Classes

CS106A, Stanford University
Laura Cruz-Albrecht

What do we know about classes?

Classes define a new variable type

Classes are like blueprints

House.java

```
public class House {

  private int nRooms;
  private double height;

  public House(int nRooms, double height) {
    this.numRooms = numRooms;
    this.height = height;
  }
  ...
}
```

House myHouse
  = new House(2, 200);

House brahmsHouse
  = new House(5, 300);

Making a class - 3 ingredients

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

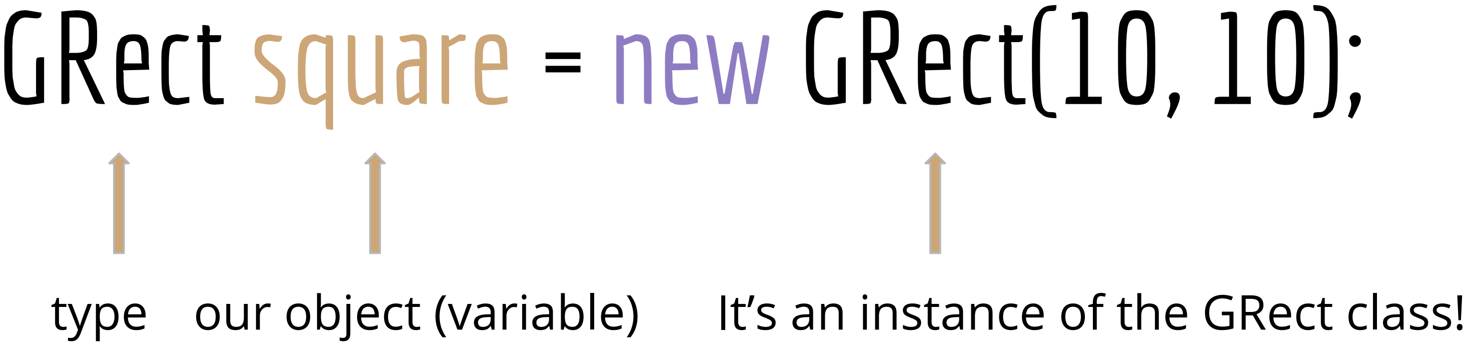
2. Define the constructor used to make a `new` instance

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

```
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

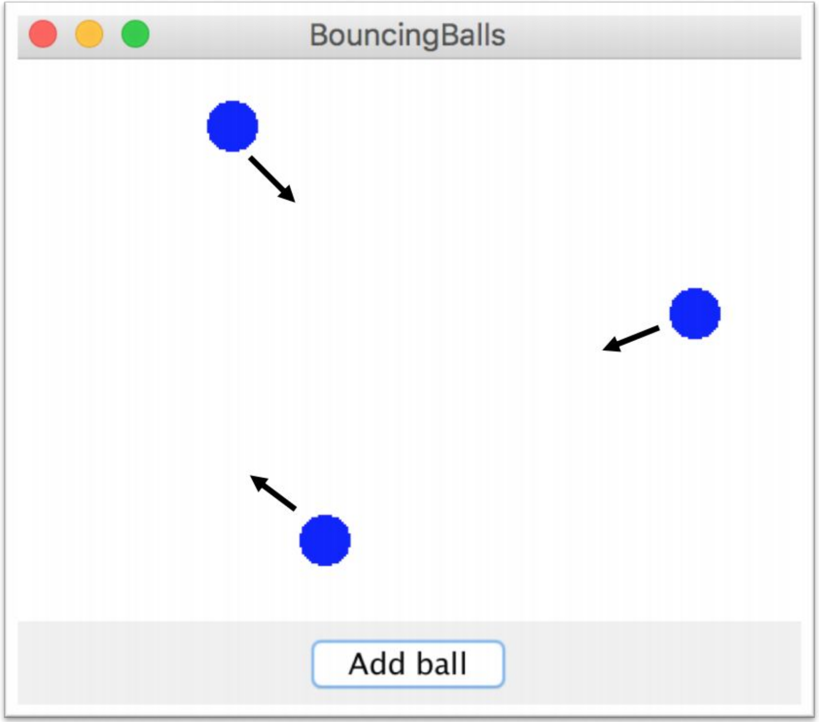
```java
public class GRect {

  // 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

Back to Bouncing Ball...



BouncingBalls
Add ball

Making a Ball variable type

1. Define the variables each instance stores (think: 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();
    }
```

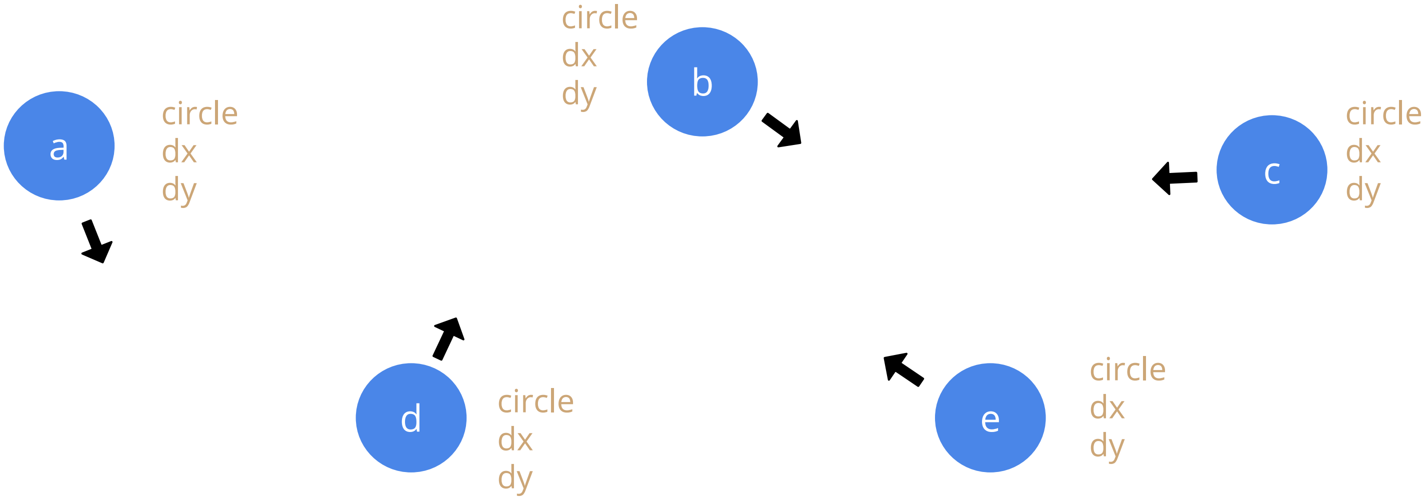
2. The constructor defines what happens when you call `new`

