Static Methods in Java

The Java construct for implementing functions is known as the *static method*. Don't worry too much about the keyword *static* just yet. We will circle back around to this concept once we dive into defining our classes as the context for this concept lies in the ownership of a feature, whether it belongs to an object or to a class. I know you want to begin functionally decomposing your programs, so I am introducing it here. We will also be talking in depth about the keyword *public.* For now, just understand that identifying a feature as public allows it to be available from *outside* the class in which it is defined.

Using and defining static methods.

The use of static methods is easy to understand. For example, when you write ***Math.abs(a-b)*** in a program, the effect is as if you were to replace that code with the *return value* that is produced by Java's Math.abs() method method when passed the expression a-b as an *argument*.
Type Conversion

Each primitive type in Java has an accompanying class type. Each of the classes has a variety of static methods (functions) that can be used to manipulate values. The *type casts* shown previously are one way to convert data between types, particularly a numeric type to a different numeric type. When performing a conversion from a String object to a numeric primitive the accepted way is to use one of the *parse* methods from the associated primitive classes. Let's take a look at the *Integer* class but understand that each primitive type (byte, char, short, int, long, float, double, boolean) has a corresponding class.

The Integer API spec:
https://docs.oracle.com/en/java/javase/13/docs/api/java.base/java/lang/Integer.html

Here is a brief snippet of the spec. Notice that there is a tab for *static methods.* These are methods that you can use *without creating an object.* That is the essence of the keyword *static.*

All Methods | Static Methods | Instance Methods | Concrete Methods

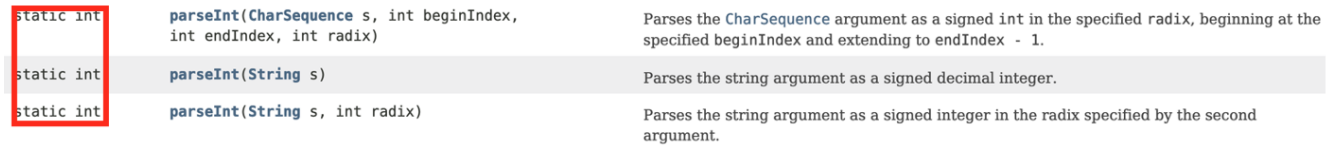
Modifier and Type	Method	Description
static int	bitCount(int i)	Returns the number of one-bits in the two's complement binary representation of the specified int value.
byte	byteValue()	Returns the value of this Integer as a byte after a narrowing primitive conversion.
static int	compare(int x, int y)	Compares two int values numerically.
int	compareTo(Integer anotherInteger)	Compares two Integer objects numerically.
static int	compareUnsigned(int x, int y)	Compares two int values numerically treating the values as unsigned.
static Integer	decode(String nm)	Decodes a String into an Integer.
Optional<Integer>	describeConstable()	Returns an Optional containing the nominal descriptor for this instance, which is the instance itself.

The Integer parse methods

The official definition of the term "parse" is: *to divide (a sentence) into grammatical parts and identify the parts and their relations to each other.* "Parsing" in the context of computer programming adds the idea of *conversion.* If you look at the parse methods in the Integer class, you will see three choices . . . all called *parseInt*. What distinguishes one method from another is the *method signature*. The signature of a method includes the number, type and order of the parameter variables.

static int	parseInt(CharSequence s, int beginIndex, int endIndex, int radix)	Parses the CharSequence argument as a signed int in the specified radix, beginning at the specified beginIndex and extending to endIndex - 1.
static int	parseInt(String s)	Parses the string argument as a signed decimal integer.
static int	parseInt(String s, int radix)	Parses the string argument as a signed integer in the radix specified by the second argument.

Notice that the methods are marked *static* and that they each ***return an int***. The static modifier means that ***you do not have to create an instance of the Integer class*** to be able to call this method. This is different from the String methods you used earlier that required a String object.



Here is a quick example using JShell

```
jshell> String n = "1234";
n ==> "1234"

jshell> int n_parsed = Integer.parseInt(n);
n_parsed ==> 1234
```

You can find documentation for each of the primitive wrapper classes in the Java API.

https://docs.oracle.com/en/java/javase/13/docs/api/java.base/java/lang/Double.html

https://docs.oracle.com/en/java/javase/13/docs/api/java.base/java/lang/Float.html

https://docs.oracle.com/en/java/javase/13/docs/api/java.base/java/lang/Character.html

https://docs.oracle.com/en/java/javase/13/docs/api/java.base/java/lang/Short.html

