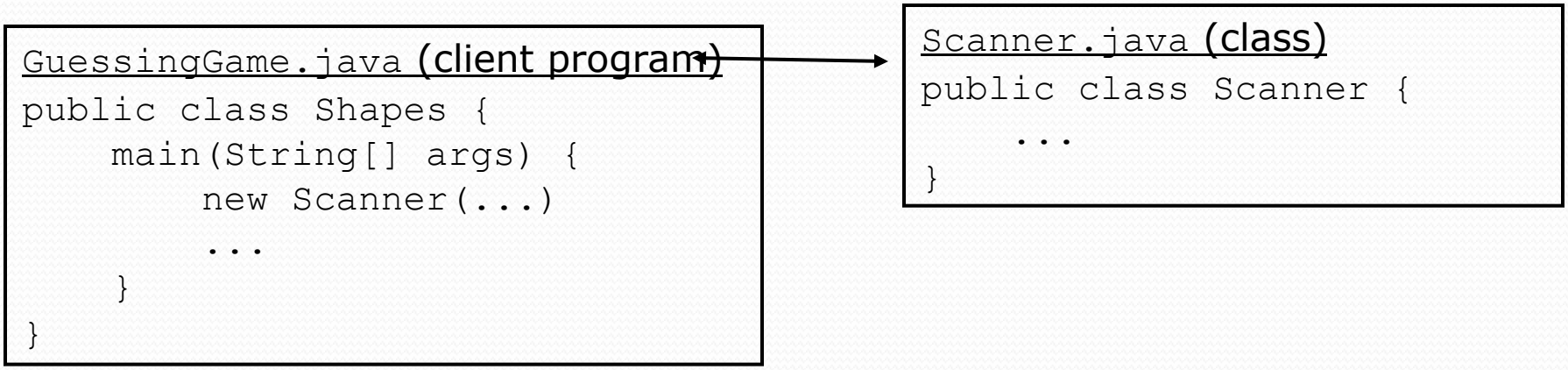
Building Java Programs

Classes and Objects

reading: 8.1 - 8.2

Clients of objects

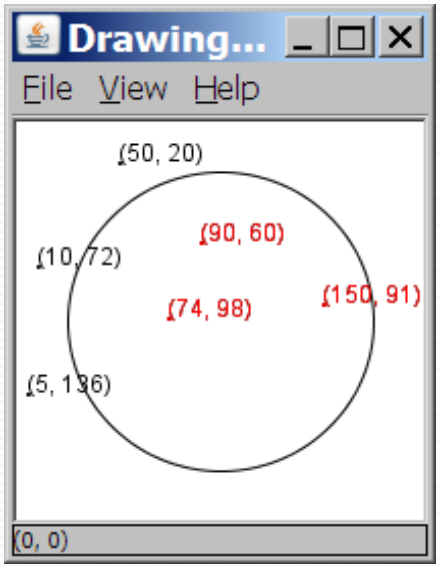
- **client program**: A program that uses objects.
  - Example: `GuessingGame` is a client of `Scanner`.



A programming problem

- Given a file of cities' (x, y) coordinates, which begins with the number of cities:

```
6
50 20
90 60
10 72
74 98
5 136
150 91
```



- Write a program that simulates an earthquake prints out a list of cities with the ones that are within a given radius marked as "hit":

```
Epicenter x? 100
Epicenter y? 100
Affected radius? 75
```

```
(50, 20)
(90, 60) - hit
(10, 72)
(74, 98) - hit
(5, 136)
```