```java
// 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…

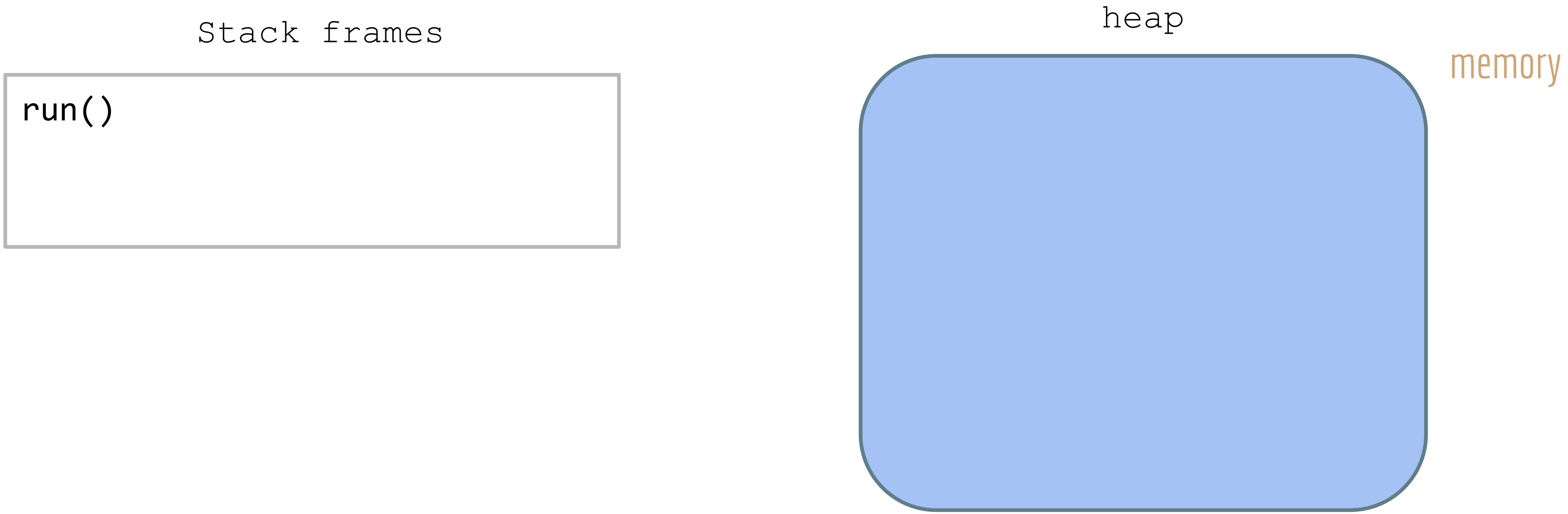
… how does Java know which one to use?

