Unit 2: Using Objects
Methods

Adapted from:

1) Building Java Programs: A Back to Basics Approach

by Stuart Reges and Marty Stepp

Modularity

modularity: Writing code in smaller, more manageable components or modules. Then combining the modules into a cohesive system.

- Modularity with methods. Break complex code into smaller tasks and organize it using **methods**.

Methods define the behaviors or functions for objects.

An object’s behavior refers to what the object can do (or what can be done to it). A method is simply a named group of statements.

static vs non-static

Variables and methods can be classified as **static** or **nonstatic(instance)**.

Non-static or instance: Part of an object, rather than shared by the class. Non-static methods are called using the dot operator along with the object variable name.

static: Part of a class, rather than part of an object. Not copied into each object; shared by all objects of that class. Static methods are called using the dot operator along with the class name unless they are defined in the enclosing class.

We will further clarify this distinction in Unit 5 when we learn to write our own classes.

Static Method Inside Driver Class

The **driver class** is the class with the main method. Note that the main method is the begin point of a run of any program. The driver class can contain other static methods. You can call a static method from another method **in the same enclosing class directly without referencing the name or object of the class.**

MyClass.java

```
public class MyClass{
     public static void main(String[] args){
          method2();
          method1();
     }
     public static void method1(){
          System.out.println("running method1");
     }
     public static void method2(){
          System.out.println("running method2");
     }
}
```

Output:
running method2
running method1

Static Method Inside Driver Class

The order of the methods in the driver class does not matter and does not affect the run or output of the program. The program below has the exact same output as the program from the previous slide. The **main method is always the starting point of the run of any program.**

MyClass.java

```
public class MyClass{
        public static void method1(){
                System.out.println("running method1");
        }
        public static void main(String[] args){
                method2();
                method1();
        }
        public static void method2(){
                System.out.println("running method2");
        }
}
```

Output:
running method2
running method1

Control flow

When a method is called, the program's execution...
- "jumps" into that method, executing its statements, then
- "jumps" back to the point where the method was called.

What is the output?

```
public class MethodsExample {
    public static void main(String[] args) {
        message1();

        message2();


    }

    ...
}
```

```
public static void message1() {
    System.out.println("This is message1.");
}
```

```
public static void message2() {
    System.out.println("This is message2.");
    message1();
    System.out.println("Done with message2.");
}
```

```
public static void message1() {
    System.out.println("This is message1.");
}
```

Output:
```
This is message1.
This is message2.
This is message1.
Done with message2.
```

Methods

Non-static or instance methods belong to individual objects. They are usually implemented inside of an object class rather than the driver class.

Methods in an object class are non-static by default unless explicitly labeled "static".

Non-static methods are called through objects of the class.

Non-static Method Call

A program's run begins and ends at the main method.

MyProgram.java

```
public class MyProgram{
  public static void main(String[] args){
    System.out.println("Begins here.");
    MyClass c = new MyClass();
    c.method1();
    c.method2();
    System.out.println("Ends here.");
  }
}
```

Output:

```
Begins here.
method1
method2
Ends here.
```

non-static method is called through the name of an object using the dot notation

MyClass.java

non-static(instance) methods

```
public class MyClass{
  …
  public void method1(){
    System.out.println("method1");
  }
  public void method2(){
    System.out.println("method2");
  }
}
```

Method Signature

A **method signature** for a method consists of the method name and the ordered, possibly empty, list of parameter types.

```
public void name(parameters){
               statements;
    }
```

Examples:

```
public void method1(){
…
}
```

void: no value is returned when method ends.

no parameters

```
public void method2(int x, double y){
…
}
```

The parameters in the method header are **formal parameters.**

Static Example

When calling a method with parameters, values provided in the parameter list need to correspond to the order and type in the method signature.

```
public class MyProgram{
  public static void main(String[] args){
     mystery1(3, 4); // error, incompatible types!
     mystery1(); // missing actual parameters
     mystery1(3); // missing actual parameters
     mystery1(3, true); // correct
     mystery2(3.2, 3.0); // error, incompatible types!
     double a = 2.5;
     int b = 5;
     mystery2(double a, int b); // error, no type in actual parameters
     mystery2(a, b); // correct

  }
  public static void mystery1(int x, boolean y){
  …
  }
  public static void mystery2(double x, int z){
  …
  }
}
```

Non-static Example

When calling a method with parameters, values provided in the parameter list need to correspond to the order and type in the method signature.