A bad solution

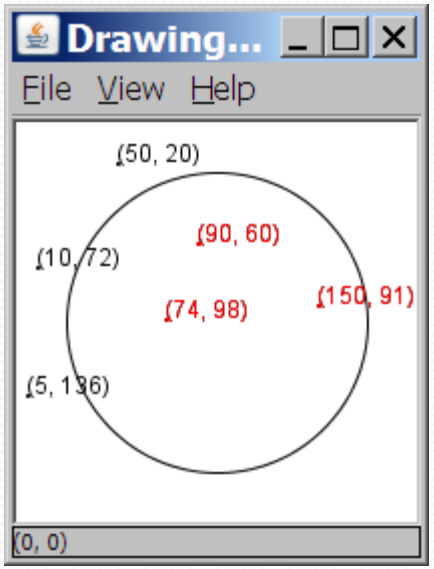
```
Scanner input = new Scanner(new File("cities.txt"));
int cityCount = input.nextInt();
int[] xCoords = new int[cityCount];
int[] yCoords = new int[cityCount];

for (int i = 0; i < cityCount; i++) {
    xCoords[i] = input.nextInt();   // read each city
    yCoords[i] = input.nextInt();
}
...
```

- parallel arrays: 2+ arrays with related data at same indexes.
  - Considered poor style.

Observations

- The data in this problem is a set of points.
- It would be better stored as `Point` objects.
  - A `Point` would store a city's x/y data.
  - We could compare distances between `Point`s to see whether the earthquake hit a given city.
  - Each `Point` would know how to draw itself.
  - The overall program would be shorter and cleaner.



Classes and objects

- **class**: A program entity that represents either:
  1. A program / module, or
  2. **A template for a new type of objects.**

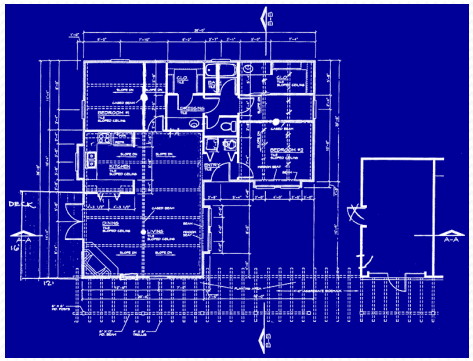
- **object**: An entity that combines state and behavior.
  - **object-oriented programming (OOP)**: Programs that perform their behavior as interactions between objects.

Blueprint analogy

iPod blueprint

state:
- current song
- volume
- battery life

behavior:
- power on/off
- change station/song
- change volume
- choose random song



creates

iPod #1

state:
- song = "1,000,000 Miles"
- volume = 17
- battery life = 2.5 hrs

behavior:
- power on/off
- change station/song
- change volume
- choose random song

iPod #2

state:
- song = "Letting You"
- volume = 9
- battery life = 3.41 hrs

behavior:
- power on/off
- change station/song
- change volume
- choose random song

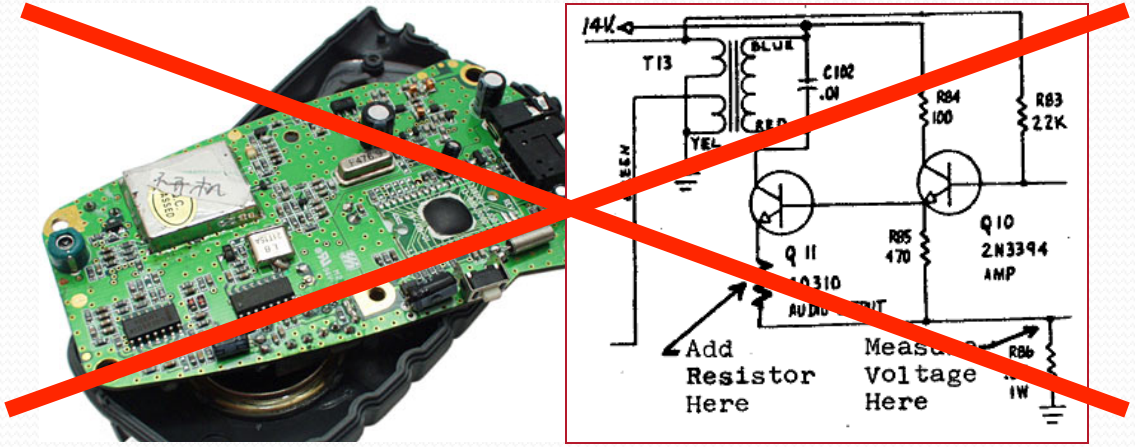
iPod #3

state:
- song = "Discipline"
- volume = 24
- battery life = 1.8 hrs

behavior:
- power on/off
- change station/song
- change volume
- choose random song

