Classes II

Lecture 22

CS106A, Summer 2019

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With inspiration from slides created by Keith Schwarz, Mehran Sahami, Eric Roberts, Stuart Reges, Chris Piech and others.

Announcements

- Assignment 5 due Monday August 5th at 10AM

Plan for Today

- Review: Classes
- Bouncing Ball
- Emailer

What do we know about classes?

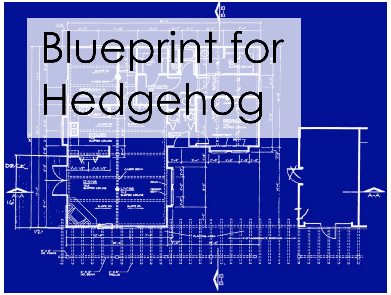
A class defines a new variable type.

Classes Are Like Blueprints

Hedgehog Class (blueprint)

State: Has name
Has color
Has cuteness level

Behavior: Can eat
Can run*
Can curl up


Blueprint for Hedgehog

Hedgehog #1 (variable)

State: **name = “Walnoot”**
color = Brown
cuteness = 10 (Very cute)

Behavior: Can eat
Can run
Can curl up

Hedgehog #2 (variable)

State: **name = “Nutmeg”**
color = Snowflake
cuteness = 15 (VERY cute)

Behavior: Can eat
Can run
Can curl up

Hedgehog #3 (variable)

State: **name = “Ruffles”**
color = Beige
cuteness = 50 (speechless)

Behavior: Can eat
Can run
Can curl up

Making a Class ~ 3 Ingredients

1. Define the **variables** each instance stores (state)

2. Define the **constructor** used to make a new instance

3. Define the **methods** you can call on an instance (behaviors)

You’ve seen them before…

GRect.java

```
public class GRect {
    public GRect(double width, double height) {
        this.width = width;
        this.height = height;
    }
    ...
}
```

```
GRect square = new GRect(10, 10);
```

type our object (variable) It’s an instance of the GRect class!

GRect.java

```
public class GRect {
    ....
    public double getX() {
        return this.xc;
    }
}
```

```
double x = square.getX()
```

Method defined in GRect class that
we can call on our object

GRect.java

```
public class GRect {
    private double width;
    public GRect(double width, double height) {
        ...
    }
    ...
}
```

Unpacking GRect

GRect.java

```
public class GRect {
```

3 Ingredients:

GRect.java

```java
public class GRect {

  // 1. Instance variables
  private double width = 0;
  private double height = 0;
  private double yc = 0;
  private double xc = 0;
  private boolean isFilled = false;
  private boolean isVisible = false;
```

3 Ingredients:

1. Define the variables each instance stores

GRect.java

```java
public class GRect {

  // 1. Instance variables
  private double width = 0;
  private double height = 0;
  private double yc = 0;
  private double xc = 0;
  private boolean isFilled = false;
  private boolean isVisible = false;

  // 2. Constructor(s)
  public GRect(double width, double height) {
    this.width = width;
    this.height = height;
  }
```

3 Ingredients:

1. Define the variables each instance stores

2. Define the constructor used to make a `new` instance

GRect.java

```java
public class GRect {

  // 1. Instance variables
  private double width = 0;
  private double height = 0;
  private double yc = 0;
  private double xc = 0;
  private boolean isFilled = false;
  private boolean isVisible = false;

  // 2. Constructor(s)
  public GRect(double width, double height) {
    this.width = width;
    this.height = height;
  }

  public GRect(double x, double y,
               double width, double height) {
    this.xc = x;
    this.yc = y;
    this.width = width;
    this.height = height;
  }
```

3 Ingredients:

1. Define the variables each instance stores

2. Define the constructor used to make a `new` instance

GRect.java

```java
public class GRect {

  // 1. Instance variables
  private double width = 0;
  private double height = 0;
  private double yc = 0;
  private double xc = 0;
  private boolean isFilled = false;
  private boolean isVisible = false;

  // 2. Constructor(s)
  public GRect(double width, double height) {
    this.width = width;
    this.height = height;
  }

  public GRect(double x, double y,
               double width, double height) {
    this.xc = x;
    this.yc = y;
    this.width = width;
    this.height = height;
  }

  // 3. Public methods
  public double getWidth() {
    return this.width;
  }

  public double getHeight() {
    return this.height;
  }

  public void setFilled(boolean newIsFilled) {
    this.isFilled = newIsFilled;
  }

  public void move(double dx, double dy) {
    this.xc += dx;
    this.yc += dy;
  }

}
```

3 Ingredients:

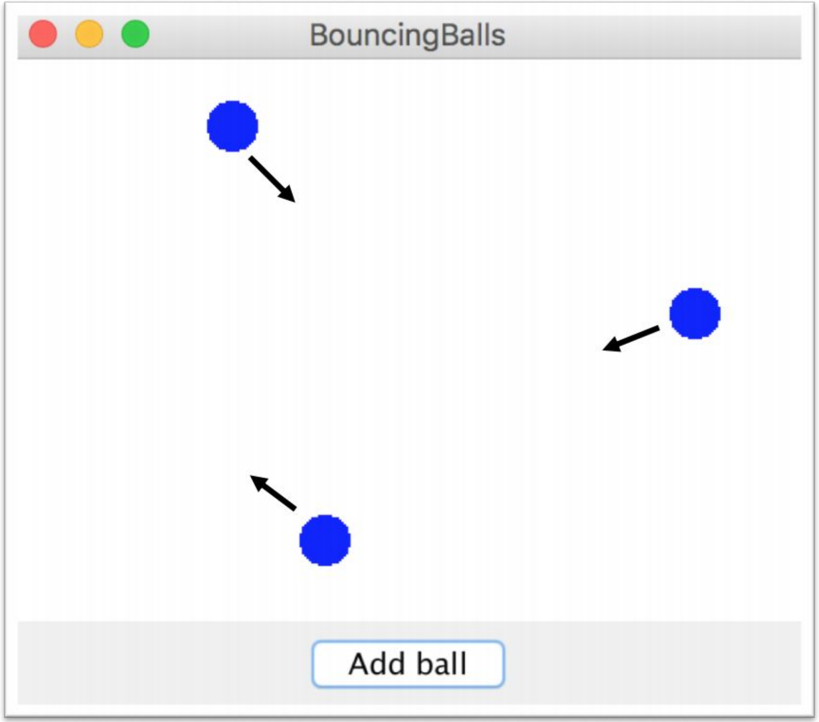
1. Define the variables each instance stores