this

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

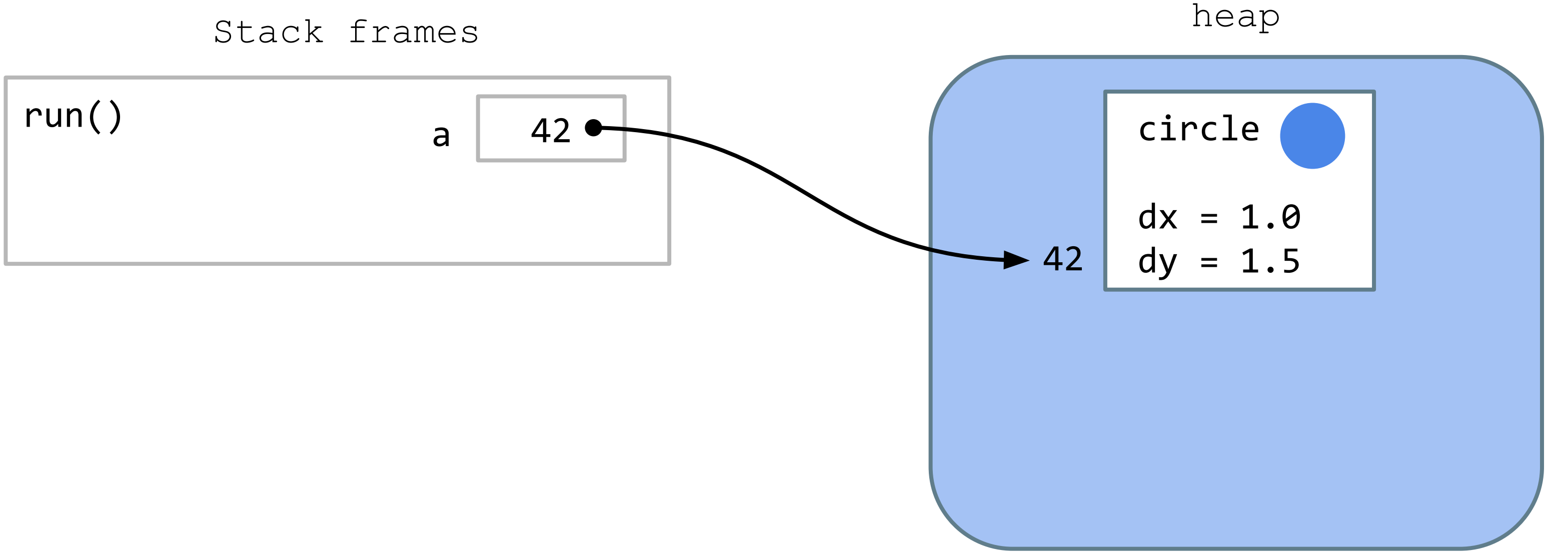
```
public class BouncingBall extends GraphicsProgram {
 ➡  public void run() {
        // make a few new bouncing balls
        Ball a = new Ball();
        Ball b = new Ball();

        // 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
            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

circle

dx = 1.0

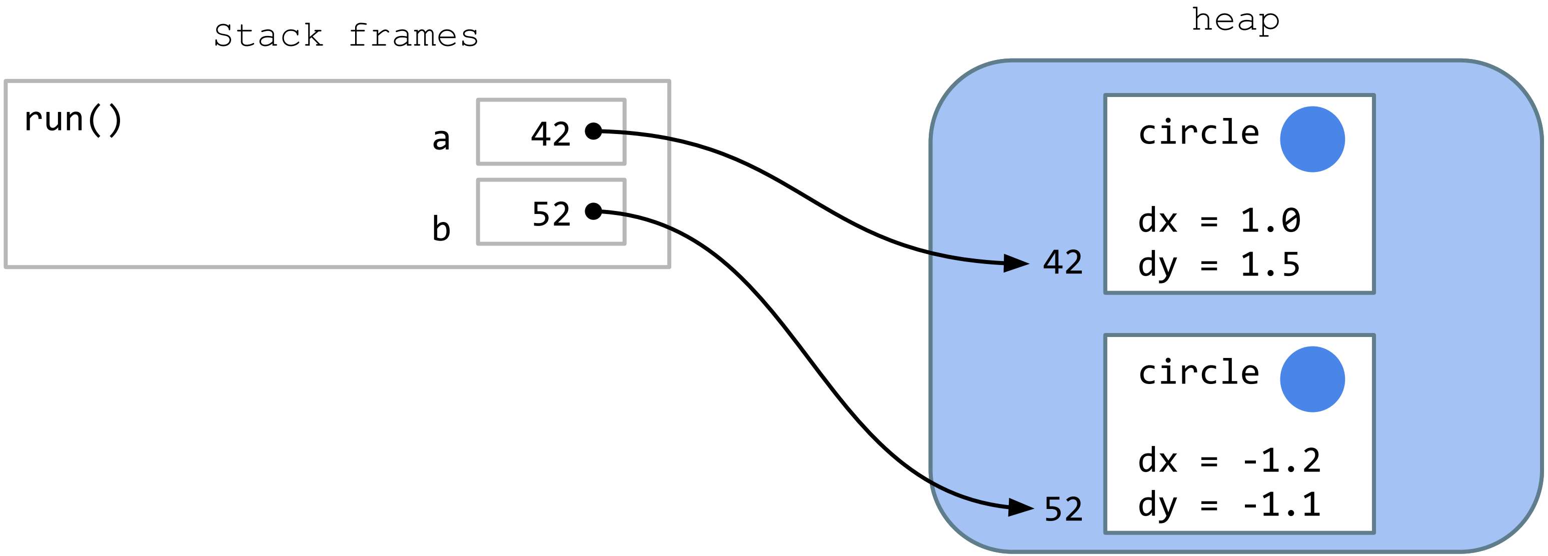
dy = 1.5

42

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());
      }
}
```

