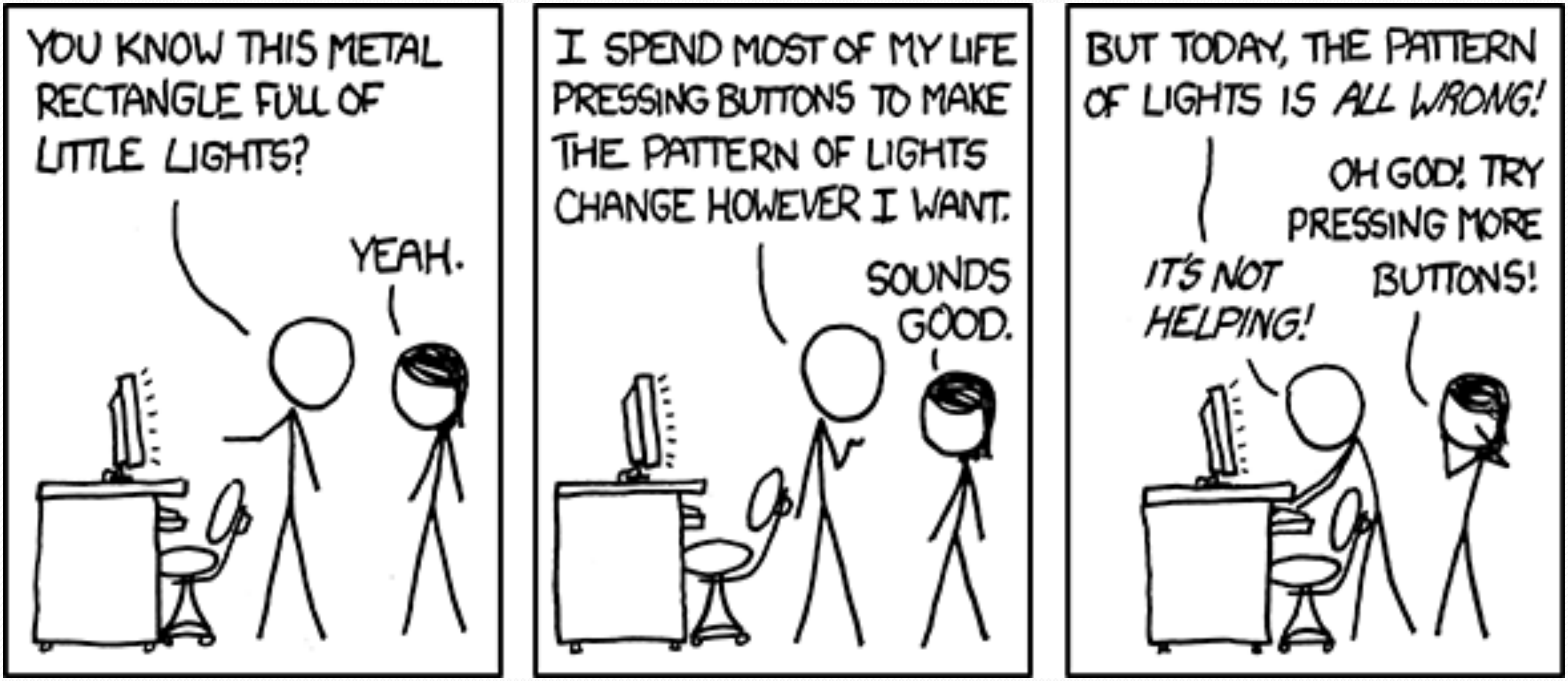
Building Java Programs

Chapter 8

Object Behavior (Methods)
and Constructors, Encapsulation, `this`

reading: 8.2 - 8.3, 8.5 – 8.6


YOU KNOW THIS METAL RECTANGLE FULL OF LITTLE LIGHTS?
YEAH.
I SPEND MOST OF MY LIFE PRESSING BUTTONS TO MAKE THE PATTERN OF LIGHTS CHANGE HOWEVER I WANT.
SOUNDS GOOD.
BUT TODAY, THE PATTERN OF LIGHTS IS ALL WRONG!
IT'S NOT HELPING!
OH GOD! TRY PRESSING MORE BUTTONS!

