Building Java Programs

Chapter 8

Lecture 8-1: Classes and Objects

reading: 8.1 - 8.3

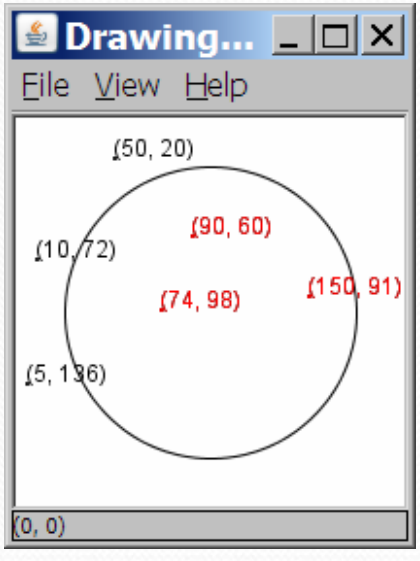
self-checks: #1-9

exercises: #1-4

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 to draw the cities on a `DrawingPanel`, then drop a "bomb" that turns all cities red that are within a given radius:

```
Blast site x? 100
Blast site y? 100
Blast radius? 75
Kaboom!
```

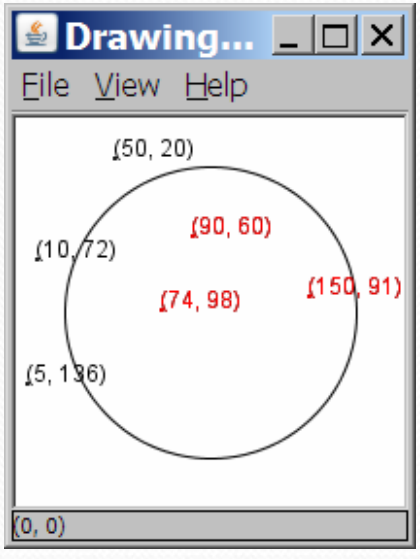
A bad solution

```
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 bomb hit a given city.
  - Each `Point` would know how to draw itself.
  - The overall program would be shorter and cleaner.



Clients of objects

- **client program**: A program that uses objects.
  - Example: `Bomb` is a client of `DrawingPanel` and `Graphics`.

`Bomb.java` (client program)

```
public class Bomb {
    main(String[] args) {
        new DrawingPanel(...)
        new DrawingPanel(...)
        ...
    }
}
```

`DrawingPanel.java` (class)

```
public class DrawingPanel {
    ...
}
```

Classes and objects

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

  - The `DrawingPanel` class is a template for creating `DrawingPanel` objects.

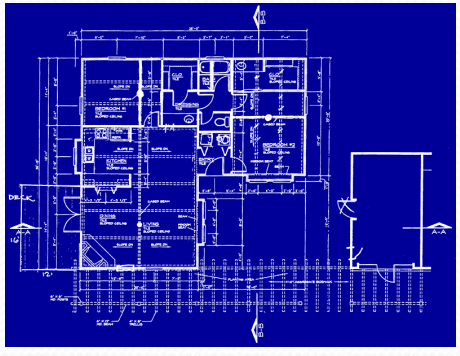
- **object**: An entity that combines state and behavior.
  - **object-oriented programming (OOP)**: Programs that perform their behavior as interactions between objects.

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

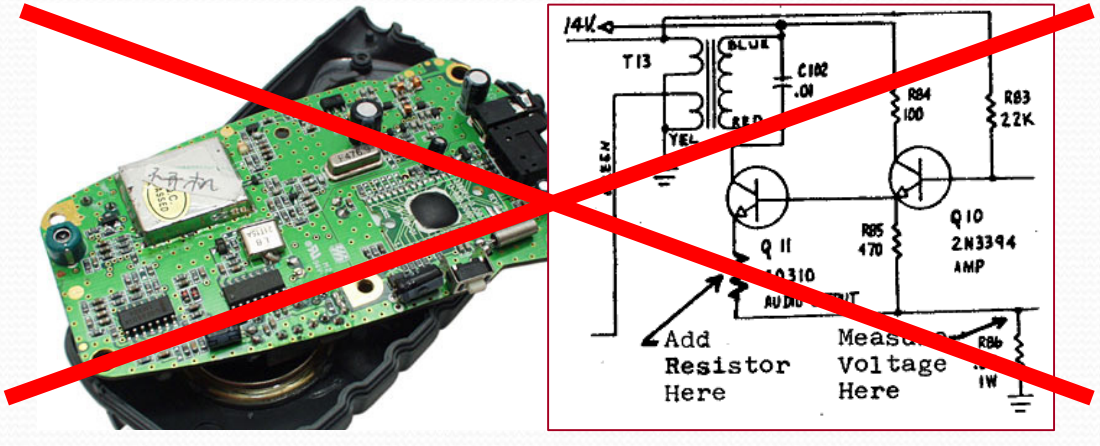
iPod #3

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.



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)
```

