CS 106A, Lecture 28
Final Exam Review 2

Plan for today

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

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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*, 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("Rishi");
```

  - 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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public void run() {
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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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            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);
                        ...
```

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                        ...
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        try {
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                        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);
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What Is A Class?

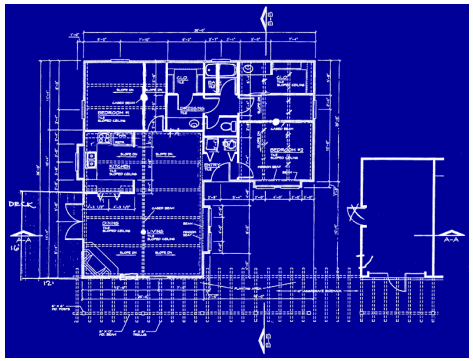
A class defines a new variable type.

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

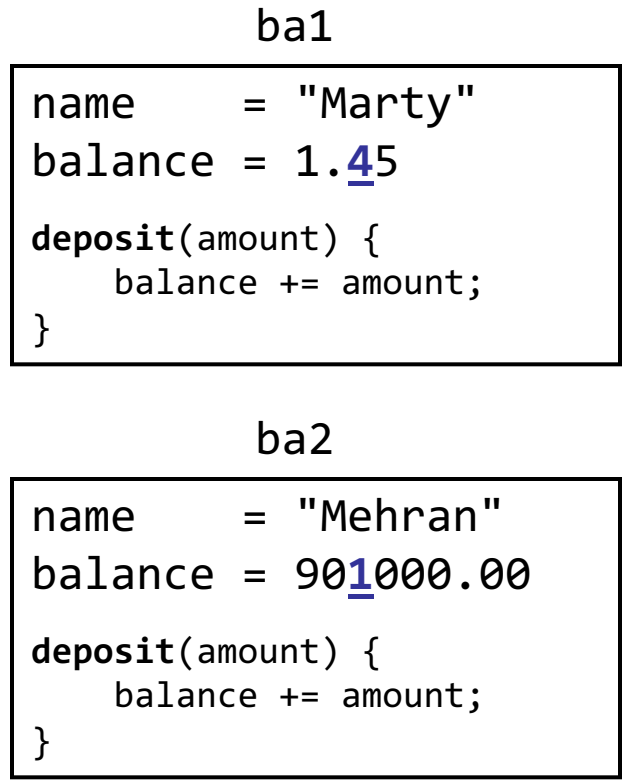
1. **What information is inside this new variable type?** These are its instance variables.
2. **What can this new variable type do?** These are its public methods.
3. **How do you create a variable of this type?** This is the constructor.

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 has *different effects.*

Constructors

```
BankAccount ba1 = new BankAccount();

BankAccount ba2 = new BankAccount("Nick", 50);
```

The constructor is executed when a new object is created.

Example: BankAccount

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

  // Step 2: the things a BankAccount can do (omitted)
  // Step 3: how to create a BankAccount
  public BankAccount(String accountName, double startBalance) {
       name = accountName;
       balance = startBalance;
  }

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

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 to your program.

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

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

Practice: Airplane!

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

    ...
```

Creating A New Class

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

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;
}
...
```

Creating A New Class

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

Practice: Airplane!