MyProgram.java

```
public class MyProgram{
  public static void main(String[] args){
    MyClass c = new MyClass();
    c.method1(); // correct!
    c.method2(); // error! Missing actual parameters
    c.method2(3.5, 4.1); // error! Wrong types
    c.method2(2, 3.1); // correct!
    c.method2(3, 4); // correct, 4 is casted to a double 4.0
  }
}
```

MyClass.java

```
public class MyClass{
  …
  public void method1(){
    …
  }
  public void method2(int x, double y){
    …
  }
}
```

Static Vs Non-static Method Calling

MyClass.java

```
public class MyClass{
        public static void main(String[] args){
            System.out.println(SomeClass.method1());
            SomeClass a = new SomeClass();
            System.out.println(a.method2());
            System.out.println(a.method1());
            System.out.println(SomeClass.method2());


        }
}
```

call static method through name of class

call non-static method through name of an object

This works also but not considered "best practice"

This is an error!

SomeClass.java

```
public class SomeClass{
        public SomeClass(){…}
        public static int method1() // static method
        {…}
        public int method2() // non-static or instance method
        {…}}
```

Note that method1 and method2 both belong to a different class than the driver class where they are being called.

Method Returns

Methods in Java can have **return types**. Such **non-void** methods return values back that can be used by the program. A method can use the keyword "**return**" to return a value.

```
public type methodName(type var1,…, type var2){
…
}
```

Examples:

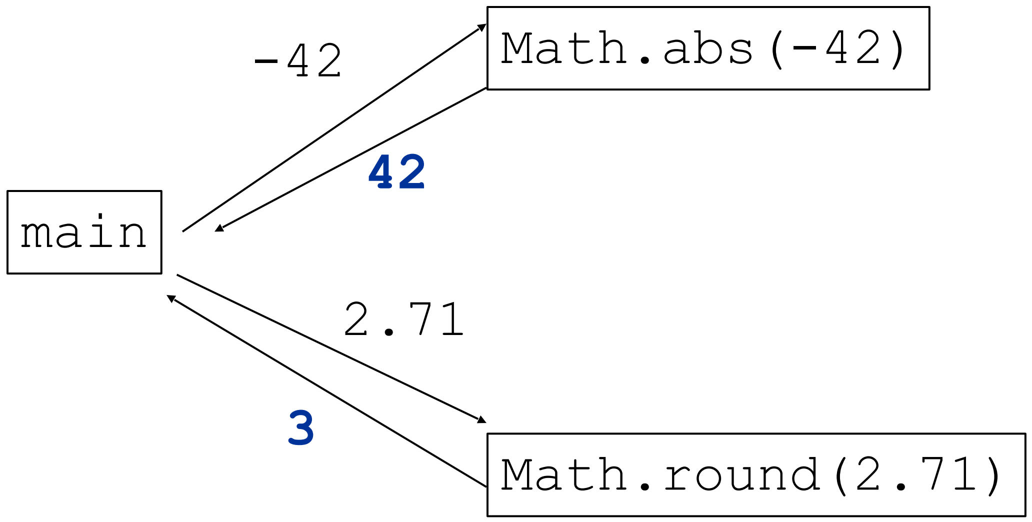
```
public int method1(){
…
}


public double method2(int x){
…
}
```

return types

Note: Method parameters are its inputs and method returns are its outputs.

Return

- **return**: To send out a value as the result of a method.
  - The opposite of a parameter:
    - Parameters send information in from the caller to the method.
    - Return values send information out from a method to its caller.
      - A call to the method can be used as part of an expression.



Return

Non-void methods return a value that is the same type as the return type in the signature.

To use the return value when calling a non-void method, it must be stored in a variable or used as part of an expression.

Procedural abstraction allows a programmer to use a method by knowing what the method does even if they do not know how the method was written.

For example, the Math library, part of the java.lang package contains many useful mathematical methods. We may not know how these methods were implemented but we can still use them.