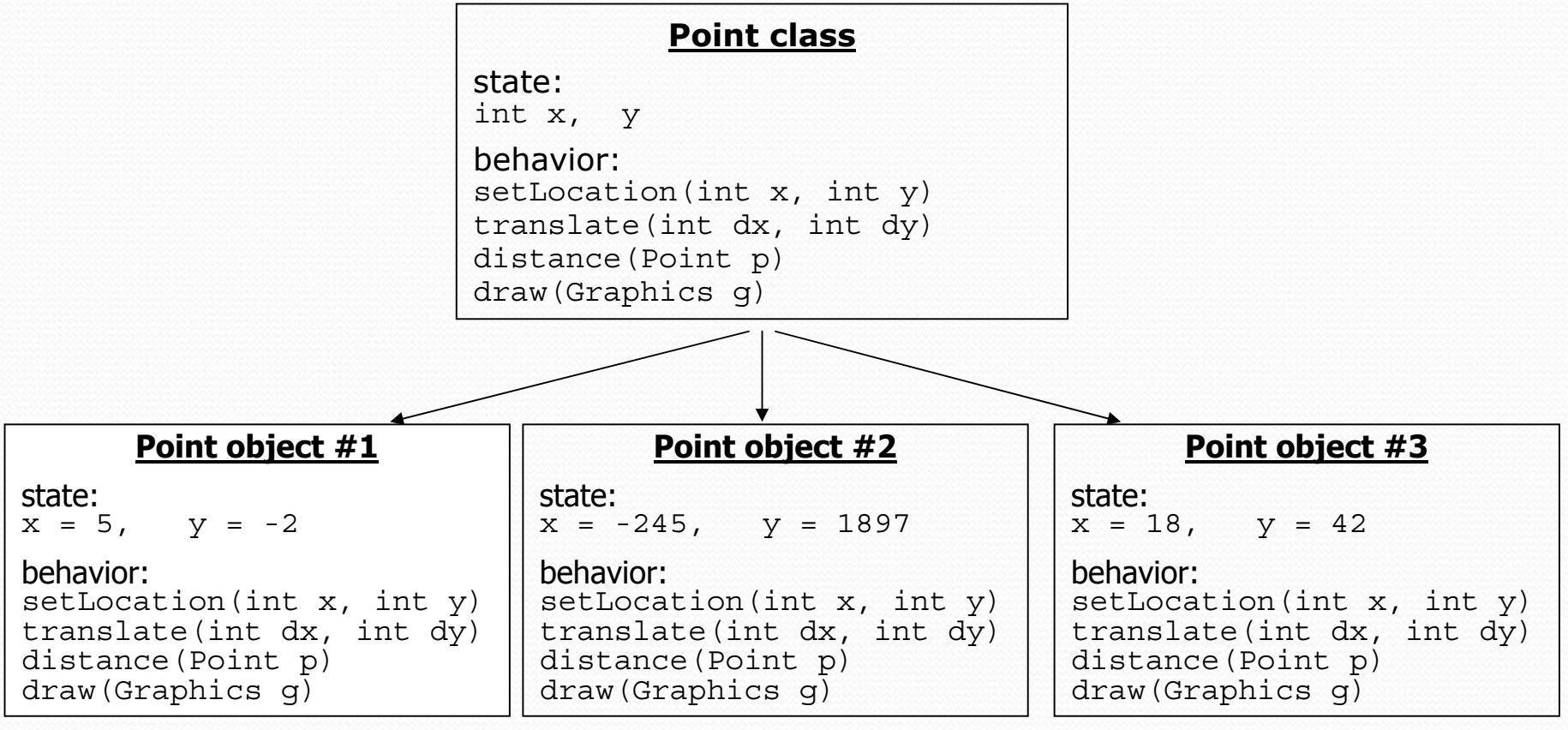
- Data in each `Point` object:

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*
`draw(`**g**`)`	displays the point on a drawing panel

`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

self-check: #5-6

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

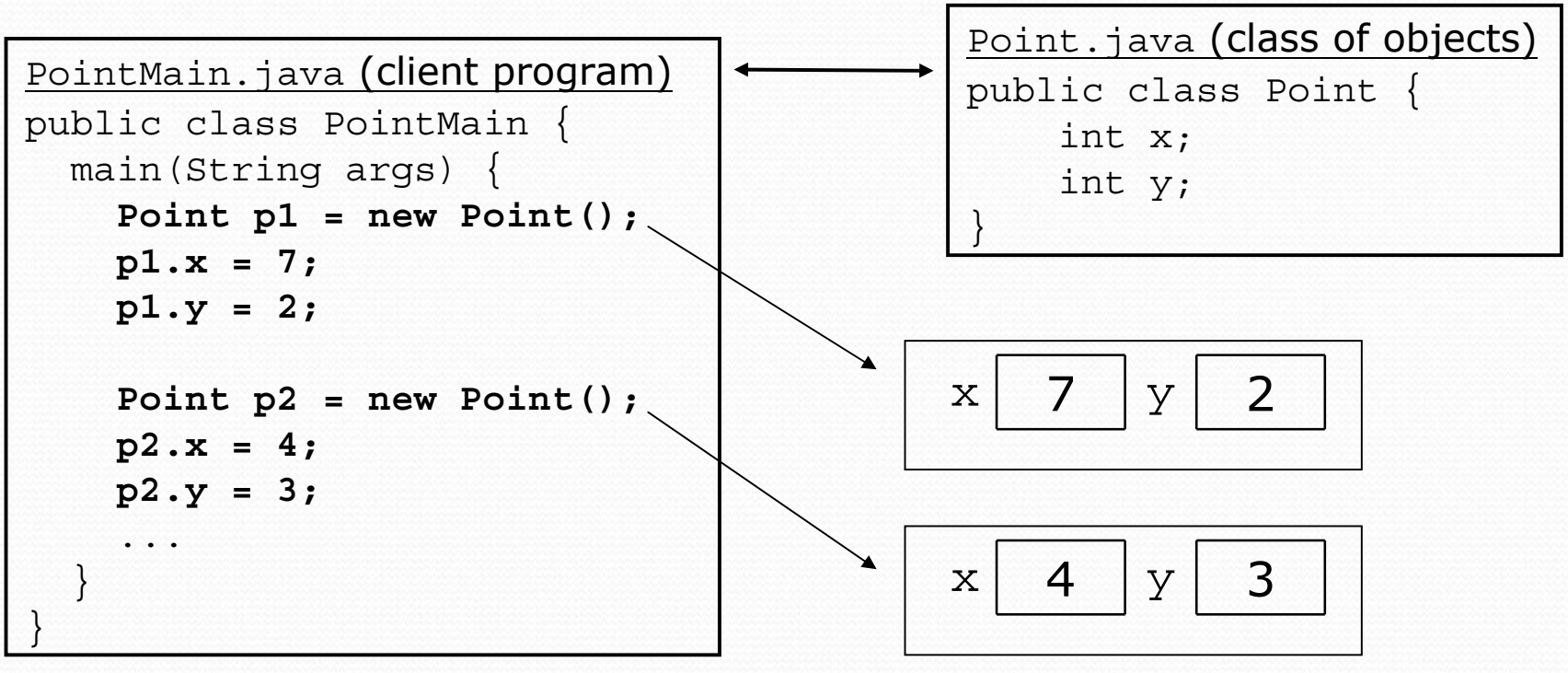
- Other classes can access/modify an object's fields.
  - access: **variable.field**
  - modify: **variable.field** = **value**;