Why objects?

- Primitive types don't model complex concepts well
  - Cost is a double. What's a person?
  - Classes are a way to define new types
  - Many objects can be made from those types

- Values of the same type often are used in similar ways
  - Promote code reuse through instance methods

Recall: Instance methods

- **instance method** (or **object method**): Exists inside each object of a class and gives behavior to each object.

  public **type name**(**parameters**) {
      statements;
  }

  - same syntax as static methods, but without `static` keyword

  Example:

```
public void shout() {
    System.out.println("HELLO THERE!");
}
```

`Point` objects w/ method

- Each `Point` object has its own copy of the `distanceFromOrigin` method, which operates on that object's state:

```
Point p1 = new Point();
p1.x = 7;
p1.y = 2;

Point p2 = new Point();
p2.x = 4;
p2.y = 3;

p1.distanceFromOrigin();
p2.distanceFromOrigin();
```

p1

x 7 y 2

```
public double distanceFromOrigin() {
    // this code can see p1's x and y
    return Math.sqrt(x * x + y * y);
}
```

p2

x 4 y 3

```
public double distanceFromOrigin() {
    // this code can see p2's x and y
    return Math.sqrt(x * x + y * y);
}
```

Kinds of methods

- **accessor**: A method that lets clients examine object state.
  - Examples: `distance`, `distanceFromOrigin`
  - often has a non-`void` return type

- **mutator**: A method that modifies an object's state.
  - Examples: `setLocation`, `translate`

Printing objects

- By default, Java doesn't know how to print objects:

```
Point p = new Point();
p.x = 10;
p.y = 7;
System.out.println("p is " + p);  // p is Point@9e8c34


// better, but cumbersome;            p is (10, 7)
System.out.println("p is (" + p.x + ", " + p.y + ")");


// desired behavior
System.out.println("p is " + p);  // p is (10, 7)
```

The `toString` method

tells Java how to convert an object into a `String`

```
Point p1 = new Point(7, 2);
System.out.println("p1: " + p1);

// the above code is really calling the following:
System.out.println("p1: " + p1.toString());
```

- Every class has a `toString`, even if it isn't in your code.
  - Default: class's name `@` object's memory address (base 16)

```
Point@9e8c34
```

`toString` syntax

```
public String toString() {
    code that returns a String representing this object;
}
```

- Method name, return, and parameters must match exactly.

- Example:

```
// Returns a String representing this Point.
public String toString() {
    return "(" + x + ", " + y + ")";
}
```

Variable names and scope

- Usually it is illegal to have two variables in the same scope with the same name.

```
public class Point {
    int x;
    int y;
    ...

    public void setLocation(int newX, int newY) {
        x = newX;
        y = newY;
    }
}
```

  - The parameters to `setLocation` are named `newX` and `newY` to be distinct from the object's fields `x` and `y`.

Variable shadowing

- An instance method parameter can have the same name as one of the object's fields:

```
// this is legal
public void setLocation(int x, int y) {
    ...
}
```

  - Fields `x` and `y` are *shadowed* by parameters with same names.
  - Any `setLocation` code that refers to `x` or `y` will use the parameter, not the field.

Avoiding shadowing w/ `this`

```
public class Point {
    int x;
    int y;

    ...

    public void setLocation(int x, int y) {
        this.x = x;
        this.y = y;
    }
}
```

- Inside the `setLocation` method,
  - When `this.x` is seen, the *field* `x` is used.
  - When `x` is seen, the *parameter* `x` is used.

