Java Control: Functions

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Functions

- A function is a block of code that accomplishes a single purpose, such as calculating an average from a list of values, or printing a message to console.
  - A function (optionally) takes some inputs (also named arguments), performs some operations, and (optionally) gives back a result.

- Proper design and use of functions can save time and make a program easy to read, maintain, organized, and efficient.

You've already been using functions

- Built-in functions are provided by the language
- Library functions are similar but provided by another programmer
- User-defined functions are created by programmers
- All functions operate the same

Build your own

Adventure?

User-Defined Functions

- Programmers can define their own functions.
- A function consists of the following components:
  - (Required) **Function name, return type of void, primitive, class name, (), {}**
  - (Semi-Optional) **public/static** (needed if you want their behaviour)
  - (Optional) **Function parameters**
  - (Optional) **Function body** (code) : The function's body must contain at least {}.

- The following is a minimal function that does nothing:

```
public static void foo(){
}
```

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  - (Optional) **Function parameters**
  - (Optional) **Function body** (code) : The function's body must contain at least {}.

- The following is a minimal function that does nothing:

Java

```
public static void foo(){
}
```

Python

```
def foo():
    pass
```

User-Defined Functions – Java Versus Python

Python functions always returned None

Instead Java has two types of functions

1. those that return **void** (syntactically cannot be assigned to a variable)
2. those that return a **type** (can return object/null [like Python None] or type like int)

Return void

```
public static void foo(){
}
```

Return type

```
public static int bar(){
    return 1;
}
```

User-Defined Functions – Java Versus Python

I can call either foo/bar without storing result

(like Python)

But only bar() can be stored

int x = foo(); is a syntax error

```
public static void main(String[] args) {
    foo();
    bar();
    int x = foo();
    int y = bar();
}
```

