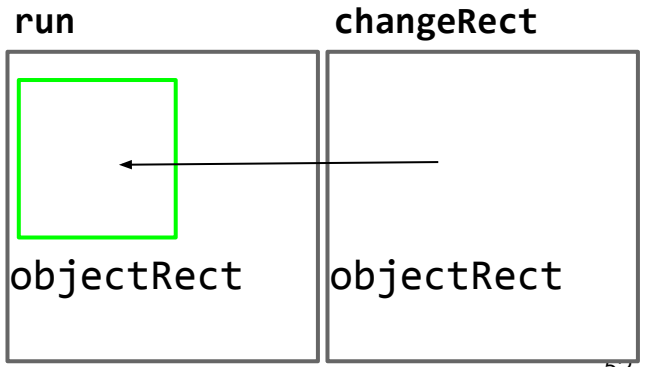

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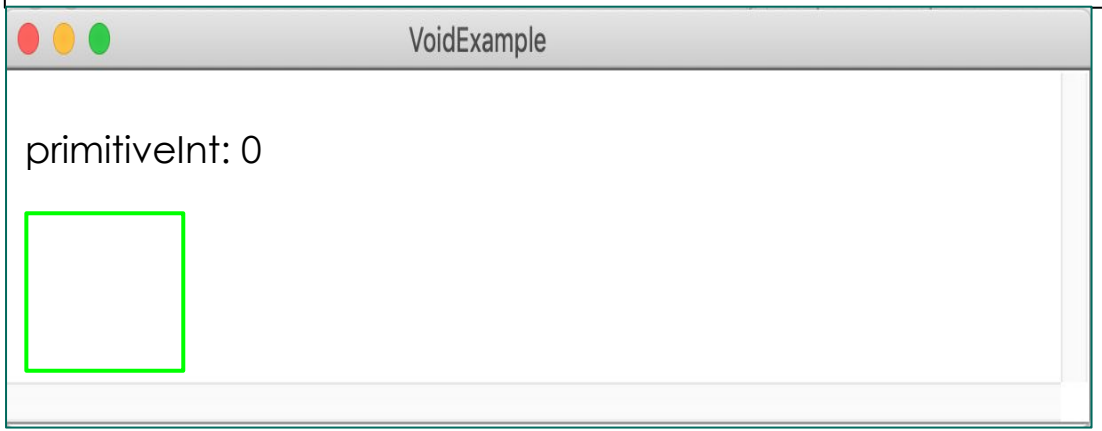
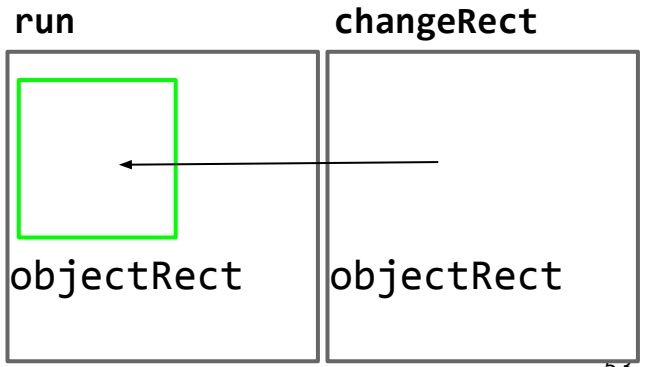
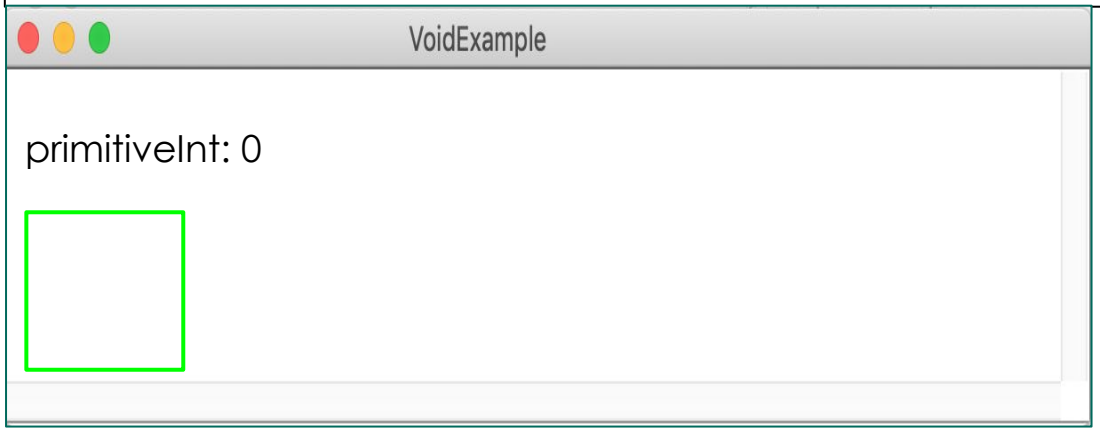


