CS 106A, Lecture 28
Final Exam Review 2

Plan for today

- Announcements
- HashMaps
- Classes
- Inheritance
- Interactors
- Closing Remarks

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Announcements

- Colin's OH ending ~10 minutes early today, canceled Wednesday and Thursday
- Exam reminders:
  - Email Annie right away if you need a laptop
  - Charge laptop fully beforehand
- Two practice exams have been posted
- Exam file and final syntax reference will be probably be posted Thursday evening

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Review: HashMaps

- A variable type that represents a collection of **key-value pairs**
- You access values by *key,* and all keys are unique
- Keys and values can be any type of **Object** (use wrapper classes to store primitives)
- Resizable – can add and remove pairs
- Has a variety of methods you can use, including *.containsKey*, *.put*, *.get*, *.keySet*, etc.

HashMap Examples

- **Phone book:** name -> phone number
- **Search engine:** URL -> webpage
- **Dictionary**: word -> definition
- **Bank**: account # -> balance
- **Social Network**: name -> profile
- **Counter**: text -> # occurrences
- And many more…

Review: HashMap Operations

- *m*.put(*key*, *value*); Adds a key/value pair to the map.

```
m.put("Eric", "650-123-4567");
```

  - Replaces any previous value for that key.

- *m*.get(*key*) Returns the value paired with the given key.

```
String phoneNum = m.get("Jenny");  // "867-5309"
```

  - Returns null if the key is not found.

- **m.remove**(*key*); Removes the given key and its paired value.

```
m.remove(“Annie”);
```

  - Has no effect if the key is not in the map.

key	value
"Jenny”	→ "867-5309"
"Mehran"	→ "123-4567"
"Marty"	→ "685-2181"
"Chris”	→ "947-2176"

Review: HashMap Operations

- *m*.containsKey(*key*); Returns true if the key is in the map, false otherwise

- *m*.size(); Returns the number of key/value pairs in the map.

- To iterate over a map:

```
for (KeyType key : map.keySet()) {
    ValueType value = map.get(key);
    // Do something with key and/or value
}
```

What data structure should I use?

- Use an **array** if…
  - Order matters for your information
  - You know how many elements you will store
  - You need the most efficiency
- Use an **ArrayList** if…
  - Order matters for your information
  - You do not know how many elements you will store, or need to resize
  - You need to use ArrayList methods
- Use a **HashMap** if…
  - Order doesn't matter for your information
  - You need to store an *association* between two types of information
  - You do not know how many elements you will store, or need to resize
  - You need to use HashMap methods

Practice: Anagrams

- Write a program to find all **anagrams** of a word the user types.

```
Type a word [Enter to quit]: scared
Anagrams of scared:
cadres cedars sacred scared
```

- Assume you are given the following:
  - A **`dictionary.txt`** file containing words in the dictionary
  - A method **`private String sortLetters(String s)`** method that takes a string and returns the string with its characters alphabetically ordered.

- How can a HashMap help us solve this problem?

Key Idea: Anagrams

- Every word has a *sorted form* where its letters are arranged into alphabetical order.

  `"fare"` → `"aefr"`

  `"fear"` → `"aefr"`

  `"swell"` → `"ellsw"`

  `"wells"` → `"ellsw"`

- Notice that anagrams have the same **sorted form** as each other.

Anagrams Solution

```
public void run() {
        HashMap<String, ArrayList<String>> anagrams =
                createAnagramsMap();
        // prompt user for words and look up anagrams in map
        String word = readLine("Type a word [Enter to quit]: ");
        while (word.length() > 0) {
            String sorted = sortLetters(word.toLowerCase());
            if (anagrams.containsKey(sorted)) {
                println("Anagrams of " + word + ":");
                println(anagrams.get(sorted));
            } else {
                println("No anagrams for " + word + ".");
            }
            word = readLine("Type a word [Enter to quit]: ");
        }
}
```

Anagrams Solution

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                createAnagramsMap();
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            if (anagrams.containsKey(sorted)) {
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                println(anagrams.get(sorted));
            } else {
                println("No anagrams for " + word + ".");
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                println(anagrams.get(sorted));
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Anagrams Solution

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                println(anagrams.get(sorted));
            } else {
                println("No anagrams for " + word + ".");
            }
            word = readLine("Type a word [Enter to quit]: ");
        }
}
```

Anagrams Solution

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        while (word.length() > 0) {
            String sorted = sortLetters(word.toLowerCase());
            if (anagrams.containsKey(sorted)) {
                println("Anagrams of " + word + ":");
                println(anagrams.get(sorted));
            } else {
                println("No anagrams for " + word + ".");
            }
            word = readLine("Type a word [Enter to quit]: ");
        }
}
```

Anagrams Solution, Part 2

```
// Returns a new map from a sorted word to all words created
// from those letters - e.g. “acers” -> {“scare”, “cares”,...}
private HashMap<String, ArrayList<String>> createAnagramsMap() {
        HashMap<String, ArrayList<String>> anagrams =
                new HashMap<>();
        try {
                Scanner scanner =
                        new Scanner(new File("res/dictionary.txt"));
                while (scanner.hasNext()) {
                        String word = scanner.next();
                        String sorted = sortLetters(word);
                        ...
```