Common error: Not storing

Many students forget to store the result of a method call.

```
public static void main(String[] args) {
  Math.abs(-4); // error! Returned value not stored nor used
                        // (not a compiler/syntax error)
       // corrected
       int result = Math.abs(-4);
       System.out.println(result); // 4

       System.out.println("the square root of 4 is " +
Math.sqrt(4));
  // the square root of 4 is 2.0
}
```

returned value is concatenated with a string

NullPointerException

Using a null reference to call a method or access an instance variable causes a **NullPointerException** to be thrown.

```
public static void main(String[] args) {

       Sprite a = null; //currently the variable a references no
object
  a.display(); // NullPointerException, can't call method on
                      // a reference to nothing!
       System.out.println(a.center_x); // NullPointerException
}
```

Void Methods

Void methods do not have return values. Once the execution of the method completes, the flow of control returns to the point immediately following where the method was called.

```
public void methodName(type var1,…, type var2){
…
}
```

Examples:

```
public void method1(){
…
}
```

void

```
public void method2(int x){
…
}
```

Void Methods

Void methods do not have return values and are therefore not called as part of an expression.

```
public class MyClass{
        public static void main(String[] args){
                int a = 3 + printX(5); //error! Does not return!
                int b = 5 * twiceX(3); // correct, b = 30
                printX(5); // correct
                           // Output: The input x is 5
        }
        public static void printX(int x){
                System.out.println("The input x is" + x);
        }
        public static int twiceX(int x){
                return 2 * x;
        }
}
```

Overloaded Methods

Methods are said to be **overloaded** when there are multiple methods with the same name but a different signature.

Three methods named “add”.

```
public class MyClass{
        public static void main(String[] args){
                double a = add(1, 2) + add(1.8, 5.2) + add(1, 2, 3);
                System.out.println(a); // 16.0
        }
        public static int add(int x, int y){
                return x + y;
        }
        public static double add(double x, double y){
                return x + y;
        }
        public static int add(int x, int y, int z){
                return x + y + z;
        }
}
```

Value Semantics

Parameters are passed using **call by value or value semantics**. Call by value initializes the formal parameters with copies of the actual parameters.

When primitive variables (`int`, `double`,`boolean`) and String(the only object class that does this) are passed as parameters, **their values are copied.**

- Modifying the parameter will not affect the variable passed in.

```
public class MyClass{
        public static void main(String[] args){
                int x = 23;
            strange(x);
            System.out.println("2. x = " + x);
        }
        public static void strange(int x){
                x = x + 1;
            System.out.println("1. x = " + x);
}
```

The x variable in main is different than the x variable in strange.

Output:

```
1. x = 24
2. x = 23
```

Note: The value of x in main did not change.

Value semantics

Value semantics: methods cannot change the values of primitive types(`int`, `boolean`, `float`) and `String`.

```
public class MyClass{
        public static void main(String[] args){
                int x = 5;
                doubleMyNumber(x);
                System.out.println("My number is" + x); //My number is 5
        }
        public static void doubleMyNumber(int x){
                        x = x * 2;
        }
}
```

Note: The value of x in main did not change.

Find all errors.

```
public class MyClass{
        public static void main(String[] args){
                printX();
                add();
                add(3, 5);
                System.out.println(printX());
        System.out.println("3 + 5 = " + add(3, 5));
                int y = 3 + add(4, 6.0);
        }
        public static void printX(int x){
                System.out.println("The input x is" + x);
        }
        public static int add(int x, int y){
                return x + y;
        }
}
```

Answers

```
public class MyClass{
        public static void main(String[] args){
                printX(); // missing actual parameter.
                add(); // missing actual parameters.
                add(3, 5); // returned value not stored
                           // but not a syntax error.
                System.out.println(printX(5)); // error!
                                                //no returned value!
                System.out.println("3 + 5 = " + add(3, 5));//correct!
                int y = 3 + add(4, 6.0); // incompatible types!
        }
        public static void printX(int x){
                System.out.println("The input x is" + x);
        }
        public static int add(int x, int y){
                return x + y;
        }
}
```

Nonstatic vs Static

Let's do one example of a object class to understand when to make a method static vs. non-static.

```
class Student{
       int id;
       public Student(int new_id){
              id = new_id;
       }
       public void printMyID(){
              System.out.println("My ID is " + id);
       }
       public static void printWelcomeMessage(){
              System.out.println("Welcome all students!");
       }
}



}
```

printMyID is a non-static method and belong to individual student objects. E.g. if there are 5 student objects, there are 5 different copies of printMyID, one for each student.