2. Define the constructor used to make a `new` instance

3. Define the methods you can call on an instance

Making our own classes

Bouncing Ball



BouncingBalls
Add ball

Making a Ball variable type

1. Define the variables each instance stores (think: state/properties)

   Each ball has its own GOval (let's call it circle)
   Each ball has its own dx
   Each ball has its own dy

2. Define the constructor used to make a `new` instance

   Set initial values for all the instance vars

3. Define the methods you can call on an instance (think: behaviors)

   heartbeat()
   getGOval()

```java
public class Ball {

      private static final int BALL_SIZE = 20;

      // 1: what variables make up a ball?
      private GOval circle;     // each ball has a GOval shape
      private double dx;        // each ball has a dx
      private double dy;        // each ball has a dy
```

1. Instance variables define what makes up a variable of type Ball

```java
public class Ball {

	private static final int BALL_SIZE = 20;

	// 1: what variables make up a ball?
	private GOval circle;     // each ball has a GOval shape
	private double dx;        // each ball has a dx
	private double dy;        // each ball has a dy

	// 2. what happens when you make a new ball?
	public Ball() {
		// make the ball's circle
		this.circle = new GOval(0, 0, BALL_SIZE, BALL_SIZE);
		this.circle.setFilled(true);
		this.circle.setColor(Color.BLUE);

		// gets a random dx and a random dy
		this.dx = getRandomSpeed();
		this.dy = getRandomSpeed();
	}
```

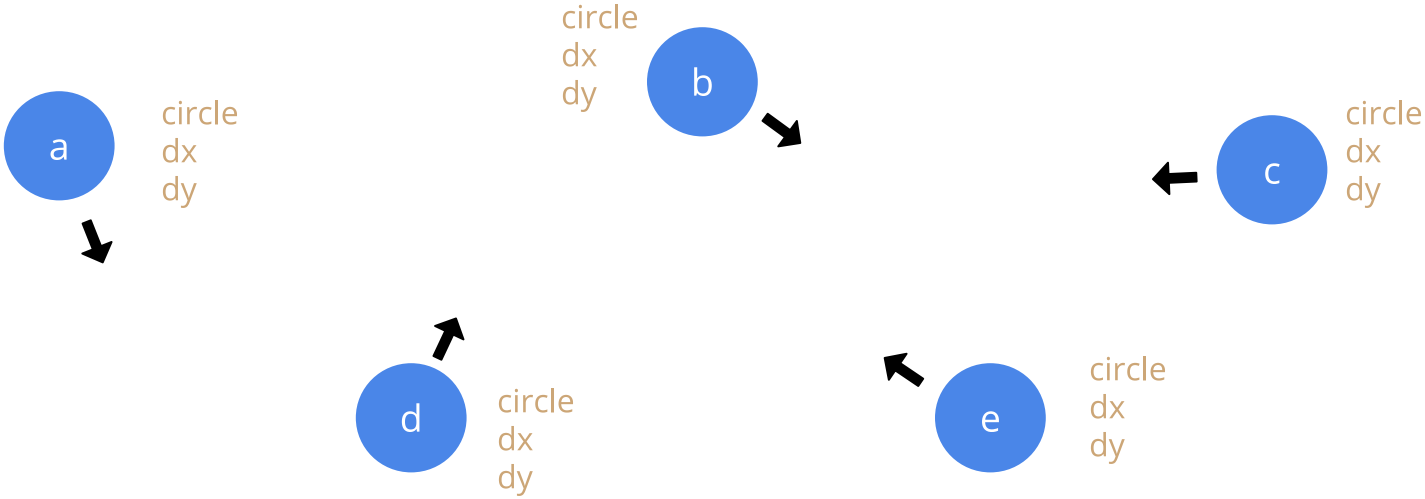
2. The constructor defines what happens when you call `new`

```
// 3. what methods can you call on a ball?
public GOval getGOval() {
	return this.circle;
}

public void heartbeat(int screenWidth, int screenHeight) {
	this.circle.move(this.dx, this.dy);
	reflectOffWalls(screenWidth, screenHeight);
}
```

3. Public methods define what the “client” can call on instances

```java
// private methods are allowed
private void reflectOffWalls(int screenWidth, int screenHeight) {
	if(this.circle.getY() < 0) {
		this.dy *= -1;
	}
	if(this.circle.getY() > screenHeight - BALL_SIZE) {
		this.dy *= -1;
	}
	if(this.circle.getX() < 0) {
		this.dx *= -1;
	}
	if(this.circle.getX() > screenWidth - BALL_SIZE) {
		this.dx *= -1;
	}
}

private double getRandomSpeed() {
	RandomGenerator rg = RandomGenerator.getInstance();
	double speed = rg.nextDouble(1,3);
	if(rg.nextBoolean()) {
		speed *= -1;
	}
	return speed;
}
```