Abstraction

- **abstraction**: A distancing between ideas and details.
  - We can use objects without knowing how they work.
- abstraction in an iPod:
  - You understand its external behavior (buttons, screen).
  - You don't understand its inner details, and you don't need to.



The Object Concept

- **procedural programming:** Programs that perform their behavior as a series of steps to be carried out

- **object-oriented programming (OOP)**: Programs that perform their behavior as interactions between objects
  - Takes practice to understand the object concept

Our task

- In the following slides, we will implement a `Point` class as a way of learning about defining classes.
  - We will define a type of objects named `Point`.
  - Each `Point` object will contain x/y data called **fields**.
  - Each `Point` object will contain behavior called **methods**.
  - **Client programs** will use the `Point` objects.

`Point` objects (desired)

```
Point p1 = new Point(5, -2);
Point p2 = new Point();              // origin, (0, 0)
```

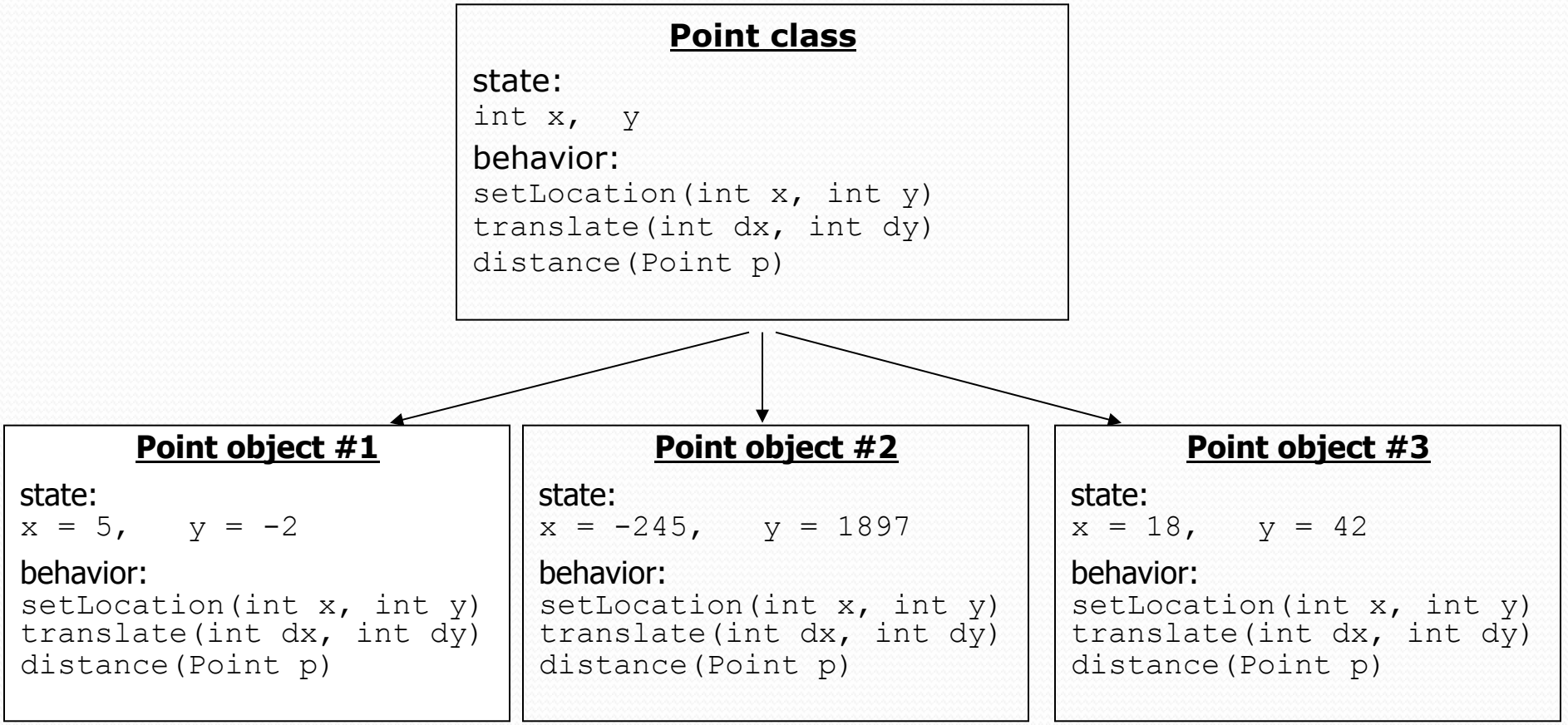
- Data in each `Point` object:

Field name	Description
`x`	the point's x-coordinate
`y`	the point's y-coordinate

- Methods in each `Point` object:

Method name	Description
`setLocation(`**x**`, `**y**`)`	sets the point's x and y to the given values
`translate(`**dx**`, `**dy**`)`	adjusts the point's x and y by the given amounts
`distance(`**p**`)`	how far away the point is from point *p*

`Point` class as blueprint



- The class (blueprint) will describe how to create objects.
- Each object will contain its own data and methods.

Object state: Fields

reading: 8.2

Point class, version 1

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

- Save this code into a file named `Point.java`.

- The above code creates a new type named `Point`.
  - Each `Point` object contains two pieces of data:
    - an `int` named `x`, and
    - an `int` named `y`.
  - `Point` objects do not contain any behavior (yet).

Fields

- **field**: A variable inside an object that is part of its state.
  - Each object has *its own copy* of each field.

- Declaration syntax:

```
type name;
```

  - Example:

```
public class Student {
    String name;     // each Student object has a
    double gpa;      // name and gpa field
}
```

Accessing fields

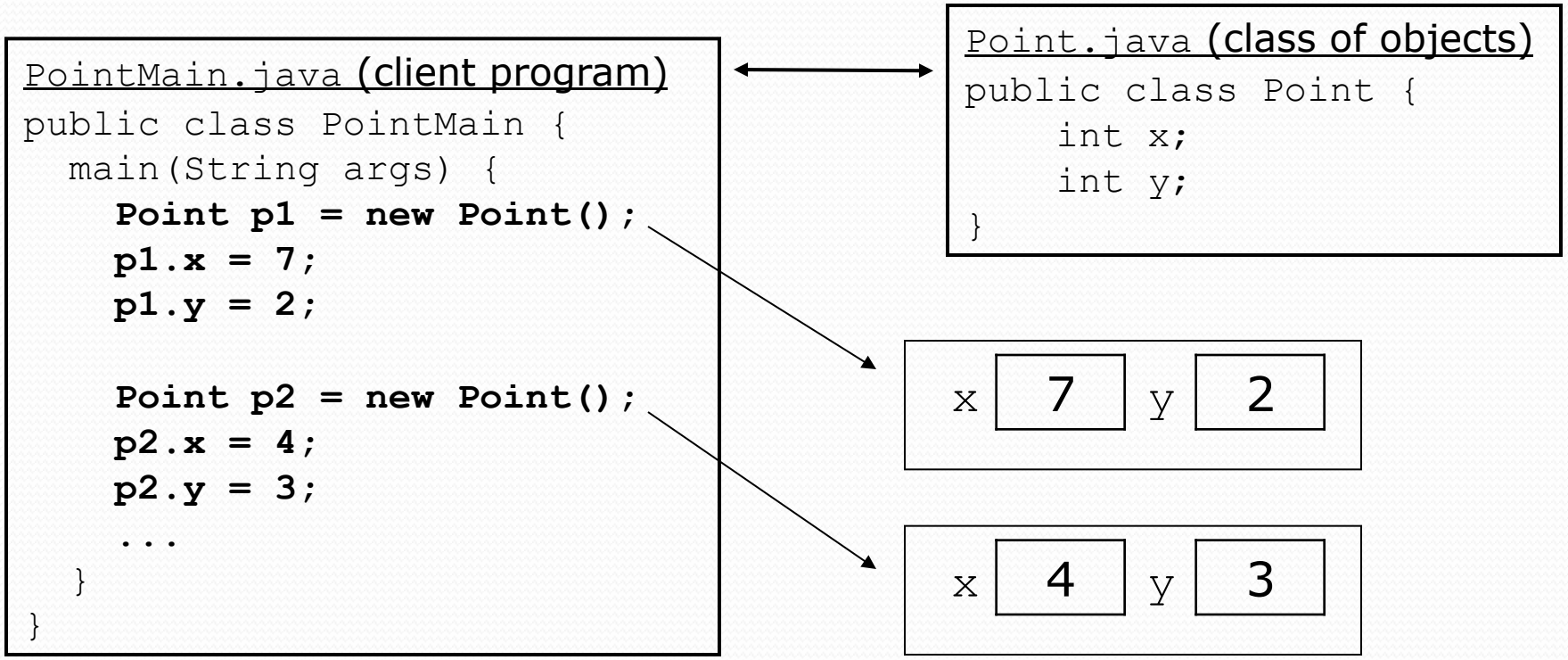
- Other classes can access/modify an object's fields.
  - access: **variable.field**
  - modify: **variable.field** = **value**;

