Chapter 04 User-defined Methods

A method is a block of code that performs a specific task. The main advantage is code reusability. We can write a method once, and use it multiple times. Methods make code more readable and easier to debug.

In Java, there are two types of methods:

- **Standard Library Methods**: These are built-in methods in Java that are available to use. `print`() method of `System` class, `sqrt`() method of the `Math` class, etc.
- **User-defined Methods**: You can create your own method based on your requirements.

1. Defining a Method

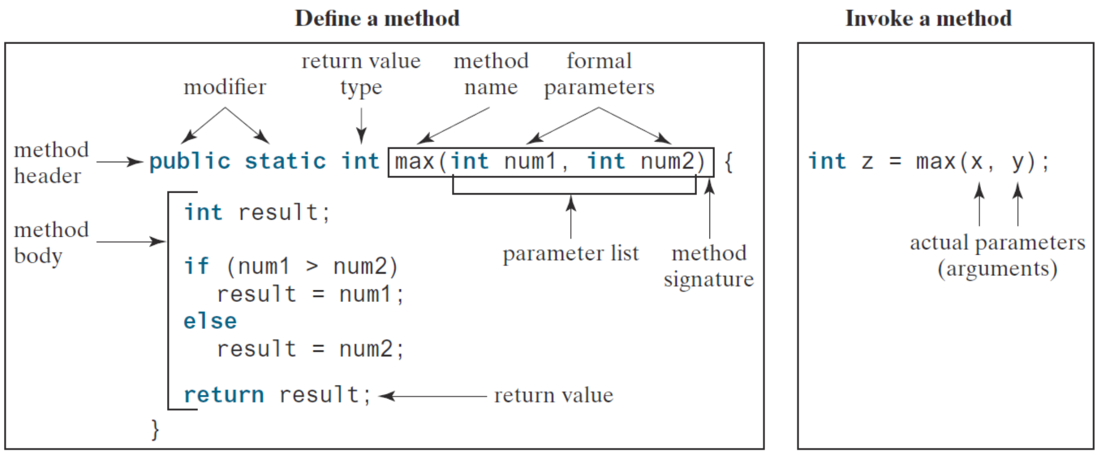
The syntax to define a method is:

```
modifier returnType methodName(parameter1, parameter2, ...) {
    // method body
}
```

Here,

- `returnType` - It specifies what type of value a method returns. For example, if a method has an `int` return type then it returns an integer value.
- If the method does not return a value, its return type is void.
- `methodName` - It is an identifier that is used to refer to the particular method in a program.
- `modifier` - It defines access types whether the method is `public`, `static`, and so on.
- `parameter1, parameter2` - These are values passed to a method. You can pass any number of arguments to a method.

Let's look at a method defined to find the larger between two integers. This method, named max, has two int parameters, `num1` and `num2`, the larger of which is returned by the method. Figure 6.1 illustrates the components of this method.



```
public static int max(int num1, int num2) {
    int result;

    if (num1 > num2)
      result = num1;
    else
      result = num2;

    return result;
}
```

```
int z = max(x, y);
```

FIGURE 6.1 A method definition consists of a method header and a method body.

Example 01: In this example, we create a method named addNumbers() which takes two parameters a and b and return sum.
Program.java

```
class Program {
    int addNumbers(int a, int b) {  // a and b are formal parameters
        int sum = a + b;

        return sum; // return statement
    }
    public static void main(String[] args) {
        int num1 = 25;
        int num2 = 15;

        // Create an object of Program
        Program obj = new Program();

        // Calling the method
        int result = obj.addNumbers(num1, num2); // num1 and num2 are actual
                                                 // parameters or arguments
        System.out.println("sum is " + result);
    }
}
```

Output

```
sum is 40
```

Here, we have called the method by passing two arguments num1 and num2. Since the method is returning some value, we have stored the value in the result variable.

Note that the method is not static. Hence, we are calling the method using an object of the Program class.

2. static Keyword

You can apply the static keyword with different objects like: variables, methods (excludes constructors), block and nested class.

An **instance variable** or **instance method** is a variable or method that belongs to an instance/object of a class, not to the class i.e., it requires an object of its class to be created before it can be called by the object.