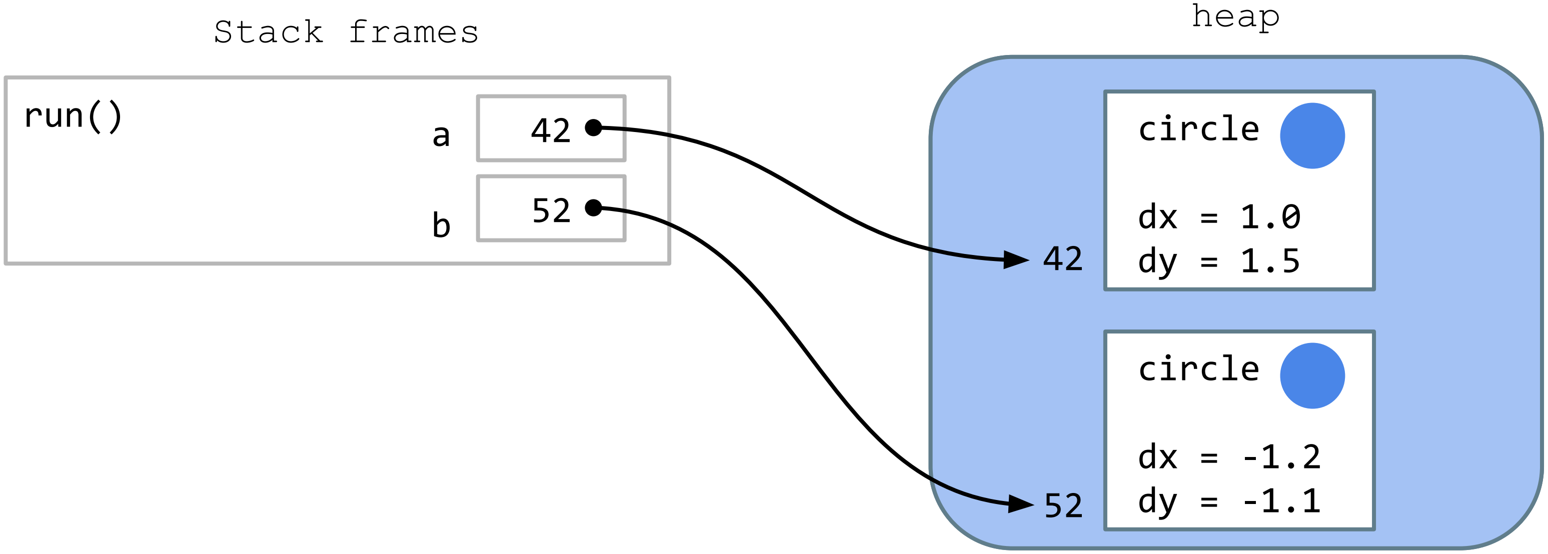
code



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());
      }
}
```

code

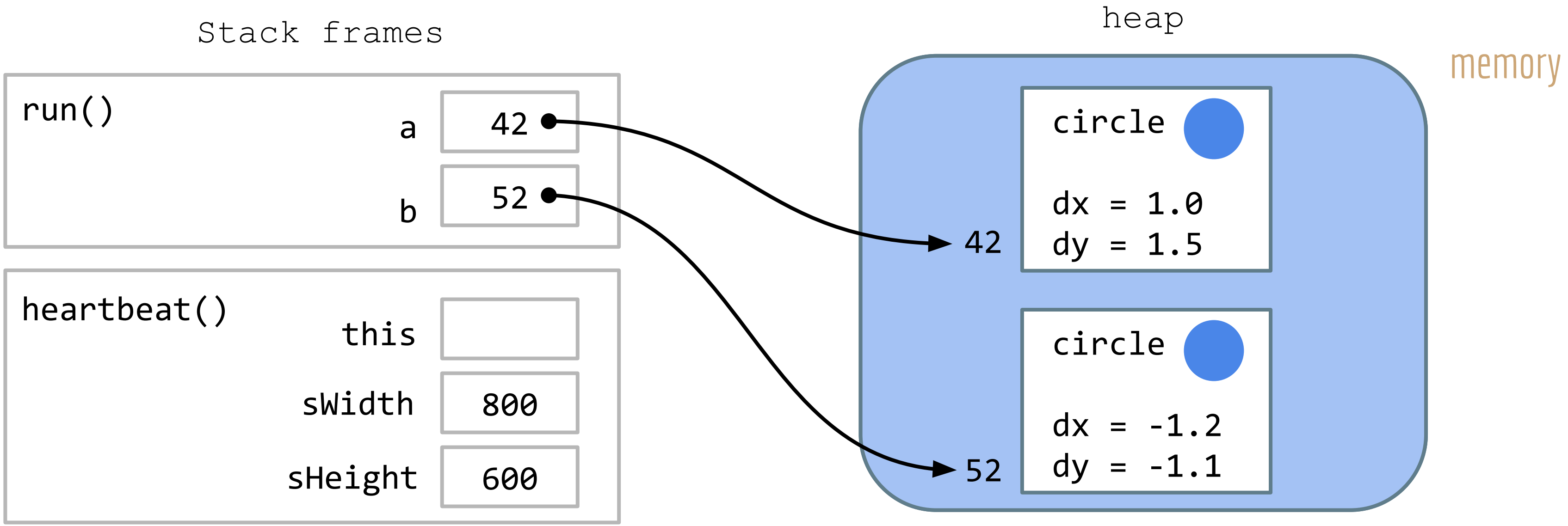


memory

```
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



Stack frames

heap

memory

run()

a 42

b 52

heartbeat()

this

sWidth 800

sHeight 600

42

circle

dx = 1.0
dy = 1.5

52

circle

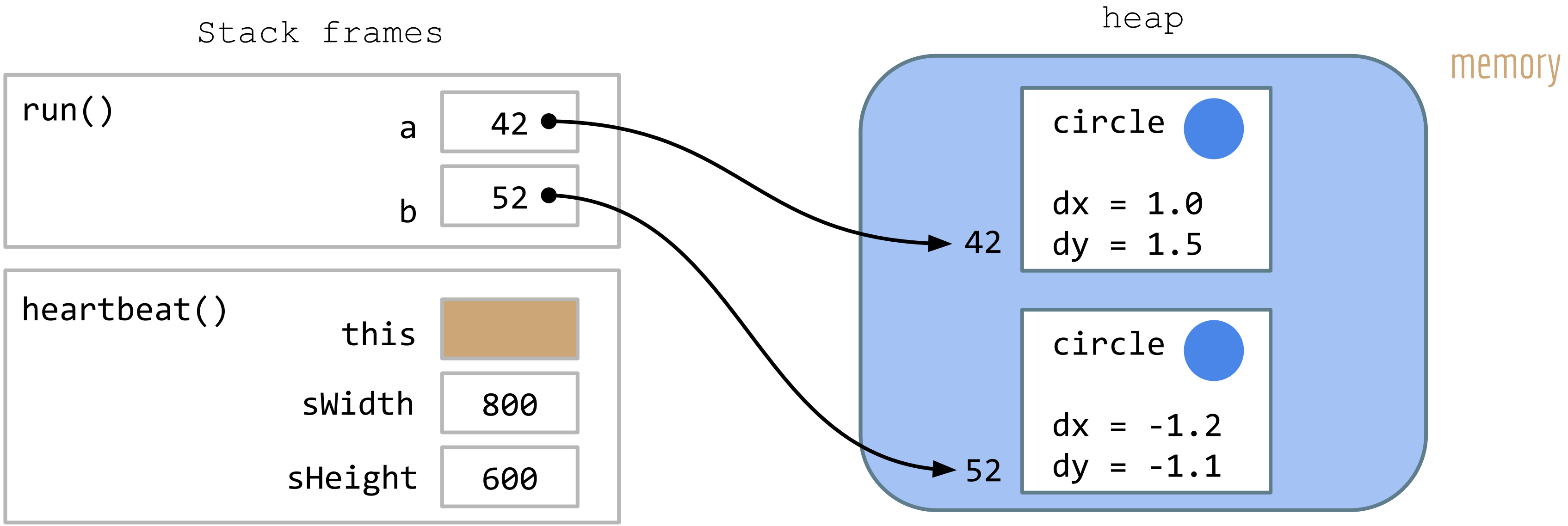
dx = -1.2
dy = -1.1

```
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

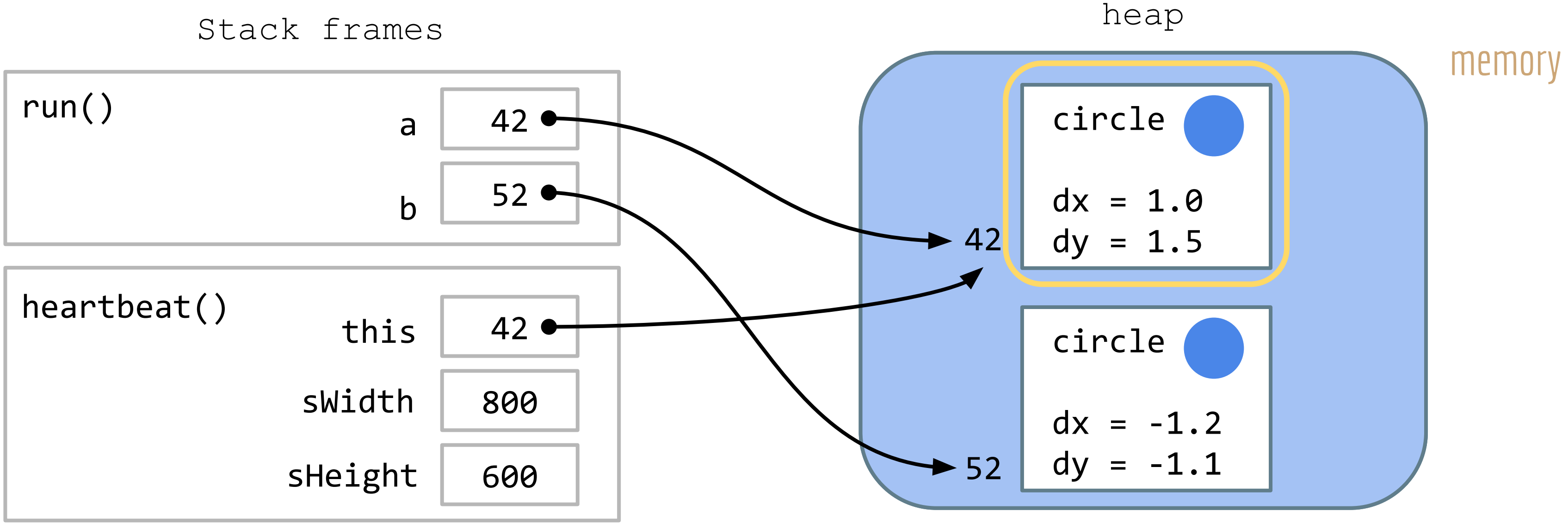


