Methods

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This is Method Man. He is part of the Wu Tang Clan. ☺

Civilization advances by extending the number of operations we can perform without thinking about them.

-Alfred North Whitehead

Learn How To:

1. Write a method that takes in input
2. Write a method that gives back output
3. Trace method calls using stacks

Calling Methods

```
turnRight();

move();          readInt("Int please! ");

println("hello world");

                 rect.setFilled(true);

drawRobotFace();

                 add(rect);

preventGlobalWarming();
```


Defining a Method

```
private void turnRight() {
    turnLeft();
    turnLeft();
    turnLeft();
}
```

Big difference with Java methods:
Java methods can **take in data**, and can **return data**!

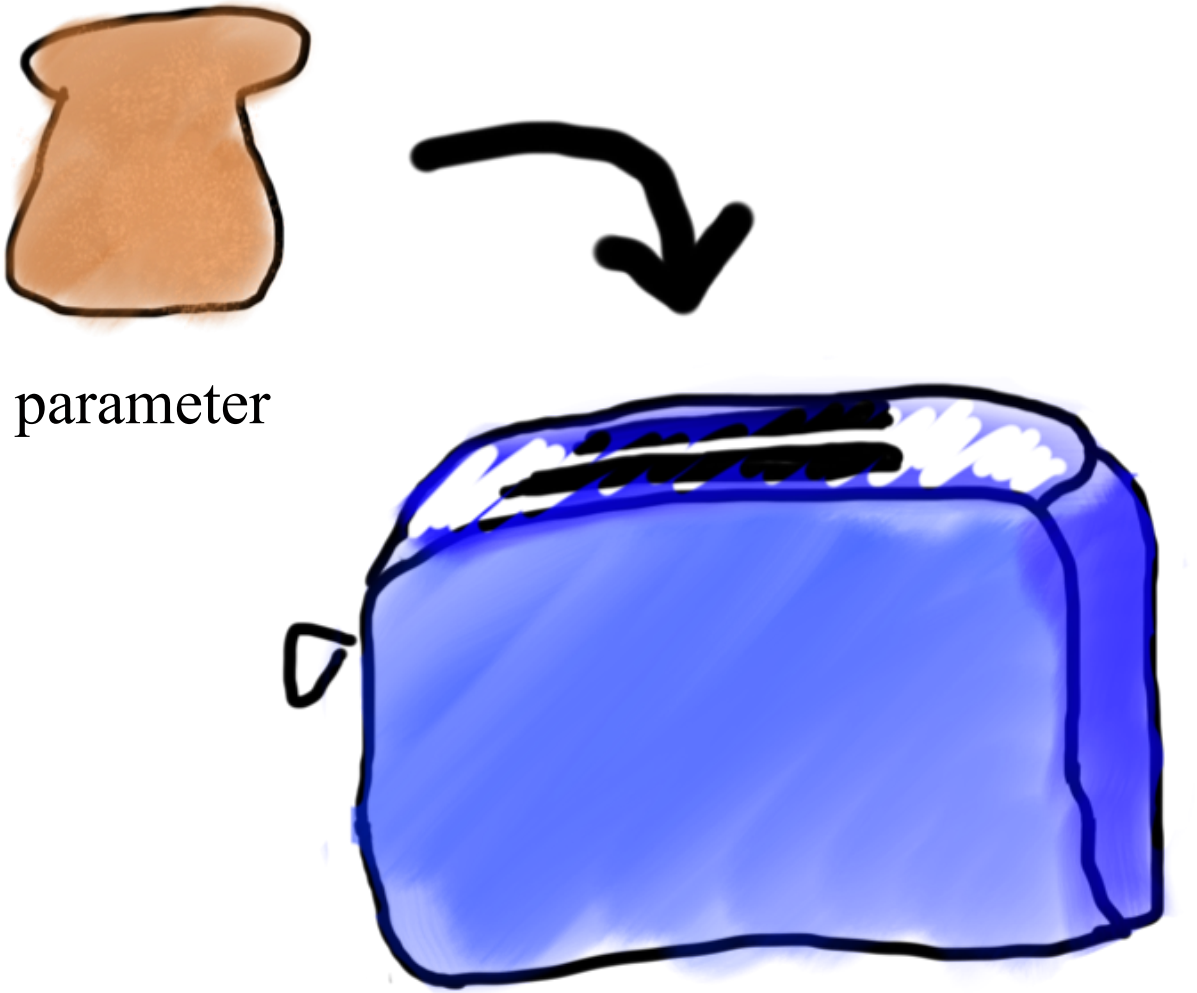
Toasters are Methods

- Thanks Mehran

Toasters are Methods

parameter

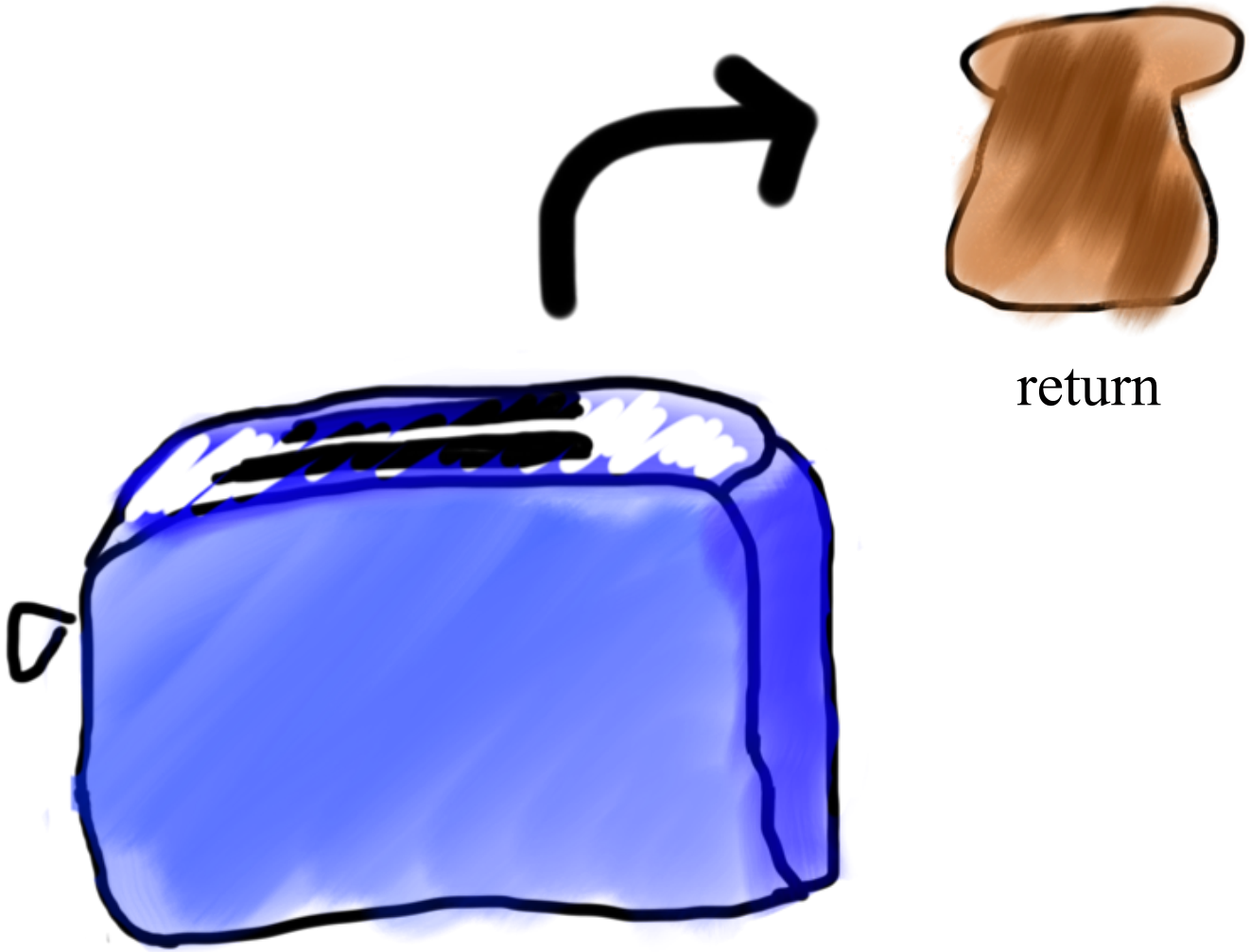
Toasters are Methods



Toasters are Methods

Toasters are Methods

Toasters are Methods



Toasters are Methods

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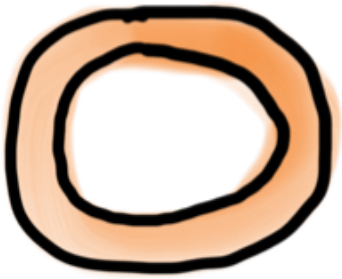
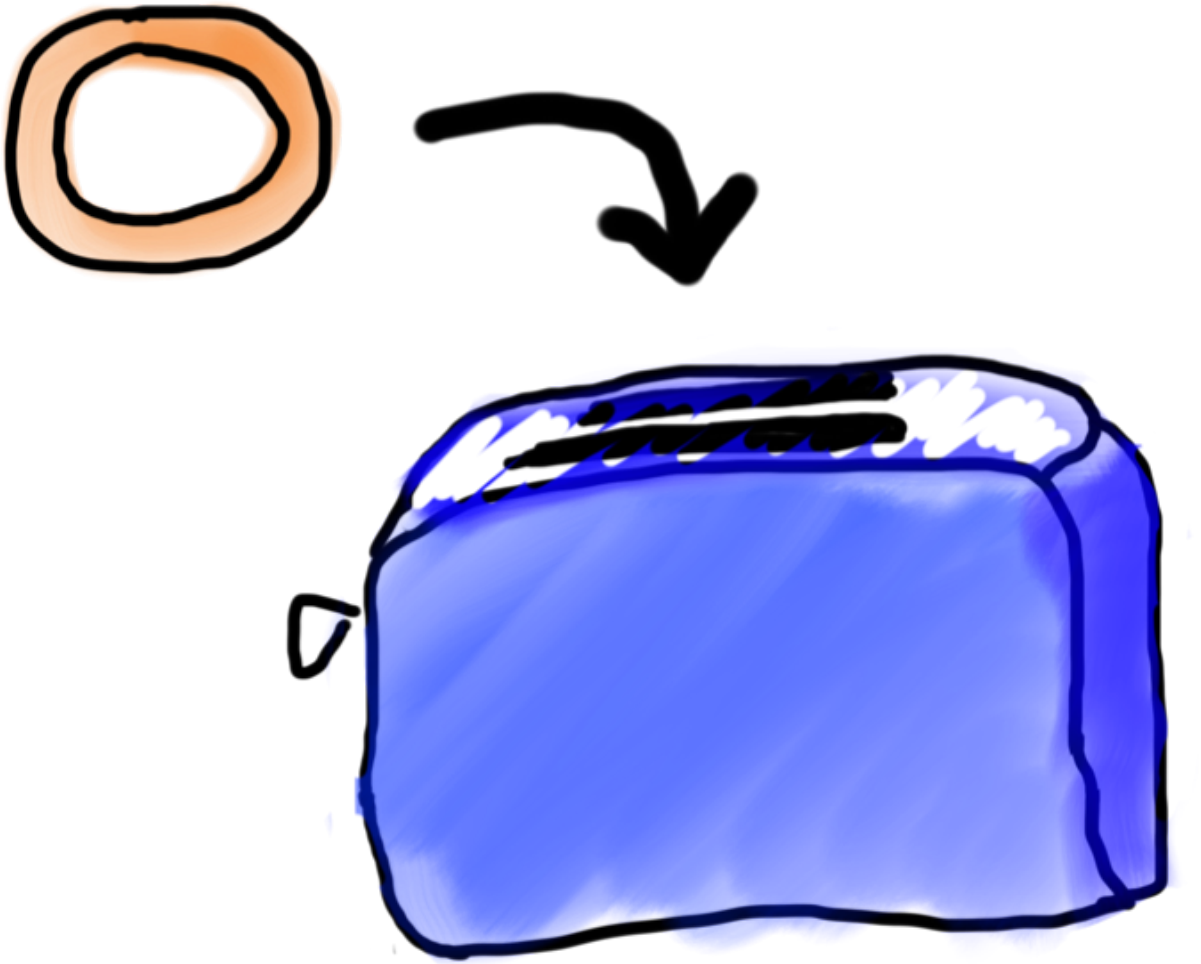
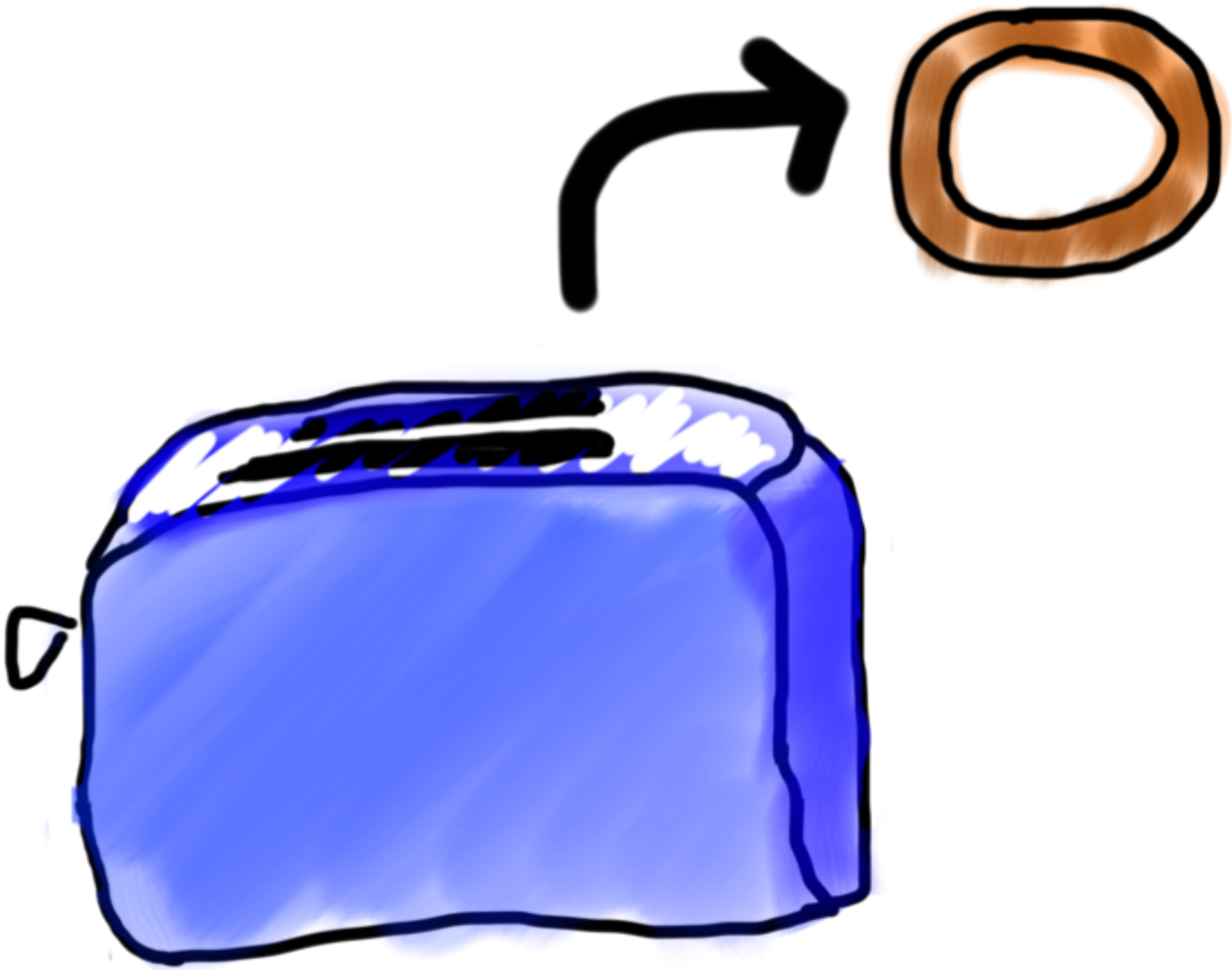