In contrast, a static variable or static method belongs to a class not to any particular instance/object of the class. It can be accessed directly from the class, without having to create an object of the class. For example, the sqrt() method of standard Math class is static. Hence, you can directly call Math.sqrt() without creating an instance of Math class. If you access a static variable or static method through an object, the compiler will show the warning message.

2.1 Instance Methods Vs. `static` Methods

Instance methods are also called non-static methods. To call an instance method, you have to use an object of the class.

Example 02: Using instance method.

```
class Program {
    int getSquare(int x){
        return x * x;
    }
    public static void main(String[] args) {
        Program obj = new Program(); // create an object

        System.out.println("Square of 5 is: " + obj.getSquare(5));
    }
}
```

Output

```
sum is 40
```

`static` methods are also called class methods. You can call `static` methods directly using the class name.

Example 03: Using `static` method.

```
class Program {
    static int getSquare(int x){
        return x * x;
    }
    public static void main(String[] args) {
        System.out.println("Square of 5 is " + Program.getSquare(5));
        System.out.println("Square of 5 is " + getSquare(5));
    }
}
```

Output

```
Square of 5 is 25
```

When you are accessing a static member from another class, you have to use the class name to access it. However, if the static member is accessed from inside the class, it can be accessed directly; the class name becomes optional.

In every Java program, you have to declare the main method `static`. It is because to run the program, the JVM should be able to invoke the `main`() method during the initial phase where no objects exist in the memory.

2.2 Type of Variables

There are three types of variables: local, instance, and `static`.

2.2.1 Local Variables

Local variables are variables declared inside the body of the method. They are declared in methods, constructors, or blocks.

Local variables are created when the method, constructor or block is entered and the variable will be destroyed once it exits the method, constructor, or block. They are visible only within the declared method, constructor, or block.

Access modifiers cannot be used for local variables.

2.2.2 Instance Variables

Instance variables are also called **non-static variables**. To access an instance variable, you have to use an object of the class.

In Java, when you create objects of a class, every object will have its own copy of all the variables of the class.

Example 04: Using instance variables.

```java
class Program {
    int var = 10;

    public static void main(String[] args) {
        Program obj1 = new Program();
        Program obj2 = new Program();

        obj1.var = 20;

        System.out.println(obj1.var);
        System.out.println(obj2.var);
    }
}
```

Output

```
20
10
```

2.2.3 `static` Variables

`static` **variables** are also known as a **class variable**. If you declare a variable `static`, all objects of the class share the same `static` variable. It is because like `static` methods, `static` variables also belong to class not to any specific object of the class.

Example 05: Using `static` variables.

```java
class Program {
    static int var = 10;

    public static void main(String[] args) {
        Program obj1 = new Program();
        Program obj2 = new Program();

        Program.var = 20;

        System.out.println(obj1.var);  // Warning
        System.out.println(obj2.var);  // Warning
        System.out.println(Program.var);
    }
}
```

Output

```
20
20
20
```

`static` variables are created at the start of program execution and destroyed automatically when execution ends.

`static` variables are rarely used in Java. Instead, the static constants are used. These static constants are defined by `static final` keyword.

Example 06: User `static` constants.

```java
class Program {
    static final int var = 10;

    public static void main(String[] args) {
        //Program.var = 20; //Error

        System.out.println("var = " + Program.var);
    }
}
```

Output

```
var = 10
```

`static` variables cannot be declared within a method, constructor or within a block of code. It can be declared on the class level only.

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

        static int var = 10;  // Error
    }
}
```

3. Passing Parameters

There are basically two types of techniques for passing the parameters in some modern programming languages, they are **pass-by-value** and **pass-by-reference**. Basically, pass-by-value means that the actual value of the variable is passed, while pass-by-reference means the reference (address) is passed.

However, in Java, the pass by reference concept is degraded. It supports only the pass by value concept.

In the pass-by-value concept, the called method copies the value of actual parameters. Since the work is done on a copy, the original values are not affected by the changes.

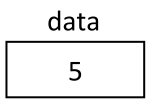
3.1 Primitive Type Vs. Reference Type

- Primitive Type: `boolean`, `char`, `byte`, `int`, `short`, `long`, `float`, `double`.
- Reference Type (or Non- primitive Type): `String`, `Arrays`, etc. Default value is `null`.

Let's see the difference:

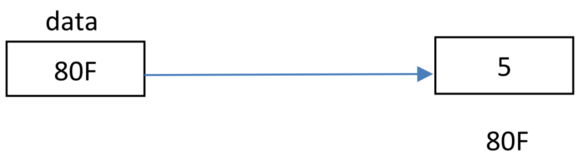
Example 1:

```
int data = 5       // The value of the data variable is 5
```



Example 2:

```
Integer data = 5   // The value of the data variable is an address (or reference)
                   // that references to 5
```



Java is pass by value, and it is not possible to pass primitive types by reference in Java.

Example 07: Passing by values in case of primitive types.