4. We can also have private methods (think helpers)



But if each Ball instance has a copy of each instance variable…

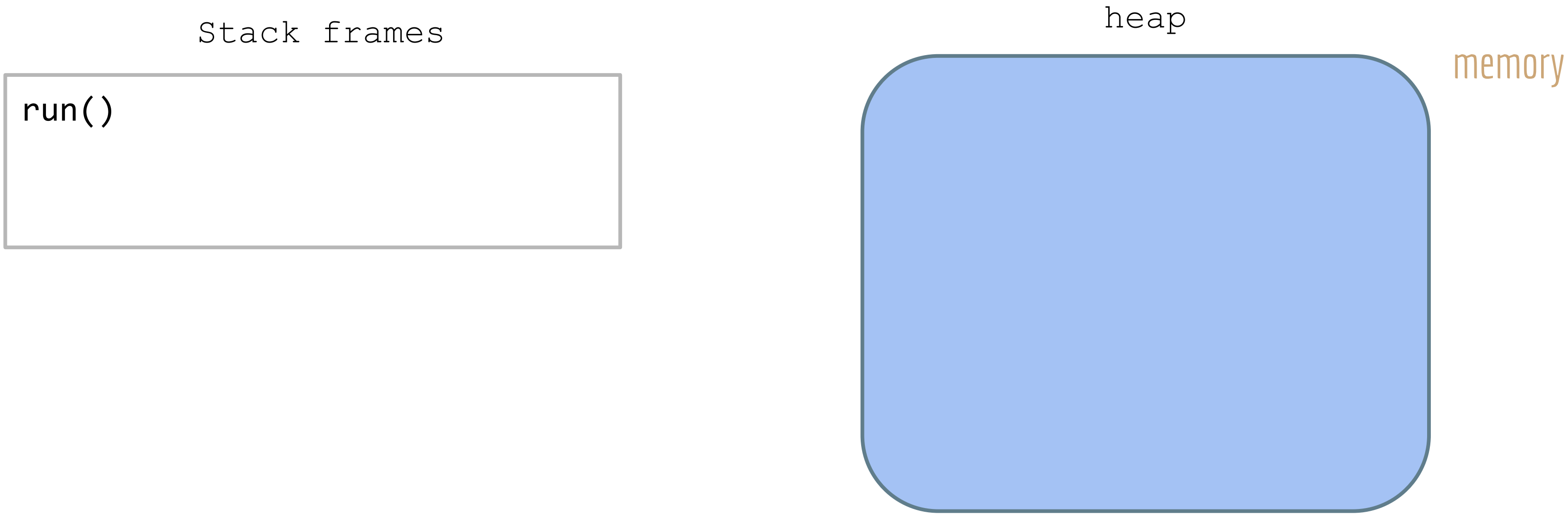
… how does Java know which one to use?

this

* all class methods and constructors have access to a this reference

```
public class BouncingBall extends GraphicsProgram {
      public void run() {
            // make a few new bouncing balls
            Ball a = new Ball();
            Ball b = new Ball();

            // call a method on one of the balls
            a.heartbeat(getWidth(), getHeight());
      }
}
```

code



```
public class BouncingBall extends GraphicsProgram {
      public void run() {
            // make a few new bouncing balls
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            a.heartbeat(getWidth(), getHeight());
      }
}
```
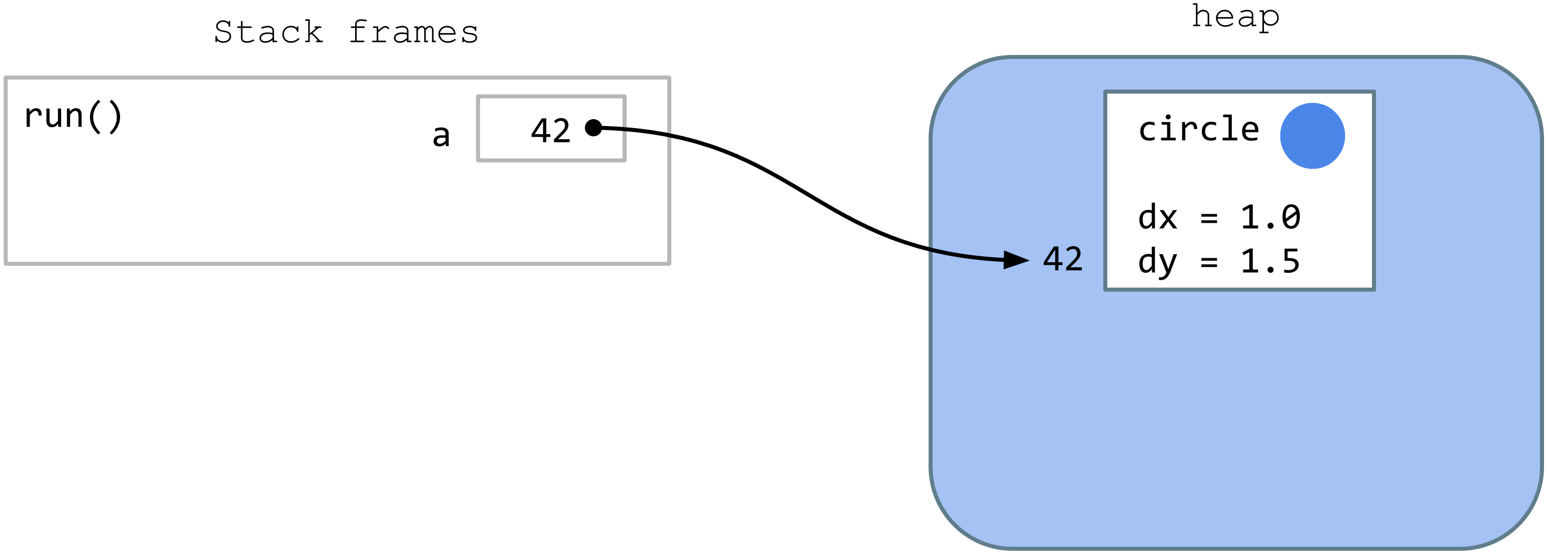