`this`

- **`this`** : A reference to the implicit parameter.
  - *implicit parameter:* object on which a method is called

- Syntax for using `this`:
  - To refer to a field:
    `this.`**field**
  - To call a method:
    `this.`**method**`(`**parameters**`);`
  - To call a constructor from another constructor:
    `this(`**parameters**`);`

Object initialization: constructors

reading: 8.3

Initializing objects

- Currently it takes 3 lines to create a `Point` and initialize it:

```
Point p = new Point();
p.x = 3;
p.y = 8;                              // tedious
```

- We'd rather specify the fields' initial values at the start:

```
Point p = new Point(3, 8);    // desired; doesn't work (yet)
```

  - We are able to this with most types of objects in Java.

Constructors

- **constructor**: Initializes the state of new objects.

```
public type(parameters) {
    statements;
}
```

  - runs when the client uses the `new` keyword
  - no return type is specified;
    it implicitly "returns" the new object being created

  - If a class has no constructor, Java gives it a *default constructor* with no parameters that sets all fields to 0.

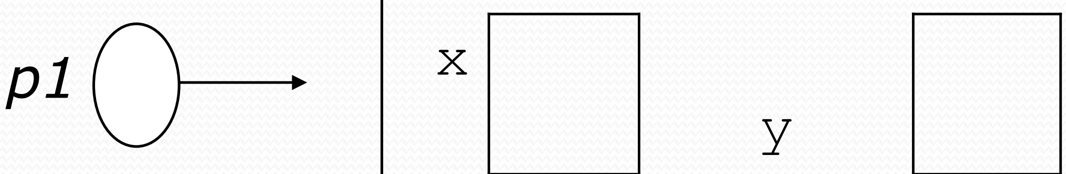
Constructor example

```
public class Point {
    int x;
    int y;

    // Constructs a Point at the given x/y location.
    public Point(int initialX, int initialY) {
        x = initialX;
        y = initialY;
    }


    public void translate(int dx, int dy) {
        x = x + dx;
        y = y + dy;
    }

    ...
}
```

Tracing a constructor call

- What happens when the following call is made?

```
Point p1 = new Point(7, 2);
```




```
public Point(int initialX, int initialY) {
    x = initialX;
    y = initialY;
}

public void translate(int dx, int dy) {
    x += dx;
    y += dy;
}
```

Common constructor bugs

1. Re-declaring fields as local variables ("shadowing"):

```
public Point(int initialX, int initialY) {
    int x = initialX;
    int y = initialY;
}
```

- This declares local variables with the same name as the fields, rather than storing values into the fields. The fields remain 0.

2. Accidentally giving the constructor a return type:

```
public void Point(int initialX, int initialY) {
    x = initialX;
    y = initialY;
}
```

- This is actually not a constructor, but a method named `Point`

Client code, version 3

```
public class PointMain3 {
    public static void main(String[] args) {
        // create two Point objects
        Point p1 = new Point(5, 2);
        Point p2 = new Point(4, 3);

        // print each point
        System.out.println("p1: (" + p1.x + ", " + p1.y + ")");
        System.out.println("p2: (" + p2.x + ", " + p2.y + ")");

        // move p2 and then print it again
        p2.translate(2, 4);
        System.out.println("p2: (" + p2.x + ", " + p2.y + ")");
    }
}
```

OUTPUT:

```
p1: (5, 2)
p2: (4, 3)
p2: (6, 7)
```

Multiple constructors

- A class can have multiple constructors.
  - Each one must accept a unique set of parameters.

- *Exercise:* Write a `Point` constructor with no parameters that initializes the point to (0, 0).

```
// Constructs a new point at (0, 0).
public Point() {
    x = 0;
    y = 0;
}
```

Multiple constructors

- It is legal to have more than one constructor in a class.
  - The constructors must accept different parameters.

```
public class Point {
    private int x;
    private int y;

    public Point() {
        x = 0;
        y = 0;
    }

    public Point(int initialX, int initialY) {
        x = initialX;
        y = initialY;
    }

    ...
}
```