- 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

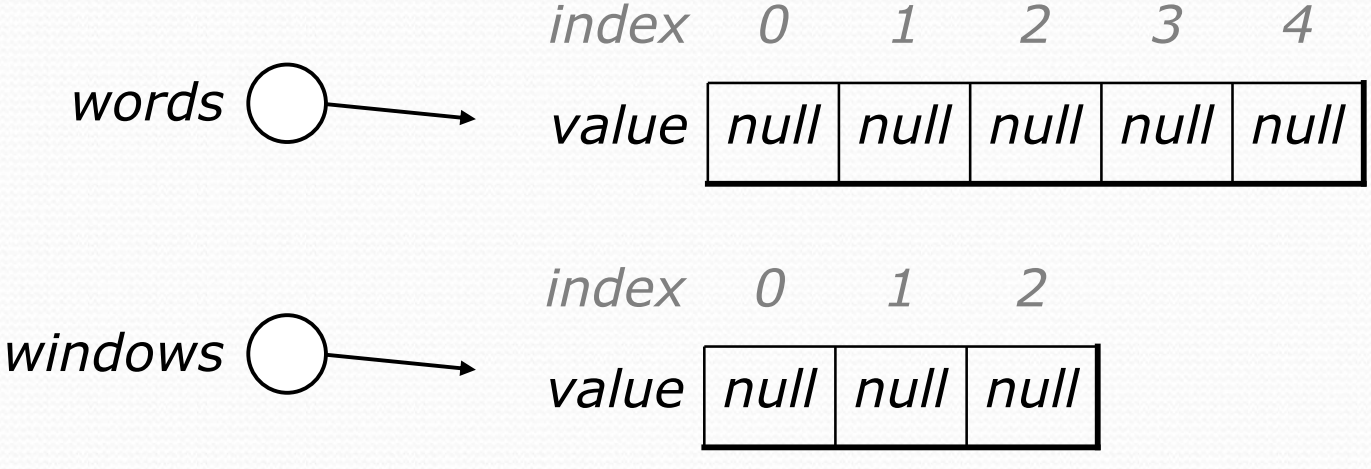
```
public class PointMain {
    public static void main(String[] args) {
        // create two Point objects
        Point p1 = new Point();
        p1.y = 2;
        Point p2 = new Point();
        p2.x = 4;

        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
    }
}
```

- Exercise: Modify the `Bomb` program to use `Point` objects.

Arrays of objects

- **`null` :** A value that does not refer to any object.
  - The elements of an array of objects are initialized to `null`.

```
String[] words = new String[5];
DrawingPanel[] windows = new DrawingPanel[3];
```



Things you **can** do w/ `null`

- store `null` in a variable or an array element

```
String s = null;
words[2] = null;
```

- print a `null` reference

```
System.out.println(s);        // null
```

- ask whether a variable or array element is `null`

```
if (words[2] == null) { ...
```

- pass `null` as a parameter to a method

```
System.out.println(null);     // null
```

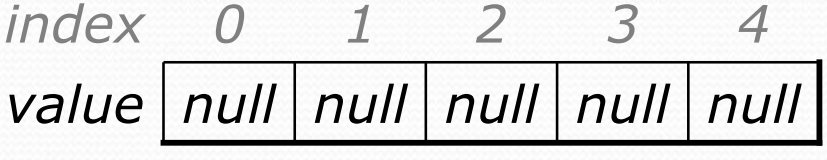
- return `null` from a method (often to indicate failure)

```
return null;
```

Null pointer exception

- **dereference**: To access data or methods of an object with the dot notation, such as `s.length()` .
  - It is illegal to dereference `null` (causes an exception).
  - `null` is not any object, so it has no methods or data.

```
String[] words = new String[5];
System.out.println("word is: " + words[0]);
words[0] = words[0].toUpperCase();   // ERROR
```



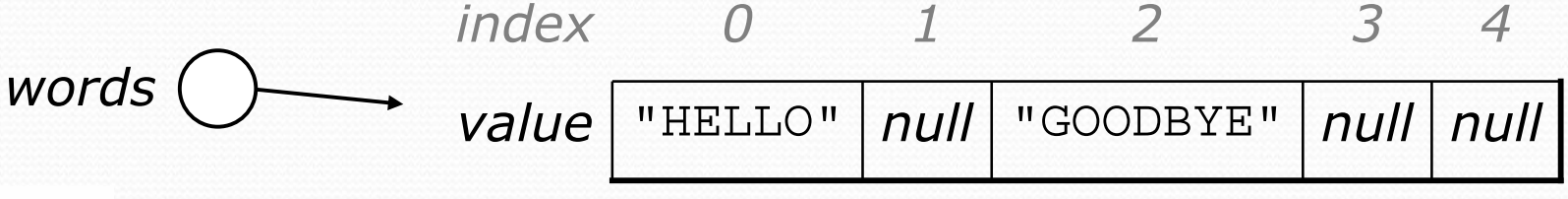
Output:

```
word is: null
Exception in thread "main"
java.lang.NullPointerException
        at Example.main(Example.java:8)
```

Looking before you leap

- You can check for `null` before calling an object's methods.