code

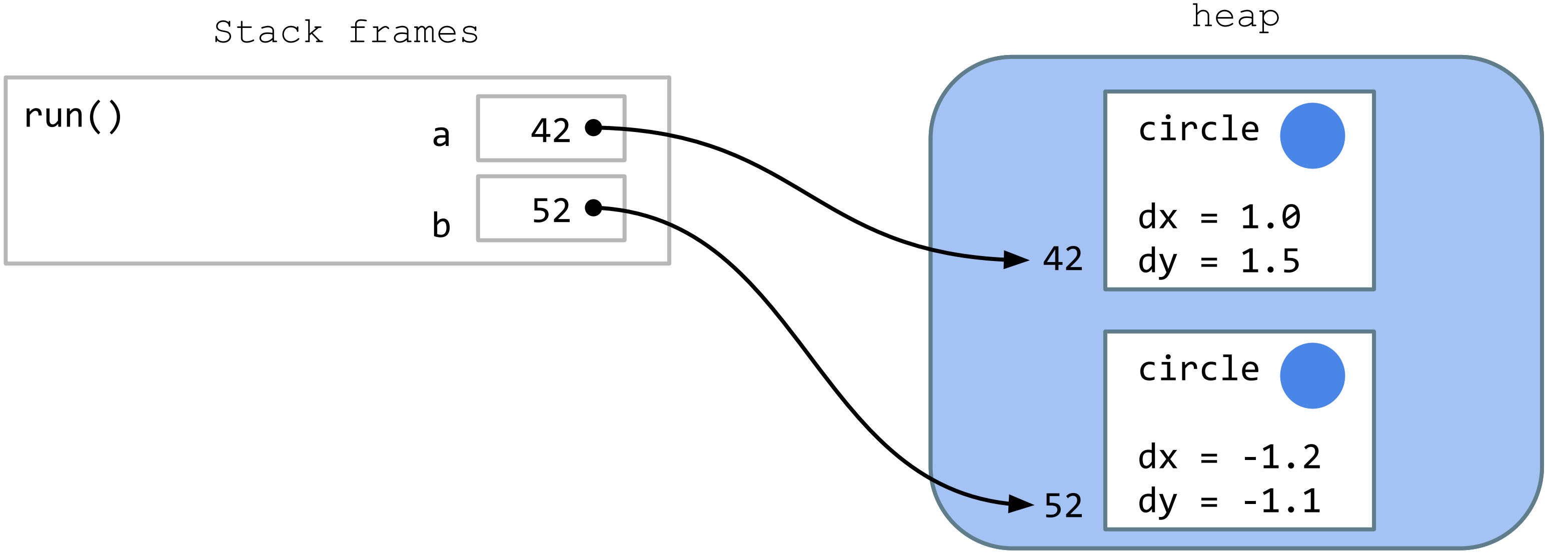


memory

```java
public class BouncingBall extends GraphicsProgram {
      public void run() {
            // make a few new bouncing balls
            Ball a = new Ball();
            Ball b = new Ball();

            // call a method on one of the balls
            a.heartbeat(getWidth(), getHeight());
      }
}
```

code



Stack frames

heap

run()

a 42

b 52

42
circle
dx = 1.0
dy = 1.5

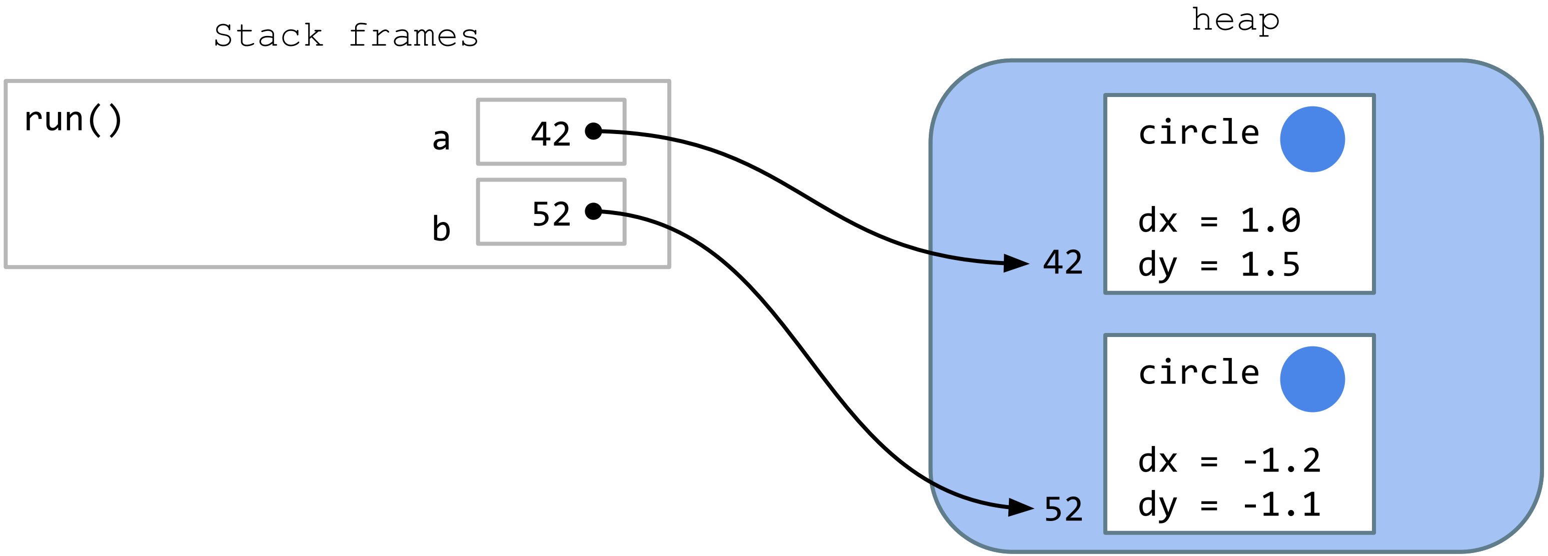
52
circle
dx = -1.2
dy = -1.1

memory

```
public class BouncingBall extends GraphicsProgram {
      public void run() {
            // make a few new bouncing balls
            Ball a = new Ball();
            Ball b = new Ball();

            // call a method on one of the balls
            a.heartbeat(getWidth(), getHeight());
      }
}
```