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

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

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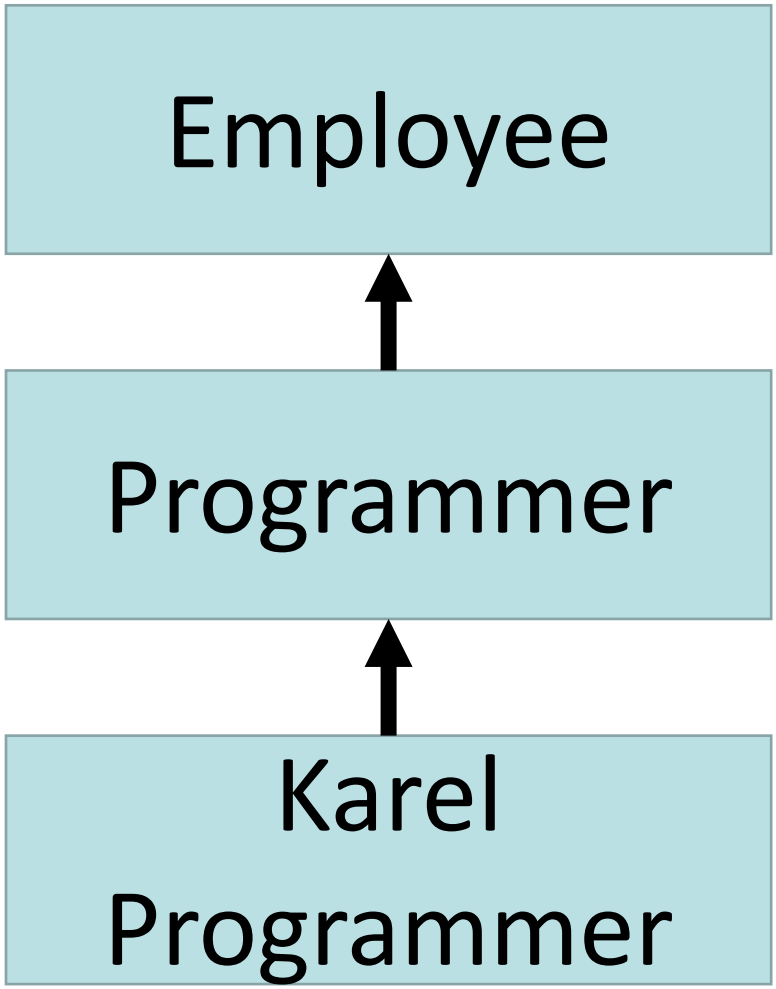
Review: Inheritance

Inheritance lets us relate our variable types to one another.

Inheritance



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

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.

Example: Programmer

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

...

Programmer rishi = new Programmer("Rishi");
rishi.code();           // from Programmer
rishi.promote();        // from Employee!
```

Example: KarelProgrammer

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

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

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.

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

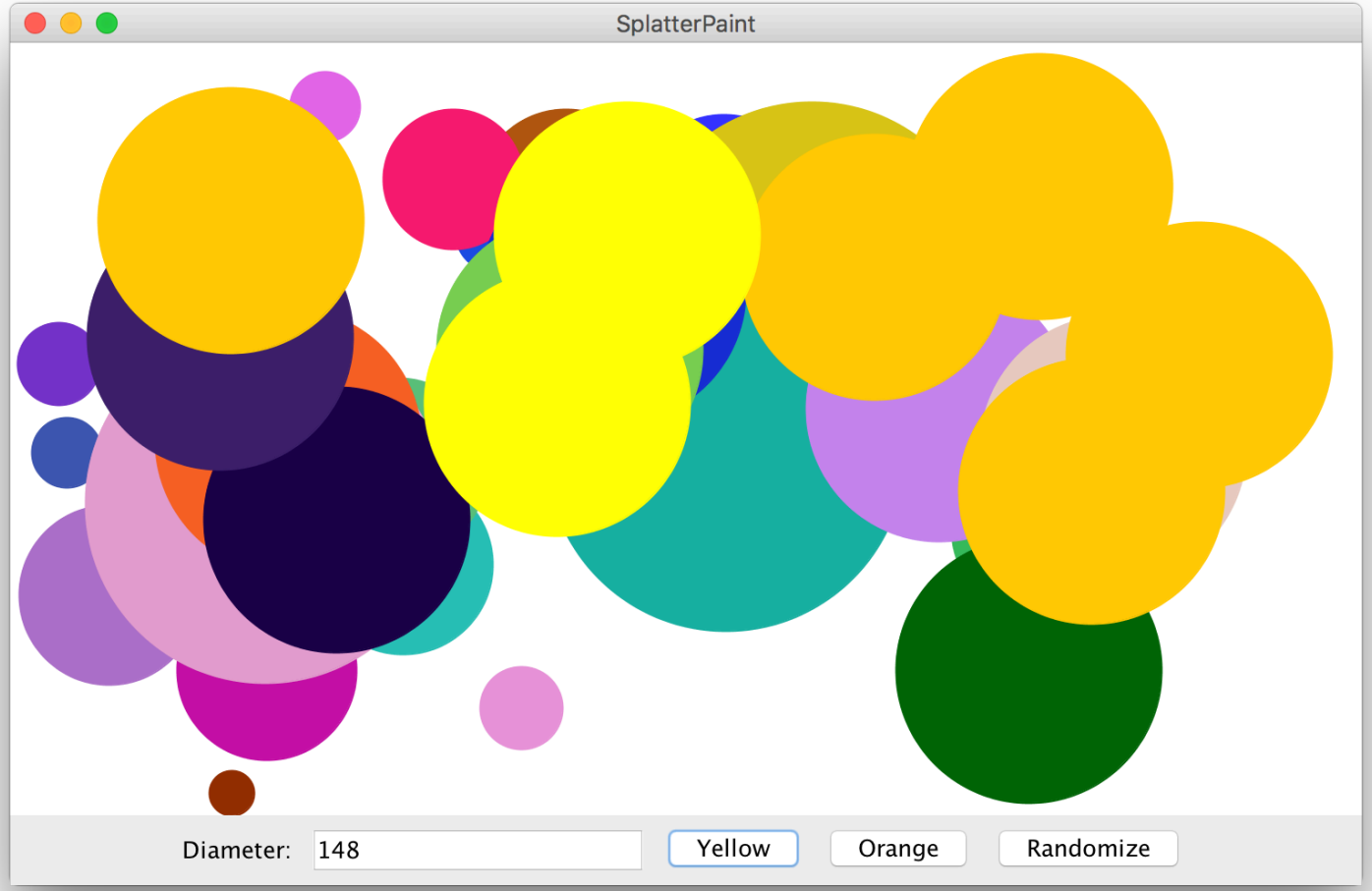
1. Add interactors in **`init()`**
2. **`addActionListeners()`** to listen for button presses
3. **`.addActionListener(this)`** on text fields for ENTER
    1. Plus (usually) **`setActionCommand(command)`**
4. Implement **`actionPerformed`**
5. Java will call **`actionPerformed`** whenever an action 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” (e.g. GOval) every time the user clicks on the “Yellow” or “Orange” buttons.
- If the user hits “ENTER” instead, 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 randomColors()`** 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.randomColors();
        }
}
```