```
class Program {
    int data = 10;

    void change(int data){
        data = 50; //changes the local variable only
    }
    public static void main(String args[]){
        Program obj = new Program();

        System.out.println("Before change, data = "+ obj.data);

        obj.change(obj.data);
        System.out.println("After change, data = "+ obj.data);
    }
}
```

Output

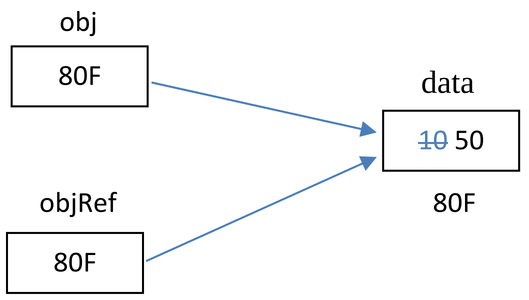
```
Before change, data = 10
After change, data = 10
```

Example 08: Passing by values in case of reference types.

```
class Program {
    int data = 10;

    void change(Program objRef){
        objRef.data = 50;
    }
    public static void main(String[] args) {
        Program obj = new Program();

        System.out.println("Before change, data = "+ obj.data);

        obj.change(obj);
        System.out.println("After change, data = "+ obj.data);
    }
}
```

Output

```
Before change, data = 10
After change, data = 50
```



So, in Java, parameters of primitive types are passed-by-value which is same as pass-by-value in some other languages, and parameters of reference types are also passed-by-value (the reference is copied) which is same as pass-by-reference in some other languages. So, in Java all parameters are passed by value only.

3.2 Immutable Classes

An object is known as immutable if its state cannot be changed after the object creation. Immutable Classes are needed because, in current days, most of the applications are running into multi-threading environment which results into concurrent modification problems.

Java provides immutable classes such as all wrapper classes (`Double`, `Float`, `Long`, `Integer`, `Short`, `Byte`, `Character`, `Boolean`), `String`, and more.

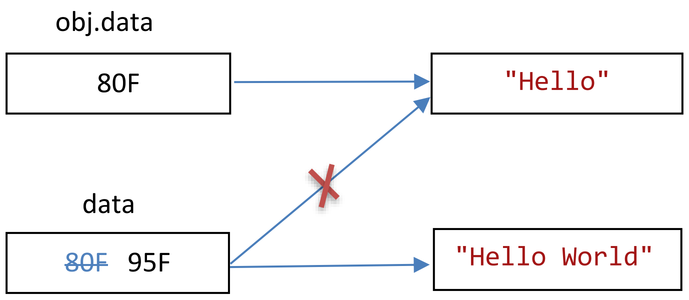
Example 09: Passing by values in case of `String`.

```
class Program {
    String data = "Hello";

    void change(String data){
        data = "Hello World";
    }
    public static void main(String args[]){
        Program obj = new Program();

        System.out.println("Before change, data = "+ obj.data);

        obj.change(obj.data);
        System.out.println("After change, data = "+ obj.data);
    }
}
```

Output

```
Before change, data = Hello
After change, data = Hello
```

`String` is a reference type, but it is immutable. The string object `data` in the `change` method at first pointed to the exact same string object `obj.data` as in the caller method, which is the `main` method. Then, the `data` in the `change` method changes its reference to a new string object `"Hello World"`. But nothing has happened to the `"Hello"` string object and `obj.data` is still referring to that.



4. Overloading Methods

Unlike C++ or Python, Java does not support assigning a default value to a method parameter. To simulate default parameters in Java, use of **method overloading**.

Two or more methods can have the same name inside the same class if they accept different arguments. This feature is known as **method overloading**.

To overload the methods, we can either change the number of arguments or change the data type of arguments.

It is not method overloading if we only change the return type of methods.

Example 10: Overloading by changing the number of parameters

```java
class Program {
    static void display(int a){
        System.out.println("Arguments: " + a);
    }
    static void display(int a, int b){
        System.out.println("Arguments: " + a + " and " + b);
    }
    public static void main(String[] args) {
        display(1);
        display(1, 2);
    }
}
```

Output:

```
Arguments: 1
Arguments: 1 and 2
```

Example 11: Method Overloading by changing the data type of parameters.