Anagrams Solution, Part 2

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                while (scanner.hasNext()) {
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                while (scanner.hasNext()) {
                        String word = scanner.next();
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                        ...
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Anagrams Solution, Part 2

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        HashMap<String, ArrayList<String>> anagrams =
                new HashMap<>();
        try {
                Scanner scanner =
                        new Scanner(new File("res/dictionary.txt"));
                while (scanner.hasNext()) {
                        String word = scanner.next();
                        String sorted = sortLetters(word);
                        ...
```

Anagrams Solution, Part 2

```
                ArrayList<String> words;
                if (anagrams.containsKey(sorted)) {
                        words = anagrams.get(sorted);
                } else {
                        words = new ArrayList<>();
                }

                words.add(word);
                anagrams.put(sorted, words);
        }
        scanner.close();
} catch (IOException ex) {
        println("Error reading file.");
}
return anagrams;
}
```

Anagrams Solution, Part 2

```
                ArrayList<String> words;
                if (anagrams.containsKey(sorted)) {
                        words = anagrams.get(sorted);
                } else {
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What Is A Class?

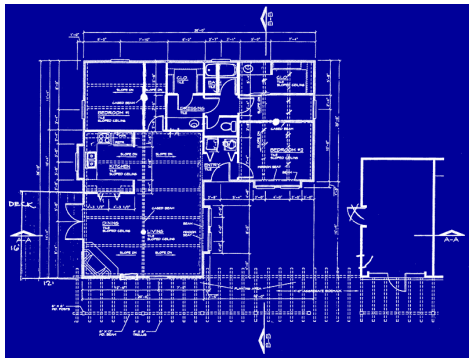
A class defines a new variable type.

Classes Are Like Blueprints

iPod blueprint (class)

state:
- current song
- volume
- battery life

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



constructs

iPod (variable) #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 (variable) #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 (variable) #3

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

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

Creating A New Class

1. **What information is inside this new variable type?**
   - These are its instance variables.
2. **How do you create a variable of this type?**
   - This is the constructor.
3. **What can this new variable type do?**
   - These are its public methods.

Using Constructors

```
BankAccount ba1 =
    new BankAccount("Marty", 1.25);
```

ba1

```
name    = "Marty"
balance = 1.25

BankAccount(nm, bal) {
    name = nm;
    balance = bal;
}
```

```
BankAccount ba2 =
    new BankAccount("Mehran", 900000.00);
```

ba2

```
name    = "Mehran"
balance = 900000.00

BankAccount(nm, bal) {
    name = nm;
    balance = bal;
}
```

- When you call a constructor (with **new**):
  - Java creates a new object of that class.
  - The constructor runs on that new object.
  - The newly created object is returned wherever constructor was called.

Example: BankAccount

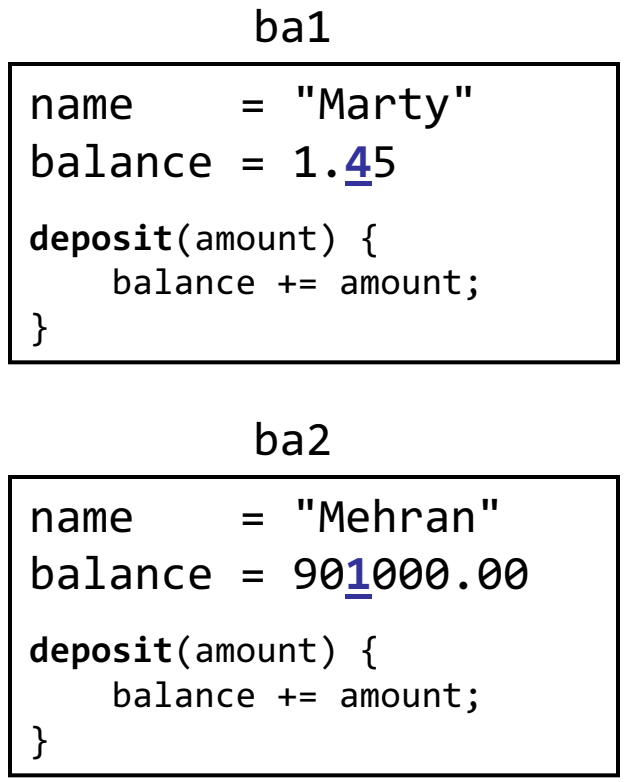
```
public class BankAccount {
  // Step 1: the data inside a BankAccount
  private String name;
  private double balance;

  // Step 2: how to create a BankAccount
  public BankAccount(String accountName, double startBalance) {
       name = accountName;
       balance = startBalance;
  }

  public BankAccount(String accountName) {
       name = accountName;
       balance = 0;
  }
}
```

Defining Methods In Classes

Methods defined in classes can be called **on an instance of that class**.

When one of these methods executes, it can reference **that object's copy** of instance variables.

```
ba1.deposit(0.20);
ba2.deposit(1000.00);
```



This means calling one of these methods on different objects will give *different results, reached via the same process*.

Example: BankAccount

```
public class BankAccount {
	// Step 1: the data inside a BankAccount
	private String name;
	private double balance;
	// Step 2: how to create a BankAccount (omitted)
	// Step 3: the things a BankAccount can do
	public void deposit(double amount) {
		balance += amount;
	}
	public boolean withdraw(double amount) {
		if (balance >= amount) {
			balance -= amount;
			return true;
		}
		return false;
	}
}
```

Practice: Airplane!