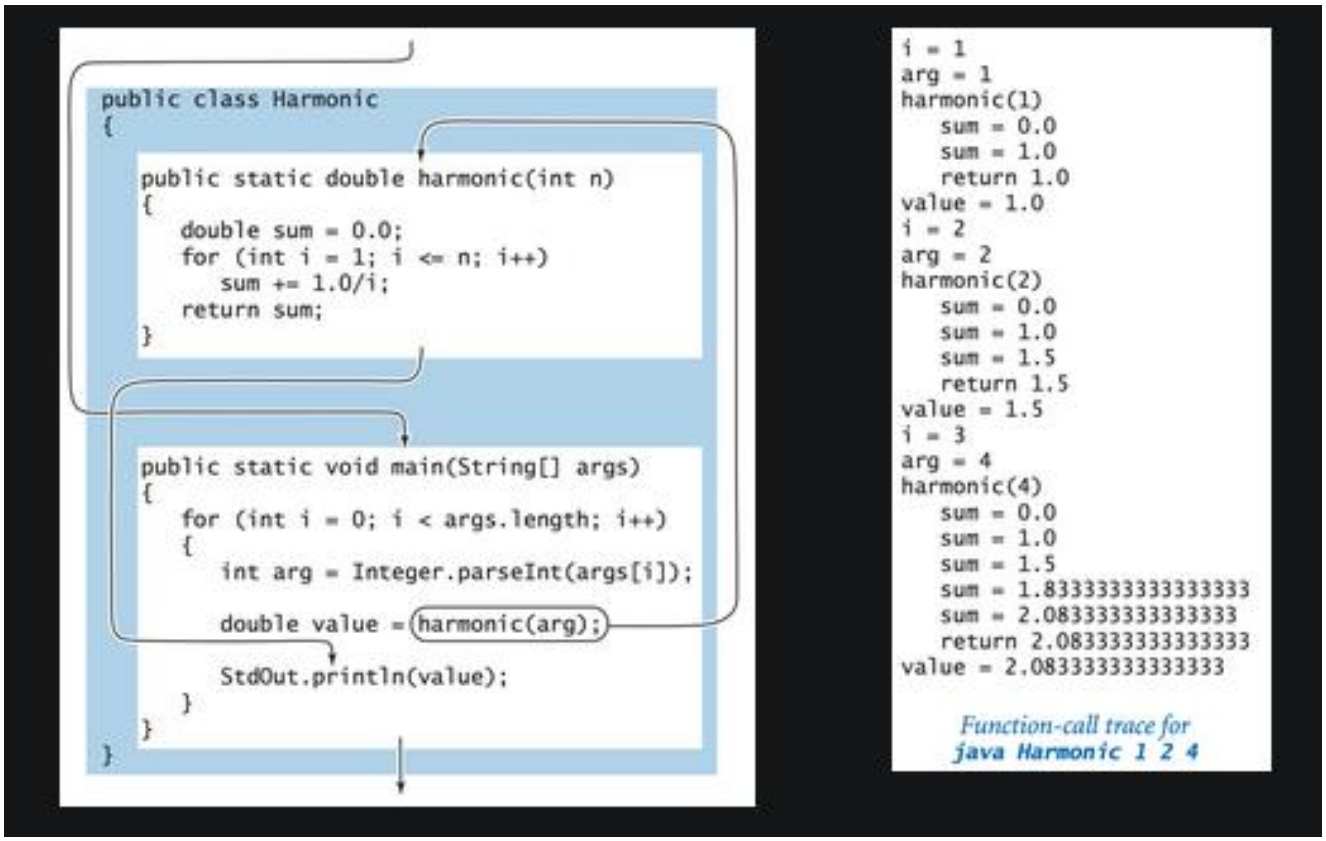
https://docs.oracle.com/en/java/javase/13/docs/api/java.base/java/lang/Byte.html

https://docs.oracle.com/en/java/javase/13/docs/api/java.base/java/lang/Boolean.html

https://docs.oracle.com/en/java/javase/13/docs/api/java.base/java/lang/Long.html

Defining static methods

In the screen shot below substitute System.out.println for StdOut. These examples use some helpers that we don't have.