code



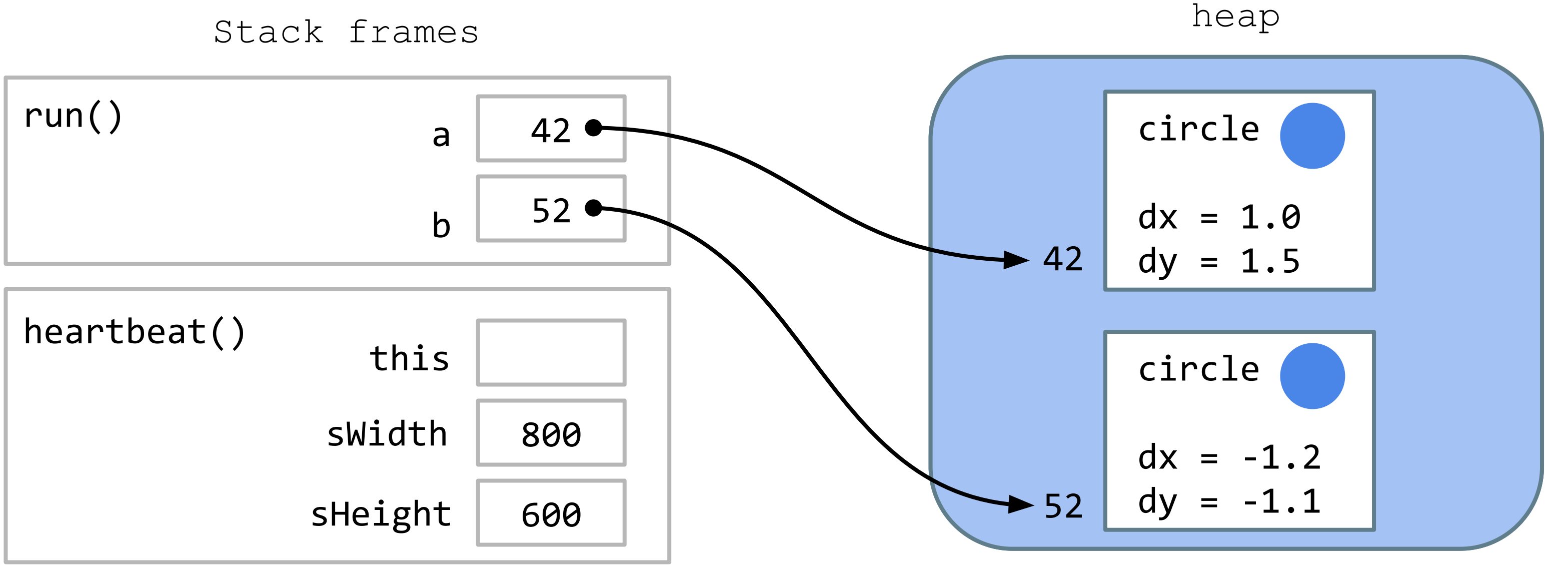
memory

```
public class BouncingBall extends GraphicsProgram {
        public void run() {
                // make a few new bouncing balls
                Ball a = new Ball();
                Ball b = new Ball();

                // call a method on one of the balls
                a.heartbeat(getWidth(), getHeight());
        }
}
```

```
public void heartbeat(int sWidth, int sHeight) {
        this.circle.move();
        reflectOffWalls(sWidth, sHeight);
}
```

code



memory

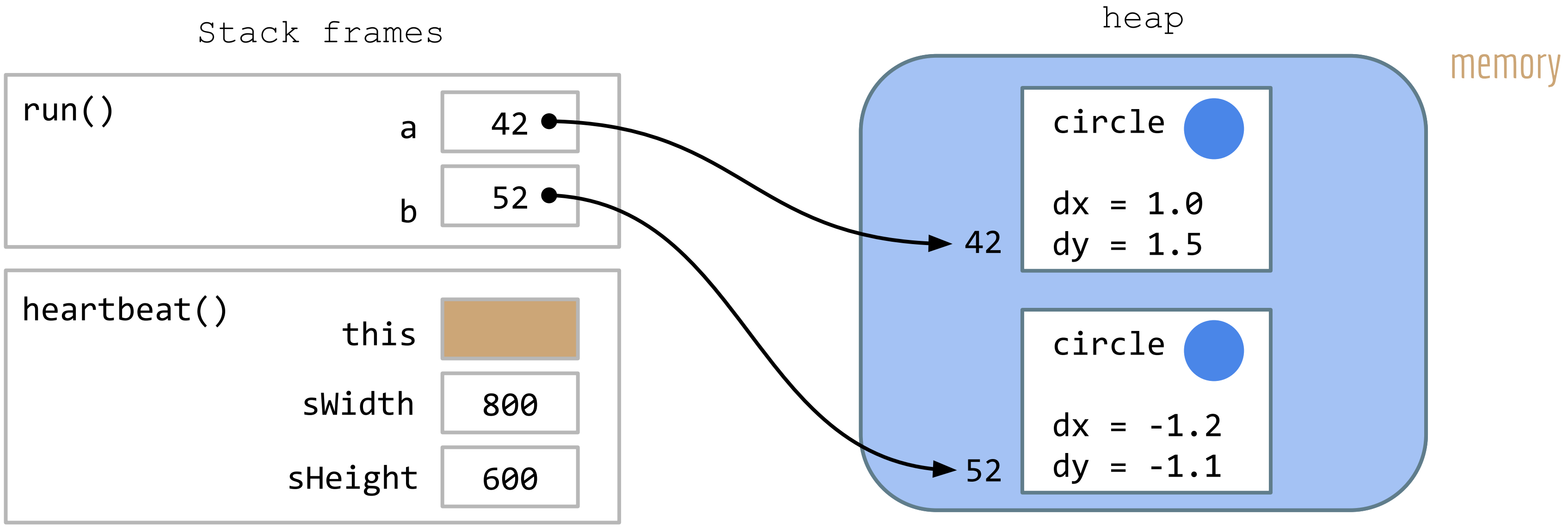
```
public class BouncingBall extends GraphicsProgram {
      public void run() {
            // make a few new bouncing balls
            Ball a = new Ball();
            Ball b = new Ball();

            // call a method on one of the balls
            a.heartbeat(getWidth(), getHeight());
      }
}
```

```
public void heartbeat(int sWidth, int sHeight) {
      this.circle.move();
      reflectOffWalls(sWidth, sHeight);
}
```

heartbeat() was called on ball **a**
⇒ So, **this** refers to **a**

code



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public class BouncingBall extends GraphicsProgram {
	public void run() {
		// make a few new bouncing balls
		Ball a = new Ball();
		Ball b = new Ball();

		// call a method on one of the balls
		a.heartbeat(getWidth(), getHeight());
	}
}
```