```java
class Program {
    static void display(int a){     // This method accepts int
        System.out.println("Got Integer value");
    }
    static void display(String a){  // This method accepts String object
        System.out.println("Got String value");
    }
    public static void main(String[] args) {
        display(1);
        display("Hello");
    }
}
```

Output

```
Got Integer value
Got String value
```

Here, both overloaded methods accept one argument. However, one accepts the argument of type int whereas other accepts String object.

5. The Scope of Variables

The scope of a variable is the part of the program where the variable can be referenced.

A variable defined inside a method is referred to as a local variable. The scope of a local variable starts from its declaration and continues to the end of the block that contains the variable. A local variable must be declared and **assigned a value** before it can be used.

A parameter is actually a local variable. The scope of a method parameter covers the entire method. A variable declared in the initial-action part of a for-loop header has its scope in the entire loop. However, a variable declared inside a for-loop body has its scope limited in the loop body from its declaration to the end of the block that contains the variable, as shown in Figure 6.5.

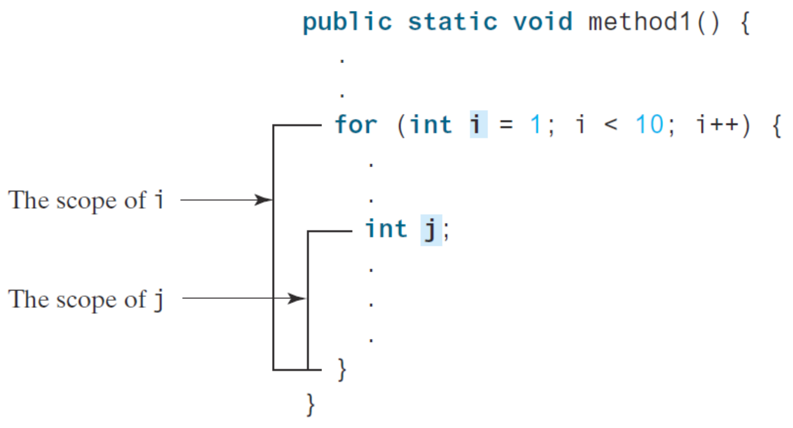
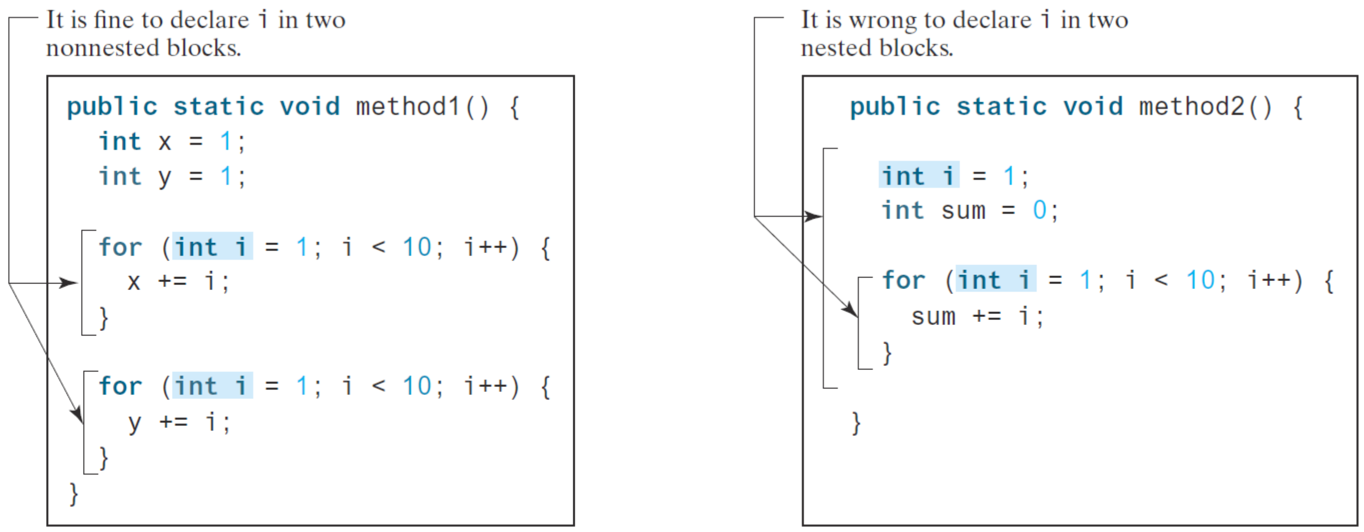

public static void method1() {
for (int i = 1; i < 10; i++) {
int j;
}
}
The scope of i
The scope of j

FIGURE 6.5 A variable declared in the initial-action part of a `for`-loop header has its scope in the entire loop.

You can declare a local variable with the same name in different blocks in a method, but you cannot declare a local variable twice in the same block or in nested blocks, as shown in Figure 6.6.


It is fine to declare i in two nonnested blocks.
It is wrong to declare i in two nested blocks.