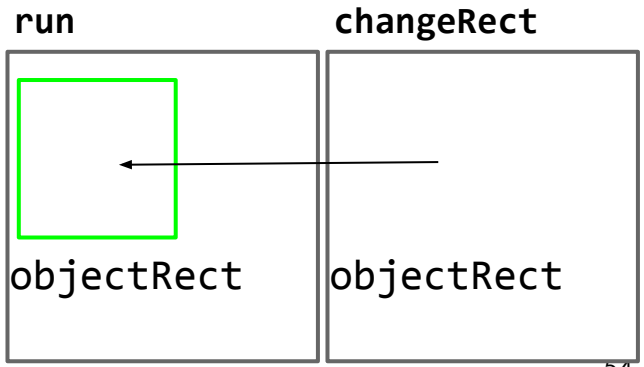


What Happened: Object

```
public void run(){
      ...

      GRect objectRect = new GRect(100, 100);
      objectRect.setFilled(true);
      objectRect.setColor(Color.BLUE);
      add(objectRect, 100, 100);
      changeRect(objectRect);
}
```





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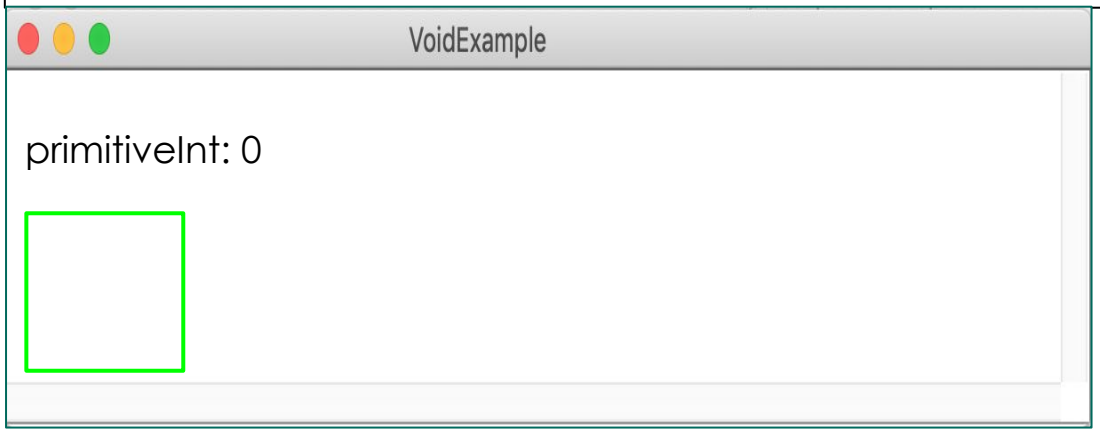

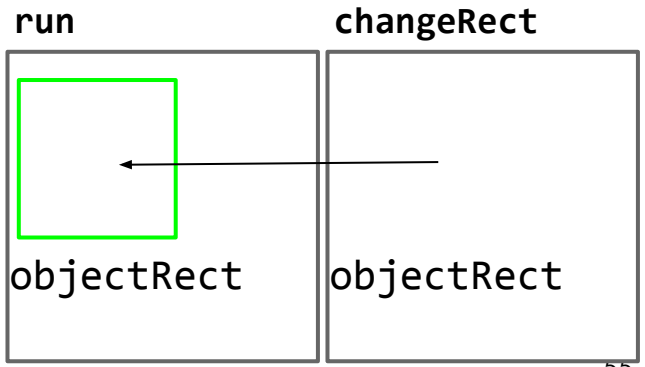

Pass by Reference vs Value

What does this mean?

If something is passed by ***reference***, it ***can*** be altered simply by passing it into a method.

If something is passed by ***value***, it ***cannot*** be altered simply by passing it into a method.

Types of Errors

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Syntax Errors:

A programming “typo”. Usually causes a red squiggly line in code.

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Execution Errors:

Something that crashes the program *after* you run it.

Logic Errors:

All of your code runs, but it produces unexpected results.

How Can We Debug Errors?

How Can We Debug Errors?

Using the Eclipse Debugger!

How Can We Debug Errors?

Could we have debugged our previous program using the Eclipse Debugger?

Debugger Commands

Suspend. Stops the program immediately as if it had hit a breakpoint.

Terminate. Exits from the program entirely.

Step Into. Executes one statement of the program and then stops again. If that statement includes a method call, the program will stop at the first line of that method. As noted below, this option is not as useful as **Step Over**.