```
public void heartbeat(int sWidth, int sHeight) {
	this.circle.move();
	reflectOffWalls(sWidth, sHeight);
}
```

heartbeat() was called on ball **a**
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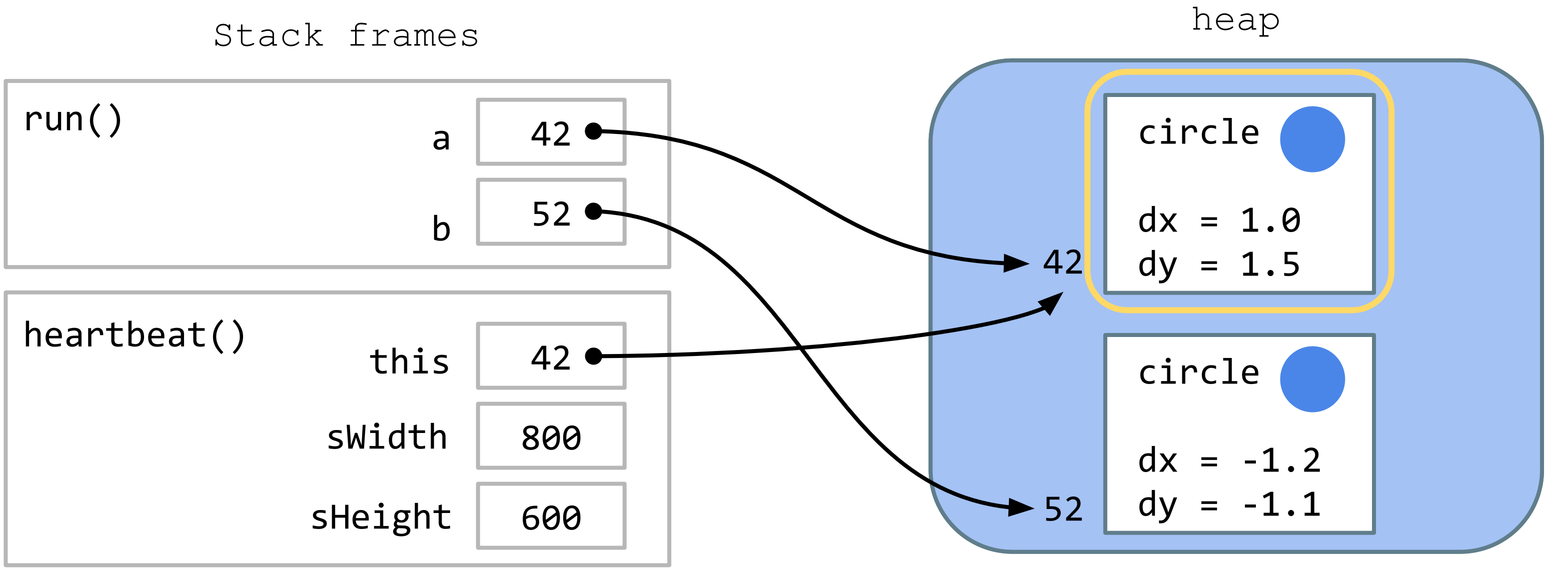
code



Stack frames

run()
a 42
b 52

heartbeat()
this 42
sWidth 800
sHeight 600

heap

42
circle
dx = 1.0
dy = 1.5

52
circle
dx = -1.2
dy = -1.1

memory

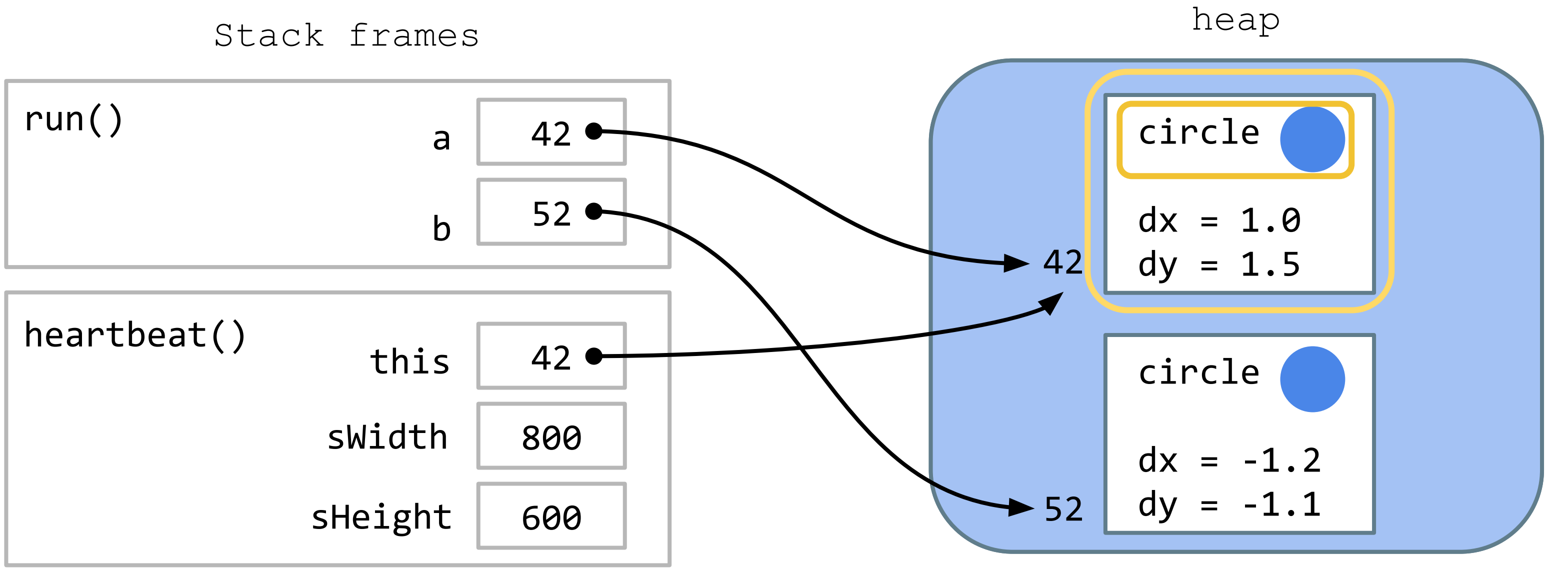
```
public class BouncingBall extends GraphicsProgram {
	public void run() {
		// make a few new bouncing balls
		Ball a = new Ball();
		Ball b = new Ball();