Nonstatic vs Static

Let's do one example of a object class to understand when to make a method static vs. non-static.

```
class Student{
       int id;
       public Student(int new_id){
              id = new_id;
       }
       public void printMyID(){
              System.out.println("My ID is " + id);
       }
       public static void printWelcomeMessage(){
              System.out.println("Welcome all students!");
       }
}


}
```

printWelcomeMessage is a static(class) method. It belongs to the class rather than individual objects. If there are 5 student objects, there is only ONE shared printWelcomeMessage.

Nonstatic vs Static

Here's how we can use the Student class.

```
class DriverClass{
      public static void main(String[] args){
      // create a Student object
      Student s1 = new Student(12343);
      // call instance or non-static printMyID()
      s1.printMyID();
      // call static printWelcomeMessage()
      Student.printWelcomeMessage();
      // this also works but not considered
      // "best practice"
      s1.printWelcomeMessage();
      }
}
```

Lab

Create a new repl on repl.it.

Write a driver class with the following five **static** methods.

```
// given two integers x and y, returns their average.
public static double average(int x, int y)
{…}
```

```
// given two points (x1, y1) and (x2,y2), returns
// the slope of the line through them. You may assume
// x1 is not equal to x2.
public static double slope(int x1,int y1,int x2,int y2)
{…}
```

Lab

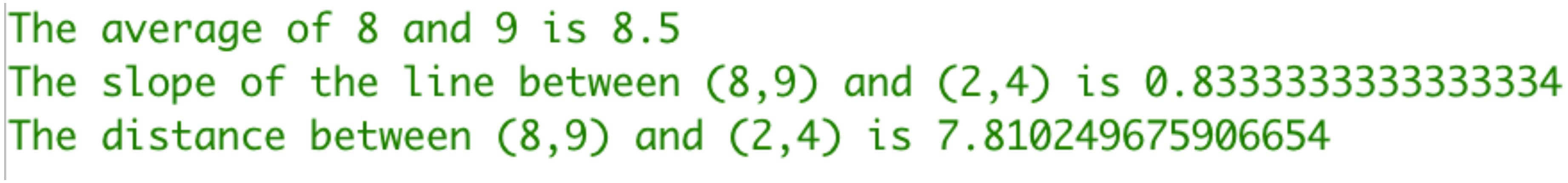
```
// given two integers x and y, returns the difference x-y
public static int difference(int x, int y)
{…}

// given an integer x returns its square x*x.
public static int square(int x)
{…}

// given two points on the plane, returns the distance between them.
// You MUST CALL the methods difference and square above.
// In addition, you CANNOT use subtraction nor multiplication in this method.
```

// distance = $\sqrt{(x1-x2)^2+(y1-y2)^2}$

```
public static double distance(int x1, int y1, int x2, int y2)
{…}
```

Lab

Write your main() method so that your program has an output similar to:



```
The average of 8 and 9 is 8.5
The slope of the line between (8,9) and (2,4) is 0.8333333333333334
The distance between (8,9) and (2,4) is 7.810249675906654
```

Notice the format of the points on the coordinate plane.

Lab 2

For this lab, please refer to optional lecture on **User Input** in Unit 2 on https://longbaonguyen.github.io/courses/apcsa/apjava.html

Create a new repl. Implement the driver class(Main.java on repl.it) to **ask the user to enter two different points(using a Scanner object)**on the plane and print out their midpoint and the distance between them.

For (x1, y1) and (x2, y2):

Midpoint: ((x1+x2)/2, (y1+y2)/2)

Lab 2

Write your program so that it has EXACTLY THE FOLLOWING OUTPUT.

Program Output: (underlined values are user-entered inputs)

```
Enter x1: 2
Enter y1: -1
Enter x2: 3
Enter y2: 5
The midpoint between (2,-1) and (3,5) is (2.5, 3.0)
The distance between (2,-1) and (3,5) is 6.082762530298219
```

Lab 2 Outline

I created a repl for this lab.

Click on the link below to go to the repl. Then "fork" it by either pressing on the "fork it" button or repl.it will fork it for you automatically if you begin editting the program.

Fill in the code as indicated by the comments.

https://repl.it/@LongNguyen18/userinputlab

References

1) CPJava Website
2) CPJava Google Classroom
3) CPJava repl.it Classroom
4) Runestone CSAwesome BUSHSCHOOL_CPJAVA Course
5) Building Java Programs: A Back to Basics Approach by Stuart Reges and Marty Stepp