```java
public class BouncingBall extends GraphicsProgram {
    public void run() {
        // make a few new bouncing balls
        Ball a = new Ball();
        Ball b = new Ball();

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

```java
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

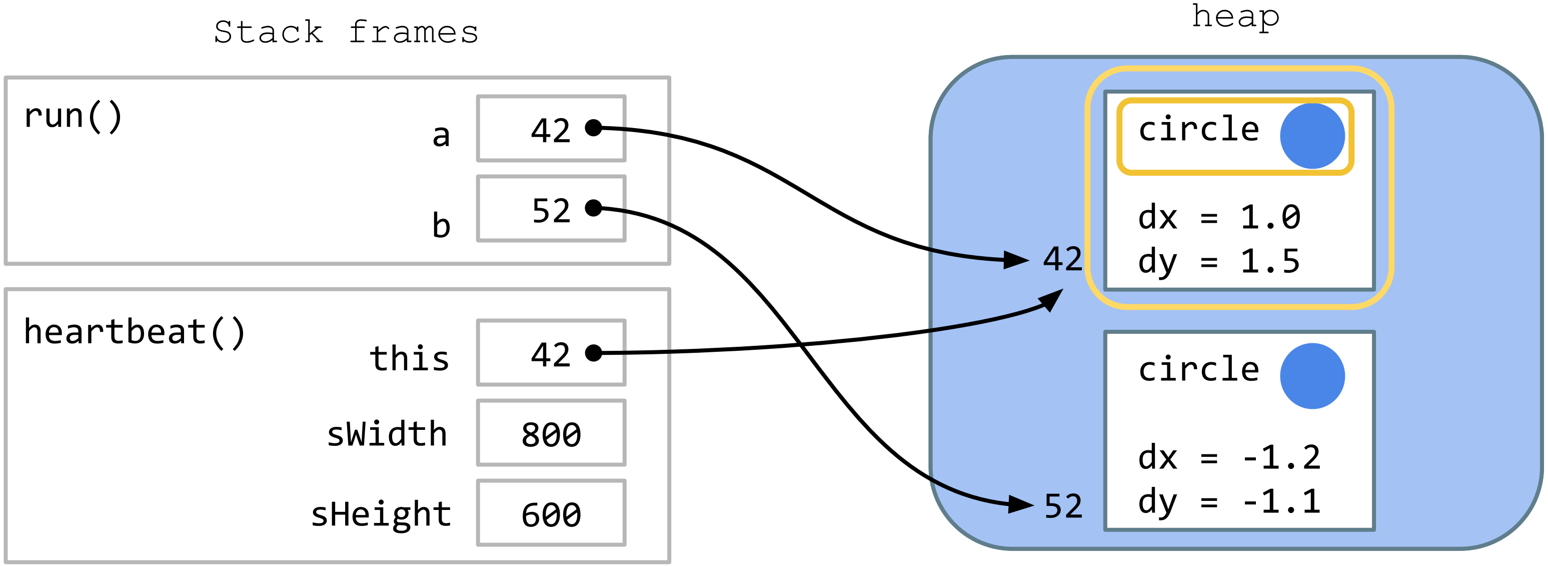


```
public class BouncingBall extends GraphicsProgram {
        public void run() {
                // make a few new bouncing balls
                Ball a = new Ball();
                Ball b = new Ball();

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

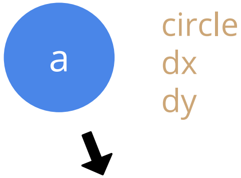
```
public void heartbeat(int sWidth, int sHeight) {
        this.circle.move();
        reflectOffWalls(sWidth, sHeight);
}
```