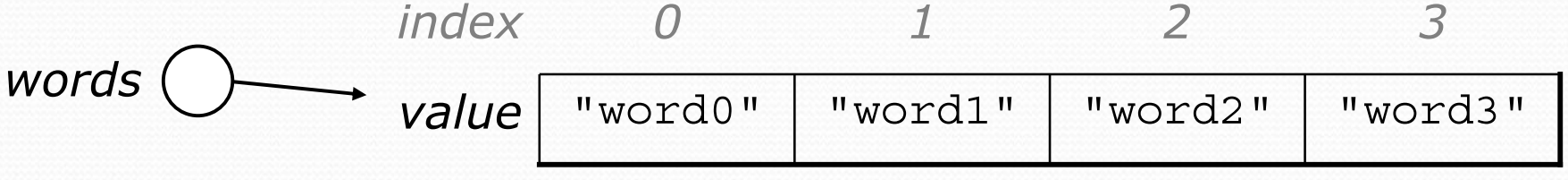
```
String[] words = new String[5];
words[0] = "hello";
words[2] = "goodbye";    // words[1], [3], [4] are null

for (int i = 0; i < words.length; i++) {
    if (words[i] != null) {
        words[i] = words[i].toUpperCase();
    }
}
```



Two-phase initialization

1) initialize the array itself (each element is initially `null`)
2) initialize each element of the array to be a new object

```
String[] words = new String[4];              // phase 1
for (int i = 0; i < words.length; i++) {
    coords[i] = "word" + i;                  // phase 2
}
```



Bomb answer 1

```
import java.awt.*;
import java.io.*;
import java.util.*;

// Displays a set of cities and simulates dropping a "bomb" on them.
public class Bomb {
    public static void main(String[] args) throws FileNotFoundException {
        DrawingPanel panel = new DrawingPanel(200, 200);
        Graphics g = panel.getGraphics();

        Scanner input = new Scanner(new File("cities.txt"));
        Point[] cities = readCities(input, g);

        // drop the "bomb"
        Scanner console = new Scanner(System.in);
        Point bomb = new Point();
        System.out.print("Blast site x? ");
        bomb.x = console.nextInt();
        System.out.print("Blast site y? ");
        bomb.y = console.nextInt();
        System.out.print("Blast radius? ");
        int radius = console.nextInt();
        boom(bomb, radius, cities, g);
    }
    ...
```

Bomb answer 2

```
// Reads input file of cities and returns them as array of Points.
public static Point[] readCities(Scanner input, Graphics g) {
    int numCities = input.nextInt();   // first line = # of cities
    Point[] cities = new Point[numCities];
    for (int i = 0; i < cities.length; i++) {
        cities[i] = new Point();
        cities[i].x = input.nextInt();  // read city x/y from file
        cities[i].y = input.nextInt();
        g.fillOval(cities[i].x, cities[i].y, 3, 3);
        g.drawString("(" + cities[i].x + ", " + cities[i].y + ")",
                cities[i].x, cities[i].y);
    }
    return cities;
}

// Simulates dropping a bomb at the given location on the given cities.
public static void boom(Point bomb, int radius, Point[] cities, Graphics g) {
    g.setColor(Color.RED);
    g.drawOval(bomb.x - radius, bomb.y - radius, 2 * radius, 2 * radius);
    for (int i = 0; i < cities.length; i++) {
        int dx = cities[i].x - bomb.x;
        int dy = cities[i].y - bomb.y;
        double distance = Math.sqrt(dx * dx + dy * dy);
        if (distance <= radius) {
            g.fillOval(cities[i].x, cities[i].y, 3, 3);
            g.drawString("(" + cities[i].x + ", " + cities[i].y + ")",
                    cities[i].x, cities[i].y);
        }
    }
    System.out.println("Kaboom!");
}
}
```