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

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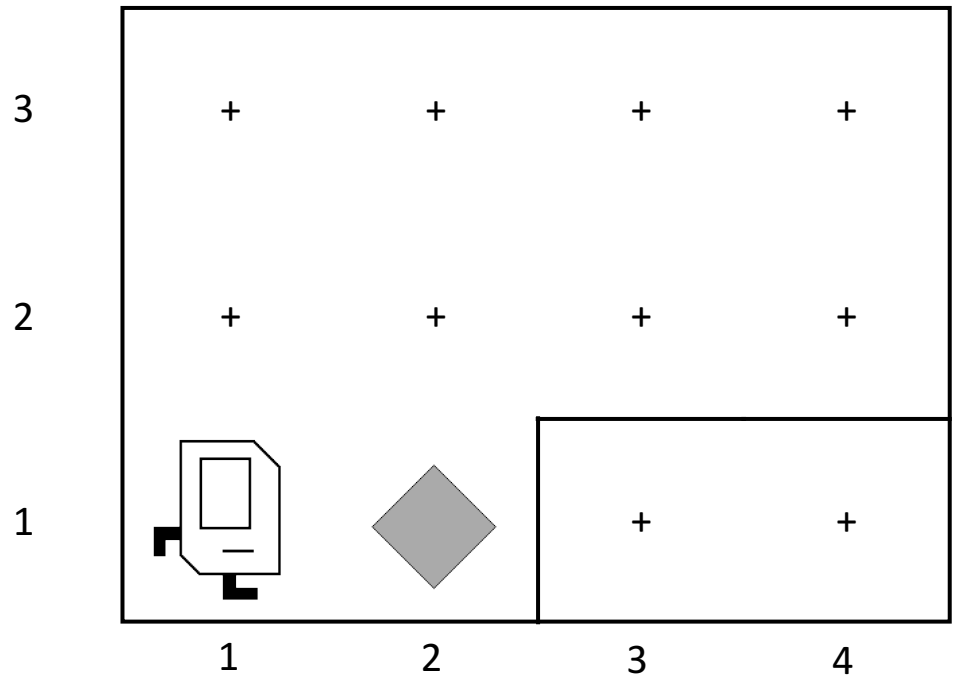
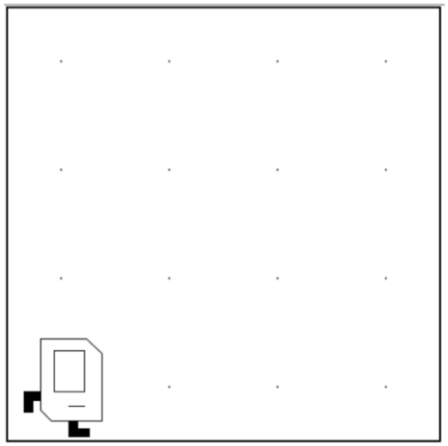
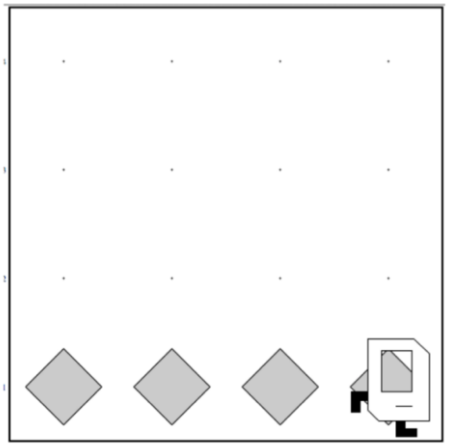
First Day