		// call a method on one of the balls
		a.heartbeat(getWidth(), getHeight());
	}
}
```

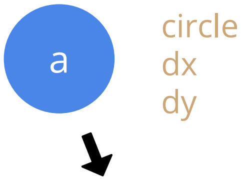
```
public void heartbeat(int sWidth, int sHeight) {
	this.circle.move();
	reflectOffWalls(sWidth, sHeight);
}
```

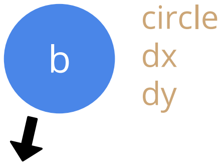
heartbeat() was called on ball **a**
⇒ So, **this** refers to **a**

code



memory

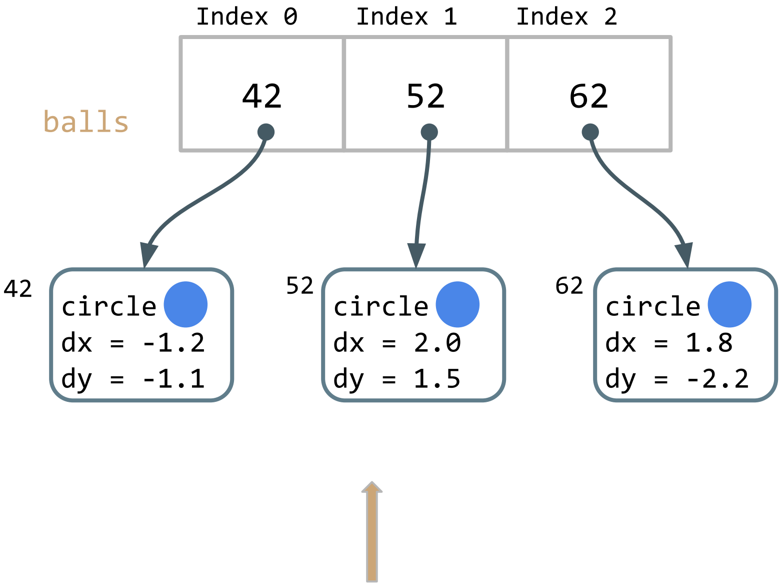




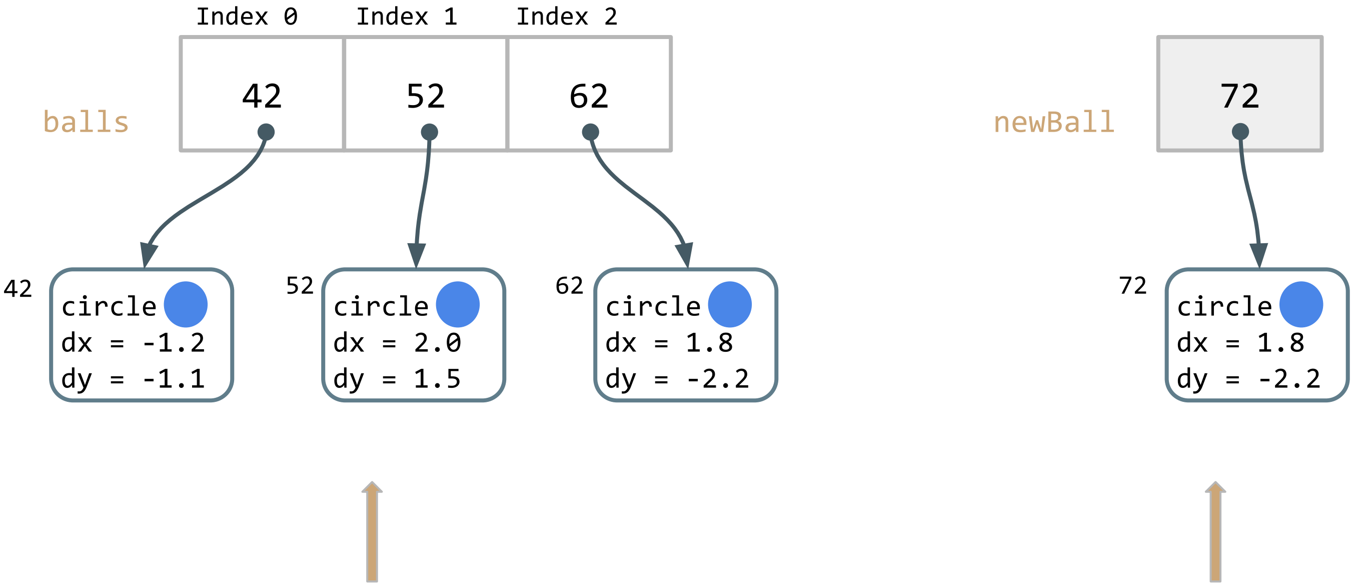
Java knows which instance you called a method on

c
circle
dx
dy

One more note



ArrayList<Ball> balls



Index 0 Index 1 Index 2

balls 42 52 62

newBall 72

42 circle dx = -1.2 dy = -1.1

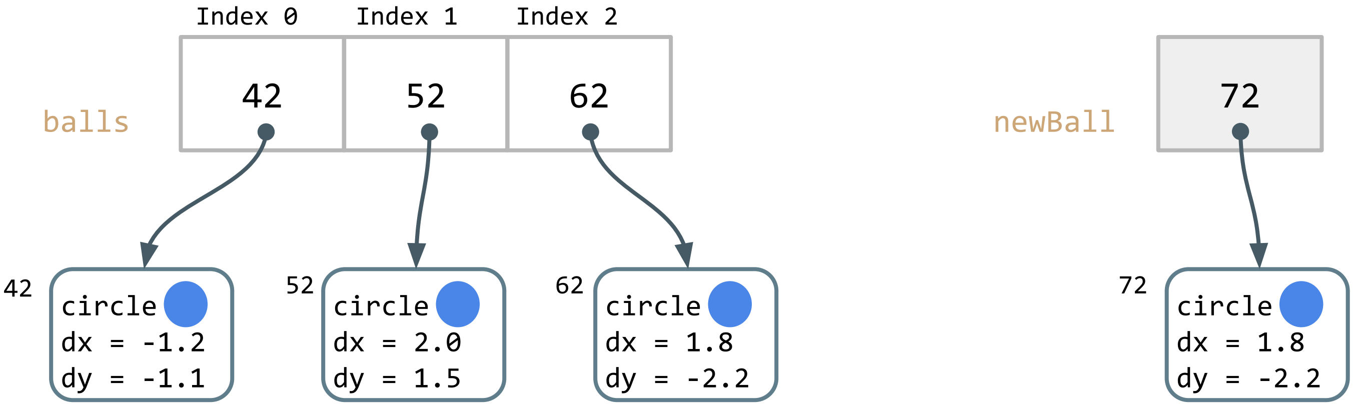
52 circle dx = 2.0 dy = 1.5

62 circle dx = 1.8 dy = -2.2

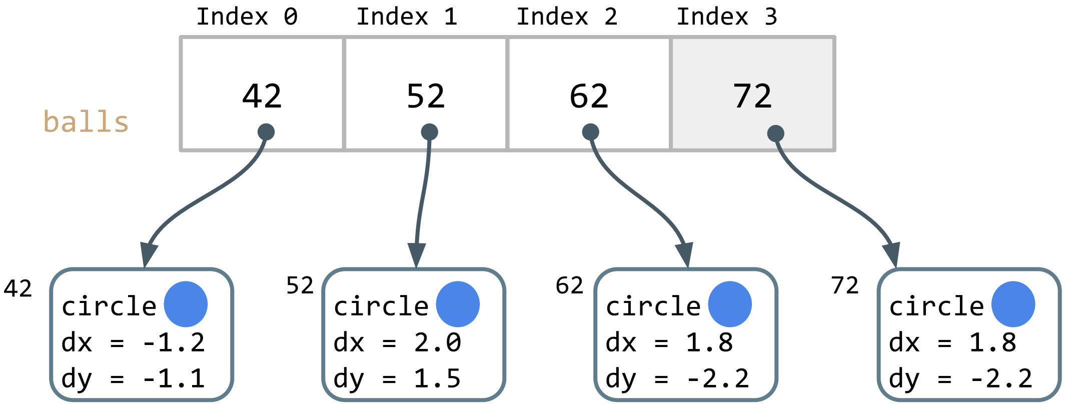
72 circle dx = 1.8 dy = -2.2

ArrayList<Ball> balls

Ball newBall = new Ball()



balls.append(newBall)



balls

Index 0	Index 1	Index 2	Index 3
42	52	62	72

42
circle
dx = -1.2