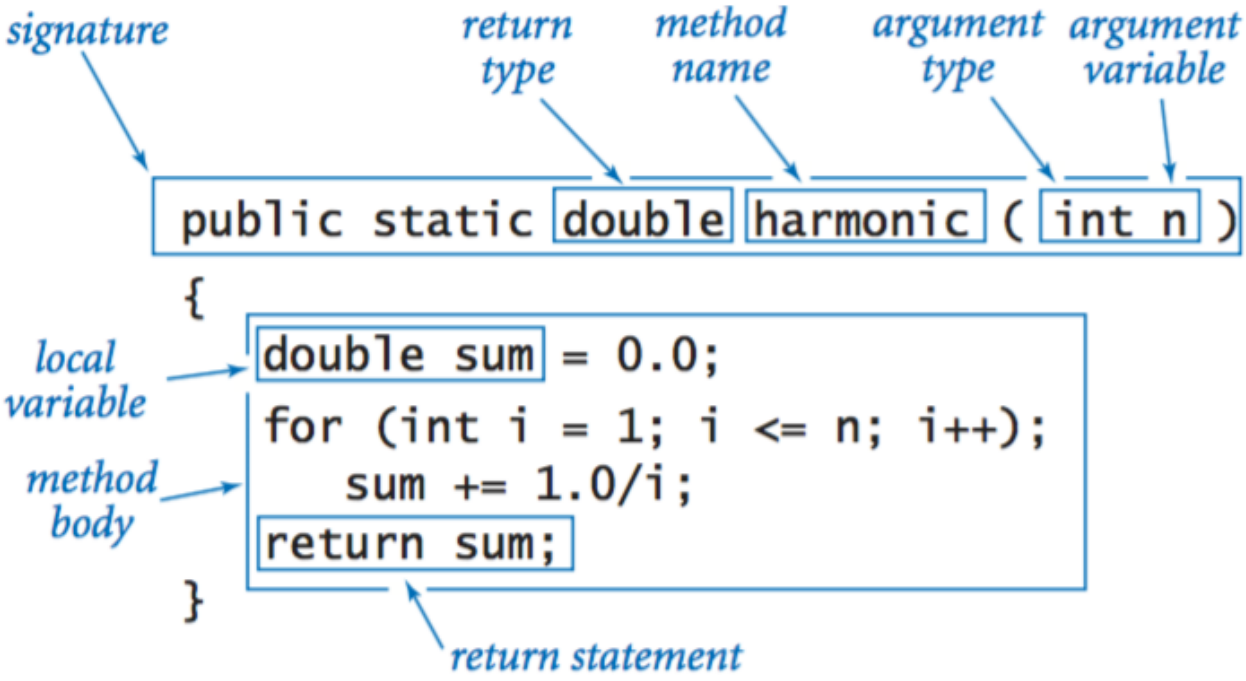
```
public class Harmonic
{
   public static double harmonic(int n)
   {
      double sum = 0.0;
      for (int i = 1; i <= n; i++)
         sum += 1.0/i;
      return sum;
   }

   public static void main(String[] args)
   {
      for (int i = 0; i < args.length; i++)
      {
         int arg = Integer.parseInt(args[i]);

         double value = harmonic(arg);

         StdOut.println(value);
      }
   }
}
```

```
i = 1
arg = 1
harmonic(1)
   sum = 0.0
   sum = 1.0
   return 1.0
value = 1.0
i = 2
arg = 2
harmonic(2)
   sum = 0.0
   sum = 1.0
   sum = 1.5
   return 1.5
value = 1.5
i = 3
arg = 4
harmonic(4)
   sum = 0.0
   sum = 1.0
   sum = 1.5
   sum = 1.8333333333333333
   sum = 2.083333333333333
   return 2.083333333333333
value = 2.083333333333333
```

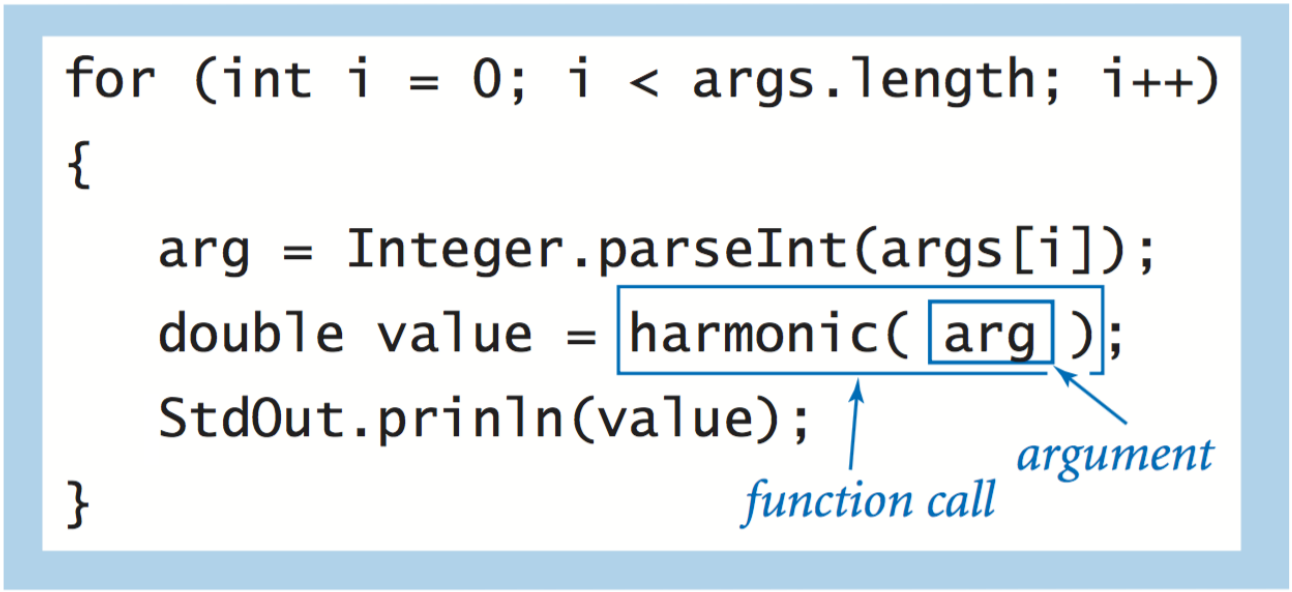
Function-call trace for
java Harmonic 1 2 4