Step Over. Executes one statement of the program at this level and then stops again. Any method calls in the statement are executed through to completion unless they contain explicit breakpoints.

Step Return. Continues to execute this method until it returns, after which the debugger stops in the caller (the method that called the current method).

The debugger allows you to step through the execution of a program, one line at a time.

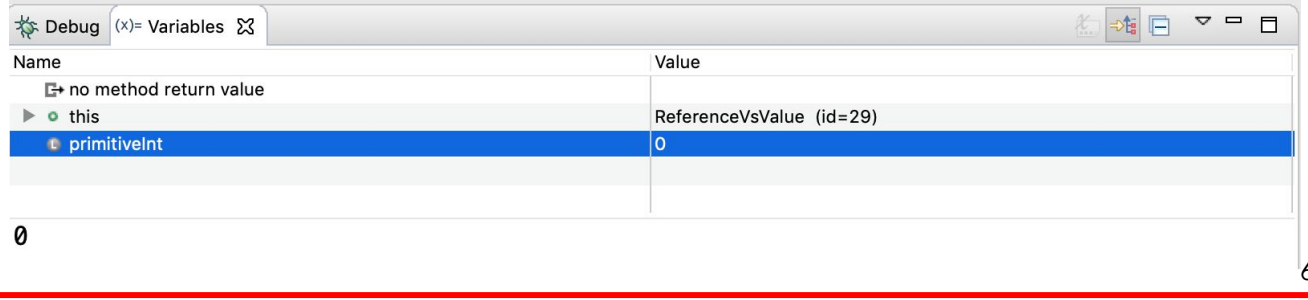
Variables View

I can view what my variables are currently equal to by opening the "Variables" View.

How?

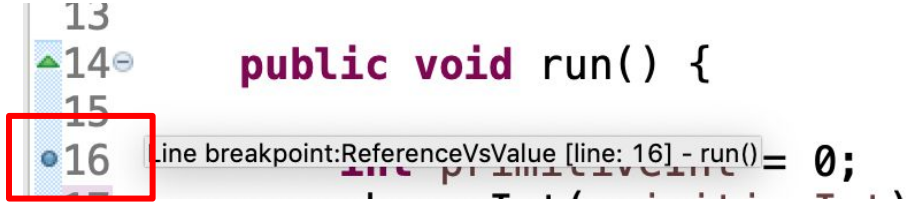
- Click **Window**
- Click **Show View**
- Click **Other…**
- Search for **Variables**
- Click **Variables**

```
14      public void run() {
Lecture11/src/PickAColor.java
16          int primitiveInt = 0;
17          changeInt(primitiveInt);
18          GLabel intLabel = new GLabel("primitiveInt: " + primitiveInt, 0, 50);
19          add(intLabel);
20
21
22          GRect objectRect = new GRect(100, 100);
23          objectRect.setFilled(true);
24          objectRect.setColor(Color.BLUE);
25          add(objectRect, 0, 100);
26          changeRect(objectRect);
27      }
28
29      /*
30       * Adds 10 to an int passed into it.
31       */
```



Setting a Breakpoint

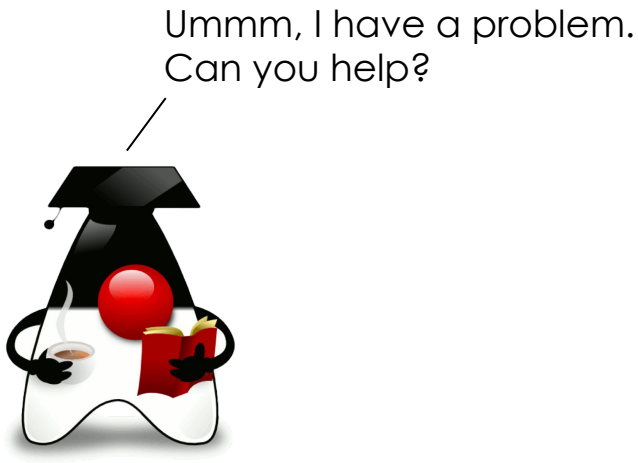
To start the debugger, it helps to set a breakpoint. Double click next to the line number where you want to set a breakpoint. This will create a little blue dot, or **breakpoint**.



Your code will stop and start the debugger when it sees the breakpoint.

Let's Debug Our Program!

What's the Problem?



What's the Problem?

I wrote my *whole program* without testing it and now I'm stuck!

Let’s Help Duke!

Plan for Today

- Review: Null, Events, Instance Variables
- Pass by Reference vs. Pass by Value
- Types of Errors
- Eclipse Debugger
- Practice!