Return void

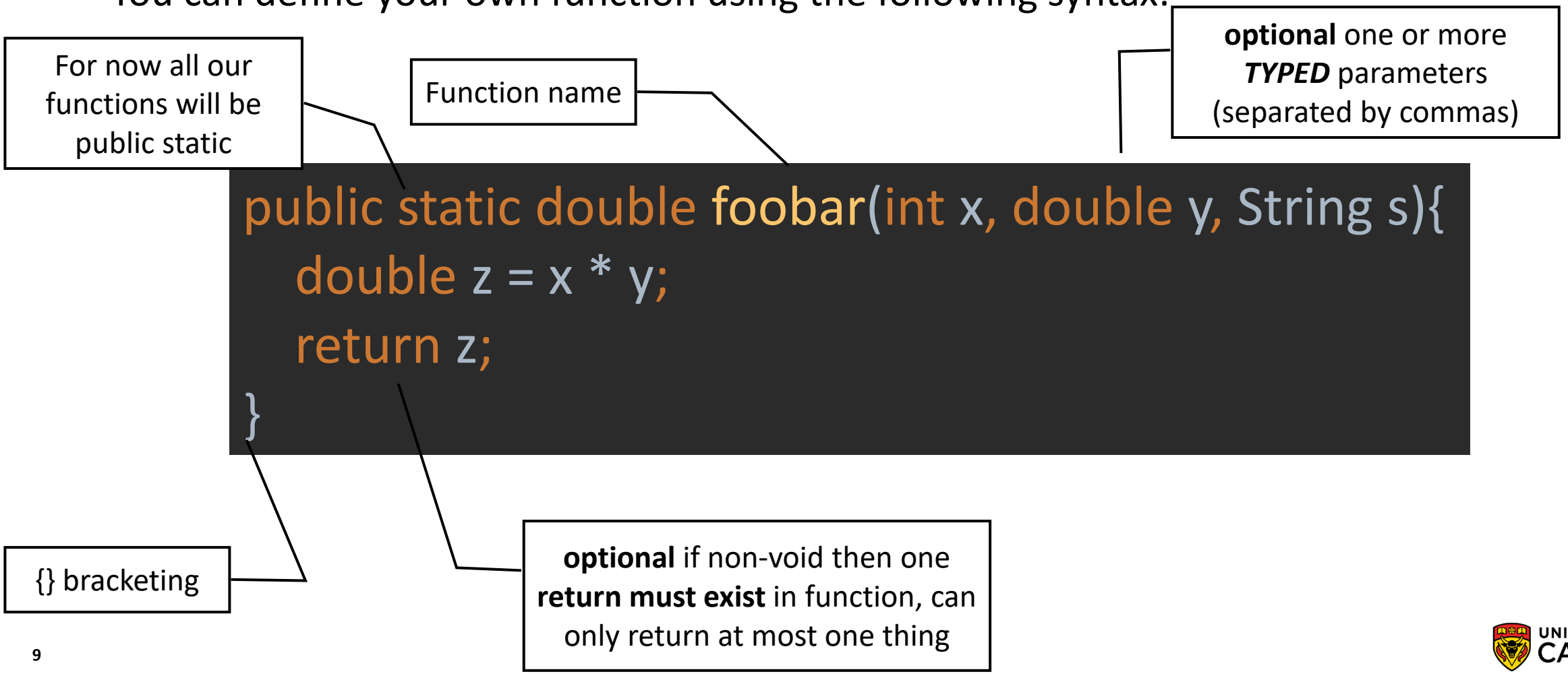
```
public static void foo(){
}
```

Return type

```
public static int bar(){
    return 1;
}
```

User-Defined Static Functions (callable from main)

- You can define your own function using the following syntax:



Overloading functions

What makes a function unique?

Function Overloading

- The whole Java file is read before main() starts (so all 4 functions and main will have been stored in memory)
- **Java functions are unique by name, parameter type/order.**
  - **(Ex. foo(double,int) is unique from foo(int,double)**
- If a function name is used more than once we call this function (**over-loaded**).
- All four of these functions can be called in the same program. In any order. As many times as we want.
- They all exist at the same time. (In Python only one function with any name existed at a time)

```
public static void main(String[] args) {
   foobar();
   foobar(1);
   foobar(2.0);
   foobar(1, 2.0);
   foobar(2.0);
   foobar(1);
   foobar();
}

public static double foobar() {
   return 1.0;
}

public static double foobar(int x) {
   return 2.0;
}

public static double foobar(double y) {
   return 3.0;
}

public static double foobar(int x, double y) {
   return 4.0;
}
```

Function Overloading

- The whole Java file is read before main() starts (so all 4 functions and main will have been stored in memory)
- Java functions are unique by name, parameter type/order.
- If a function name is used more than once we call this function (over-loaded).
- All four of these functions can be called in the same program. In any order. As many times as we want.
- They all exist at the same time. (In Python only one function with any name existed at a time)
- There is no foobar(double,int) here, so that would be a syntax error if we tried to use it

```
public static void main(String[] args) {
   foobar();
   foobar(1);
   foobar(2.0);
   foobar(1, 2.0);
   foobar(2.0);
   foobar(1);
   foobar();
}

public static double foobar() {
   return 1.0;
}

public static double foobar(int x) {
   return 2.0;
}

public static double foobar(double y) {
   return 3.0;
}

public static double foobar(int x, double y) {
   return 4.0;
}
```

Storing functions

Think of what “import java.util.Math” did

Accessing functions in other libraries

Fun.java

```
public class Fun{
    public static void fun(){
        System.out.println("Hello, world!");
    }
}
```

Foo.java

```
public class Foo{
    public static void foo(){
        System.out.println("Goodbye, world!");
    }
}
```

Main.java

```
public class Main {
    public static void main(String[] args) {
        Foo.foo();
        Fun.fun();
    }
}
```

No import needed if folders in same directory
Compile all 3 and run.
Functions protected by Class name they are stored in (which matches filename)

Non-public?

Fun.java

```
public class Fun{
   static void fun(){
      System.out.println("Hello, world!");
   }
}
```

Foo.java

```
public class Foo{
   private static void foo(){
      System.out.println("Goodbye, world!");
   }
}
```

Main.java

```
public class Main {
   public static void main(String[] args) {
      Foo.foo();
      Fun.fun();
   }
}
```

Other modifiers can prevent Main class from accessing the code in the other classes

More on this later in course!

Non-public?

Modifiers won't affect function access in same class file

```
public class Main {
    public static void main(String[] args) {
        foo();
        fun();
    }
 private static void foo(){
        System.out.println("Goodbye, world!");
    }
   static void fun(){
        System.out.println("Hello, world!");
    }

}
```

Parameters

There are no optional parameters

Function Overloading – Optional?

- We can simulate Python style optional parameters with an overloaded function in which we replace the parameter that wasn't provided with a default value.

- We cannot call parameters by name
  - foobar(x=10); is not valid syntax

```
public static void main(String[] args) {
   foobar();
   foobar(1);
   foobar(2.0);
   foobar(1, 2.0);
   foobar(2.0);
   foobar(1);
   foobar();
}

public static double foobar() {
   return foobar(1, 2.0);
}

public static double foobar(int x) {
   return foobar(x,2.0)
}

public static double foobar(double y) {
   return foobar(1, y);
}

public static double foobar(int x, double y) {
   return 4.0;
}
```

Variable Length Arguments

Variable Argument Functions

- int…
- String…
- double…
- Produces an iterable (foreach can loop) list of parameters

- We can only have one of these at end
- We can add our non flexible parameters in front of this variable length portion

```
public static void main(String[] args) {
    System.out.println(sum(1,2,3,4,5));
}

public static int sum(int... numbers) {
    int sum = 0;
    for (int num : numbers) {
        sum = sum + num;
    }
    return sum;
}
```

null?