Let's write a class called **Airplane** that implements functionality for boarding/unboarding passengers from a plane.

```
Airplane plane = new Airplane(100);
while (!plane.isFull()) {
	String passengerName = readLine("Name: ");
	boolean priority = readBoolean("Priority? ");
	plane.boardPassenger(passengerName, priority);
}
// fly...
while (!plane.isEmpty()) {
	String passengerName = plane.unboardPassenger();
	println("Unboarded " + passengerName);
}
```

Practice: Airplane!

Let's write a class called **Airplane** that implements functionality for boarding/unboarding passengers from a plane.

It should implement the following methods:

```
// Constructor should take 1 parameter (plane capacity)

/** Boards 1 passenger, at front or back **/
public void boardPassenger(String name, boolean priority);

public boolean isFull();
public boolean isEmpty();

/** Unboards and returns next passenger **/
public String unboardPassenger();
```

Creating A New Class

1. **What information is inside this new variable type?**
   - These are its instance variables.
2. **How do you create a variable of this type?**
   - This is the constructor.
3. **What can this new variable type do?**
   - These are its public methods.

Practice: Airplane!

```
public class Airplane {
    private ArrayList<String> passengers;
    private int capacity;

    ...
```

Creating A New Class

1. What information is inside this new variable type?
   - These are its instance variables.
2. **How do you create a variable of this type?**
   - This is the constructor.
3. What can this new variable type do?
   - These are its public methods.

Practice: Airplane!

```
// Private instance variables
private ArrayList<String> passengers;
private int capacity;

public Airplane(int numSeats) {
      capacity = numSeats;
      passengers = new ArrayList<>();
}
...
```

Creating A New Class

1. What information is inside this new variable type?
   - These are its instance variables.
2. How do you create a variable of this type?
   - This is the constructor.
3. **What can this new variable type do?**
   - These are its public methods.

boardPassenger

```
...
public void boardPassenger(String name, boolean priority) {
        if (!isFull()) {
                if (priority) {
                        passengers.add(0, name);
                } else {
                        passengers.add(name);
                }
        }
}
...
```

isFull

```
...
public boolean isFull() {
      return capacity == passengers.size();
}
...
```

isEmpty

```
...
public boolean isEmpty() {
      return passengers.isEmpty();
}
...
```

unboardPassenger

```
...
public String unboardPassenger() {
      if (!isEmpty()) {
            return passengers.remove(0);
      }
      return null;
}
...
```

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Review: Inheritance

Inheritance lets us relate our variable types to one another.

Using Inheritance

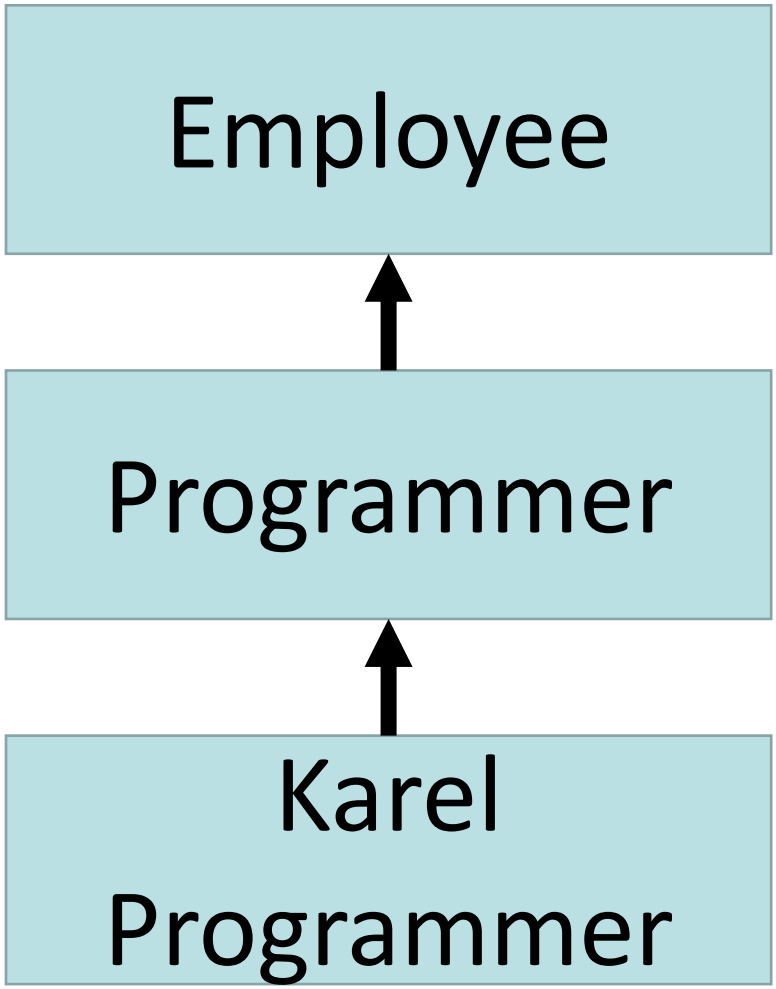
```
public class Name extends Superclass {
```

– Example:

```
public class Programmer extends Employee {
    ...
}
```

- By extending Employee, this tells Java that `Programmer` can do **everything an Employee can do, plus more**.
- Programmer automatically inherits all of the code from Employee!
- The **superclass** is Employee, the **subclass** is Programmer.