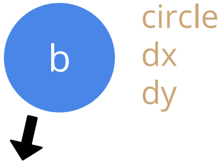
heartbeat() was called on ball **a**
⇒ So, **this** refers to **a**

code

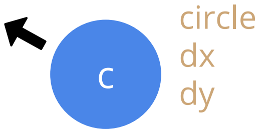


memory

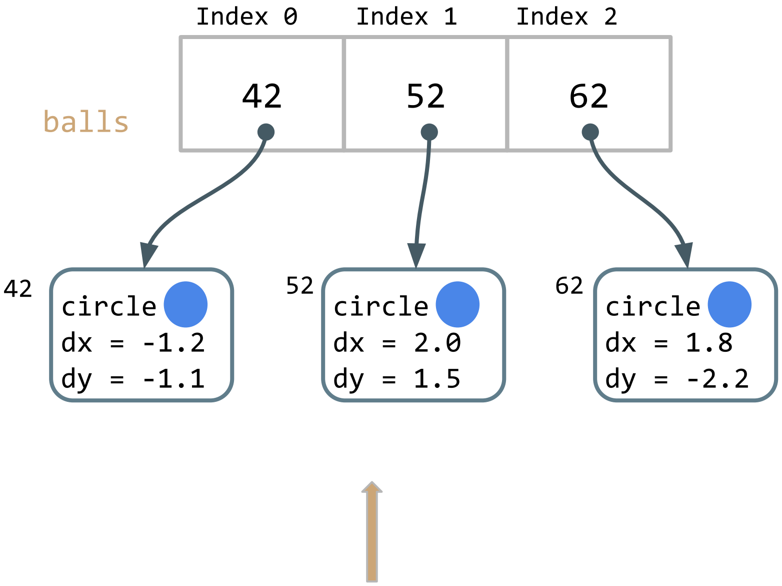




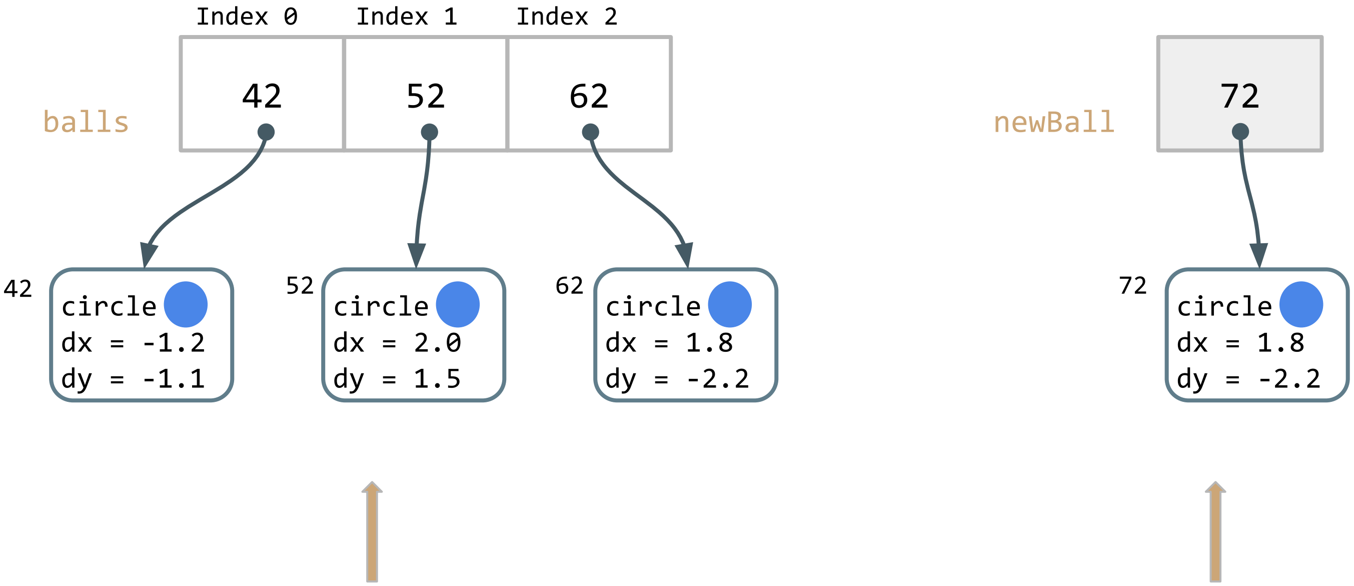
Java knows which instance you called a method on