Functions return null to mean Nothing

Non-void functions always return something

- That something can also be **null** if what is being returned is an **Object reference**
- **null** is a special keyword
- (We often use **null** in other places in our code to show nothing has been stored in an Object variable yet)

```
public static Integer Nothing_Integer() {
    return null;
}
public static int Nothing_int() {
    return null;  //SYNTAX ERROR
}
```

Examples

Some simple functions

```
public static void main(String[] args) {
    System.out.println(circle_area(10));
    System.out.println(sum_to(10));
    System.out.println(is_even(202));
    System.out.println(is_odd(501));
}
```

```
public static double circle_area(double radius) {
    return Math.PI * Math.pow(radius, 2);
}

public static double sum_to(int n) {
    return (n * (n + 1)) / 2;
}

public static boolean is_even(int number) {
    return number % 2 == 0;
}

public static boolean is_odd(int number) {
    return !is_even(number);
}
```

Design

User-Defined Functions - Commenting

- A good function always contains explicit comments that describe the purpose of the function, the parameters, and returned values. – Javadoc commenting

```
/**
 * Calculate area of circle from double radius
 * @param radius Double radius of circle
 * @return Area of the circle using pi * (radius ^ 2)
 */
public static double circle_area(double radius) {
    return Math.PI * Math.pow(radius, 2);
}
```

- See: https://docs.oracle.com/en/java/javase/20/docs/api/java.base/java/lang/Math.html

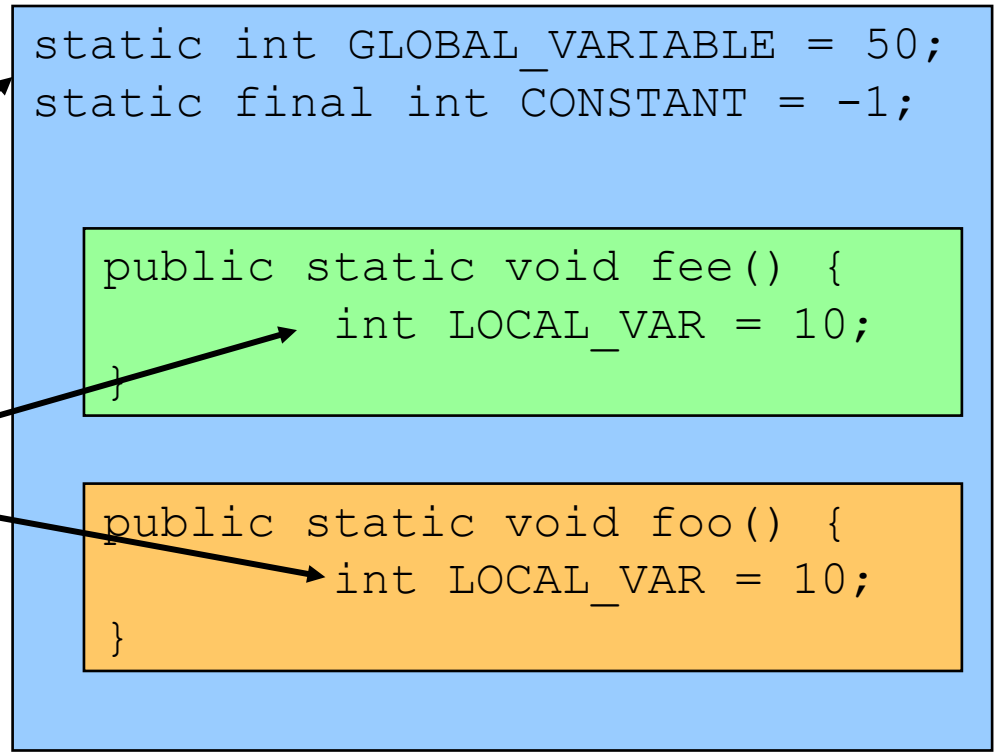
Scope

Scope of Variables

- Variables are memory locations that are used for the temporary storage of data
- The scope of a variable is the section of code in which it is accessible

The global scope:
Accessible by both functions

Local scopes:
Two different memory spaces,
Accessible only within their functions