```java
public static void method1() {
  int x = 1;
  int y = 1;

  for (int i = 1; i < 10; i++) {
    x += i;
  }

  for (int i = 1; i < 10; i++) {
    y += i;
  }
}
```

```java
public static void method2() {

  int i = 1;
  int sum = 0;

  for (int i = 1; i < 10; i++) {
    sum += i;
  }

}
```

FIGURE 6.6 A variable can be declared multiple times in nonnested blocks, but only once in nested blocks.

6. Arrays and Methods

6.1 Passing Arrays to Methods

Just as you can pass primitive type values to methods, you can also pass arrays to methods. When passing an array to a method, the reference of the array is passed to the method.

Example 12: The following method displays the elements in an integer array.

```java
class Program {
    static void printArray(int[] array) {
        for (int i = 0; i < array.length; i++) {
            System.out.print(array[i] + " ");
        }
    }
    public static void main(String[] args) {
        printArray(new int[]{3, 1, 2, 6, 4, 2});
    }
}
```

Output

```
3 1 2 6 4 2
```

Example 13: The following method updates the elements in an integer array.

```java
import java.util.Arrays;

class Program {
    static void updateArray(int[] array) {
        Arrays.fill(array, 8);
    }
    public static void main(String[] args) {
        int[] array = {3, 1, 2, 6, 4, 2};

        updateArray(array);

        System.out.print(Arrays.toString(array));
    }
}
```

Output

```
[8, 8, 8, 8, 8, 8]
```

Example 14: Passing 2D array to a method.

```java
import java.util.Arrays;

class Program {
    static void updateArray(int[][] array2D) {
        array2D[1][1] = 100;
    }
    public static void main(String[] args) {
        int[][] array2D = {
            {3, 1, 2, 6, 4, 2},
            {1, 6, 4, 2},
        };

        updateArray(array2D);

        System.out.print(Arrays.deepToString(array2D));
    }
}
```

Output

```
[[3, 1, 2, 6, 4, 2], [1, 100, 4, 2]]
```

6.2 Returning an Array from a Method

You can pass arrays when invoking a method. A method may also return an array. When a method returns an array, the reference of the array is returned.

Example 15: The following method returns an array that is the reversal of another array.

```
import java.util.Arrays;

class Program {
    static int[] reverse(int[] array) {
        int[] result = new int[array.length];

        for (int i = 0, j = result.length - 1; i < array.length; i++, j--) {
            result[j] = array[i];
        }
        return result;
    }
    public static void main(String[] args) {

        int[] array1 = {10, 25, 3, 15, 5, 60};
        int[] array2 = reverse(array1);

        System.out.print(Arrays.toString(array2));
    }
}
```

Output

```
[60, 5, 15, 3, 25, 10]
```

Example 16: Returning 2D array from a method.