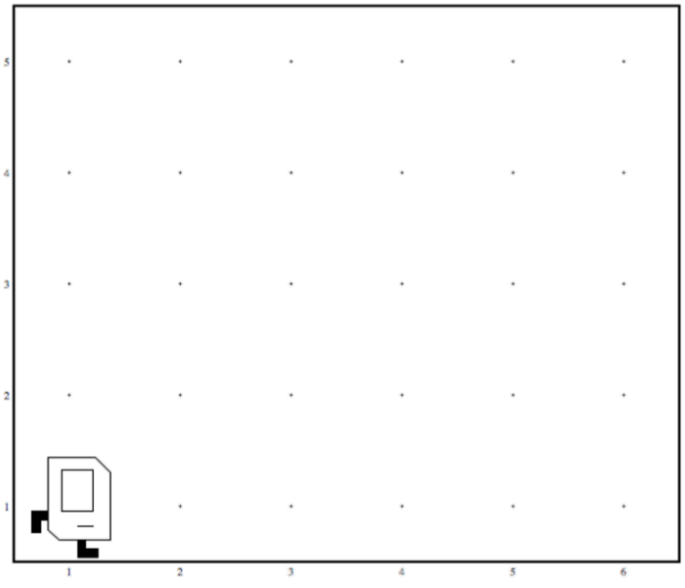
Generalization

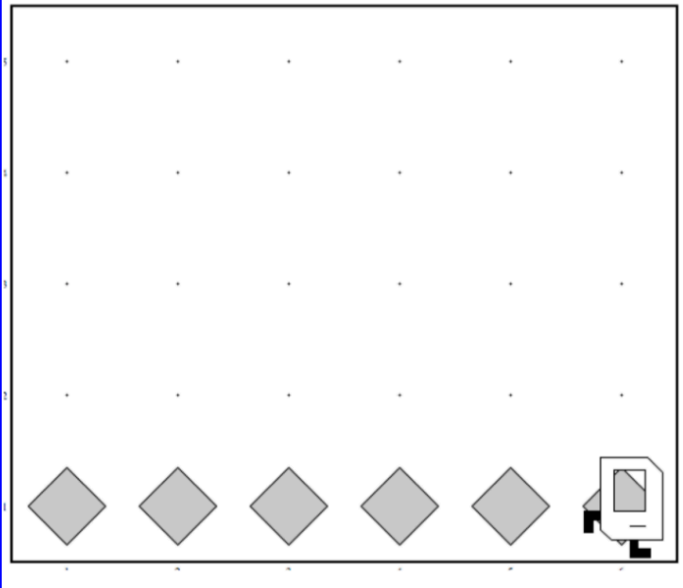




Before

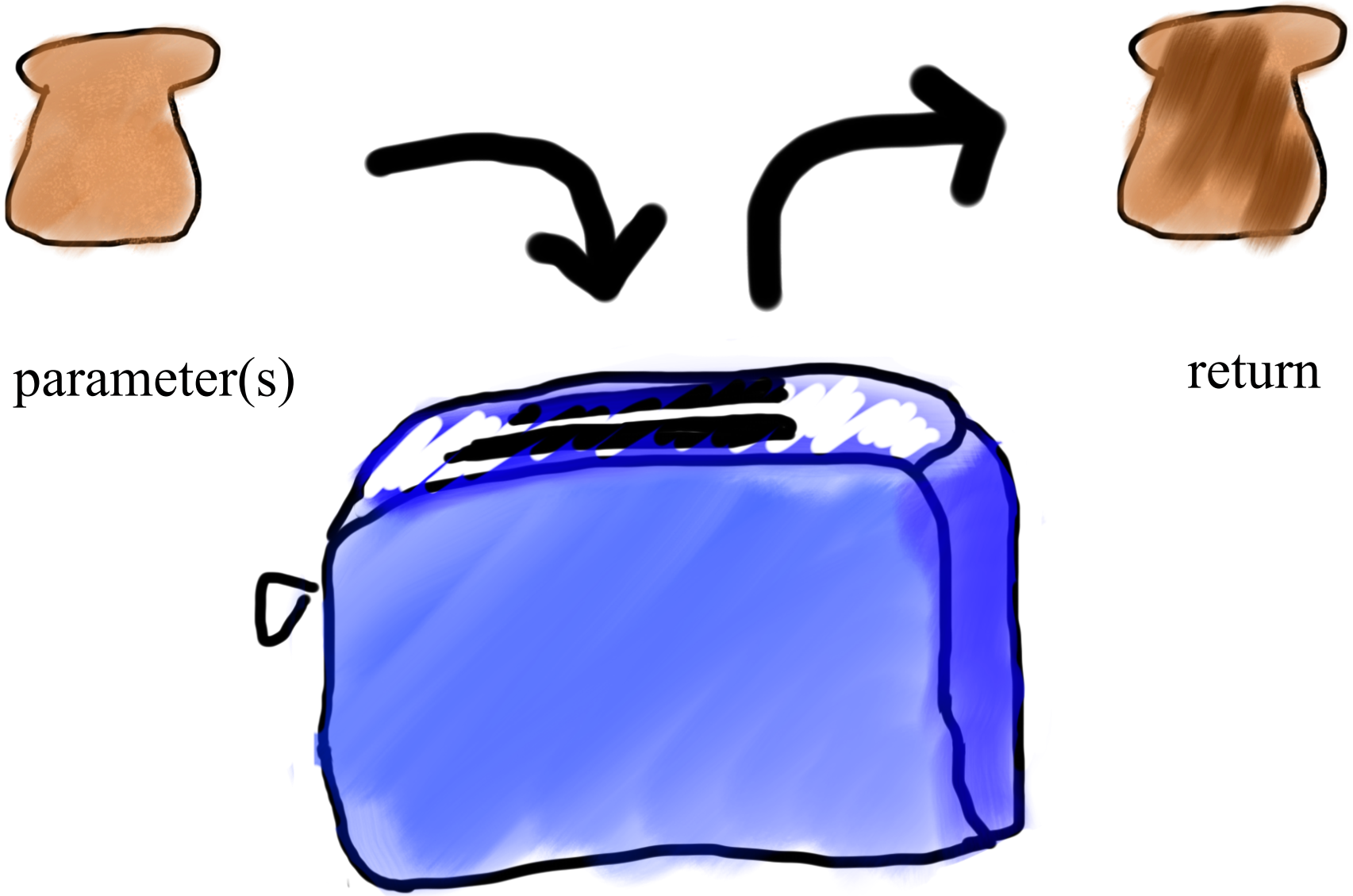
After



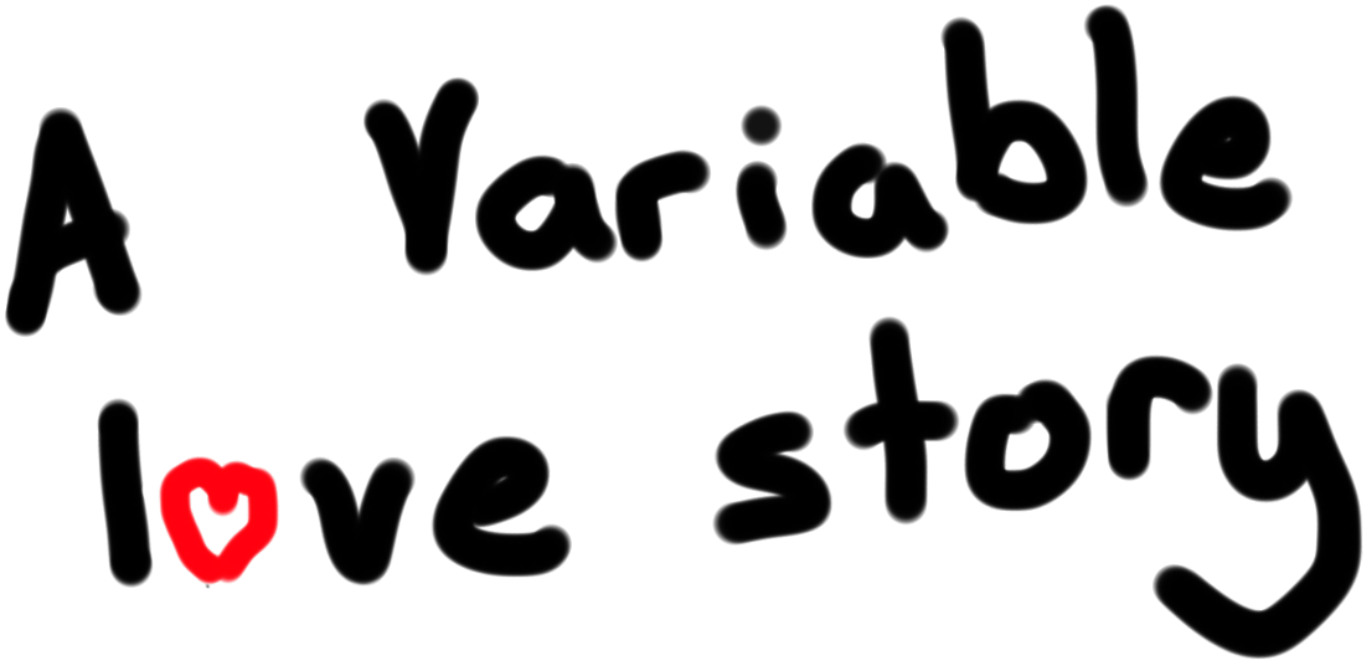