Inheritance



Variable types can seem to "inherit" from one other. We don't want to have to duplicate code for each one!

Extending GCanvas

- Sometimes, we want to be able to have all of our graphics-related code in a separate file.
- To do this, instead of using the provided **GraphicsProgram** canvas, we **define our own subclass of GCanvas,** have our program **extend Program**, and add our own canvas ourselves.
- Then, all graphics-related code can go in our **GCanvas** subclass.

Example: Programmer

```
public class Programmer extends Employee {
      private int timeCoding;
      ...
      public void code() {
            timeCoding += 10;
      }
}

...

Programmer annie = new Programmer("Annie");
annie.code();           // from Programmer
annie.promote();        // from Employee!
```

Example: KarelProgrammer

```
public class KarelProgrammer extends Programmer {
      private int numBeepersPicked;
      ...
      public void pickBeepers() {
            numBeepersPicked += 2;
      }
}

...
KarelProgrammer colin = new KarelProgrammer("Colin");
colin.pickBeepers();          // from KarelProgrammer
colin.code();                 // from Programmer!
colin.promote();              // From Employee!
```

Extending GCanvas

```
public class MyCanvas extends GCanvas {
      public void addCenteredSquare(int size) {
            GRect rect = new GRect(size, size);
            int x = getWidth() / 2.0 –
                  rect.getWidth() / 2.0;
            int y = getHeight() / 2.0 –
                  rect.getHeight() / 2.0;
            add(rect, x, y);
      }
}
```

Extending GCanvas

```
public class Graphics extends Program {
	public void run() {
		// We have to make our own GCanvas now
		MyCanvas canvas = new MyCanvas();
		add(canvas);

		canvas.addCenteredSquare(20);
	}
}
```

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Review: Interactors

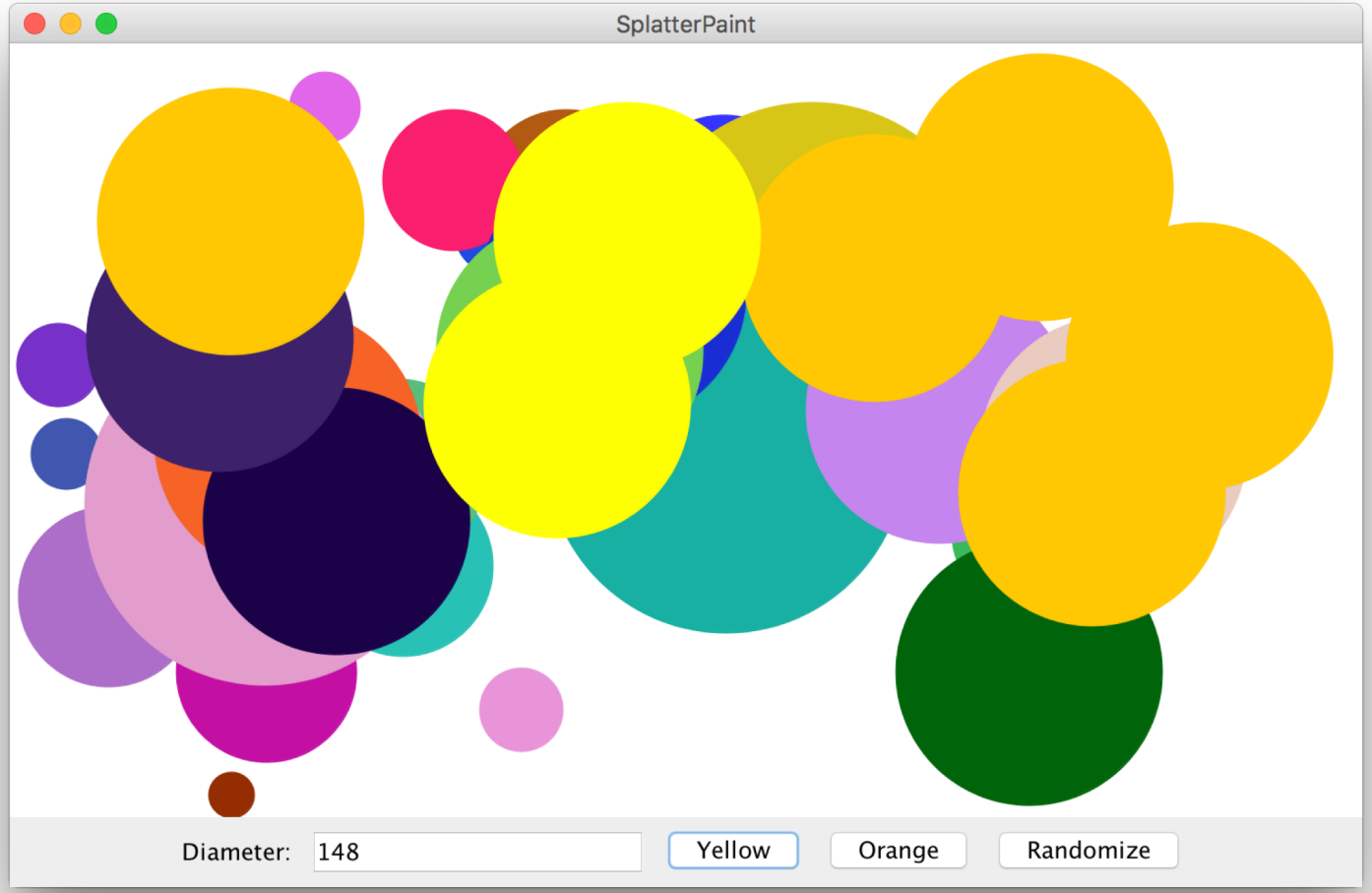
1. Add interactors in **`init()`**
2. **`addActionListeners()`** to listen for button presses
3. **`.addActionListener(this)`** on text fields for ENTER
   - Plus (usually) **`setActionCommand(command)`**
4. Implement **`actionPerformed`**
5. Java will call **`actionPerformed`** whenever an action event occurs.