One more note

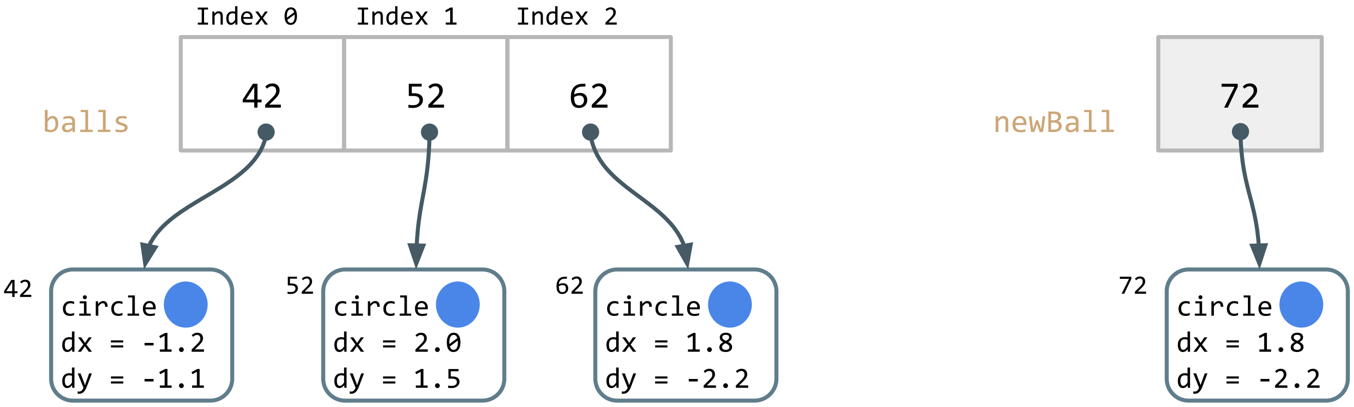


ArrayList<Ball> balls

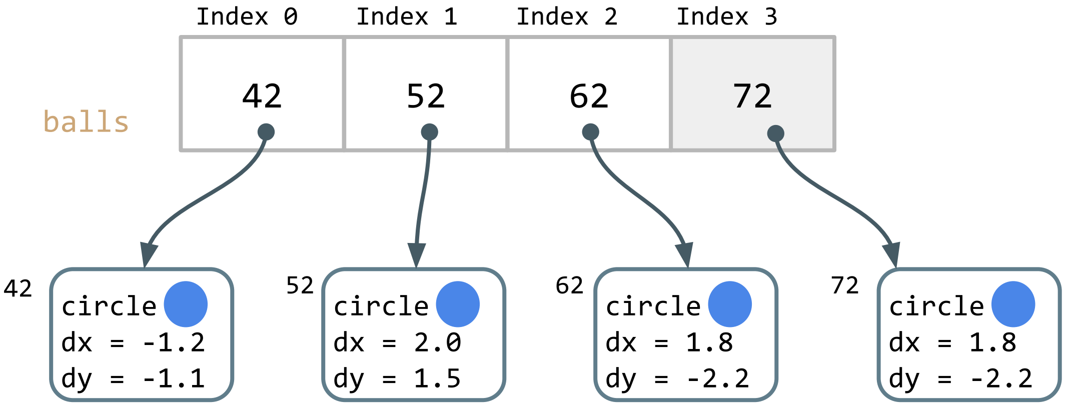


ArrayList‹Ball› balls

Ball newBall = new Ball()

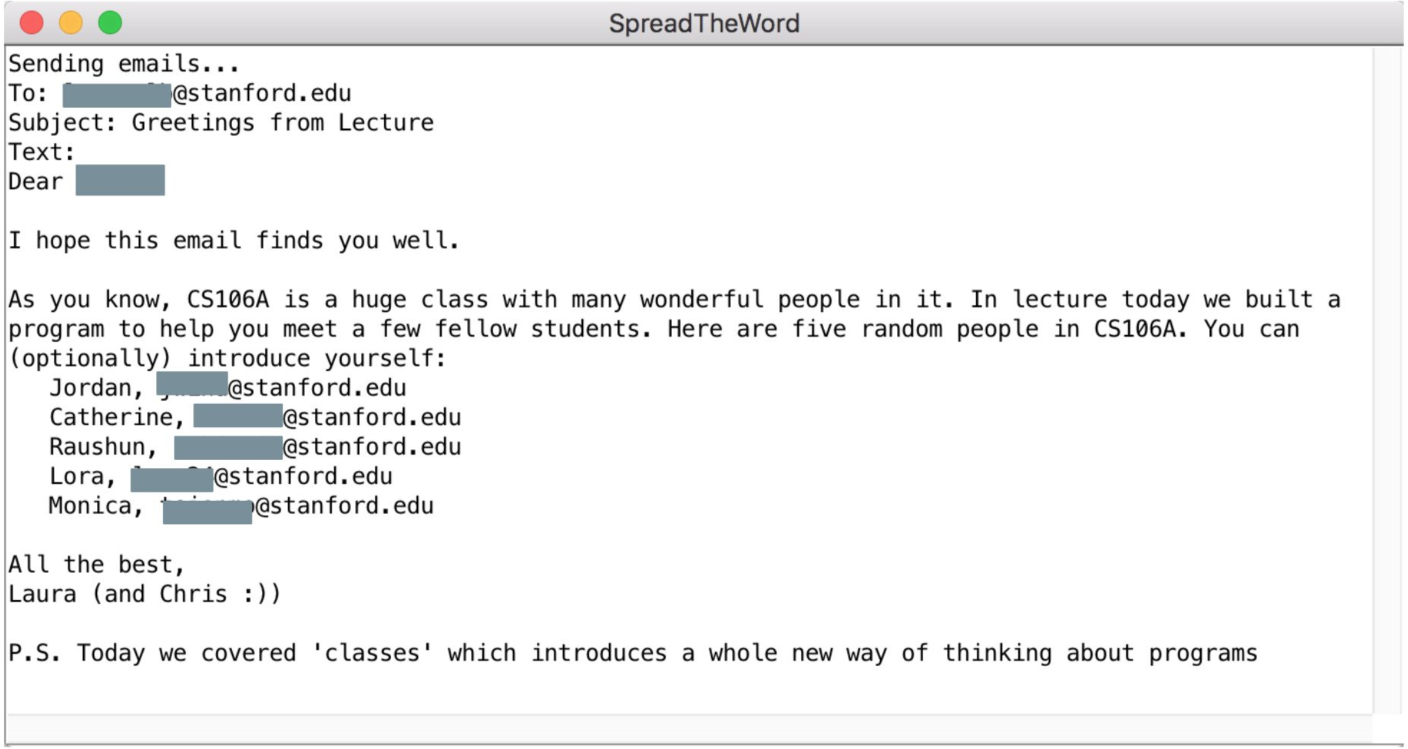


```
balls.append(newBall)
```



balls.append(newBall)

Let’s build something bigger



```
Sending emails...
To: [redacted]@stanford.edu
Subject: Greetings from Lecture
Text:
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:
   Jordan, [redacted]@stanford.edu
   Catherine, [redacted]@stanford.edu
   Raushun, [redacted]@stanford.edu
   Lora, [redacted]@stanford.edu
   Monica, [redacted]@stanford.edu

All the best,
Laura (and Chris :))

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

More practice

What’s in a Guinea Pig?

Guinea Pigs have properties and behaviors

- Properties → …
- Behaviors → …

How do we model this with classes?

- Properties → Instance variables
- Behaviors → Methods

Making a Guinea Pig variable type

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

   Name, color, age, likes to squeak

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

   Initialize our instance variables

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

   Getters & setters (to access/modify properties), squeak()

GuineaPig.java

```java
public class GuineaPig {

  // 1. Instance variables
  private String name;
  private String color;
  private int age;
  private boolean likesToSqueak;
```

GuineaPig.java

```java
public class GuineaPig {

  // 1. Instance variables
  private String name;
  private String color;
  private int age;
  private boolean likesToSqueak;

  // 2. Constructor
  public GuineaPig(String name, String color,
                   int age, boolean likesToSqueak) {
    this.name = name;
    this.color = color;
    this.age = age;
    this.likesToSqueak = likesToSqueak;
  }
```

GuineaPig.java

```java
public class GuineaPig {

  // 1. Instance variables
  private String name;
  private String color;
  private int age;
  private boolean likesToSqueak;

  // 2. Constructor
  public GuineaPig(String name, String color,
                   int age, boolean likesToSqueak) {
    this.name = name;
    this.color = color;
    this.age = age;
    this.likesToSqueak = likesToSqueak;
  }
```

```java
// 3. Methods
public String getName() {      // Getters & setters
  return this.name;
}

public int getAge() {
  return this.age;
}

public void setAge(int newAge) {
  this.age = newAge;
}
```

GuineaPig.java

```java
public class GuineaPig {

  // 1. Instance variables
  private String name;
  private String color;
  private int age;
  private boolean likesToSqueak;

  // 2. Constructor
  public GuineaPig(String name, String color,
                   int age, boolean likesToSqueak) {
    this.name = name;
    this.color = color;
    this.age = age;
    this.likesToSqueak = likesToSqueak;
  }
```

```java
// 3. Methods
public String getName() {      // Getters & setters
  return this.name;
}

public int getAge() {
  return this.age;
}

public void setAge(int newAge) {
  this.age = newAge;
}

public String squeak() {       // behaviors
  String squeakStr = "Squeak.";
  if (this.likesToSqueak) {
    squeakStr += " Squeak, squeak!";
  }
  return "I’m " + this.name + ". " + squeakStr;
}
```

GuineaPig.java

```java
public class GuineaPig {

  // 1. Instance variables
  private String name;
  private String color;
  private int age;
  private boolean likesToSqueak;

  // 2. Constructor
  public GuineaPig(String name, String color,
                  int age, boolean likesToSqueak) {
    this.name = name;
    this.color = color;
    this.age = age;
    this.likesToSqueak = likesToSqueak;
  }

  // 3. Methods
  public String getName() {      // Getters & setters
    return this.name;
  }

  public int getAge() {
    return this.age;
  }

  public void setAge(int newAge) {
    this.age = newAge;
  }

  public String squeak() {       // behaviors
    String squeakStr = "Squeak.";
    if (this.likesToSqueak) {
      squeakStr += " Squeak, squeak!";
    }
    return "I’m " + this.name + ". " + squeakStr;
  }

  public String toString() {     // to String
    return "Guinea Pig: " + this.name;
  }
}
```

We can now make GuineaPigs!

GuineaPig.java

```
public class GuineaPig {

  private String name;
  ...

  public GuineaPig(String name, String color,
                   int age, boolean likesToSqueak) {
    this.name = name;
    ...
  }

  public String squeak() {
    String squeakStr = " Squeak.";
    if (this.likesToSqueak) {
      squeakStr += " Squeak, squeak!";
    }
    return "I’m " + this.name + ". " + squeakStr;
  }

  public String toString() {
    return "Guinea Pig: " + this.name;
  }
}
```

MyPets.java

```
Public class MyPets extends ConsoleProgram {
  public void run() {

    GuineaPig walnut = new GuineaPig("Walnut", "brown",
                                     3, false);
    GuineaPig chestnut = new GuineaPig("Chestnut", "beige",
                                       2, true);







  }
}
```

console

We can now make GuineaPigs!

GuineaPig.java

```
public class GuineaPig {

  private String name;
  ...

  public GuineaPig(String name, String color,
                   int age, boolean likesToSqueak) {
    this.name = name;
    ...
  }

  public String squeak() {
    String squeakStr = " Squeak.";
    if (this.likesToSqueak) {
      squeakStr += " Squeak, squeak!";
    }
    return "I’m " + this.name + ". " + squeakStr;
  }

  public String toString() {
    return "Guinea Pig: " + this.name;
  }
}
```

MyPets.java

```
Public class MyPets extends ConsoleProgram {
  public void run() {

    GuineaPig walnut = new GuineaPig("Walnut", "brown",
                                      3, false);
    GuineaPig chestnut = new GuineaPig("Chestnut", "beige",
                                        2, true);

    println(walnut);  // toString




  }
}
```

console

```
Guinea Pig: Walnut
```

We can now make GuineaPigs!

GuineaPig.java

```
public class GuineaPig {

  private String name;
  ...

  public GuineaPig(String name, String color,
                   int age, boolean likesToSqueak) {
    this.name = name;
    ...
  }

  public String squeak() {
    String squeakStr = " Squeak.";
    if (this.likesToSqueak) {
      squeakStr += " Squeak, squeak!";
    }
    return "I’m " + this.name + ". " + squeakStr;
  }

  public String toString() {
    return "Guinea Pig: " + this.name;
  }
}
```

MyPets.java

```
Public class MyPets extends ConsoleProgram {
  public void run() {

    GuineaPig walnut = new GuineaPig("Walnut", "brown",
                                      3, false);
    GuineaPig chestnut = new GuineaPig("Chestnut", "beige",
                                        2, true);

    println(walnut);  // toString

    walnut.setAge(walnut.getAge() + 1);
    println(walnut.getName() + "’s age: " + walnut.getAge());


  }
}
```

console

```
Guinea Pig: Walnut
Walnut’s age: 4
```

We can now make GuineaPigs!

GuineaPig.java

```java
public class GuineaPig {

  private String name;
  ...

  public GuineaPig(String name, String color,
                   int age, boolean likesToSqueak) {
    this.name = name;
    ...
  }

  public String squeak() {
    String squeakStr = " Squeak.";
    if (this.likesToSqueak) {
      squeakStr += " Squeak, squeak!";
    }
    return "I’m " + this.name + ". " + squeakStr;
  }

  public String toString() {
    return "Guinea Pig: " + this.name;
  }
}
```

MyPets.java

```java
Public class MyPets extends ConsoleProgram {
  public void run() {

    GuineaPig walnut = new GuineaPig("Walnut", "brown",
                                      3, false);
    GuineaPig chestnut = new GuineaPig("Chestnut", "beige",
                                        2, true);

    println(walnut);  // toString

    walnut.setAge(walnut.getAge() + 1);
    println(walnut.getName() + "’s age: " + walnut.getAge());

    println(chestnut.squeak());
  }
}
```

console

```
Guinea Pig: Walnut
Walnut’s age: 4
I’m Chestnut. Squeak. Squeak, squeak!
```

squeak
squeak