* You don’t need a second toaster if you want to toast bagels. Use the same one.

Toasters are Methods

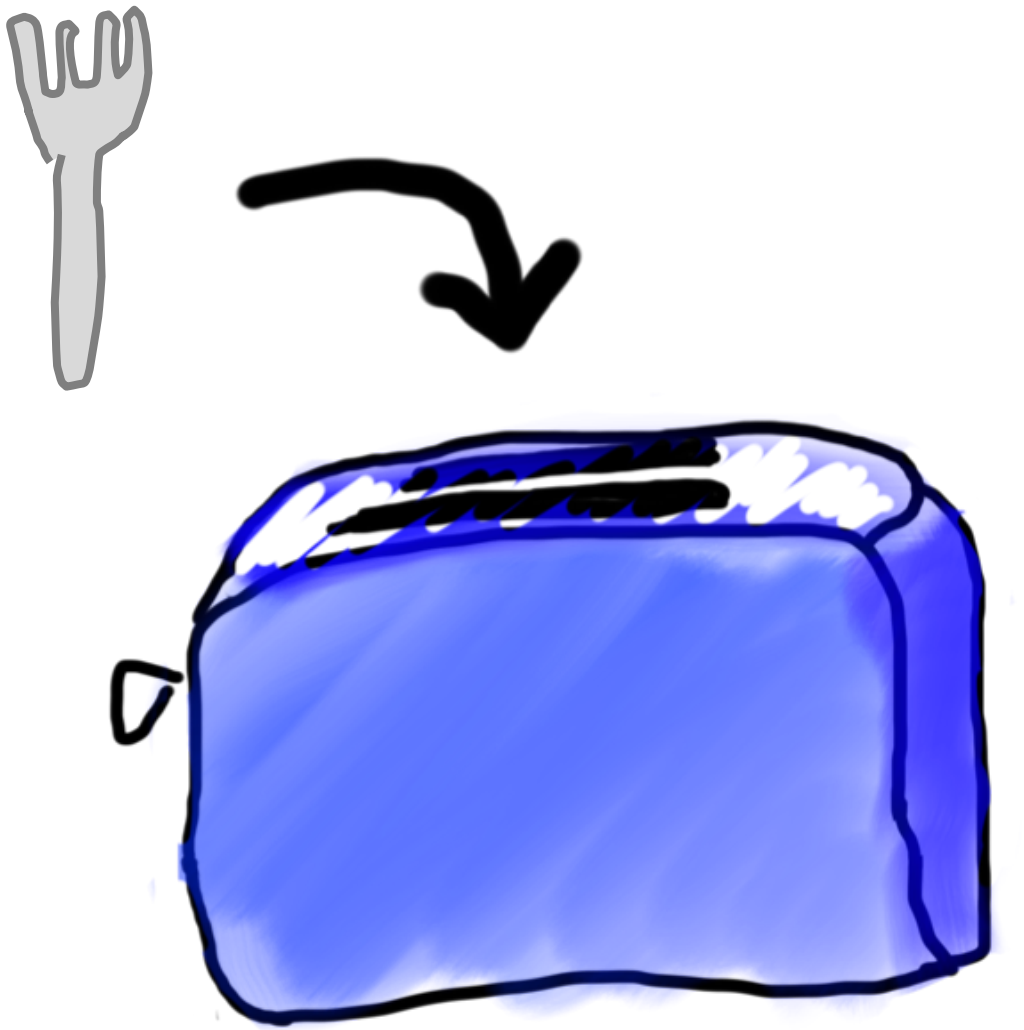


Toasters are Methods



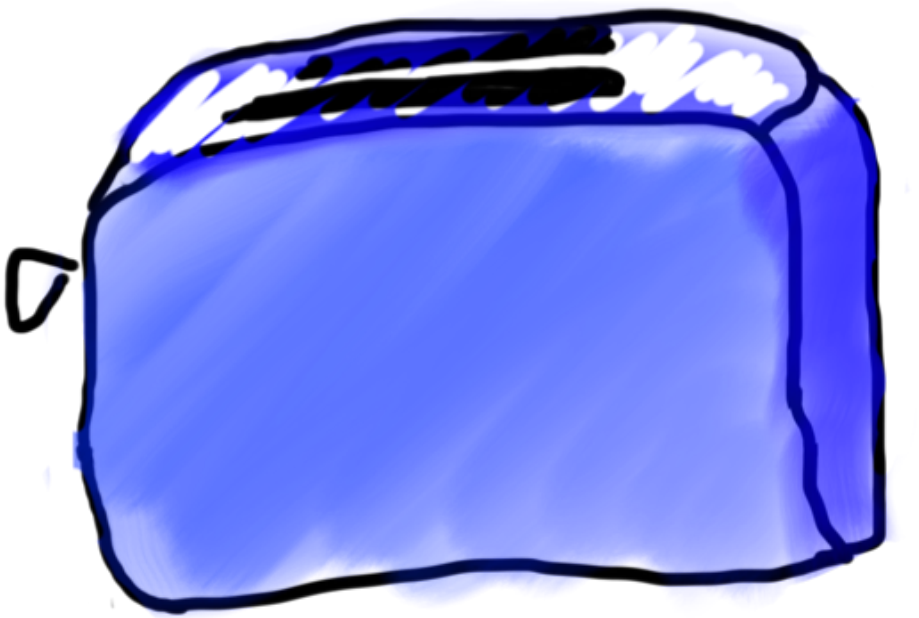
Toasters are Methods

Toasters are Methods

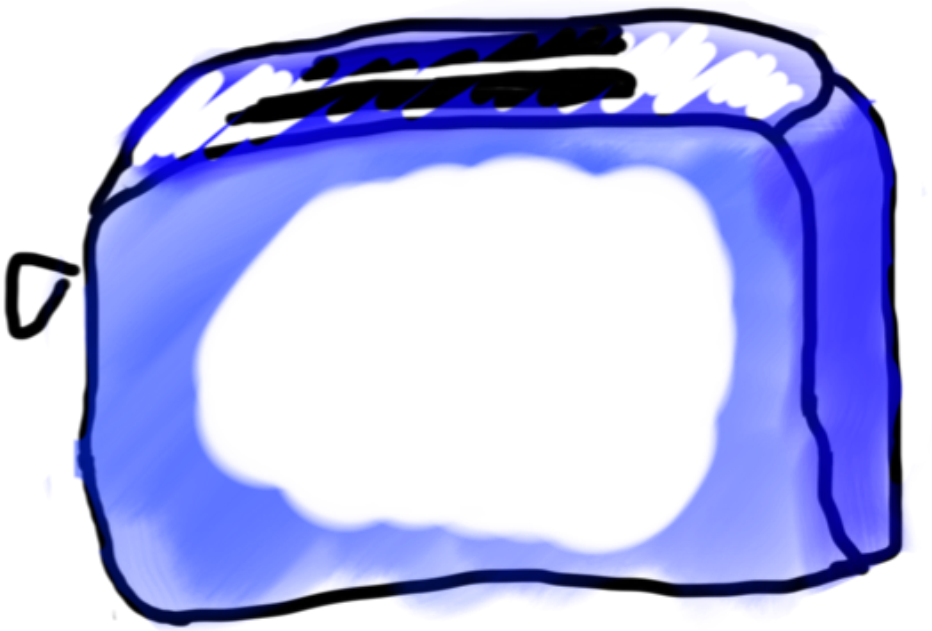


Toasters are Methods

Methods are Like Toasters

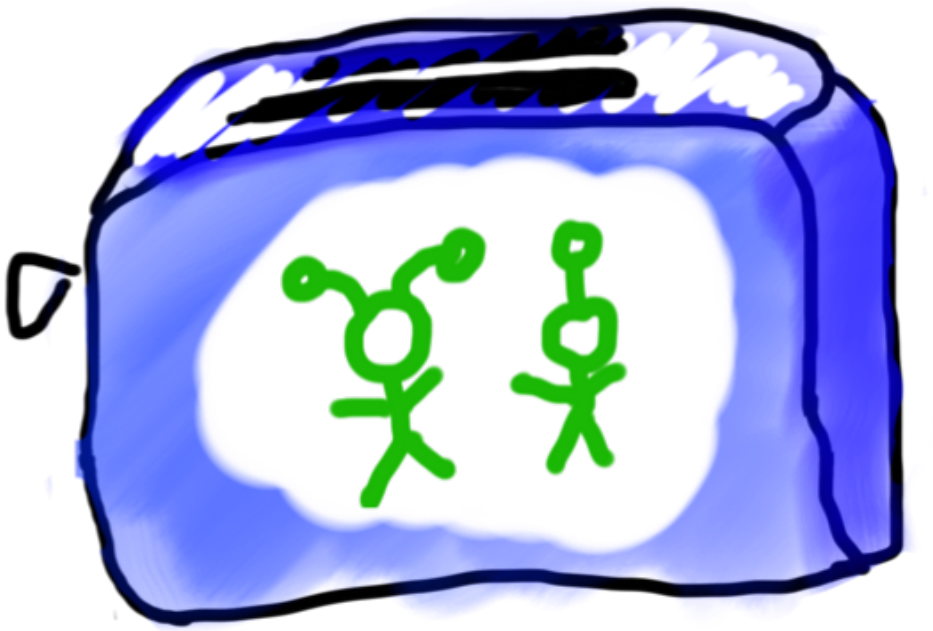


Methods are Like Toasters

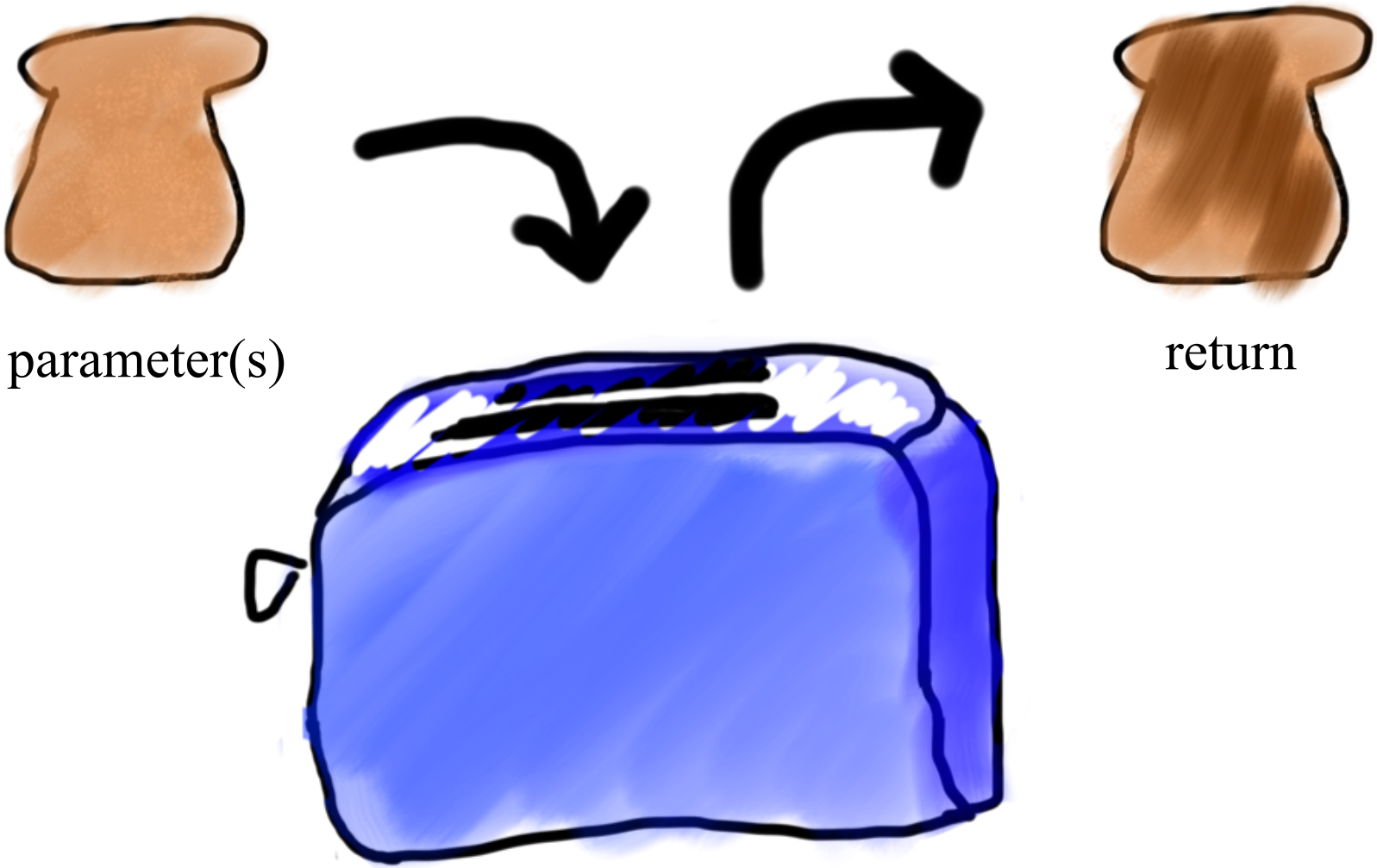


Methods are Like Toasters

Methods are Like Toasters



Methods are Like Toasters



Formally

***visibility type nameOfMethod*(*parameters*) {**
    statements
}

- ***visibility:*** usually **`private`** or **`public`**
- ***type:*** type returned by method (e.g., **`int`**, **`double`**, *etc*.)
  - Can be **`void`** to indicate that nothing is returned
- ***parameters:*** information passed into method

Anatomy of a method

```
public void run() {
    double mid = average(5.0, 10.2);
    println(mid);
}
```

```
private double average(double a, double b) {
    double sum = a + b;
    return sum / 2;
}
```


Anatomy of a method

```
public void run() {
    double mid = average(5.0, 10.2);
    println(mid);
}
```

method "definition"

```
private double average(double a, double b) {
    double sum = a + b;
    return sum / 2;
}
```

Anatomy of a method

```
public void run() {
    double mid = average(5.0, 10.2);
    println(mid);
}
```

Output expected