Interactors

```
public void actionPerformed(ActionEvent e) {
        if (e.getActionCommand().equals("My Interactor")) {
                ...
        }
}

// ... equivalent to ...
public void actionPerformed(ActionEvent e) {
        if (e.getSource() == myInteractor) {
                ...
        }
}
```

Practice: SplatterPaint



Practice: SplatterPaint

- Add a new “splatter” (GOval) every time the user clicks on the “Yellow” or “Orange” buttons.
- If the user presses “ENTER” in the text field, add a yellow splatter.
- The splatter’s diameter should be what is entered in the text box (assume it’s valid), and placed randomly **entirely onscreen.**
- If the user clicks “Randomize”, **all onscreen splatters** should be changed to different random colors.

How would we implement this? How should we design our custom GCanvas class?

Solution: SplatterPaint

- Have a **`SplatterPaint`** class that **`extends Program`**, to which we add our custom GCanvas.
- Have a **`SplatterPaintCanvas`** class that **`extends GCanvas`**, which contains all graphics logic. It could have public methods such as:
  - **`public void addSplatter(int diameter, Color color)`** Adds a splatter with the given diameter and color randomly onscreen
  - **`public void randomizeColors()`** Randomizes the colors of all onscreen splatters.

SplatterPaint.java

```
public class SplatterPaint extends Program {
	// The width of the diameter text field (in chars)
	private static final int DIAMETER_FIELD_WIDTH = 15;

	// The field for entering the splatter diameter
	private JTextField diameterField;

	// The custom canvas that displays all splatters
	private SplatterPaintCanvas canvas;


...

}
```

SplatterPaint.java

```
public void init() {
        canvas = new SplatterPaintCanvas();
        add(canvas);
        // Add the text field
        add(new JLabel("Diameter: "), SOUTH);
        diameterField = new JTextField(DIAMETER_FIELD_WIDTH);
        diameterField.setActionCommand("Yellow");
        diameterField.addActionListener(this);
        add(diameterField, SOUTH);
        // Add the buttons
        add(new JButton("Yellow"), SOUTH);
        add(new JButton("Orange"), SOUTH);
        add(new JButton("Randomize"), SOUTH);
        addActionListeners();
}
```

SplatterPaint.java

```
public void actionPerformed(ActionEvent e) {
        if (e.getActionCommand().equals("Yellow")) {
                // Add a yellow circle
                int diameter =
                        Integer.parseInt(diameterField.getText());
                canvas.addSplatter(diameter, Color.yellow);
        } else if (e.getActionCommand().equals("Orange")) {
                // Add an orange circle
                int diameter =
                        Integer.parseInt(diameterField.getText());
                canvas.addSplatter(diameter, Color.orange);
        } else if (e.getActionCommand().equals("Randomize")) {
                // Randomize all existing splatters
                canvas.randomizeColors();
        }
}
```

SplatterPaintCanvas.java

```
public class SplatterPaintCanvas extends GCanvas {
	ArrayList<GOval> splatters;

	public SplatterPaintCanvas() {
		splatters = new ArrayList<>();
	}



...



}
```

SplatterPaintCanvas.java

```
public void addSplatter(int diameter, Color color) {
	int x = RandomGenerator.getInstance()
		.nextInt(0, getWidth() - diameter);
	int y = RandomGenerator.getInstance()
		.nextInt(0, getHeight() - diameter);

	GOval splatter = new GOval(x, y, diameter, diameter);
	splatter.setFilled(true);
	splatter.setColor(color);
	add(splatter);
	splatters.add(splatter);
}
```