Scope of Variables

- Produces?

```
static int GLOBAL_VARIABLE = 50;
static final int CONSTANT = -1;

public static void fee() {
    int LOCAL_VAR = 10;
    GLOBAL_VARIABLE = 0;
}

public static void foo() {
    int LOCAL_VAR = 20;
    GLOBAL_VARIABLE = 99;
}

public static void main(String[] args) {
    System.out.println(GLOBAL_VARIABLE + " " + CONSTANT);
    fee();
    System.out.println(GLOBAL_VARIABLE + " " + CONSTANT);
    foo();
    System.out.println(GLOBAL_VARIABLE + " " + CONSTANT);
}
```

Scope of Variables

- 50 -1
- 0 -1
- 99 -1

```
static int GLOBAL_VARIABLE = 50;
static final int CONSTANT = -1;

public static void fee() {
   int LOCAL_VAR = 10;
   GLOBAL_VARIABLE = 0;
}

public static void foo() {
   int LOCAL_VAR = 20;
   GLOBAL_VARIABLE = 99;
}

public static void main(String[] args) {
   System.out.println(GLOBAL_VARIABLE + " " + CONSTANT);
   fee();
   System.out.println(GLOBAL_VARIABLE + " " + CONSTANT);
   foo();
   System.out.println(GLOBAL_VARIABLE + " " + CONSTANT);
}
```

Scope of Variables

- What about?

```
static int GLOBAL_VARIABLE = 50;
static final int CONSTANT = -1;

public static void fee() {
    int LOCAL_VAR = 10;
    GLOBAL_VARIABLE = 0;
}

public static void foo() {
    int LOCAL_VAR = 20;
    GLOBAL_VARIABLE = 99;
}

public static void main(String[] args) {
    CONSTANT = 10000;
    System.out.println(GLOBAL_VARIABLE + " " + CONSTANT);
    fee();
    System.out.println(GLOBAL_VARIABLE + " " + CONSTANT);
    foo();
    System.out.println(GLOBAL_VARIABLE + " " + CONSTANT);
}
```

Scope of Variables

- Syntax error as constants can’t be changed

```
static int GLOBAL_VARIABLE = 50;
static final int CONSTANT = -1;

public static void fee() {
    int LOCAL_VAR = 10;
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}

public static void foo() {
    int LOCAL_VAR = 20;
    GLOBAL_VARIABLE = 99;
}

public static void main(String[] args) {
    CONSTANT = 10000;
    System.out.println(GLOBAL_VARIABLE + " " + CONSTANT);
    fee();
    System.out.println(GLOBAL_VARIABLE + " " + CONSTANT);
    foo();
    System.out.println(GLOBAL_VARIABLE + " " + CONSTANT);
}
```
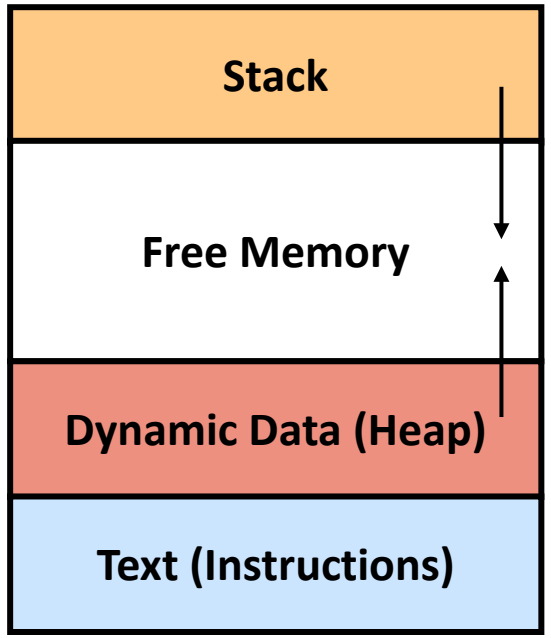

Memory

Memory Organization

- The memory for a program is organized into three regions
  - **Text (Instructions)**: holds program instructions. Contains your **bytecode**
  - **Dynamic Data (Heap)**: objects (referenced from stack)
  - **Stack**: functions, local primitive variables and data, local reference object variables in functions (data in heap)
  - *In python we had no primitives so we only had reference object variables and all of the referenced data were objects in heap*



Abusing Memory

- Running out of stack space in Java
  - Recursion forever
  - Exception in thread "main" java.lang.StackOverflowError
- Running out of heap space in Java
  - Make objects forever
  - Exception in thread "main" java.lang.OutOfMemoryError: Java heap space

```
public static void kill_stack() {
    Long LOCAL_VAR = 10L;
    kill_stack();
}
```

```
public static void kill_heap() {
    ArrayList list = new ArrayList();
    Long LOCAL_VAR = 10L;
    while (true){
        list.add(LOCAL_VAR++);
    }
}
```

Onward to … Data Structures.

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