Input expected

```
private double average(double a, double b) {
    double sum = a + b;
    return sum / 2;
}
```


Anatomy of a method

```
public void run() {
    double mid = average(5.0, 10.2);
    println(mid);
}
```

Return Type

Parameters

```
private double average(double a, double b) {
    double sum = a + b;
    return sum / 2;
}
```


Anatomy of a method

```
public void run() {
    double mid = average(5.0, 10.2);
    println(mid);
}
```

name

```
private double average(double a, double b) {
    double sum = a + b;
    return sum / 2;
}
```


Anatomy of a method

```
public void run() {
    double mid = average(5.0, 10.2);
    println(mid);
}
```

```
private double average(double a, double b) {
    double sum = a + b;
    return sum / 2;
}
```

body

Anatomy of a method

```
public void run() {
    double mid = average(5.0, 10.2);
    println(mid);
}
```

```
private double average(double a, double b) {
    double sum = a + b;
    return sum / 2;
}
```

Ends the method and gives back a single value

Anatomy of a method

```
public void run() {
    double mid = average(5.0, 10.2);
    println(mid);
}
```

```
private double average(double a, double b) {
    double sum = a + b;
    return sum / 2;
}
```

This statement is necessary because **`average`** promised to return a double

Anatomy of a method

method "call"

```
public void run() {
    double mid = average(5.0, 10.2);
    println(mid);
}