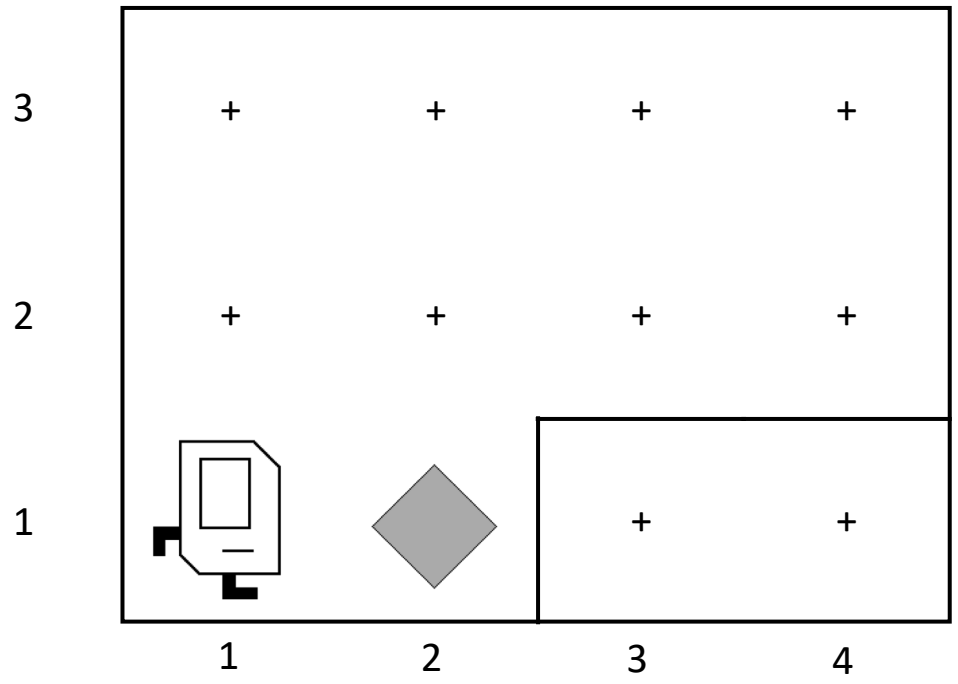
SplatterPaintCanvas.java

```
public void randomizeColors() {
	for (GOval splatter : splatters) {
		Color newColor =
			RandomGenerator.getInstance().nextColor();
		splatter.setColor(newColor);
	}
}
```

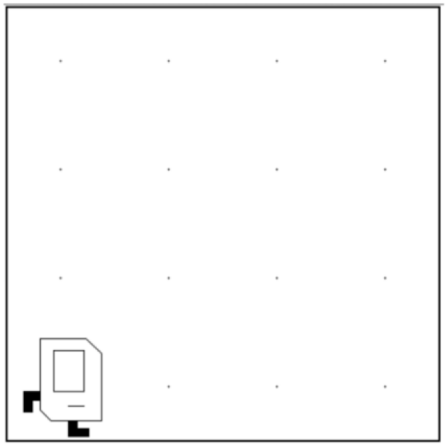
Plan for today

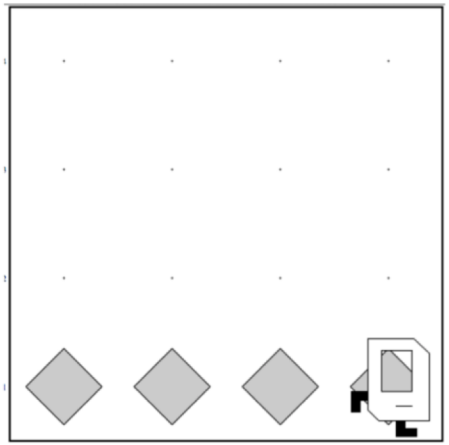
- Announcements
- HashMaps
- Classes
- Inheritance
- Interactors
- Closing Remarks