Variables Are Like Boxes!

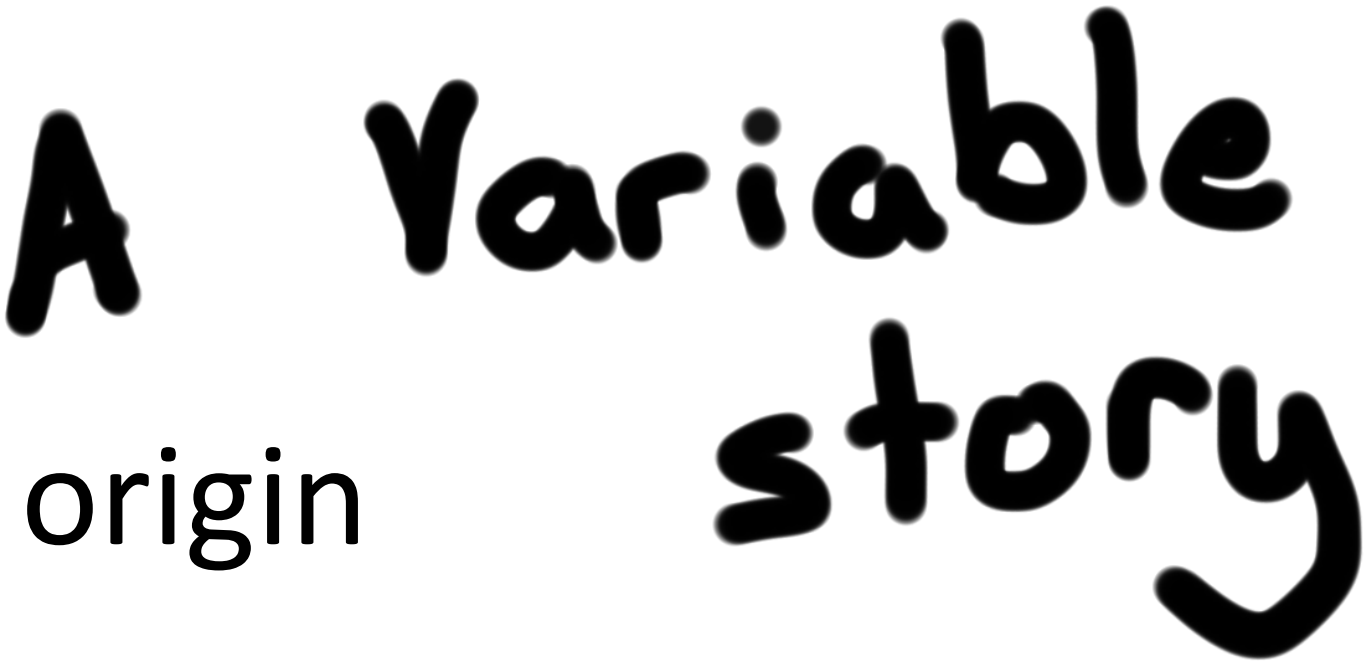
Methods Are Like Toasters!



A Variable Love Story



A Variable Love Story



origin

Matrices

Anyone can be a computer scientist.

Computer science is **using computing to solve problems.**

Anyone **is**
welcome to be a
computer scientist.

We hope 106A **excited you** about learning more computer science!