private double average(double a, double b) {
    double sum = a + b;
    return sum / 2;
}
```


Anatomy of a method

Return Type Parameters

```
public void run() {
    double mid = average(5.0, 10.2);
    println(mid);
}


private double average(double a, double b) {
    double sum = a + b;
    return sum / 2;
}
```


Anatomy of a method

```
public void run() {
    double mid = average(5.0, 10.2);
    println(mid);
}
```

When a method ends it "returns"

```
private double average(double a, double b) {
    double sum = a + b;
    return sum / 2;
}
```


Parameters

Parameters let you provide a method some information when you are calling it.

Learn by Example

Void Example

```
private void printIntro() {
   println("Welcome to class");
   println("It's the best part of my day.");
}


public void run() {
   printIntro();
}
```

Parameter and Return Example

```
private double metersToCm(double meters) {
    return 100 * meters;
}
```

```
public void run() {
    double result = metersToCm(5.2);
    println(result);
}
```


Parameter and Return Example

```
private double metersToCm(double meters) {
    return 100 * meters;
}
```

```
public void run() {
    println(metersToCm(5.2));
    println(metersToCm(9.1));
}
```


Parameter Example

```
private void printOpinion(int num) {
    if(num == 5) {
        println("I love 5!");
    } else {
        println("Whattever");
    }
}

public void run() {
    printOpinion(5);
}
```

