# Building Java Programs

Chapter 8

Lecture 8-3: Constructors; Encapsulation

**reading: 8.3 - 8.6**

self-checks: #13-18, 20-21

exercises: #5, 9, 14

# The `toString` method

**reading: 8.6**

self-check: #18, 20-21

exercises: #9, 14

# 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 + ")";
}
```

# Object initialization: constructors

**reading: 8.4**

self-check: #10-12

exercises: #9, 11, 14, 16

# 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);    // better!
```

  - 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.

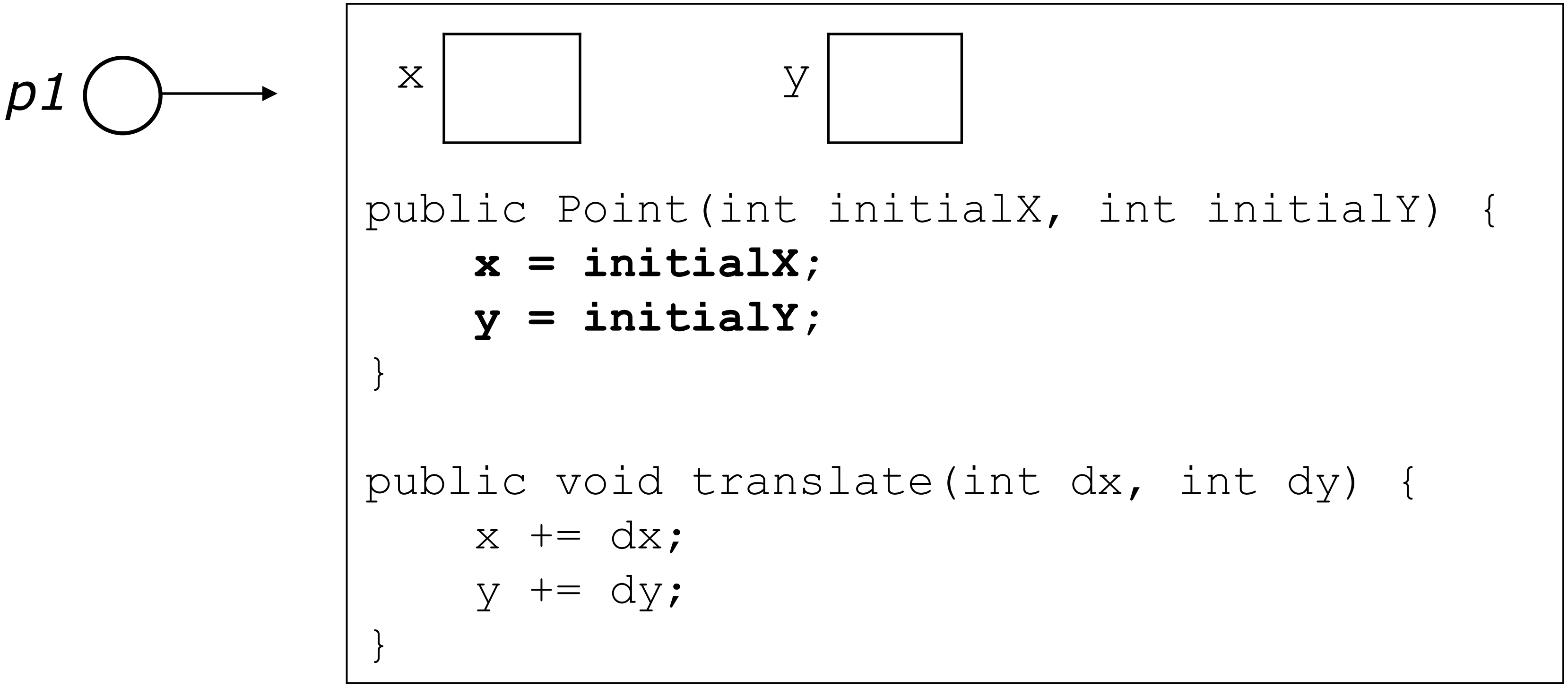
# Constructor example

```
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;
}
```

# 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;
}
```

# 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`

# Encapsulation

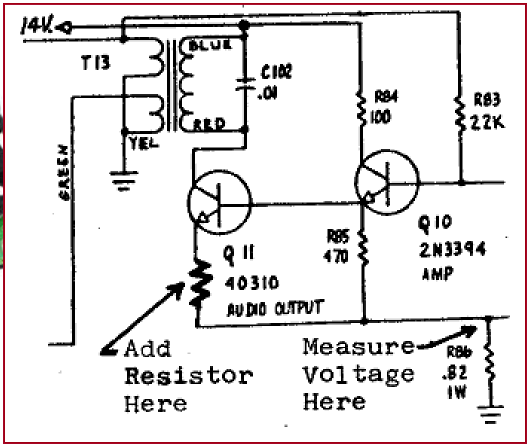
**reading: 8.5 - 8.6**

self-check: #13-17

exercises: #5

# Encapsulation

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



# Private fields

*A field that cannot be accessed from outside the class*

```
private type name;
```

- Examples:

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

- Client code won't compile if it accesses private fields:

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

# Accessing private state

```
// 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.getX());
p1.setX(14);
```

# Point class, version 4

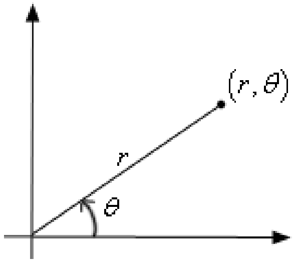
```
// A Point object represents an (x, y) location.
public class Point {
    private int x;
    private int y;

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

    public int getX() {
        return x;
    }

    public int getY() {
        return y;
    }

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

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

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

# Benefits of encapsulation

- Abstraction between object and clients

- Protects object from unwanted access
  - Example: Can't fraudulently increase an `Account`'s balance.

- Can change the class implementation later
  - Example: `Point` could be rewritten in polar coordinates (*r*, *ϑ*) with the same methods.



- Can constrain objects' state (**invariants**)
  - Example: Only allow `Account`s with non-negative balance.
  - Example: Only allow `Date`s with a month from 1-12.

# The keyword `this`

**reading: 8.7**

# The `this` keyword

- **`this`** : Refers to the implicit parameter inside your class.
  *(a variable that stores the object on which a method is called)*

| | |
|---|---|
| - Refer to a field: | `this.`**field** |
| - Call a method: | `this.`**method**`(`**parameters**`);` |
| - One constructor can call another: | `this(`**parameters**`);` |

# Variable shadowing

- **shadowing**: 2 variables with same name in same scope.
  - Normally illegal, except when one variable is a field.

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

    ...

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

  - In most of the class, `x` and `y` refer to the fields.
  - In `setLocation`, `x` and `y` refer to the method's parameters.

# Fixing shadowing

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

    ...

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

- Inside `setLocation`,
  - To refer to the data field `x`, say `this.x`
  - To refer to the parameter `x`, say `x`

# Calling another constructor

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

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

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

    ...
}
```

- Avoids redundancy between constructors
- Only a constructor (not a method) can call another constructor