- Example:

```
Point p1 = new Point();
Point p2 = new Point();
System.out.println("the x-coord is " + p1.x);    // access
p2.y = 13;                                       // modify
```

A class and its client

- `Point.java` is not, by itself, a runnable program.
  - A class can be used by **client** programs.



PointMain client example

```
public class PointMain {
    public static void main(String[] args) {
        // create two Point objects
        Point p1 = new Point();
        p1.y = 2;
        Point p2 = new Point();
        p2.x = 4;

        System.out.println(p1.x + ", " + p1.y);   // 0, 2

        // move p2 and then print it
        p2.x += 2;
        p2.y++;
        System.out.println(p2.x + ", " + p2.y);   // 6, 1
    }
}
```

Object behavior: Methods

reading: 8.3

Client code redundancy

- Suppose our client program wants to draw `Point` objects:

```
// draw each city
Point p1 = new Point();
p1.x = 15;
p1.y = 37;
System.out.println(p1.x + ", " + p1.y);
```

- To draw other points, the same code must be repeated.
  - We can remove this redundancy using a method.

Eliminating redundancy, v1

- We can eliminate the redundancy with a static method:

```
// Draws the given point.
public static void draw(Point p) {
    System.out.println(p1.x + ", " + p1.y);
}
```

- `main` would call the method as follows:

```
draw(p1);
```

Problems with static solution

- We are missing a major benefit of objects: code reuse.
  - Every program that draws `Point`s would need a `draw` method.

- The syntax doesn't match how we're used to using objects.

```
draw(p1);    // static (bad)
```

- The point of classes is to combine state and behavior.
  - The `draw` behavior is closely related to a `Point`'s data.
  - The method belongs *inside* each `Point` object.

```
p1.draw();     // inside the object (better)
```

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!");
}
```

Instance method example

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

    // Draws this Point object.
    public void draw() {
        ...
    }
}
```

- The `draw` method no longer has a `Point p` parameter.
- How will the method know which point to draw?
  - How will the method access that point's x/y data?