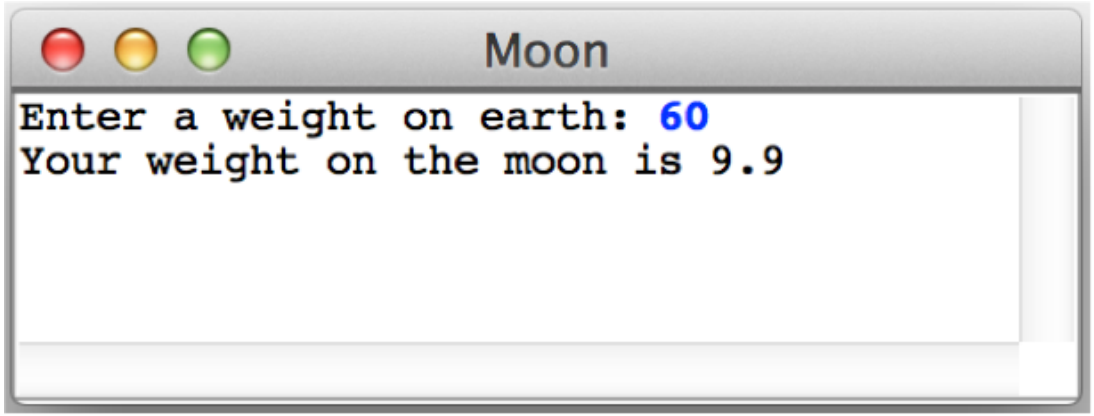

Multiple Return Statements

* Note: typo in lecture. Used to have a void, should have an int

```
private int max(int num1, int num2) {
    if(num1 >= num2) {
        return num1;
    }
    return num2;
}
```

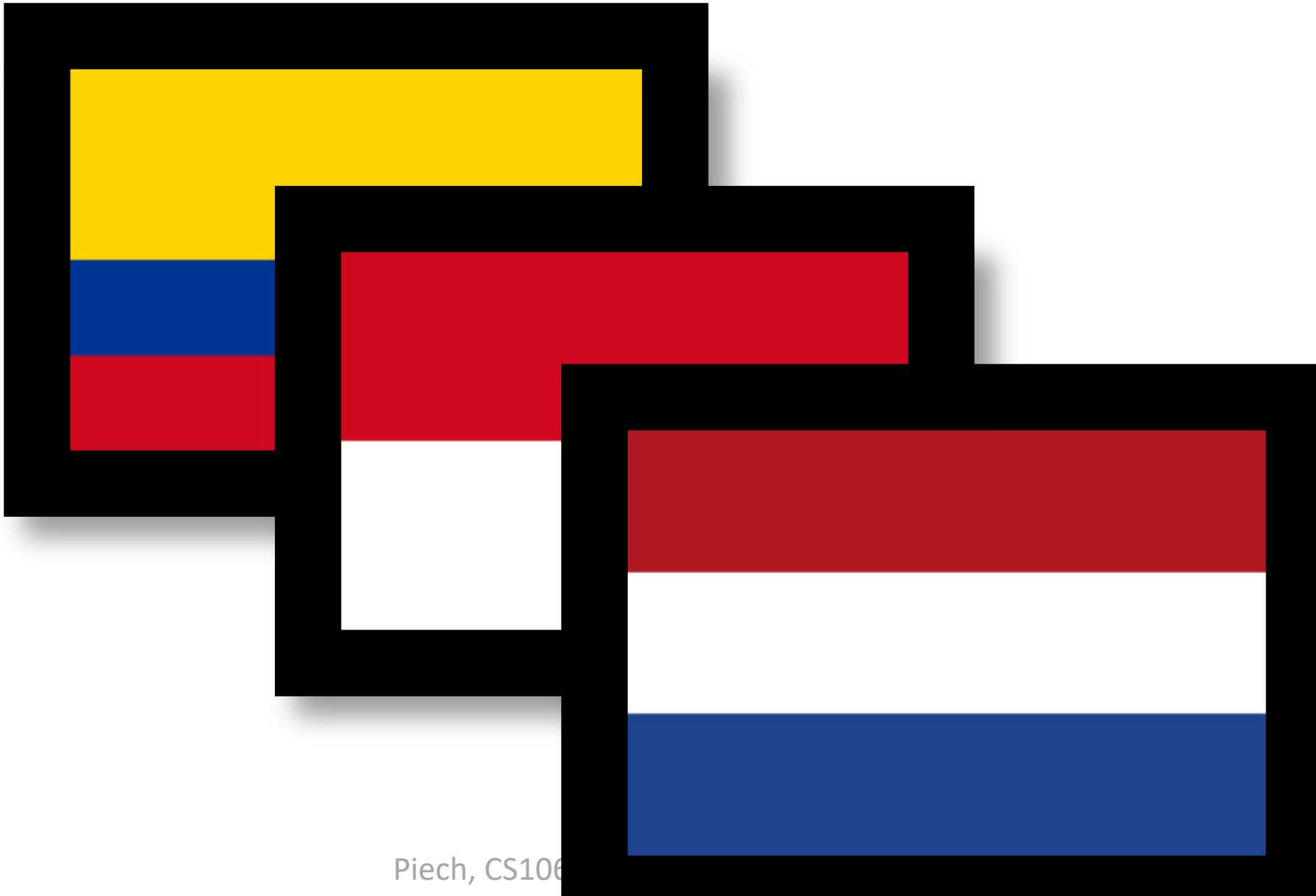
```
public void run() {
    int larger = max(5, 1);
}
```


Method for Weight on Moon



* Your weight on the moon is 16.5% your weight on the earth

Passing in Classes



A Full Program

```
public class FactorialExample extends ConsoleProgram {

   private static final int MAX_NUM = 4;

   public void run() {
       for(int i = 0; i < MAX_NUM; i++) {
             println(i + "! = " + factorial(i));
       }
   }

   private int factorial(int n) {
       int result = 1;
       for (int i = 1; i <= n; i++) {
             result *= i;
       }
       return result;
   }
}
```

A Full Program

```
public class FactorialExample extends ConsoleProgram {

   private static final int MAX_NUM = 4;

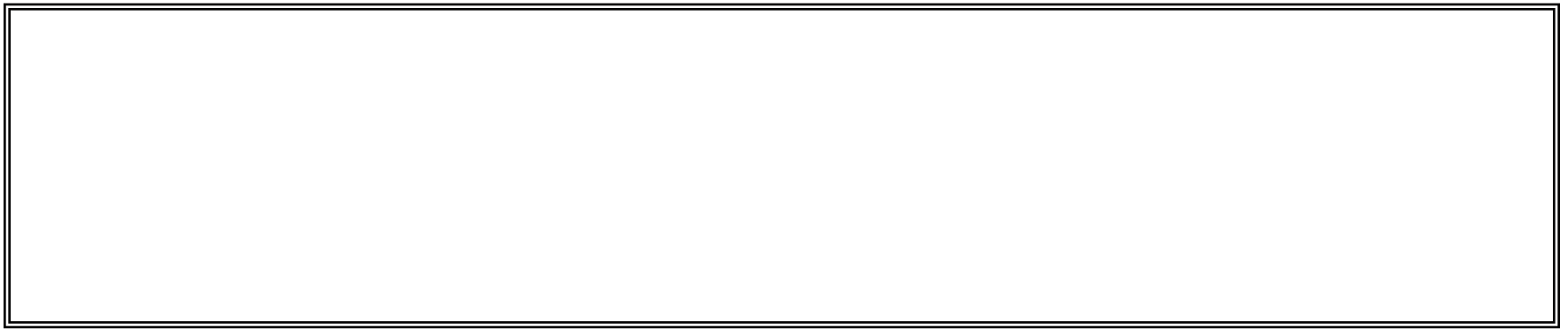
   public void run() {
       for(int i = 0; i < MAX_NUM; i++) {
             println(i + "! = " + factorial(i));
       }
   }

   private int factorial(int n) {
       int result = 1;
       for (int i = 1; i <= n; i++) {
             result *= i;
       }
       return result;
   }
}
```