Function-call trace. One simple approach to following the flow of control through function calls is to imagine that each function prints its name and argument value when it is called and its return value just before returning, with indentation added on calls and subtracted on returns.
Debugger. A better way to understand control flow through methods, loops and decision structures is to set break points and step through running code in debug mode.

Static method definition. The first line of a static method definition, known as the *signature*, gives a name to the method and to each *parameter variable*. It also specifies the *type* of each parameter variable and the *return type* of the method. Following the signature is the *body* of the method, enclosed in curly braces. The body consists of the kinds of statements we discussed in Chapter 1. It also can contain a *return statement*, which transfers control back to the point where the static method was called and returns the result of the computation or *return value*. The body may declare *local variables*, which are variables that are available only inside the method in which they are declared. Also understand that methods do not have to return anything. If the method does not compute a new value that needs to be made available to the calling area of the program, it can simply not return anything. Such a method is called a *void method* and will have a return type of *void.*



Function calls. A static method call is nothing more than the method name followed by its arguments, separated by commas and enclosed in parentheses. A method call is an expression, so you can use it to build up more complicated expressions. Similarly, an argument is an expression—Java evaluates the expression and passes the resulting value to the method. So, you can write code like Math.exp(-x*x/2) / Math.sqrt(2*Math.PI) and Java knows what you mean.



Properties of static methods.

Multiple arguments. Like a mathematical function, a Java static method can accept more than one argument, and therefore can have more than one parameter variable.

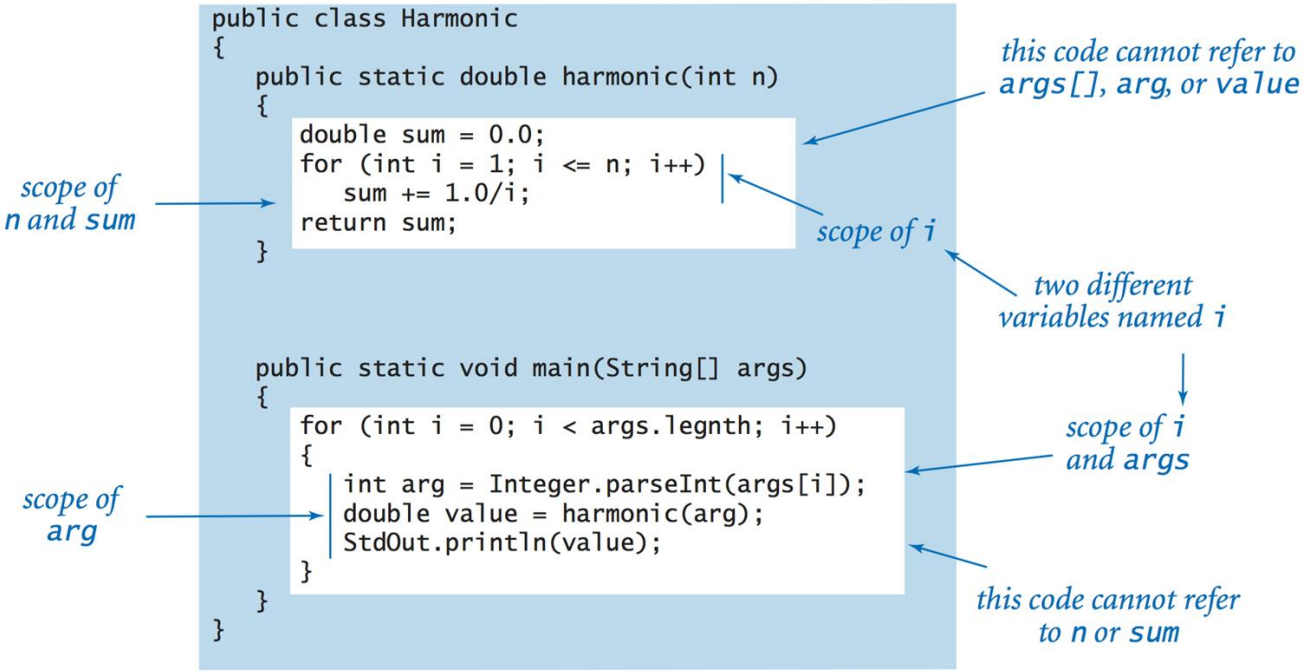
Multiple methods. You can define as many static methods as you want in a .java file. These methods are independent and can appear in any order in the file. A static method can call any other static method in the same file or any static method in a Java library such as Math.