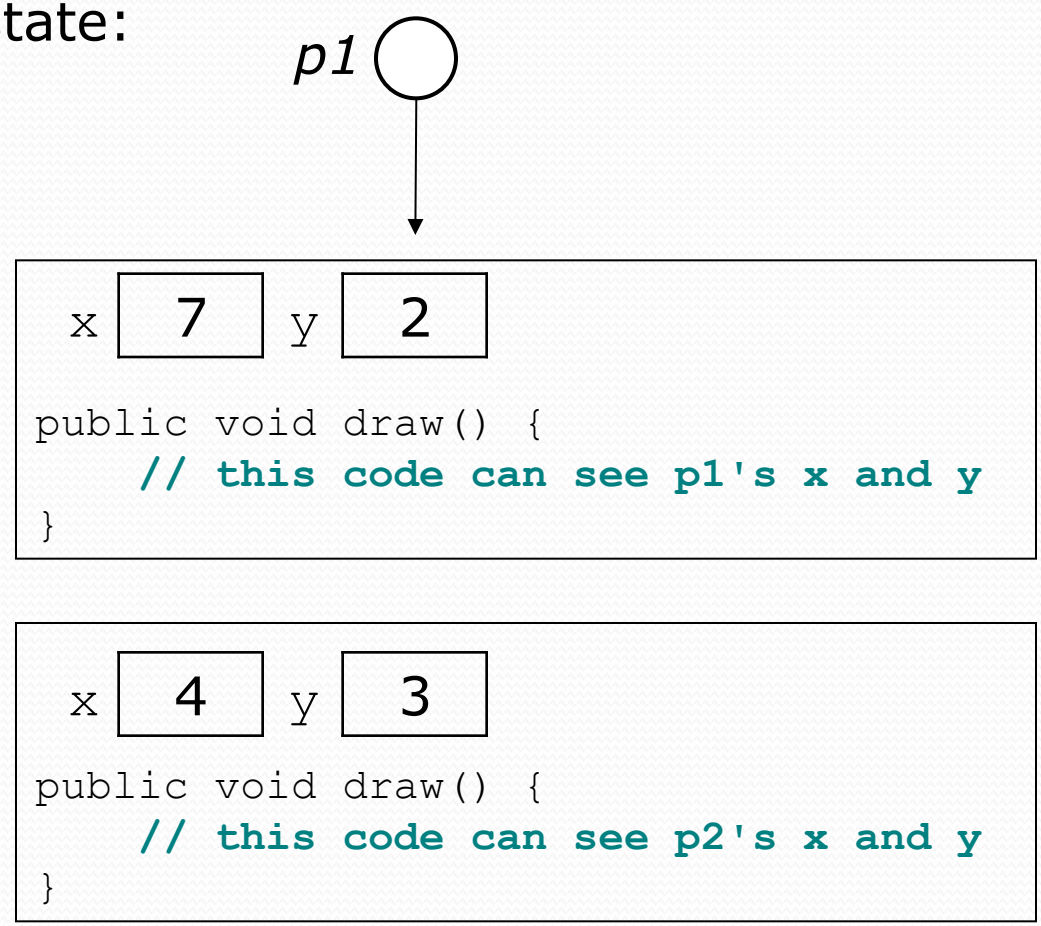
`Point` objects w/ method

- Each `Point` object has its own copy of the `draw` 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.draw();
p2.draw();
```



The implicit parameter

- **implicit parameter**:
  The object on which an instance method is called.
  - During the call `p1.draw();`
    the object referred to by `p1` is the implicit parameter.
  - During the call `p2.draw();`
    the object referred to by `p2` is the implicit parameter.
  - The instance method can refer to that object's fields.
    - We say that it executes in the *context* of a particular object.
    - `draw` can refer to the `x` and `y` of the object it was called on.

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.draw());


// 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 + ")";
}
```

`Point` class, version 2

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

    // returns a String representing this Point object.
    public String toString() {
        return "(" + p1.x + ", " + p1.y + ")";
    }
}
```

- Each `Point` object contains a `toString` method that draws the point's current `x`/`y` position.