Understand the Mechanism

```
public void run() {
   for(int i = 0; i < MAX_NUM; i++) {
      println(i + "! = " + factorial(i));
   }
}
```

i 



```
public void run() {
    for(int i = 0; i < MAX_NUM; i++) {
        println(i + "! = " + factorial(i));
    }
}
```

i | 0

```
public void run() {
    for(int i = 0; i < MAX_NUM; i++) {
        println(i + "! = " + factorial(i));
    }
}
```

i | 0

```
public void run() {
    for(int i = 0; i < MAX_NUM; i++) {
        println(i + "! = " + factorial(i));
    }
}
```

i | 0

```
public void run() {
   for(int i = 0; i < MAX_NUM; i++) {
      println(i + "! = " + factorial(i));
   }
}
```

i | 0

```
private int factorial(int n) {
    int result = 1;
    for (int i = 1; i <= n; i++) {
        result *= i;
    }
    return result;
}
```

n 0 result i

```
private int factorial(int n) {
    int result = 1;
    for (int i = 1; i <= n; i++) {
        result *= i;
    }
    return result;
}
```

n 0 result 1 i

```
private int factorial(int n) {
    int result = 1;
    for (int i = 1; i <= n; i++) {
        result *= i;
    }
    return result;
}
```

n	0	result	1	i	1

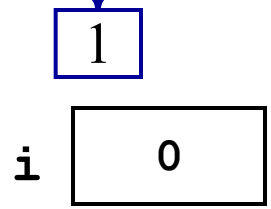
```
private int factorial(int n) {
    int result = 1;
    for (int i = 1; i <= n; i++) {
        result *= i;
    }
    return result;
}
```

n	0	result	1	i	1

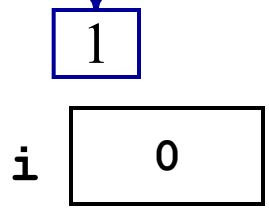
```
private int factorial(int n) {
    int result = 1;
    for (int i = 1; i <= n; i++) {
        result *= i;
    }
    return result;
}
```

n	0	result	1	i	1

```
public void run() {
   for(int i = 0; i < MAX_NUM; i++) {
      println(i + "! = " + factorial(i));
   }
}
```



```
public void run() {
    for(int i = 0; i < MAX_NUM; i++) {
        println(i + "! = " + factorial(i));
    }
}
```




```
0! = 1
```

```
public void run() {
    for(int i = 0; i < MAX_NUM; i++) {
        println(i + "! = " + factorial(i));
    }
}
```

i | 1

```
0! = 1
```

```
public void run() {
    for(int i = 0; i < MAX_NUM; i++) {
        println(i + "! = " + factorial(i));
    }
}
```

i | 1

```
0! = 1
```

```
public void run() {
    for(int i = 0; i < MAX_NUM; i++) {
        println(i + "! = " + factorial(i));
    }
}
```

i | 1

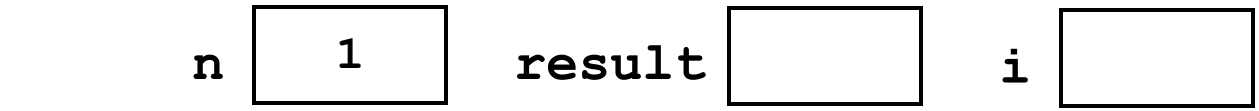
```
0! = 1
```

```
public void run() {
    for(int i = 0; i < MAX_NUM; i++) {
        println(i + "! = " + factorial(i));
    }
}
```

i | 1

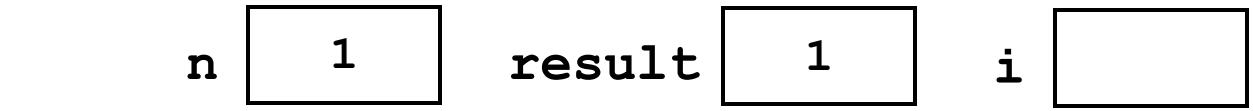
```
0! = 1
```

```
private int factorial(int n) {
    int result = 1;
    for (int i = 1; i <= n; i++) {
        result *= i;
    }
    return result;
}
```



0! = 1

```
private int factorial(int n) {
    int result = 1;
    for (int i = 1; i <= n; i++) {
        result *= i;
    }
    return result;
}
```



0! = 1

```
private int factorial(int n) {
    int result = 1;
    for (int i = 1; i <= n; i++) {
        result *= i;
    }
    return result;
}
```

n	1	result	1	i	1

0! = 1

```
private int factorial(int n) {
    int result = 1;
    for (int i = 1; i <= n; i++) {
        result *= i;
    }
    return result;
}
```

n	1	result	1	i	1

0! = 1

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private int factorial(int n) {
    int result = 1;
    for (int i = 1; i <= n; i++) {
        result *= i;
    }
    return result;
}
```

n	1	result	1	i	1

0! = 1

```
private int factorial(int n) {
    int result = 1;
    for (int i = 1; i <= n; i++) {
        result *= i;
    }
    return result;
}
```

n	1	result	1	i	2

```
0! = 1
```

```
private int factorial(int n) {
    int result = 1;
    for (int i = 1; i <= n; i++) {
        result *= i;
    }
    return result;
}
```

n	1	result	1	i	2

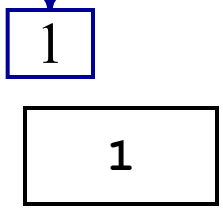
0! = 1

```
private int factorial(int n) {
    int result = 1;
    for (int i = 1; i <= n; i++) {
        result *= i;
    }
    return result;
}
```

n	1	result	1	i	2

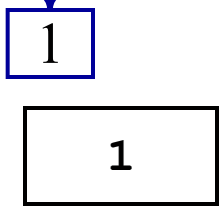
```
0! = 1
```

```
public void run() {
   for(int i = 0; i < MAX_NUM; i++) {
      println(i + "! = " + factorial(i));
   }
}
```




```
0! = 1
```

```
public void run() {
    for(int i = 0; i < MAX_NUM; i++) {
        println(i + "! = " + factorial(i));
    }
}
```




```
0! = 1
1! = 1
```

```
public void run() {
    for(int i = 0; i < MAX_NUM; i++) {
        println(i + "! = " + factorial(i));
    }
}
```

i | 2