Overloading. Static methods with different signatures are different methods. whose signatures differ are different static methods. Using the same name for two static methods whose signatures differ is known as *overloading*.

Multiple return statements. You can put return statements in a method wherever you need them: control goes back to the calling program as soon as the first return statement is reached.

Single return value. A Java method provides only one return value to the caller, of the type declared in the method signature. If you need to return more than one value you will have to return some sort of Collection like an array, an array list of some sort of composite object type.

Scope. The *scope* of a variable is the part of the program that can refer to that variable by name. The general rule in Java is that the scope of the variables declared in a block of statements is limited to the statements in that block. In particular, the scope of a variable declared in a static method is limited to that method's body. Therefore, you cannot refer to a variable in one static method that is declared in another.



Side effects. A *pure function* is a function that, given the same arguments, always returns the same value, without producing any observable *side effects*, such as consuming input, producing output, or otherwise changing the state of the system. The function harmonic() is an example of a pure function. However, in computer programming, we often define functions whose *only* purpose is to produce side effects. In Java, a static method may use the keyword void as its return type, to indicate that it has no return value.

Using static methods to organize code.

With the ability to define functions, we can better organize our programs by defining functions within them when appropriate. Check the file ***CouponCollector.java*** to study a program broken into static methods.

Given *n*, compute a random coupon value.
Given *n*, do the coupon collection experiment.
Get *n* from the command line, and then compute and print the result.

```
16  public class Coupon {
17
18      // return a random coupon between 0 and n-1
19      public static int getCoupon(int n) {
20          return (int) (Math.random() * n);
21      }
22
23      // return number of cards you collect before obtaining one of each of the n types
24      public static int collect(int n) {
25          boolean[] isCollected = new boolean[n];  // isCollected[i] = true if card type i already collected
26          int count = 0;                           // number of cards collected
27          int distinct  = 0;                       // number of distinct card types collected
28
29          // repeat until you've collected all n card types
30          while (distinct < n) {
31              int value = getCoupon(n);            // pick a random card
32              count++;                             // one more card
33              if (!isCollected[value]) {           // discovered a new card type
34                  distinct++;
35                  isCollected[value] = true;
36              }
37          }
38          return count;
39      }
40
41      // test client
42      public static void main(String[] args) {
43          int n = Integer.parseInt(args[0]);
44          int count = collect(n);
45          System.out.println(count);
46      }
47  }
```

Whenever you can clearly separate tasks in programs, you should do so.

Passing arguments and returning values.

Next, we examine the specifics of Java's mechanisms for passing arguments to and returning values from functions. Study the file ***ArrayFunctionExamples.java*** to see illustrations of the following concepts.

Pass by value. You can use parameter variables anywhere in the body of the function; the same way you use local variables. The only difference between a parameter variable and a local variable is that Java evaluates the argument provided by the calling code and initializes the parameter variable with the resulting value. This approach is known as ***pass by value.***

Arrays as arguments. When a method takes an array as an argument, it implements a function that operates on an arbitrary number of values of the same type. Methods that accept arrays as arguments can modify the ***original array*** because it is the address of the array (reference) that is passed into the method. The array itself is not copied, the method is simply provided with the location in memory of the array, essentially granting the method permission to modify.

Side effects with arrays. It is often the case that the purpose of a static method that takes an array as argument is to produce a side effect (change values of array elements). Methods that produce side effects on arrays are often ***void*** as the array itself is modified.

Arrays as return values. A method can also provide an array as a return value.

See the examples provided in the accompanying file.