First Day



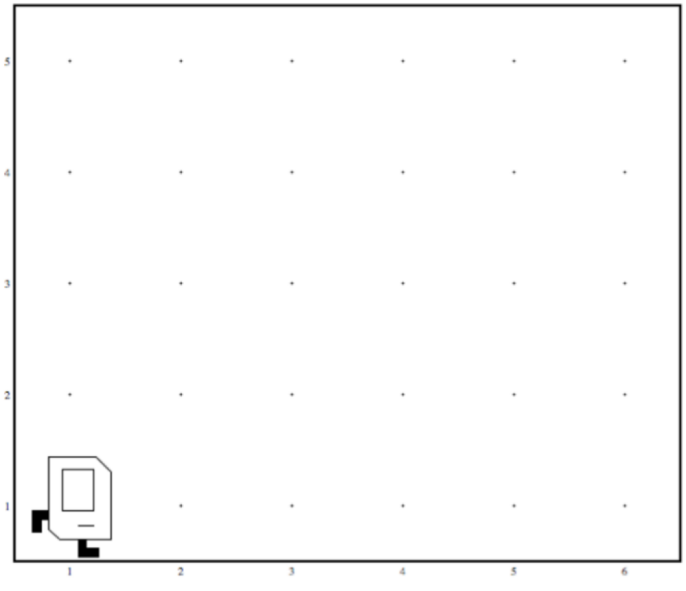
Generalization

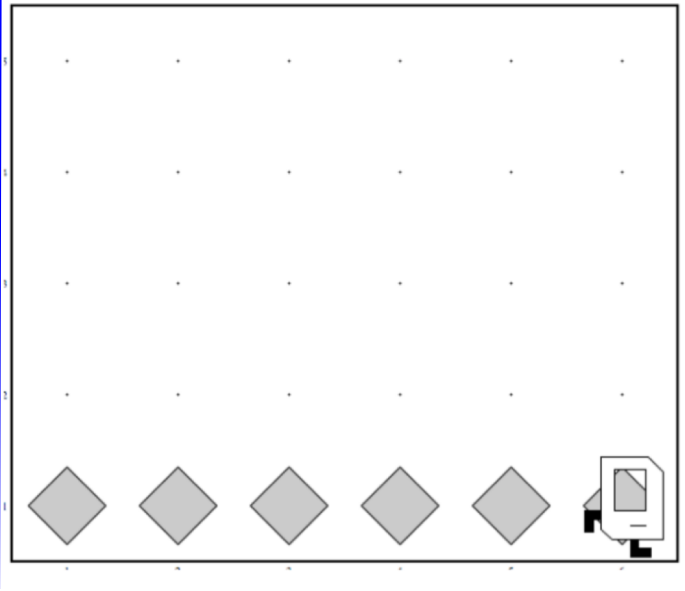




Before

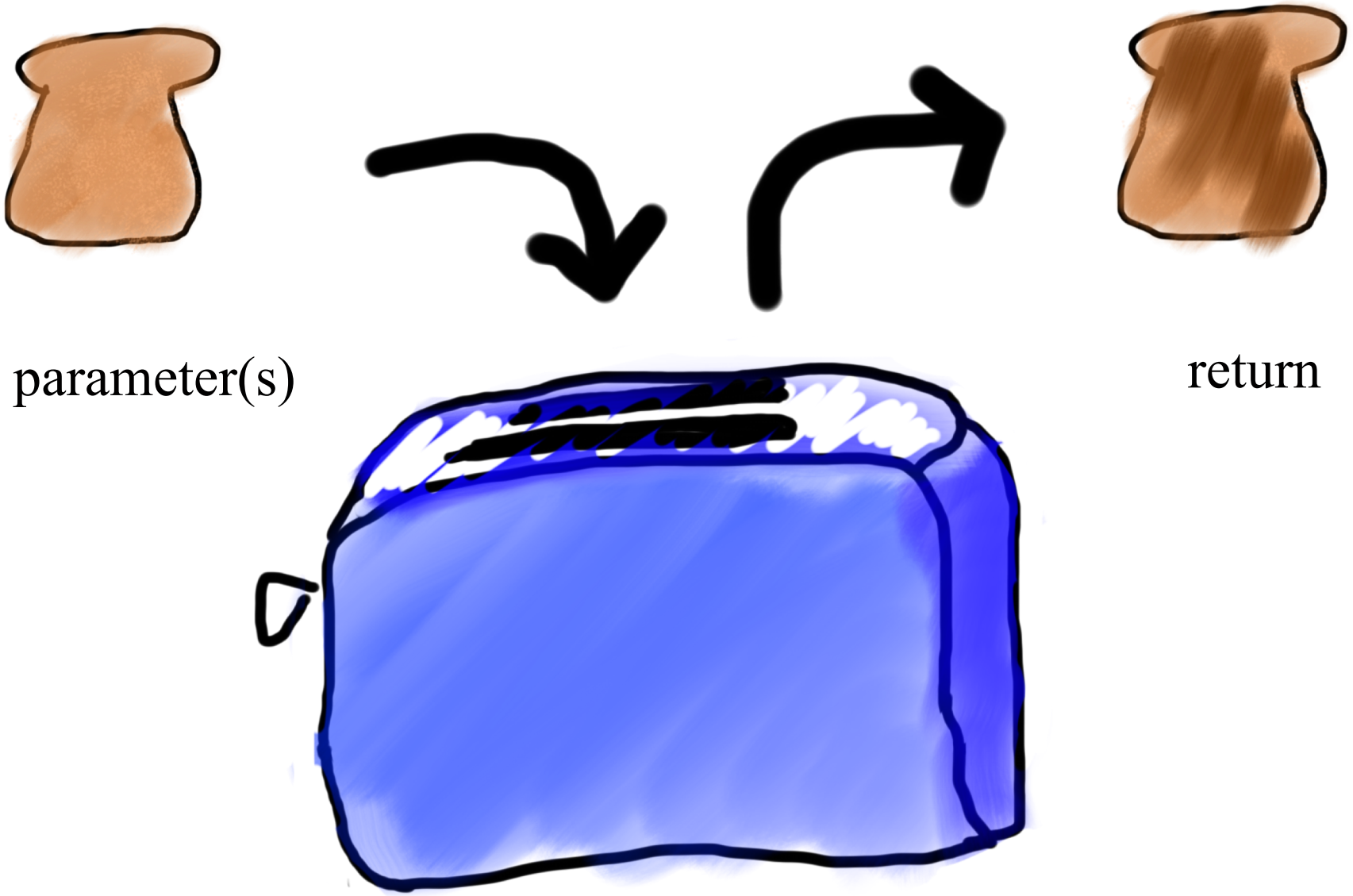
After



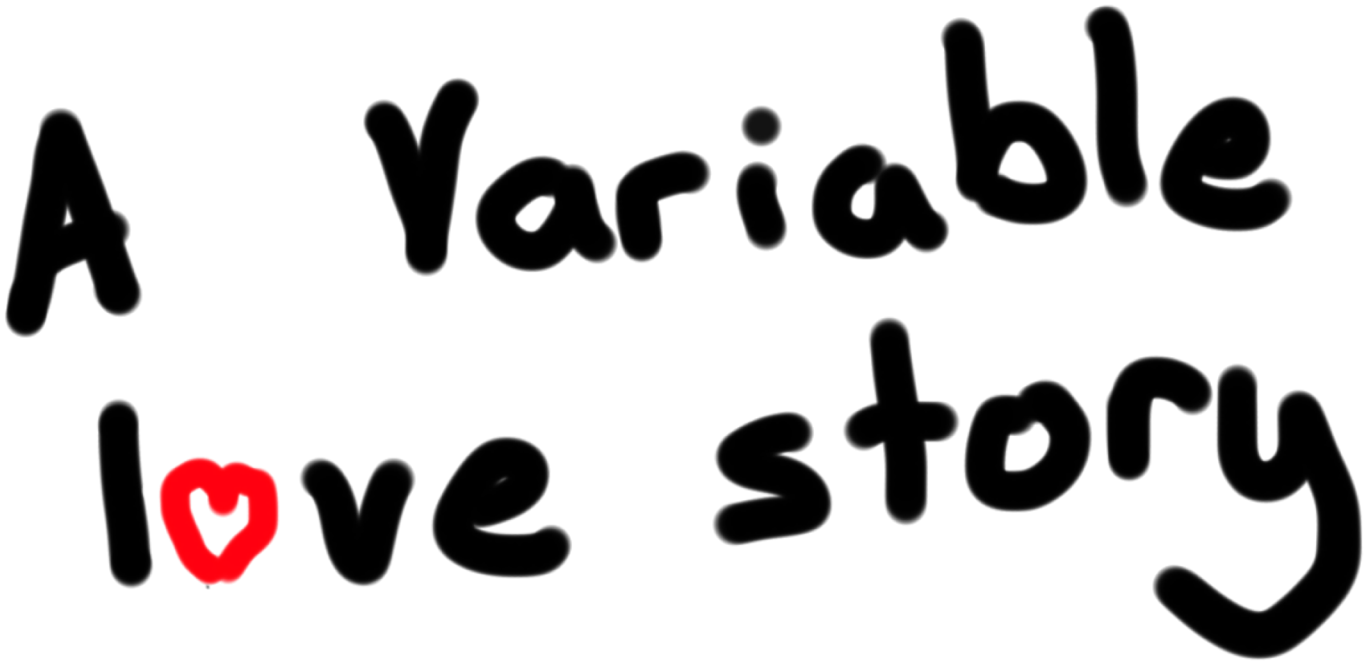


Variables Are Like Boxes!

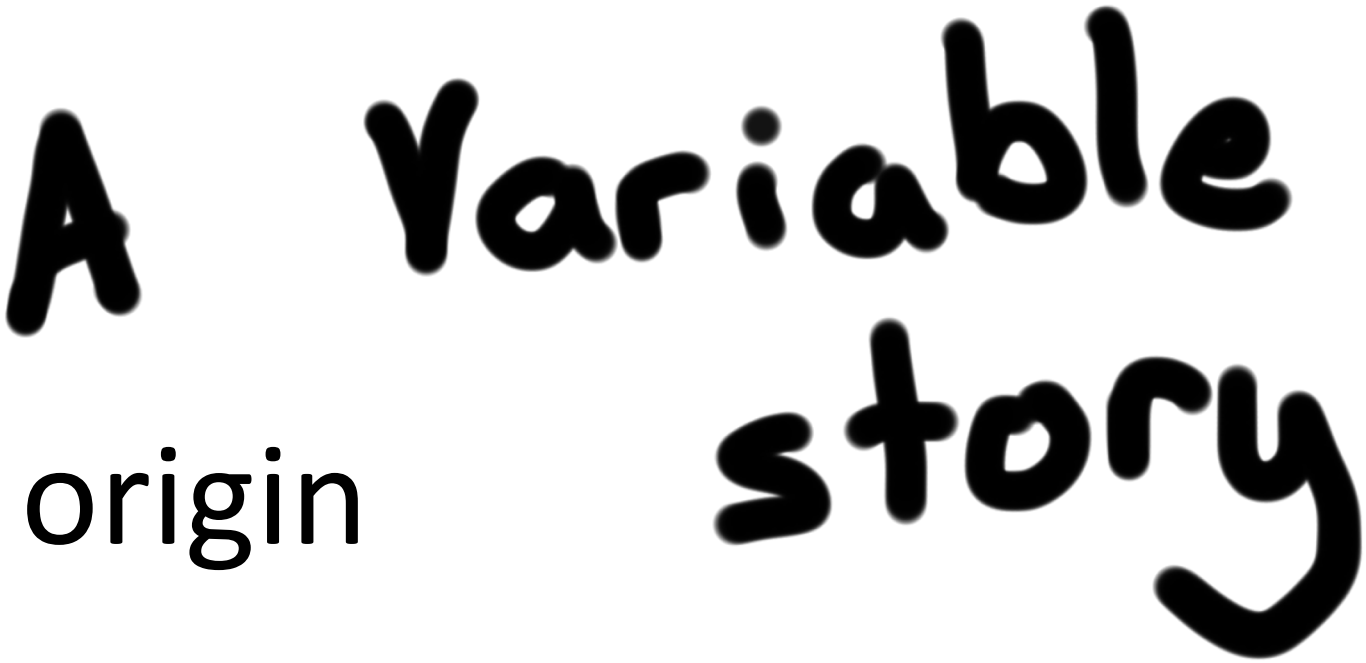
Methods Are Like Toasters!



A Variable Love Story



A Variable Love Story



origin

Matrices

Graphics, Animation, Classes!

Anyone can be a computer scientist.

Anyone can use computer science without being a computer scientist.

Computer science is using computing to solve problems.

Anyone is **welcome** to study computer science.

We hope 106A excited you to use the CS you know and to learn more!