dy = -1.1

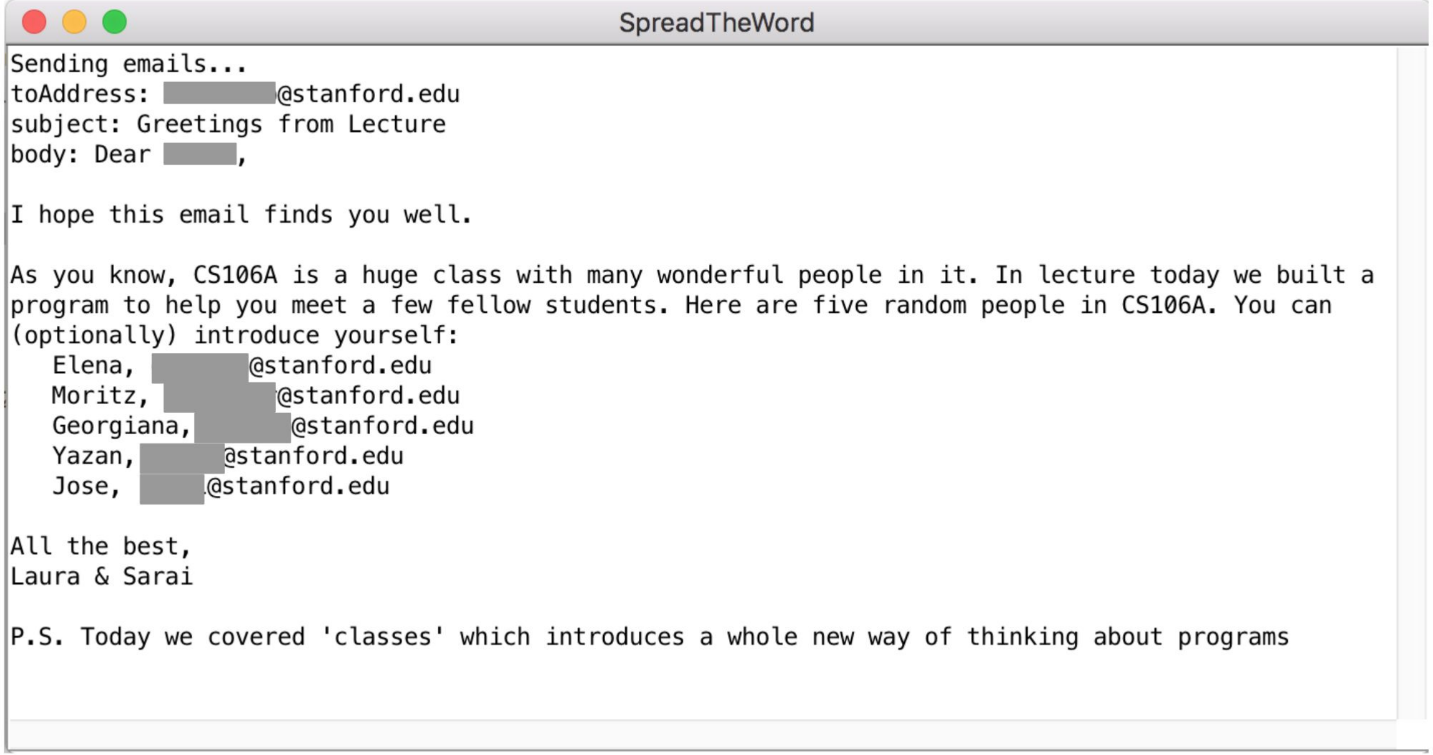
52
circle
dx = 2.0
dy = 1.5

62
circle
dx = 1.8
dy = -2.2

72
circle
dx = 1.8
dy = -2.2

```
balls.append(newBall)
```

Let’s build something bigger



```
Sending emails...
toAddress: [redacted]@stanford.edu
subject: Greetings from Lecture
body: Dear [redacted],

I hope this email finds you well.

As you know, CS106A is a huge class with many wonderful people in it. In lecture today we built a
program to help you meet a few fellow students. Here are five random people in CS106A. You can
(optionally) introduce yourself:
   Elena, [redacted]@stanford.edu
   Moritz, [redacted]@stanford.edu
   Georgiana, [redacted]@stanford.edu
   Yazan, [redacted]@stanford.edu
   Jose, [redacted]@stanford.edu

All the best,
Laura & Sarai

P.S. Today we covered 'classes' which introduces a whole new way of thinking about programs
```

Plan for Today

- Review: Classes
- Bouncing Ball
- Emailer

Next Time: Interactors