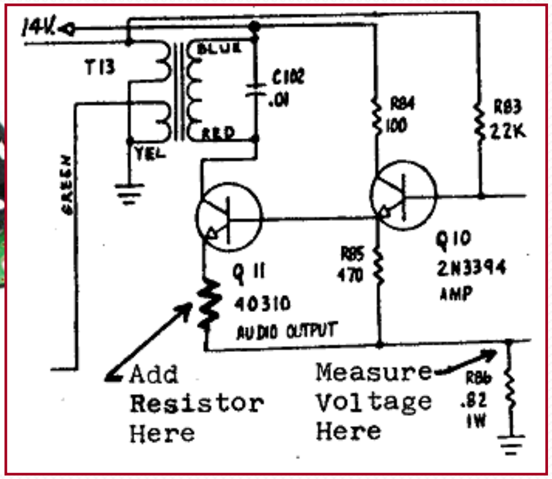
Constructors and `this`

- One constructor can call another using `this`:

```
public class Point {
    private int x;
    private int y;

    public Point() {
        this(0, 0);  // calls the (x, y) constructor
    }

    public Point(int x, int y) {
        this.x = x;
        this.y = y;
    }

    ...
}
```

Encapsulation

- **encapsulation**: Hiding implementation details of an object from its clients.
  - Encapsulation provides *abstraction*.
    - separates external view (behavior) from internal view (state)
  - Encapsulation protects the integrity of an object's data.



Private fields

- A field can be declared *private*.
  - No code outside the class can access or change it.

```
private type name;
```

  - Examples:

```
private int id;
private String name;
```

- Client code sees an error when accessing private fields:

```
PointMain.java:11: x has private access in Point
System.out.println("p1 is (" + p1.x + ", " + p1.y + ")");
                                 ^
```

Accessing private state

- We can provide methods to get and/or set a field's value:

```
// A "read-only" access to the x field ("accessor")
public int getX() {
    return x;
}

// Allows clients to change the x field ("mutator")
public void setX(int newX) {
    x = newX;
}
```

  - Client code will look more like this:

```
System.out.println("p1: (" + p1.getX() + ", " + p1.getY() + ")");
p1.setX(14);
```

Point class, version 4

```
// A Point object represents an (x, y) location.
public class Point {
    private int x;
    private int y;

    public Point(int initialX, int initialY) {
        x = initialX;
        y = initialY;
    }

    public double distanceFromOrigin() {
        return Math.sqrt(x * x + y * y);
    }

    public int getX() {
        return x;
    }

    public int getY() {
        return y;
    }

    public void setLocation(int newX, int newY) {
        x = newX;
        y = newY;
    }

    public void translate(int dx, int dy) {
        x = x + dx;
        y = y + dy;
    }
}
```

Client code, version 4

```
public class PointMain4 {
    public static void main(String[] args) {
        // create two Point objects
        Point p1 = new Point(5, 2);
        Point p2 = new Point(4, 3);

        // print each point
        System.out.println("p1: (" + p1.getX() + ", " + p1.getY() + ")");
        System.out.println("p2: (" + p2.getX() + ", " + p2.getY() + ")");

        // move p2 and then print it again
        p2.translate(2, 4);
        System.out.println("p2: (" + p2.getX() + ", " + p2.getY() + ")");
    }
}
```

OUTPUT:

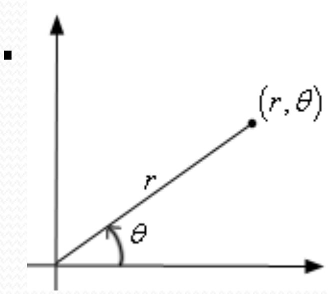
```
p1 is (5, 2)
p2 is (4, 3)
p2 is (6, 7)
```

Benefits of encapsulation

- Provides abstraction between an object and its clients.

- Protects an object from unwanted access by clients.
  - A bank app forbids a client to change an `Account`'s balance.

- Allows you to change the class implementation.
  - `Point` could be rewritten to use polar coordinates (radius *r*, angle θ), but with the same methods.



- Allows you to constrain objects' state (**invariants**).
  - Example: Only allow `Point`s with non-negative coordinates.