```java
import java.util.Arrays;

class Program {
    static int[][] getUpdatedArray(int[][] array2D) {
        array2D[1][1] = 100;

        return array2D;
    }
    public static void main(String[] args) {
        int[][] array2D = {
            {3, 1, 2, 6, 4, 2},
            {1, 6, 4, 2},
        };

        //int[][] result = getUpdatedArray(array2D);

        int[][] result = new int[array2D.length][];
        result = getUpdatedArray(array2D);

        System.out.println(Arrays.deepToString(result));
    }
}
```

Output

```
[[3, 1, 2, 6, 4, 2], [1, 100, 4, 2]]
```

7. Variable-Length Argument Lists

A variable number of arguments of the same type can be passed to a method and treated as an array. The parameter in the method is declared as follows:

```java
dataType... parameterName
```

In the method declaration, you specify the type followed by an ellipsis (`...`). Only one variable-length parameter may be specified in a method, and this parameter must be the last parameter. Any regular parameters must precede it.

Java treats a variable-length parameter as an array. You can pass an array or a variable number of arguments to a variable-length parameter. When invoking a method with a variable number of arguments, Java creates an array and passes the arguments to it.

Example 17: The following method prints the maximum value in a list of an unspecified number of values.

```java
class Program {
    static void printMax(double... numbers) {
        if (numbers.length == 0) {
            System.out.println("No argument passed");

            return;
        }

        double result = numbers[0];

        for (int i = 1; i < numbers.length; i++)
            if (numbers[i] > result)
                result = numbers[i];

        System.out.println("The max value is " + result);
    }
    public static void main(String[] args) {
        printMax(34, 3, 3, 2, 56.5);
        printMax(new double[]{1, 2, 3});
    }
}
```

Output:

```
The max value is 56.5
The max value is 3.0
```

Exercises

In all of the following exercises, you are asked to write methods and test programs that call the methods to show that they work as intended. Note: you can create more methods per your needs.

1. *(Twin primes)* Twin primes are a pair of prime numbers that differ by 2. For example, 3 and 5 are twin primes, 5 and 7 are twin primes, and 11 and 13 are twin primes. Write a method called `diplayTwinPrimes` that displays all twin primes less than 1200. Here is a sample run:

```
The twin prime numbers which are less than 1200:
(3, 5)
(5, 7)
...
```

2. A palindrome is a word, number, or other sequence of characters which reads the same backward as forward. Write a method called `generatePalindromes` asks the user how many even palindromes they want, then returns an array that contains those palindromes. Write a test program as below:

```
Enter the number of even palindromes you want the program to generate: 10
0   2   4   6   8   22   44   66   88   202
```

3. *(Palindromic prime)* A palindromic prime is a prime number and also palindromic. For example, 131 is a prime and also a palindromic prime, as are 313 and 757. Write a method called `generatePalindromicPrimes` that displays the first 50 palindromic prime numbers. Display 10 numbers per line as follows:

```
2   3    5   7   11   101  131  151  181  191
313 353  373  383  727  757  787  797  919  929
…
```

4. *(Sort characters in a string ignore case)* Write a `static` method called `sort` that accepts a string, and returns a new ignore-case sorted string using the following header:

   ```
   public static String sort(String s)
   ```

   For example, `sort("acb")` returns `abc`.

   Write a test program that asks the user to enter a string and displays the sorted string.

5. Two words are anagrams if they contain the same letters in different orders, for example, *binary* and *brainy*. Write a method called `isAnagram` that takes two strings and returns `true` if they are anagrams, otherwise, returns `false`.

6. Write a method called `split` that will accept a sentence then split it into words, and returns an array of those words. Note: the input sentence might contain special characters, but words cannot. Also, you are not allowed to use the `split`() method from the `String` class.

7. Write a method called `removeSubstring` that will accept two strings named `substring` and `string`, then removes all the occurrences of the `substring` from the `string`.

8. *(Check Valid Password)* Some websites impose certain rules for passwords. Suppose the rules are:
   - A password must have exactly 8 characters.
   - A password must consist of only digits and letters.
   - A password must always start with a digit.
   - A password must contain at least one uppercase letter.

   Write a method called `checkValidPassword` that accepts a password and displays if the password entered is valid or invalid. If it is invalid, let the user know why.

9. Write a method called `displayLargest` that accepts **any number** of integers, then displays the largest number.

10. Write a method called `countOccurences` that accepts **any number** of integers, then counts the occurrences of each. Here is a sample run:

    ```
    The occurrences of each number in the array:
    2 occurs 2 times
    25 occurs 1 time
    6 occurs 1 time
    …
    ```

    Write the test program that randomly generates an array of 20 integers, then call the method.

11. Write a method called `verbose` that, given an integer number less than 10^9, returns the number in English. Example: `verbose`(987123456) will return nine hundred eighty-seven million, one hundred twenty-three thousand, four hundred fifty-six.

12. Write a method that takes in a 2D array of numbers and find the value of the **second largest** number stored in that array. Use the following header:

```
public static int secondLargest(int[][] array2D)
```

13. *(Shuffle rows)* Write a method that shuffles the rows in a 2D array of characters using the following header: `public static void shuffleRows(char[][] array2D)`

    Write a test program that shuffles the following matrix:

```
char[][] array2D = {
    {'A', 'A', 'A', 'A'},
    {'B', 'B', 'B', 'B'},
    {'B', 'B', 'B', 'B'},
    {'C', 'C', 'C', 'C'}
};
```

14. *(Shuffle columns)* Write a method that shuffles the colums in a 2D array of characters using the following header: `public static void shuffleColumns(char[][] array2D)`

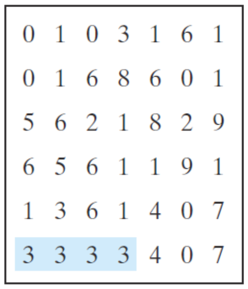
    Write a test program that shuffles the following matrix:

```
char[][] array2D = {
    {'A', 'B', 'C', 'D'},
    {'A', 'B', 'C', 'D'},
    {'A', 'B', 'C', 'D'},
    {'A', 'B', 'C', 'D'}
};
```

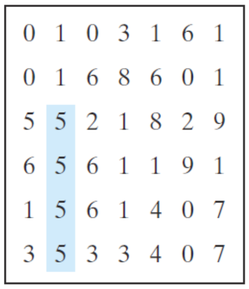
15. *(Pattern recognition: four consecutive equal numbers)* Write a method that checks whether a 2D array has four consecutive numbers of the same value, either horizontally, vertically, or diagonally. Use the following header:

```
public static boolean isConsecutiveFour(int[][] array2D)
```

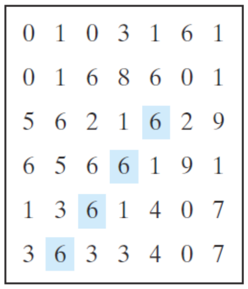
    Here are some examples of the true cases:



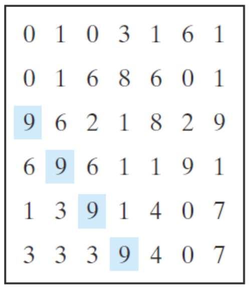
0	1	0	3	1	6	1
0	1	6	8	6	0	1
5	6	2	1	8	2	9
6	5	6	1	1	9	1
1	3	6	1	4	0	7
3	3	3	3	4	0	7



0	1	0	3	1	6	1
0	1	6	8	6	0	1
5	5	2	1	8	2	9
6	5	6	1	1	9	1
1	5	6	1	4	0	7
3	5	3	3	4	0	7



0	1	0	3	1	6	1
0	1	6	8	6	0	1
5	6	2	1	6	2	9
6	5	6	6	1	9	1
1	3	6	1	4	0	7
3	6	3	3	4	0	7



0	1	0	3	1	6	1
0	1	6	8	6	0	1
9	6	2	1	8	2	9
6	9	6	1	1	9	1
1	3	9	1	4	0	7
3	3	3	9	4	0	7

16. Write a **void** method called `removeInt` that will accept an integer, an array and the size of the array, then remove all the occurrences of the integer from the array. Write the test program to call the method. Then, in the test program, display the array. Note: you are **not allowed** to use a second array, and you **must** use the standard/static array.

17. Write a **void** method called `removeDupplicate` that will remove the duplicates from an integer array that is passed to it. Write the test program to call the method. Then, in the test program, display the array. Note: you are **not allowed** to use a second array, and you **must** use the standard/static array.

Reference

[1] Y. Daniel Liang. ‘Introduction to Java Programming’, 11e – 2019

[2] https://www.programiz.com/java-programming