```
0! = 1
1! = 1
```

```
public void run() {
    for(int i = 0; i < MAX_NUM; i++) {
        println(i + "! = " + factorial(i));
    }
}
```

i | 2

```
0! = 1
1! = 1
```

```
public void run() {
    for(int i = 0; i < MAX_NUM; i++) {
        println(i + "! = " + factorial(i));
    }
}
```

i | 2

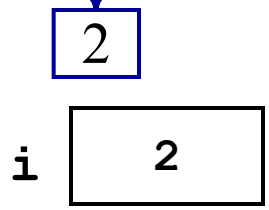
```
0! = 1
1! = 1
```

```
public void run() {
    for(int i = 0; i < MAX_NUM; i++) {
        println(i + "! = " + factorial(i));
    }
}
```

i | 2

```
0! = 1
1! = 1
```

```
public void run() {
   for(int i = 0; i < MAX_NUM; i++) {
      println(i + "! = " + factorial(i));
   }
}
```




```
0! = 1
1! = 1
```

```
public void run() {
    for(int i = 0; i < MAX_NUM; i++) {
        println(i + "! = " + factorial(i));
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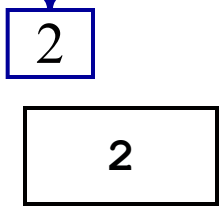
}
```




```
0! = 1
1! = 1
2! = 2
```

```
public void run() {
    for(int i = 0; i < MAX_NUM; i++) {
        println(i + "! = " + factorial(i));
    }
}
```

i | 3

```
0! = 1
1! = 1
2! = 2
```

```
public void run() {
    for(int i = 0; i < MAX_NUM; i++) {
        println(i + "! = " + factorial(i));
    }
}
```

i | 3

```
0! = 1
1! = 1
2! = 2
```

```
public void run() {
    for(int i = 0; i < MAX_NUM; i++) {
        println(i + "! = " + factorial(i));
    }
}
```

i | 3

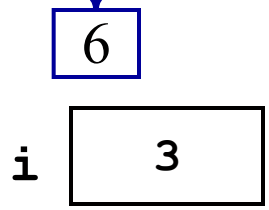
```
0! = 1
1! = 1
2! = 2
```

```
public void run() {
   for(int i = 0; i < MAX_NUM; i++) {
      println(i + "! = " + factorial(i));
   }
}
```

i 3

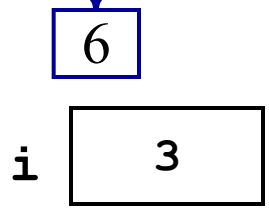
```
0! = 1
1! = 1
2! = 2
```

```
public void run() {
    for(int i = 0; i < MAX_NUM; i++) {
        println(i + "! = " + factorial(i));
    }
}
```




```
0! = 1
1! = 1
2! = 2
```

```
public void run() {
    for(int i = 0; i < MAX_NUM; i++) {
        println(i + "! = " + factorial(i));
    }
}
```




```
0! = 1
1! = 1
2! = 2
3! = 6
```

```
public void run() {
    for(int i = 0; i < MAX_NUM; i++) {
        println(i + "! = " + factorial(i));
    }
}
```

i | 4

```
0! = 1
1! = 1
2! = 2
3! = 6
```

```
public void run() {
    for(int i = 0; i < MAX_NUM; i++) {
        println(i + "! = " + factorial(i));
    }
}
```

i | 4

```
0! = 1
1! = 1
2! = 2
3! = 6
```

Parameters

Every time a method is called, new memory is created for the call.

Bad Times With Methods

```
// NOTE: This program is buggy!!

private void addFive(int x) {
  x += 5;
}


public void run() {
  int x = 3;
  addFive(x);
  println("x = " + x);
}
```

Let's "trace" this program on the board

Good Times With Methods

```
// NOTE: This program is feeling just fine...

private int addFive(int x) {
   x += 5;
   return x;
}

public void run() {
   int x = 3;
   x = addFive(x);
   println("x = " + x);
}
```


For primitives: Variables are **not** passed when you use parameters. Values are passed

Pass by "Value"

- Thanks Mehran

More Examples

Changed Name

```
private void run() {
    int num = 5;
    cow(num);
}

private void cow(int grass) {
    println(grass);
}
```

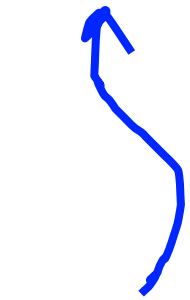

Same Variable Name

```
private void run() {
    int num = 5;
    cow();
    println(num);
}

private void cow() {
    int num = 10;
    println(num);
}
```


Methods Called on Objects

```
GRect rect = new GRect(20, 20);
rect.setColor(Color.Blue);
```



receiver

* We will talk about how to define these later in the class

No Methods in Methods

```
private void run() {
    println("hello world");
    private void sayGoodbye() {
        println("goodbye!");
    }
}
```

Illegal modifier for parameter goodbye, only final is permitted

No Methods in Methods

```
private void run() {
    println("hello world");
    sayGoodbye();
}

private void sayGoodbye() {
    println("goodbye!");
}
```


Remember Booleans?

Boolean Variable

```
boolean karelIsAwesome = true;

boolean myBool = 1 < 2;
```


Boolean Operations

```
boolean a = true;

boolean b = false;


boolean and = a && b;

boolean or = a || b;

boolean not = !a;
```

Is Divisible By

```
private void run() {
   for(int i = 1; i <= 100; i++) {
      if(isDivisibleBy(i, 7)) {
         println(i);
      }
   }
}
```


Boolean Return

```
private void run() {
   for(int i = 1; i <= 100; i++) {
      if(isDivisibleBy(i, 7)) {
         println(i);
      }
   }
}

private boolean isDivisibleBy(int a, int b) {
   if((a % b) == 0) {
      return true;
   } else {
      return false;
   }
}
```

Boolean Return

```
private void run() {
   for(int i = 1; i <= 100; i++) {
      if(isDivisibleBy(i, 7)) {
         println(i);
      }
   }
}

private boolean isDivisibleBy(int a, int b) {
   return a % b == 0;
}
```


Learn How To:

1. Write a method that takes in input
2. Write a method that gives back output
3. Trace method calls using stacks

Extra Exercise

- Greek mathematicians took a special interest in numbers that are equal to the sum of their proper divisors (a proper divisor of *n* is any divisor less than *n* itself). They called such numbers ***perfect numbers***. For example, 6 is a perfect number because it is the sum of 1, 2, and 3, which are the integers less than 6 that divide evenly into 6. Similarly, 28 is a perfect number because it is the sum of 1, 2, 4, 7, and 14.
- Design and implement a Java program that finds all the perfect numbers between two limits. For example, if the limits are 1 and 10000, the output should look like this: