AP Computer Science A

Java Programming Essentials [Ver.4.0]

Unit 3: Class Creation

CHAPTER 10: METHOD AND TESTING

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AP Computer Science Curriculum

- Methods: How to Write Them? (T3.5)
- Methods: Passing and Returning, References of an Object (T3.6)
- Scope and Access (T3.8)

Objectives:

- Features for basic functions.
- Method as class function or instance function.
- Calling Method, Parameters, Return Values, and Activation Records
- Procedural Abstraction
- Overloading

Function

Lecture 1

Functions

- Functions are "self contained" modules of code that accomplish a specific task. Functions usually "take in" data, process it, and "return" a result. Once a function is written, it can be used over and over and over again. Functions can be "called" from the inside of other functions.

Why do we Write Functions?

1. They allow us to conceive of our program as a bunch of sub-steps. (Each sub-step can be its own function. When any program seems too hard, just break the overall program into sub-steps!)
2. They allow us to reuse code instead of rewriting it.
3. Functions allow us to keep our variable namespace clean (local variables only "live" as long as the function does). In other words, function_1 can use a variable called i, and function_2 can also use a variable called i and there is no confusion. Each variable i only exists when the computer is executing the given function.
4. Functions allow us to test small parts of our program in isolation from the rest. This is especially true in interpreted languages, such as Matlab, but can be useful in C, Java, ActionScript, etc.

Steps to Writing a Function

1. Understand the purpose of the function.
2. Define the data that comes into the function from the caller (in the form of parameters)!
3. Define what data variables are needed inside the function to accomplish its goal.
4. Decide on the set of steps that the program will use to accomplish this goal. (The Algorithm)

Functional Abstraction

- A function is a named subprogram that performs a specific task when it is called.
- The function’s specification is a description of what the function does.
- Functions use a parameter list for data flow from the caller to the function and from the function to the caller.

Scope and Lifetime of Variables

- The scope of a variable defines the section of the code in which the variable is visible. As a general rule, variables that are defined within a block are not accessible outside that block.
- The lifetime of a variable refers to how long the variable exists before it is destroyed. Destroying variables refers to deallocating the memory that was allotted to the variables when declaring it. We have written a few classes till now.
- You might have observed that not all variables are the same. The ones declared in the body of a method were different from those that were declared in the class itself. There are there types of variables: instance variables, formal parameters or local variables and local variables.

Formal and Actual Parameters

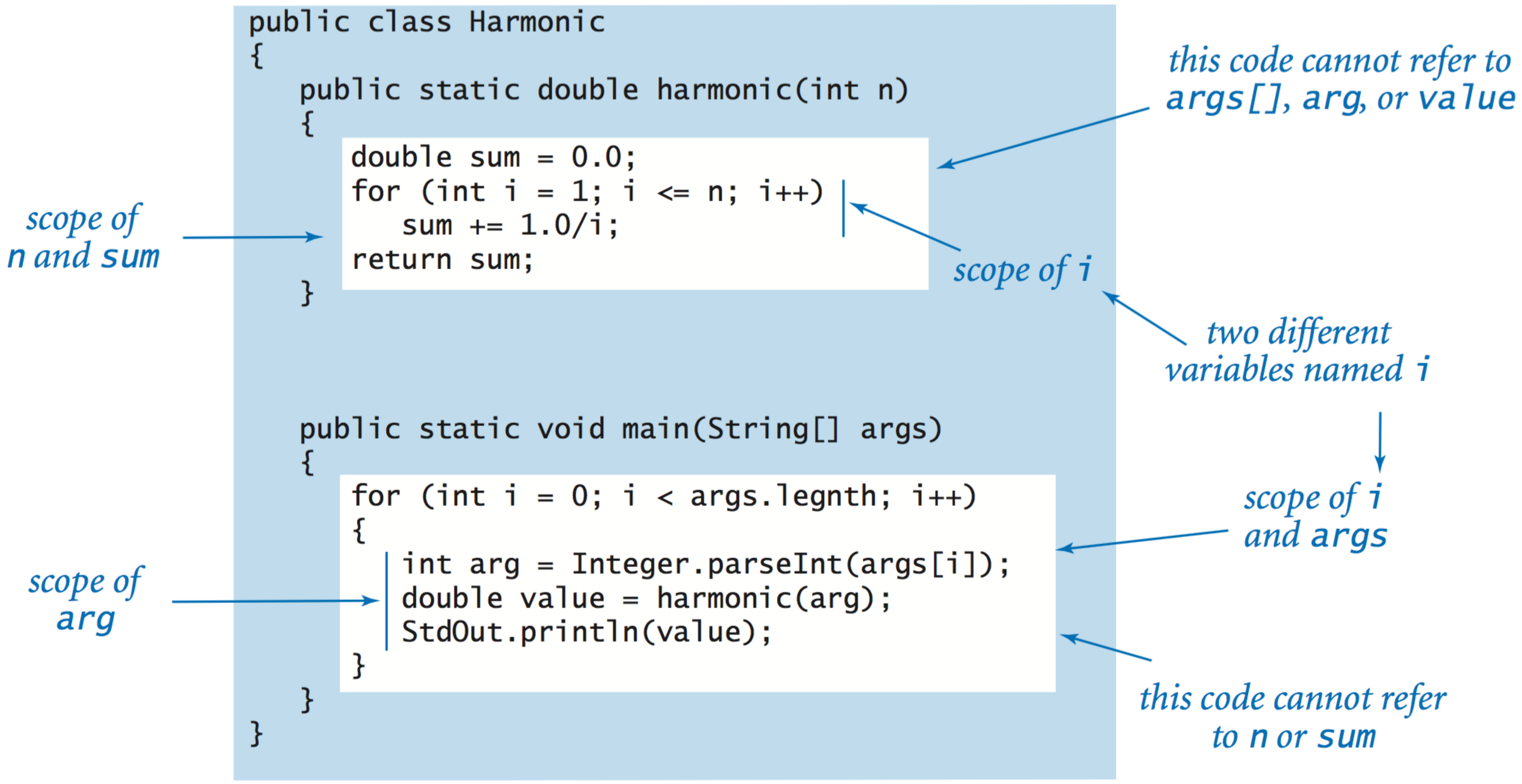
- An **identifier** is a name used for a class, a variable, a method, or a parameter. The following definitions are useful:
  - **formal parameter** — the identifier used in a method to stand for the value that is passed into the method by a caller.
    - For example, amount is a formal parameter of processDeposit
  - **actual parameter** — the actual value that is passed into the method by a caller.
    - For example, the 200 used when processDeposit is called is an actual parameter.
    - actual parameters are often called **arguments**

Return statement

- In programming, return is a statement that tells the program to leave the subroutine and return to the return address, directly after where the subroutine was called.
- In most programming languages, the return statement is either return or return value, where value is a variable or other information coming back from the subroutine. Below is an example of how the return statement could be used in the Perl programming language.

Function and Method

- A **function** is a piece of code that is called by name. It can be passed data to operate on (i.e. the parameters) and can optionally return data (the return value). All data that is passed to a function is explicitly passed.
- A **method** is a piece of code that is called by a name that is associated with an object. In most respects it is identical to a function except for two key differences:
  1. A method is implicitly passed the object on which it was called.
  2. A method is able to operate on data that is contained within the class (remembering that an object is an instance of a class - the class is the definition, the object is an instance of that data).


this code cannot refer to args[], arg, or value
scope of n and sum
scope of i
two different variables named i
scope of i and args
scope of arg
this code cannot refer to n or sum

```
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.legnth; i++)
      {
         int arg = Integer.parseInt(args[i]);
         double value = harmonic(arg);
         StdOut.println(value);
      }
   }
}
```

Method

Lecture 2

Opening Problem: Code Reusability

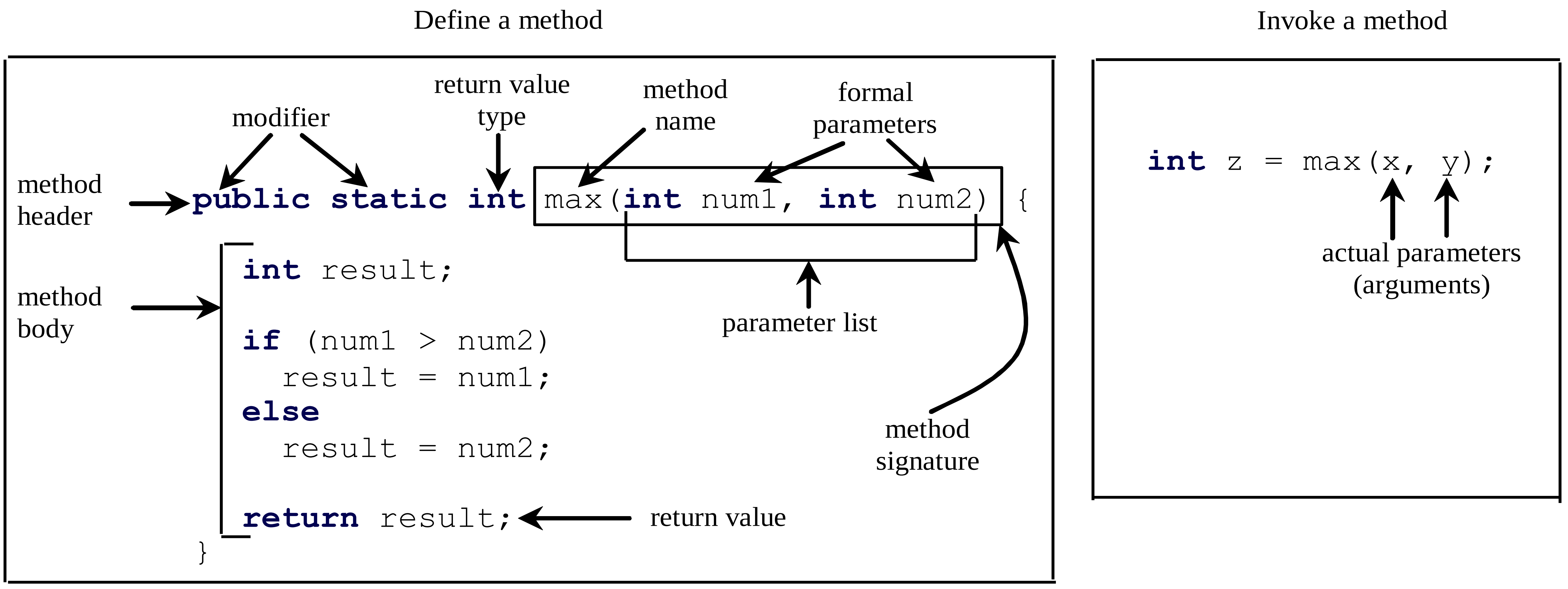
Find the sum of integers from 1 to 10, from 20 to 37, and from 35 to 49, respectively.

```
int sum = 0;     /* redundancy */
for (int i = 1; i <= 10; i++)
  sum += i;
System.out.println("Sum from 1 to 10 is " + sum);

sum = 0;         /* redundancy */
for (int i = 20; i <= 37; i++)
  sum += i;
System.out.println("Sum from 20 to 37 is " + sum);

sum = 0;         /* redundancy */
for (int i = 35; i <= 49; i++)
  sum += i;
System.out.println("Sum from 35 to 49 is " + sum);
```

```
public static int sum(int i1, int i2) {
  int result = 0;
  for (int i = i1; i <= i2; i++)
    result += i;
  return result;
}

public static void main(String[] args) {
  System.out.println("Sum from 1 to 10 is " + sum(1, 10));
  System.out.println("Sum from 20 to 37 is " + sum(20,
37));
  System.out.println("Sum from 35 to 49 is " + sum(35,
49));
}
```

Defining Methods

A method is a collection of statements that are grouped together to perform an operation.

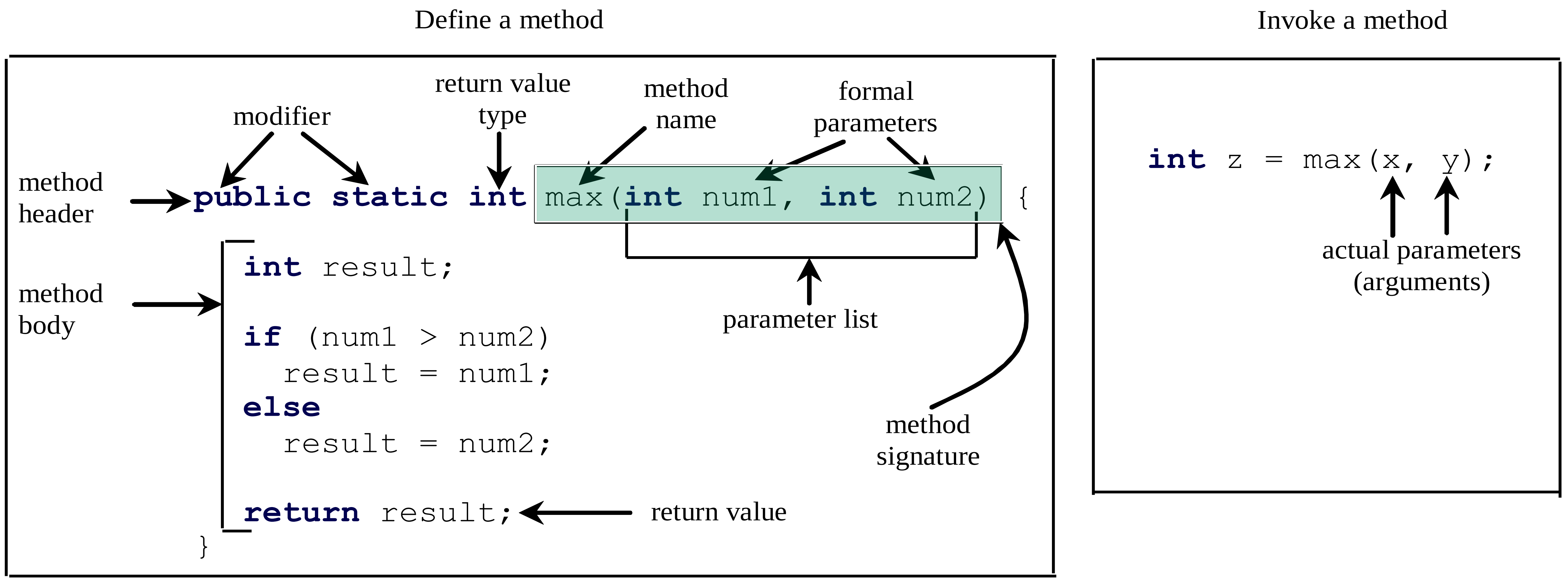


```
public static int max(int num1, int num2) {
    int result;

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

    return result;
}
```

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

Method Signature

Method signature is the combination of the method name and the parameter list.



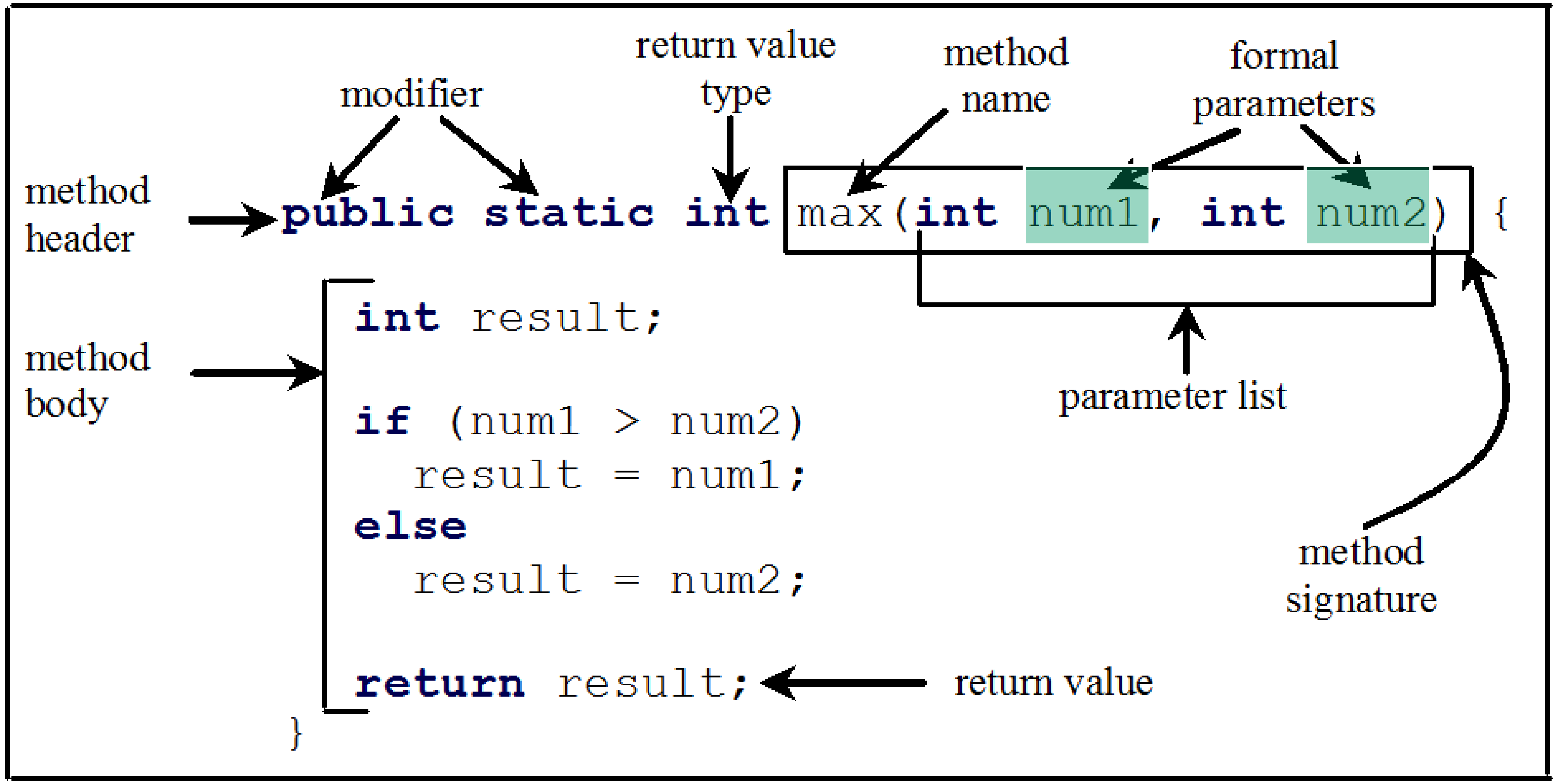
```
public static int max(int num1, int num2) {
    int result;

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

    return result;
}
```

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

Formal Parameters

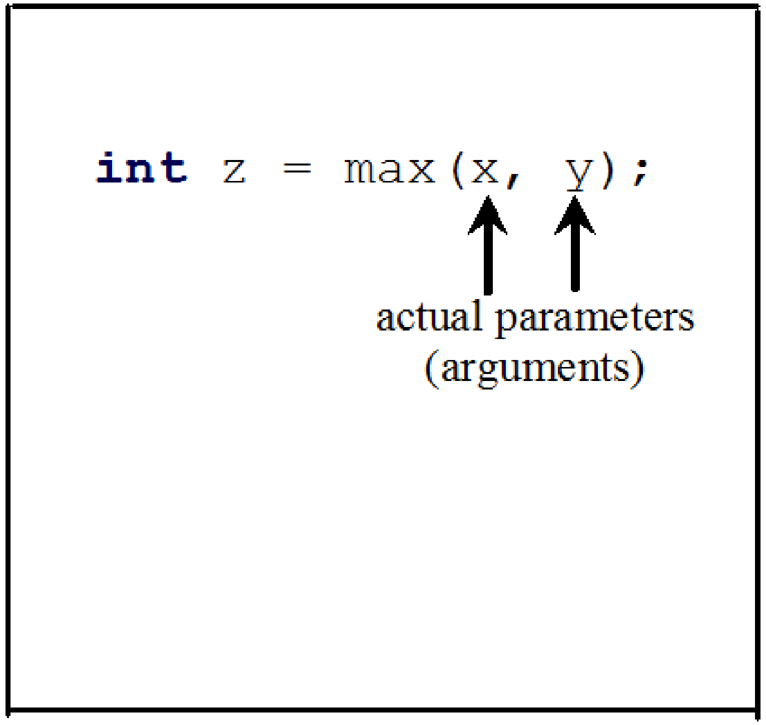
The variables defined in the method header are known as *formal parameters*.

Define a method



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

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

    return result;
}
```

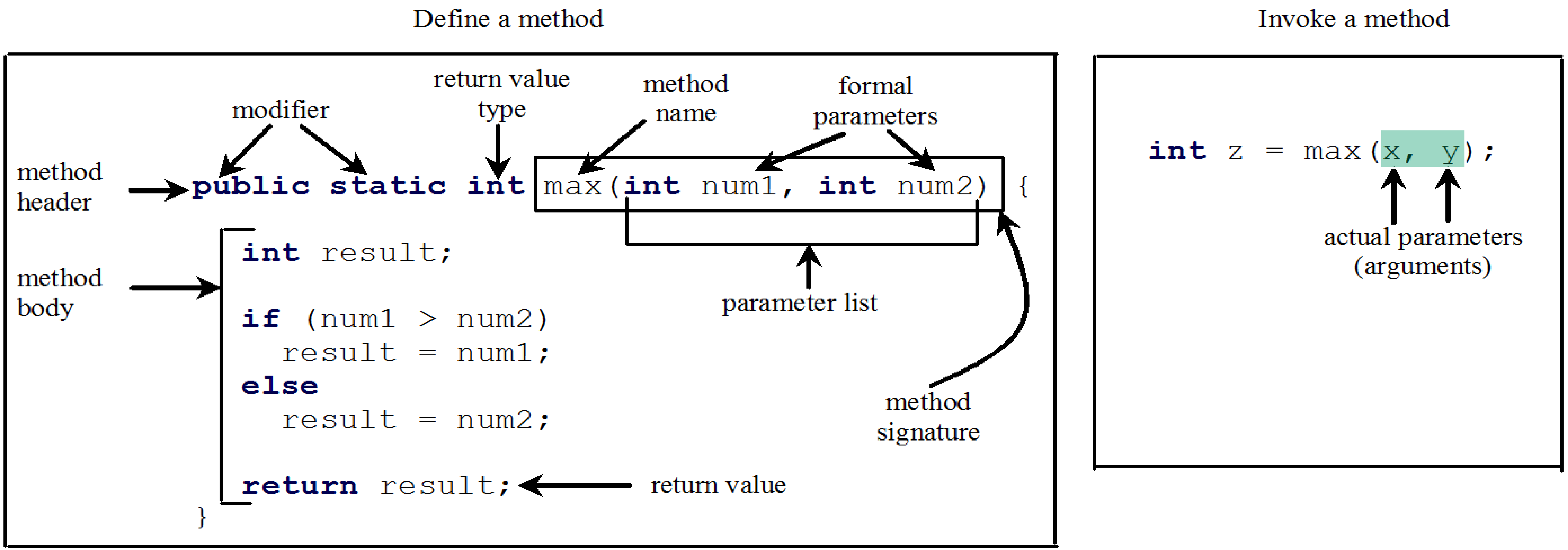
Invoke a method



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

Actual Parameters

When a method is invoked, you pass a value to the parameter. This value is referred to as *actual parameter or argument*.

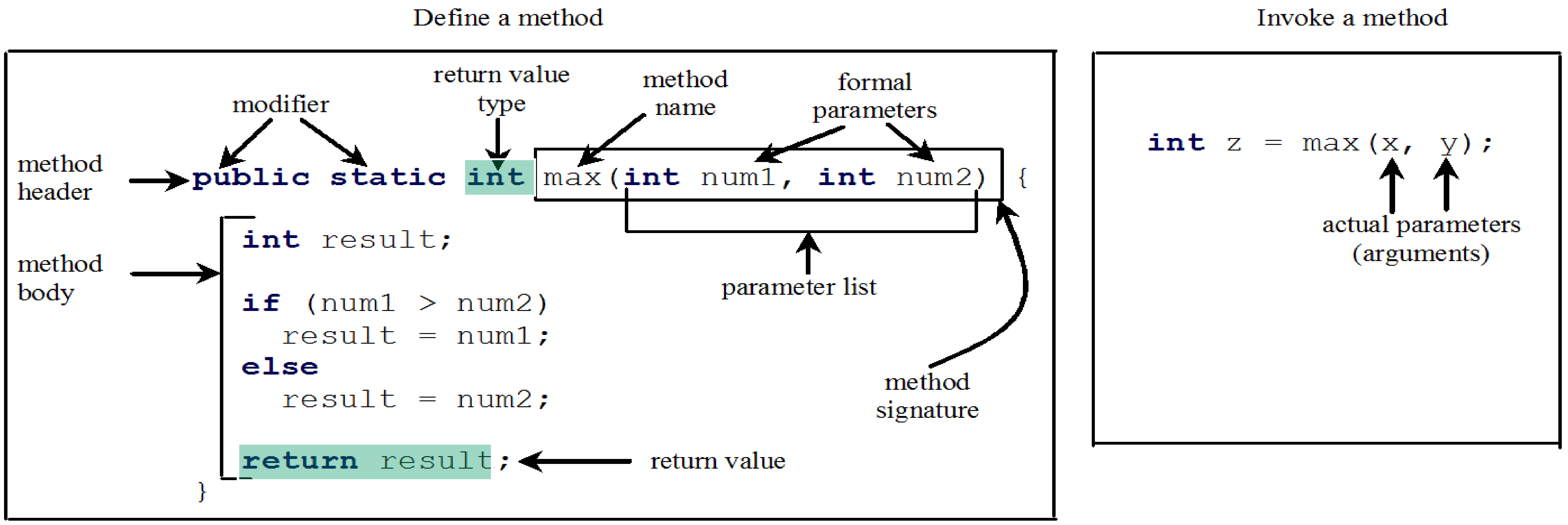


```
public static int max(int num1, int num2) {
    int result;

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

    return result;
}
```

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

Return Value Type

A method may return a value. The returnValueType is the data type of the value the method returns. If the method does not return a value, the returnValueType is the keyword void. For example, the returnValueType in the main method is void.

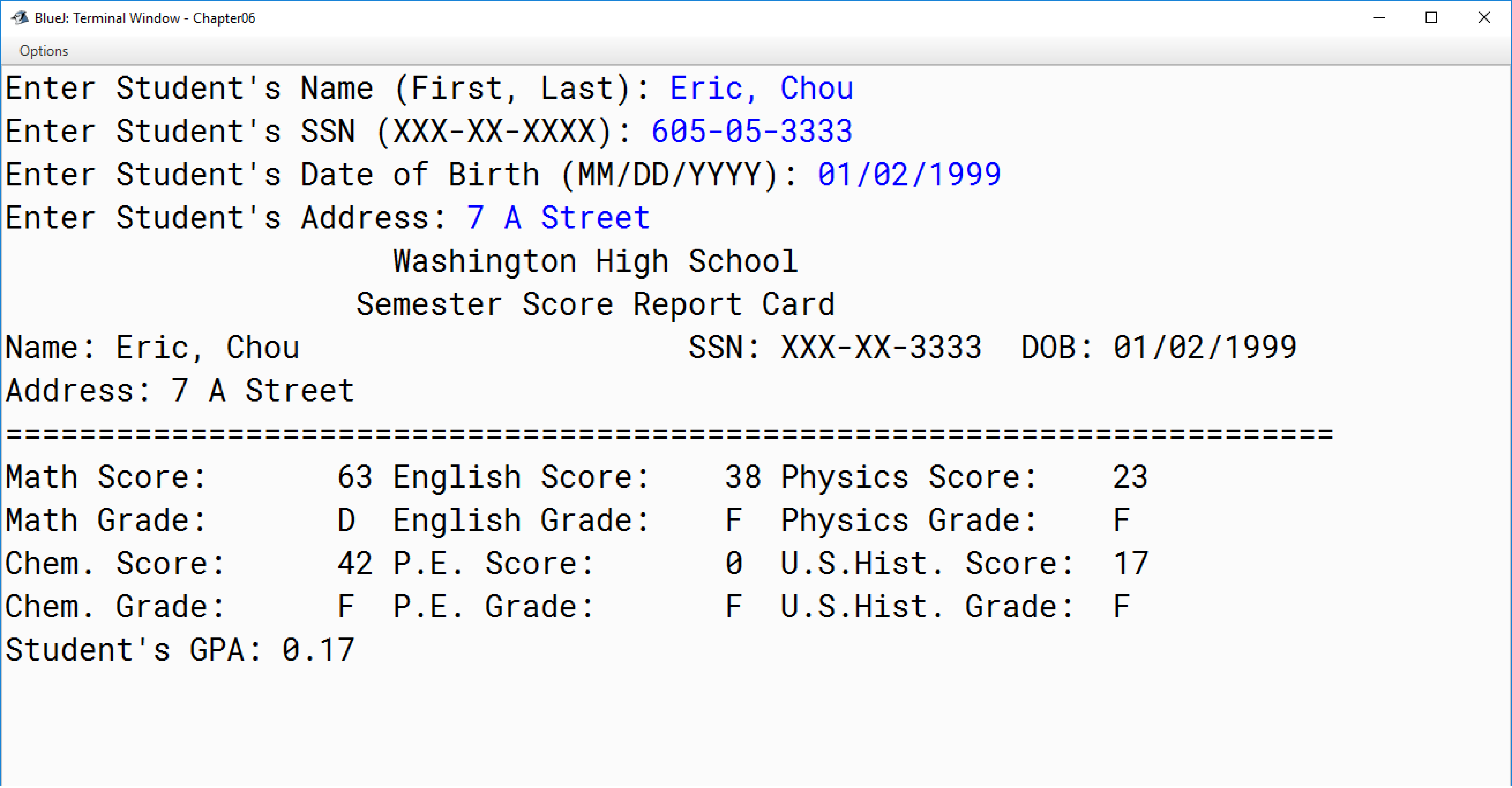


```
public static int max(int num1, int num2) {
    int result;

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

    return result;
}
```

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

Demonstration Program

StudentGPAMethod.java


BlueJ: Terminal Window - Chapter06

```
Enter Student's Name (First, Last): Eric, Chou
Enter Student's SSN (XXX-XX-XXXX): 605-05-3333
Enter Student's Date of Birth (MM/DD/YYYY): 01/02/1999
Enter Student's Address: 7 A Street
                     Washington High School
                   Semester Score Report Card
Name: Eric, Chou                     SSN: XXX-XX-3333  DOB: 01/02/1999
Address: 7 A Street
========================================================================
Math Score:      63 English Score:    38 Physics Score:    23
Math Grade:      D  English Grade:    F  Physics Grade:    F
Chem. Score:     42 P.E. Score:       0  U.S.Hist. Score:  17
Chem. Grade:     F  P.E. Grade:       F  U.S.Hist. Grade:  F
Student's GPA: 0.17
```

Calling a Method

Lecture 3

Similarity between Mathematical Function and Java Methods

Mathematical function:

$y = f(x) = x^2 + x + 1$

*x: independent variable over **domain***

y: dependent variable over field

Use of function:

$y = f(3) = 3^2 + 3 + 1$

Java Method:

```
public double f(double x){
  double y = x * x + x + 1;
  return y;
}
```

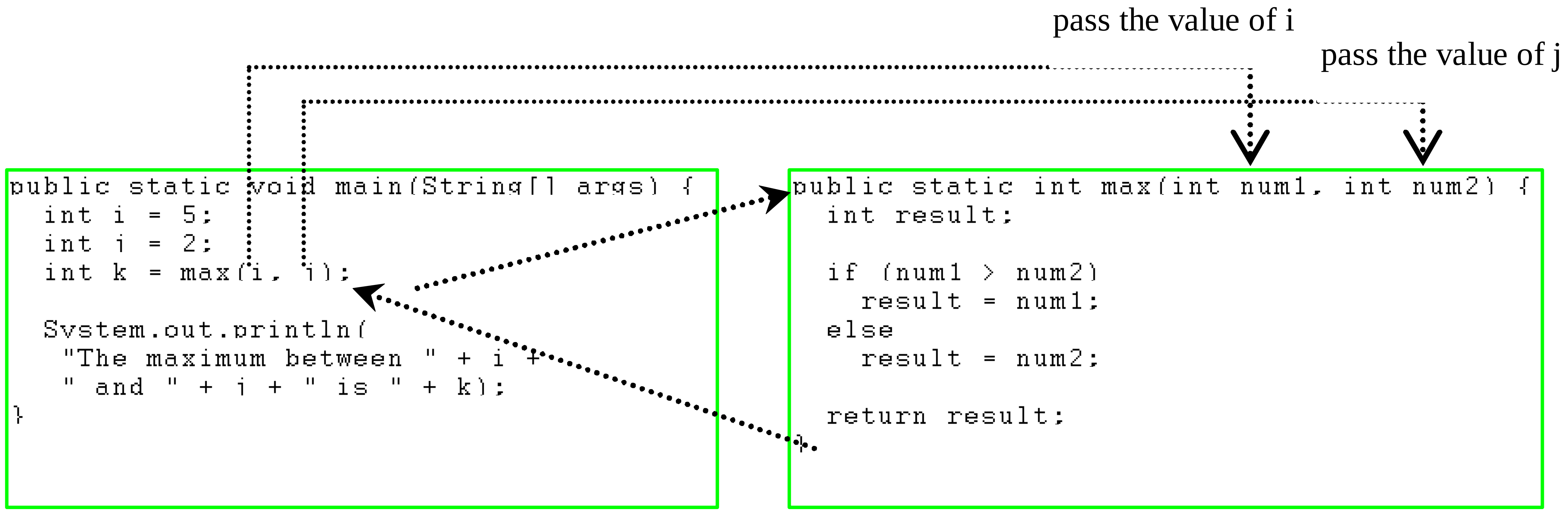
Calling f(x):

```
  y = f(3);  // one sample point.
```

Calling Methods

- Testing the max method
- This lecture illustrates calling a method max to return the largest of the int values.

Calling Methods, cont.



```
public static void main(String[] args) {
  int i = 5;
  int j = 2;
  int k = max(i, j);

  System.out.println(
   "The maximum between " + i +
   " and " + j + " is " + k);
}
```

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

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

  return result;
}
```

Trace Method Invocation

i is now 5

```
public static void main(String[] args) {
  int i = 5;
  int j = 2;
  int k = max(i, j);

  System.out.println(
   "The maximum between " + i +
   " and " + j + " is " + k);
}
```

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

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

  return result;
}
```

Trace Method Invocation

j is now 2

```
public static void main(Strin  ] args) {
  int i = 5;
  int j = 2;
  int k = max(i, j);

  System.out.println(
   "The maximum between " + i +
   " and " + j + " is " + k);
}
```

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

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

  return result;
}
```

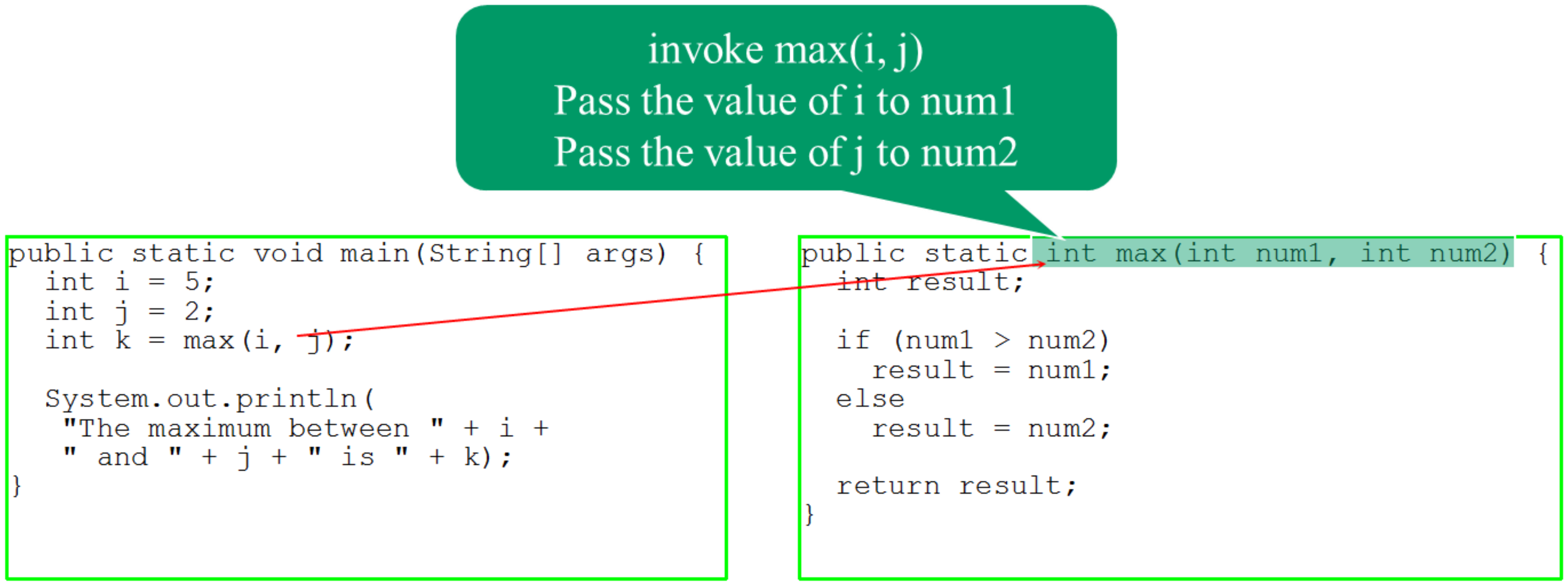
Trace Method Invocation

invoke max(i, j)

```
public static void main(Strin      args)  {
  int i = 5;
  int j = 2;
  int k = max(i, j);

  System.out.println(
   "The maximum between " + i +
   " and " + j + " is " + k);
}
```

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

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

  return result;
}
```

Trace Method Invocation

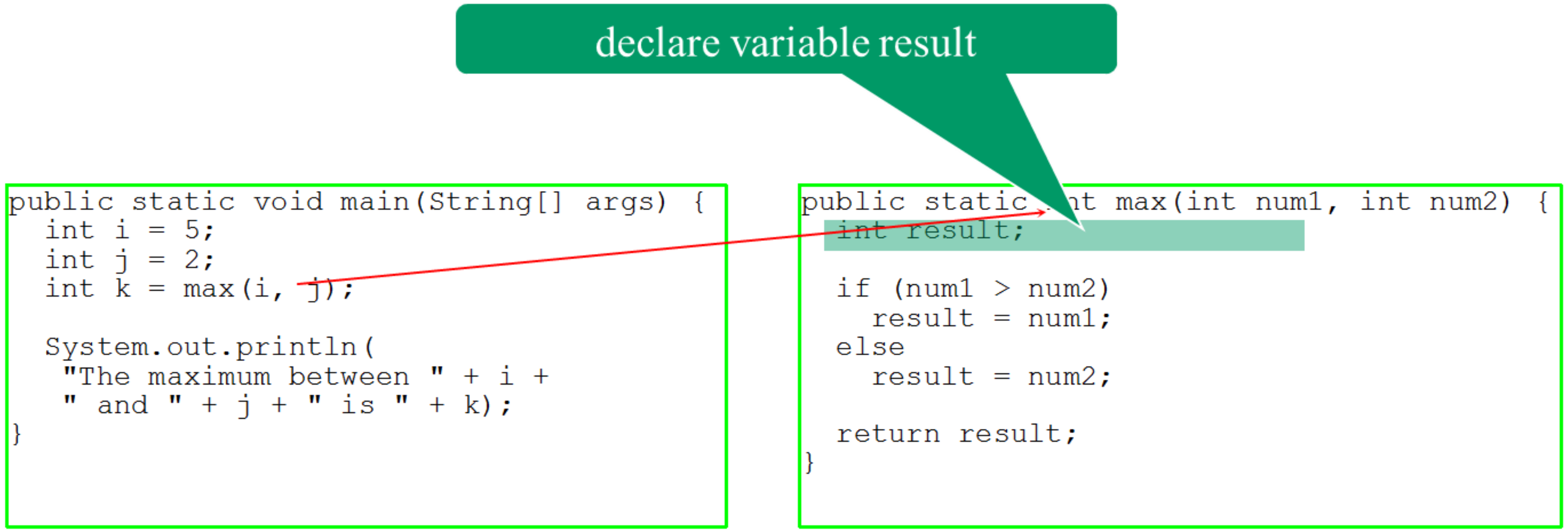


invoke max(i, j)
Pass the value of i to num1
Pass the value of j to num2

```
public static void main(String[] args) {
  int i = 5;
  int j = 2;
  int k = max(i, j);

  System.out.println(
   "The maximum between " + i +
   " and " + j + " is " + k);
}
```

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

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

  return result;
}
```

Trace Method Invocation



```
public static void main(String[] args) {
  int i = 5;
  int j = 2;
  int k = max(i, j);

  System.out.println(
   "The maximum between " + i +
   " and " + j + " is " + k);
}
```

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

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

  return result;
}
```

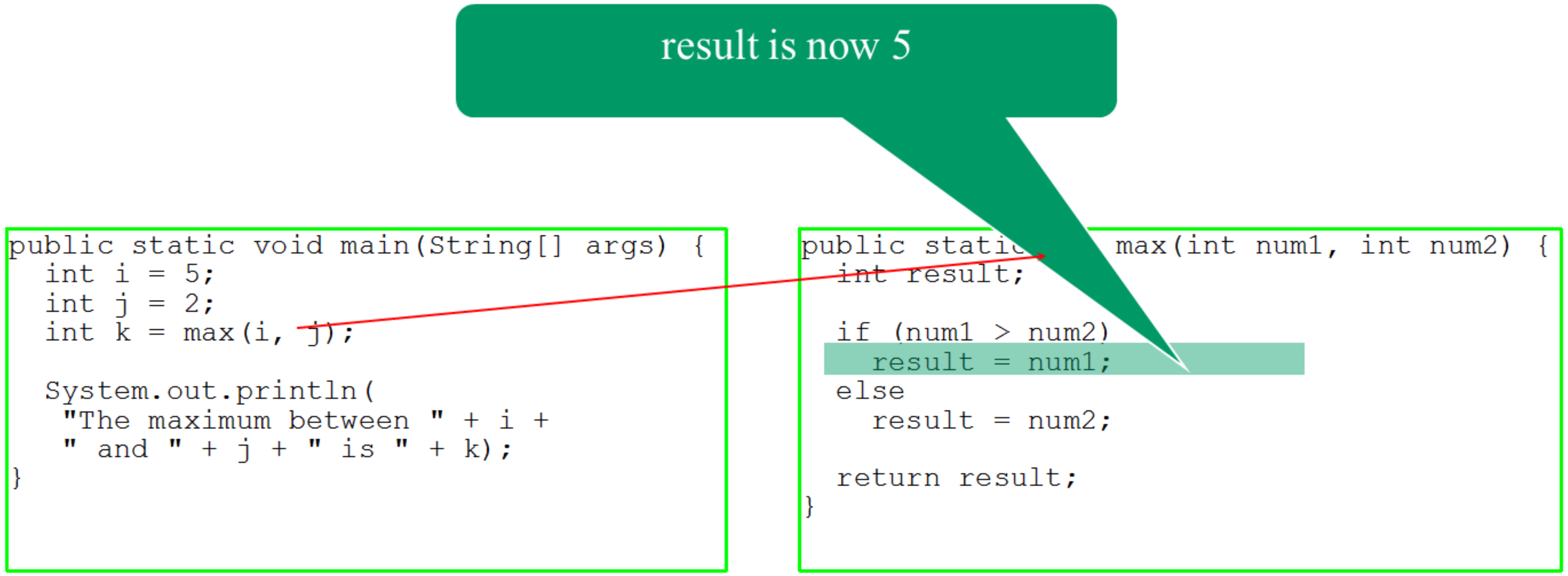
Trace Method Invocation

(num1 > num2) is true since num1 is 5 and num2 is 2

```
public static void main(String[] args) {
  int i = 5;
  int j = 2;
  int k = max(i, j);

  System.out.println(
   "The maximum between " + i +
   " and " + j + " is " + k);
}
```

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

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

  return result;
}
```

Trace Method Invocation



```
public static void main(String[] args) {
  int i = 5;
  int j = 2;
  int k = max(i, j);

  System.out.println(
   "The maximum between " + i +
   " and " + j + " is " + k);
}
```

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

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

  return result;
}
```

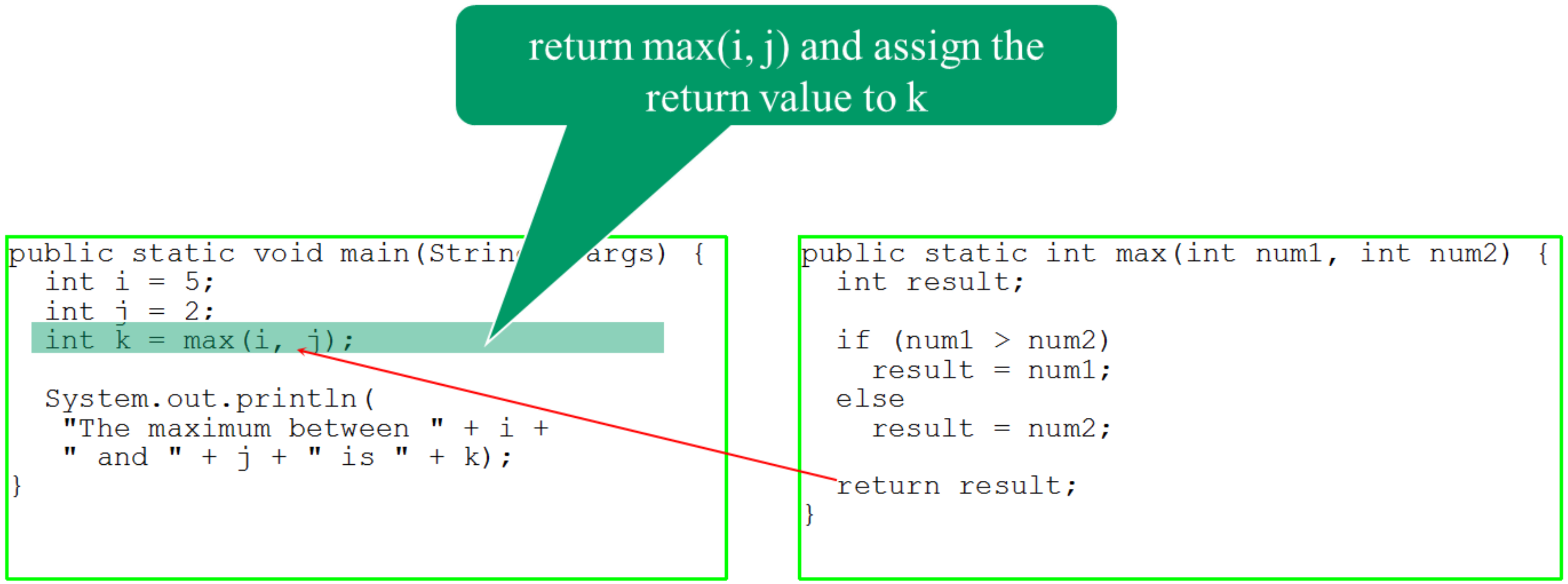
Trace Method Invocation

return result, which is 5

```
public static void main(String[] args) {
  int i = 5;
  int j = 2;
  int k = max(i, j);

  System.out.println(
   "The maximum between " + i +
   " and " + j + " is " + k);
}
```

```
pul        tatic int max(int num1, int num2) {
            esult;

           num1 > num2)
          esult = num1;
         se
         result = num2;

  return result;
}
```

Trace Method Invocation



```
public static void main(Strin    args) {
  int i = 5;
  int j = 2;
  int k = max(i, j);

  System.out.println(
   "The maximum between " + i +
   " and " + j + " is " + k);
}
```

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

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

  return result;
}
```

Trace Method Invocation

Execute the print statement

```
public static void main(String[illegible]gs) {
  int i = 5;
  int j = 2;
  int k = max(i, j);

  System.out.println(
   "The maximum between " + i +
   " and " + j + " is " + k);
}
```

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

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

  return result;
}
```

CAUTION

A return statement is required for a value-returning method. The method shown below in (a) is logically correct, but it has a compilation error because the Java compiler thinks it possible that this method does not return any value.

```java
public static int sign(int n) {
  if (n > 0)
    return 1;
  else if (n == 0)
    return 0;
  else if (n < 0)
    return -1;
}
```

(a)

Should be

```java
public static int sign(int n) {
  if (n > 0)
    return 1;
  else if (n == 0)
    return 0;
  else
    return -1;
}
```

(b)

To fix this problem, delete *if (n < 0)* in (a), so that the compiler will see a return statement to be reached regardless of how the if statement is evaluated.

Reuse Methods from Other Classes

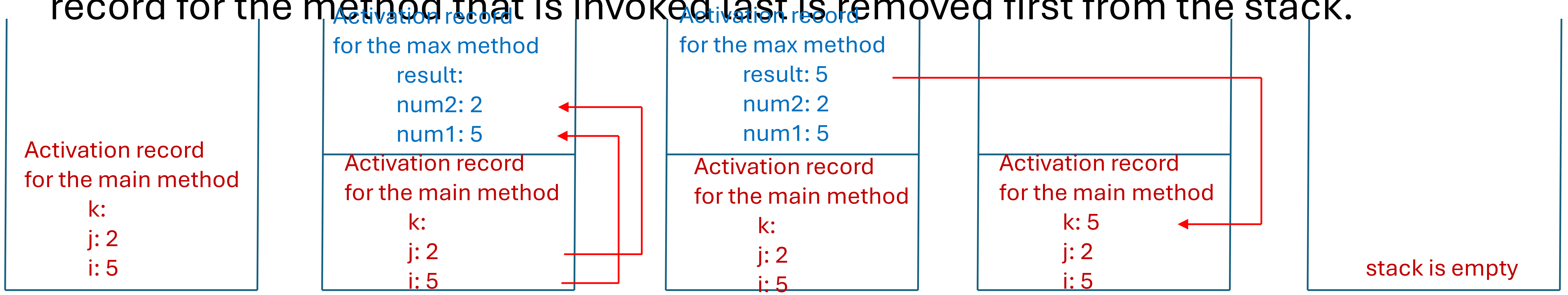
- NOTE: One of the benefits of methods is for reuse. The max method can be invoked from any class besides TestMax. If you create a new class Test, you can invoke the max method using ClassName.methodName (e.g., TestMax.max).

Activation Record

Lecture 4

Activation Record

- Each time a method is invoked, the system creates an activation record (also called an **activation frame**) that stores parameters and variables for the method and places the activation record in an area of memory known as a call stack.
- A **call stack** is also known as *an execution stack, runtime*, or *machine stack*, and it is often shortened to just "*the stack*."
- A call stack stores the activation records in a last-in, first-out fashion: The activation record for the method that is invoked last is removed first from the stack.



(a) The main method is invoked.

(b) The max method is invoked.

(c) The max method is being executed.

(d) The max method is finished and the return value is sent to k.

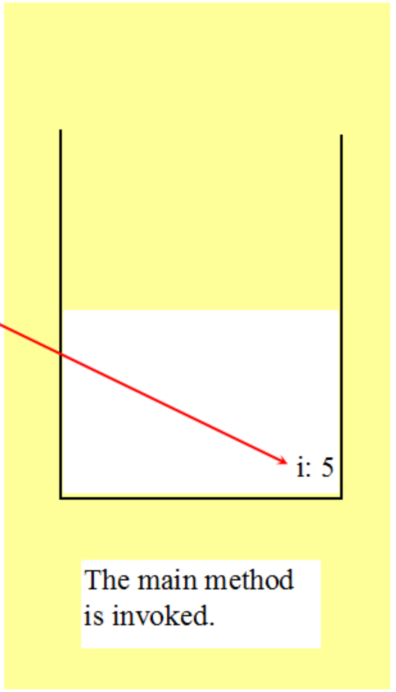
(e) The main method is finished.

Trace Call Stack

i is declared and initialized

```
public static void main(String[] args) {
  int i = 5;
  int j = 2;
  int k = max(i, j);

  System.out.println(
   "The maximum between " + i +
   " and " + j + " is " + k);
}
```

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

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

  return result;
}
```

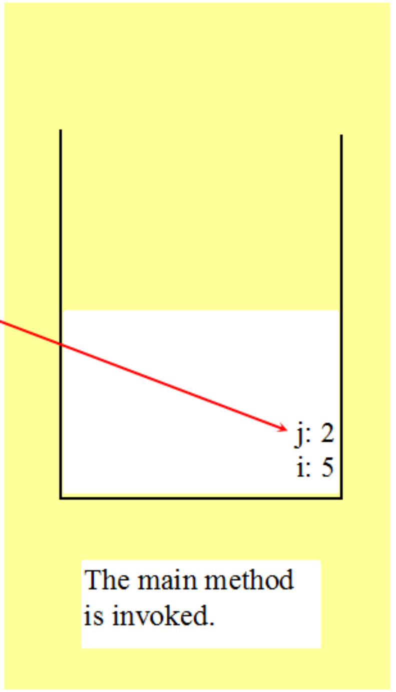


Trace Call Stack

j is declared and initialized

```
public static void main(String[] args) {
  int i = 5;
  int j = 2;
  int k = max(i, j);

  System.out.println(
   "The maximum between " + i +
   " and " + j + " is " + k);
}
```

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

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

  return result;
}
```



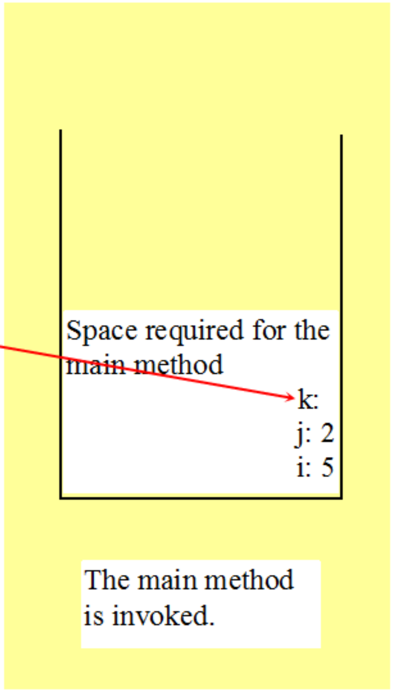
The main method is invoked.

Trace Call Stack

Declare k

```
public static void main(String[] args) {
  int i = 5;
  int j = 2;
  int k = max(i, j);

  System.out.println(
   "The maximum between " + i +
   " and " + j + " is " + k);
}
```

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

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

  return result;
}
```

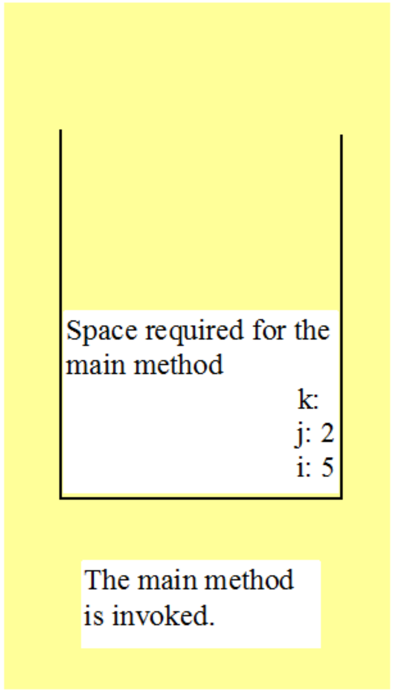

Space required for the main method
k:
j: 2
i: 5
The main method is invoked.

Trace Call Stack

Invoke max(i, j)

```
public static void main(String[] args) {
  int i = 5;
  int j = 2;
  int k = max(i, j);

  System.out.println(
   "The maximum between " + i +
   " and " + j + " is " + k);
}
```

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

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

  return result;
}
```

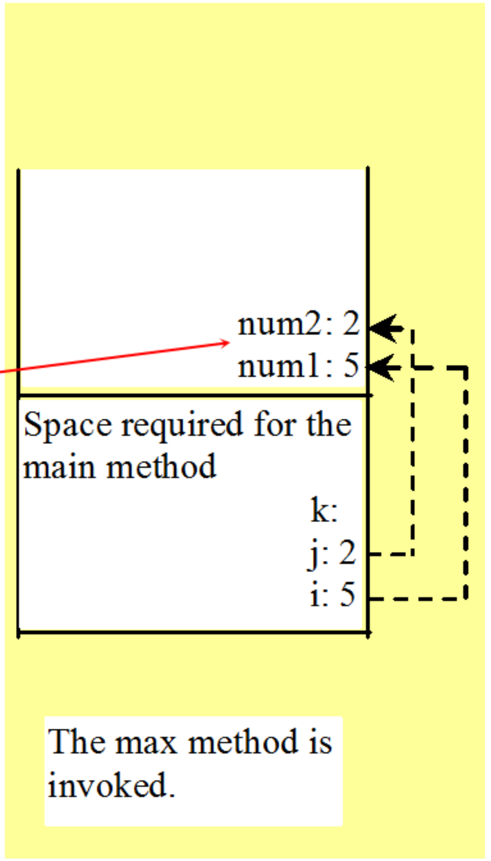

Space required for the main method
k:
j: 2
i: 5
The main method is invoked.

Trace Call Stack

```
public static void main(String[] args) {
  int i = 5;
  int j = 2;
  int k = max(i, j);

  System.out.println(
   "The maximum between " + i +
   " and " + j + " is " + k);
}
```

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

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

  return result;
}
```

pass the values of i and j to num1 and num2



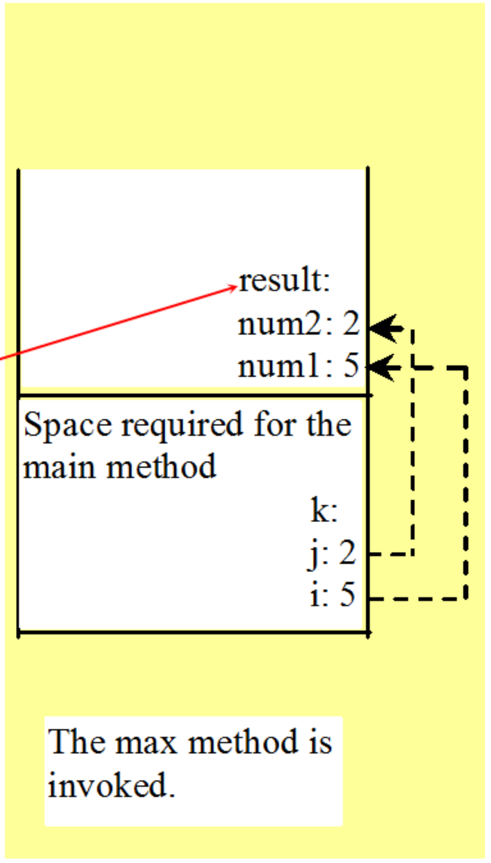
The max method is invoked.

Trace Call Stack

Declare result

```
public static void main(String[] args) {
  int i = 5;
  int j = 2;
  int k = max(i, j);

  System.out.println(
   "The maximum between " + i +
   " and " + j + " is " + k);
}
```

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

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

  return result;
}
```



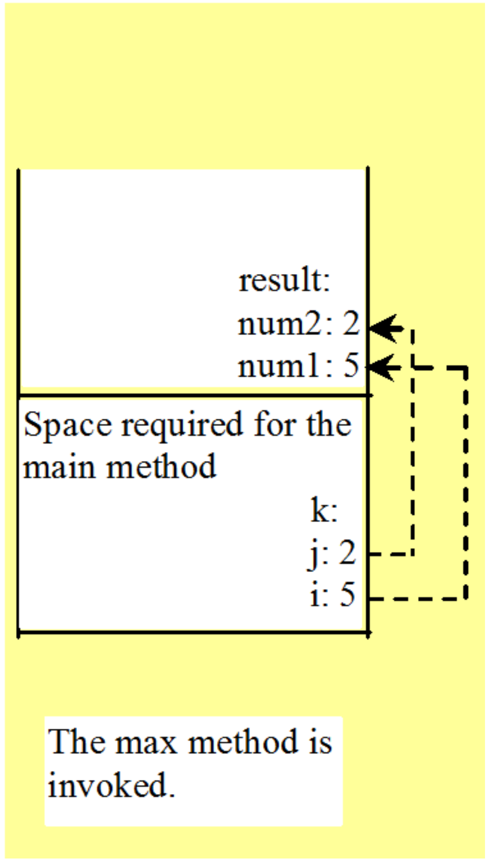
result:
num2: 2
num1: 5
Space required for the main method
k:
j: 2
i: 5
The max method is invoked.

Trace Call Stack

(num1 > num2) is true

```
public static void main(String[] args) {
  int i = 5;
  int j = 2;
  int k = max(i, j);

  System.out.println(
   "The maximum between " + i +
   " and " + j + " is " + k);
}
```

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

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

  return result;
}
```



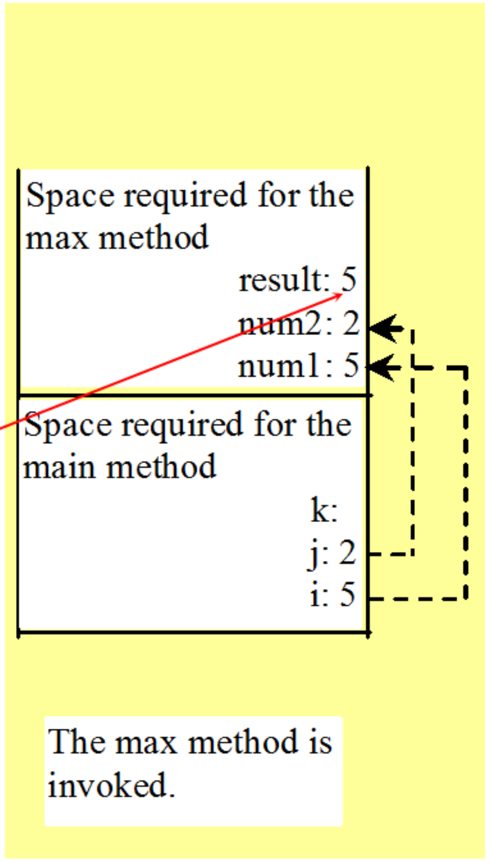
result:
num2: 2
num1: 5
Space required for the main method
k:
j: 2
i: 5
The max method is invoked.

Trace Call Stack

Assign num1 to result

```
public static void main(String[] args) {
  int i = 5;
  int j = 2;
  int k = max(i, j);

  System.out.println(
   "The maximum between " + i +
   " and " + j + " is " + k);
}
```

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

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

  return result;
}
```

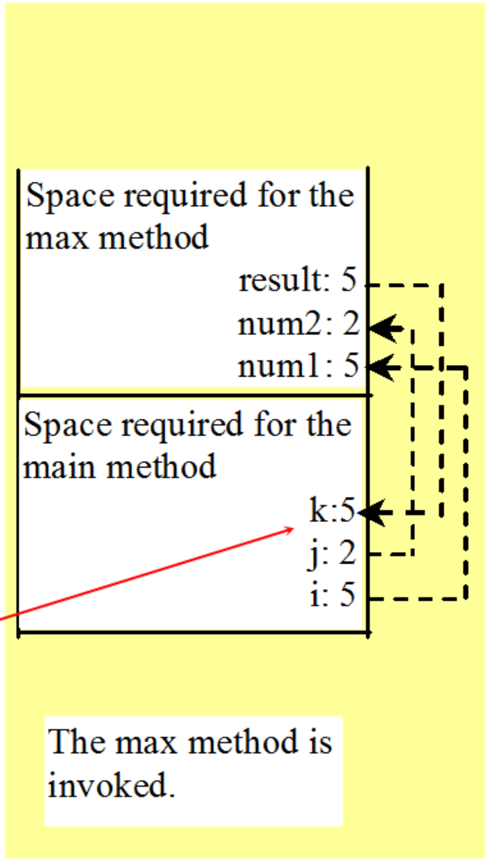

Space required for the max method
result: 5
num2: 2
num1: 5
Space required for the main method
k:
j: 2
i: 5
The max method is invoked.

Trace Call Stack

Return result and assign it to k

```
public static void main(String[] args) {
   int i = 5;
   int j = 2;
   int k = max(i, j);

   System.out.println(
    "The maximum between " + i +
    " and " + j + " is " + k);
}
```

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

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

   return result;
}
```



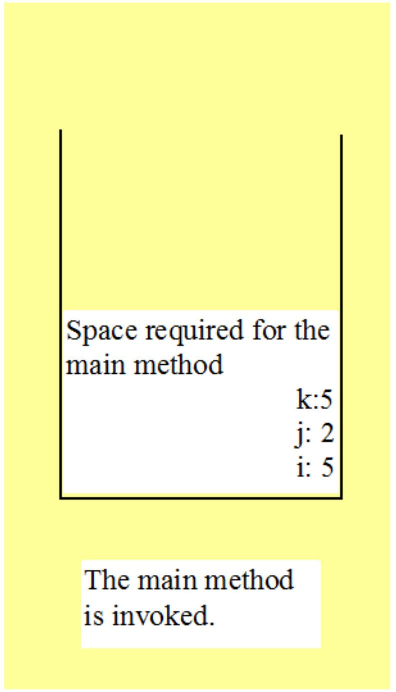
Space required for the max method
result: 5
num2: 2
num1: 5
Space required for the main method
k:5
j: 2
i: 5
The max method is invoked.

Trace Call Stack

Execute print statement

```
public static void main(String[] args) {
  int i = 5;
  int j = 2;
  int k = max(i, j);

  System.out.println(
   "The maximum between " + i +
   " and " + j + " is " + k);
}
```

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

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

  return result;
}
```



Space required for the main method
k:5
j: 2
i: 5
The main method is invoked.

Void Method

Lecture 5

void Method Example

methods do not pass value

- This type of method does not return a value. The method performs some actions.
- Sometimes, this kind of method is also called as **procedure**.
- (In **Pascal** language, **procedure** and **function** are different.)

Statistics Methods

Lecture 6

Demonstration Program

Stats01.java

Demo Program: Stats01.java

- The simplest user-defined statistics methods for only two inputs.
- As we move on to the next chapters, more robust version will rolls out.

Summary:

- 1. As the parameter list grows, the maximum and minimum methods become very unsystematic.
- 2. When the length of the parameter list grows, we need to rewrite the method definition.
- 3. Some data structure may help. (See next Chapter for another version) **Use loop and array combination.**

Call by Value

Lecture 7

Passing Parameters

- Suppose you invoke the method using nPrintln(“Welcome to Java”, 5);
- What is the output?
- Suppose you invoke the method using nPrintln(“Computer Science”, 15);
- What is the output?
- Can you invoke the method using nPrintln(15, “Computer Science”);

```
public static void nPrintln(String message, int n) {
  for (int i = 0; i < n; i++)
    System.out.println(message);
}
```

Pass by Value

- This program demonstrates passing values to the methods.

- Increase.java

Demonstration Program

Increase.java

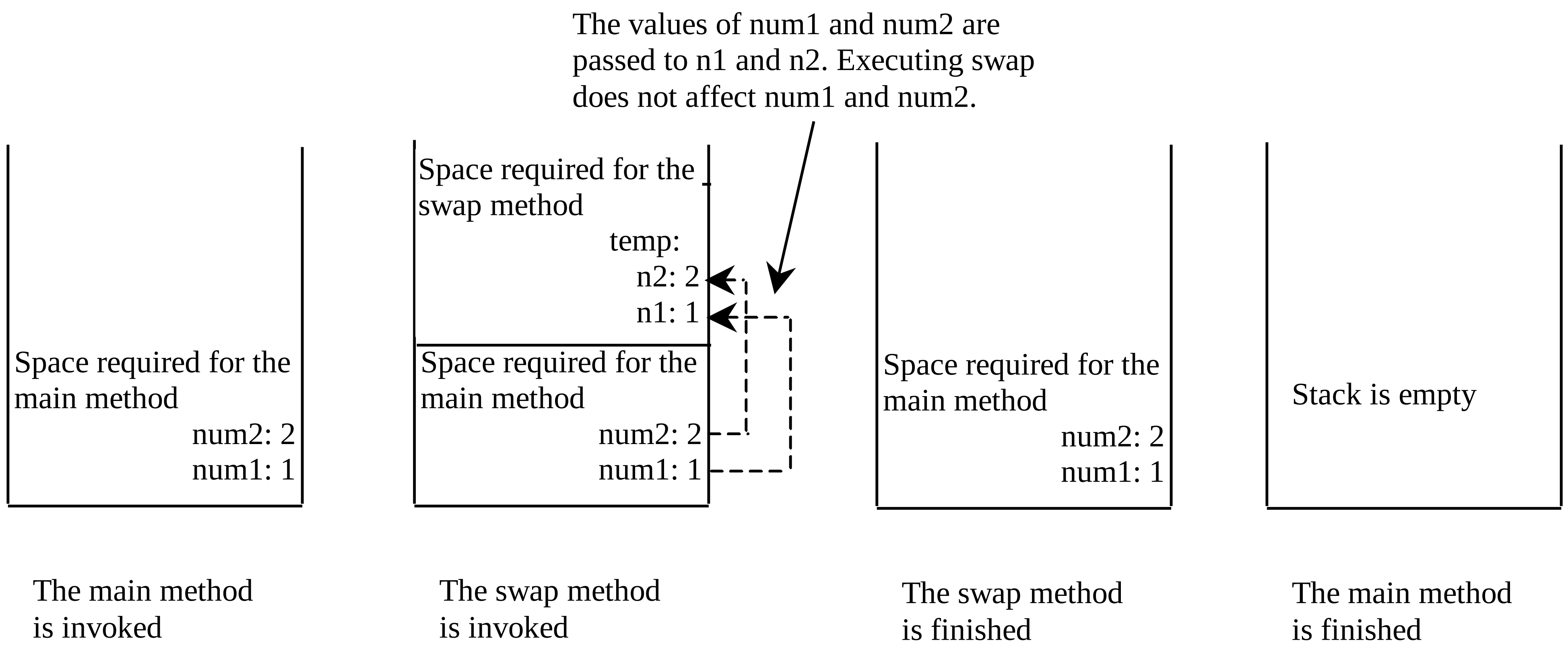
Pass by Value

- Testing Pass by value
- This program demonstrates passing values to the methods.
- TestPassByValue.java

Demonstration Program

TestPassByValue.java

Pass by Value, cont.


The values of num1 and num2 are passed to n1 and n2. Executing swap does not affect num1 and num2.
Space required for the main method
num2: 2
num1: 1
Space required for the swap method
temp:
n2: 2
n1: 1
Space required for the main method
num2: 2
num1: 1
Space required for the main method
num2: 2
num1: 1
Stack is empty
The main method is invoked
The swap method is invoked
The swap method is finished
The main method is finished

Four types of variables
(declaration location, modifiers)

1. Variables in a class (object) (alive with the class or instance (object))
2. Variable in a method. (alive only with the method)
3. Variable in the parameter list. (alive only with the method)
4. Variable in a loop. (alive only with the loop)

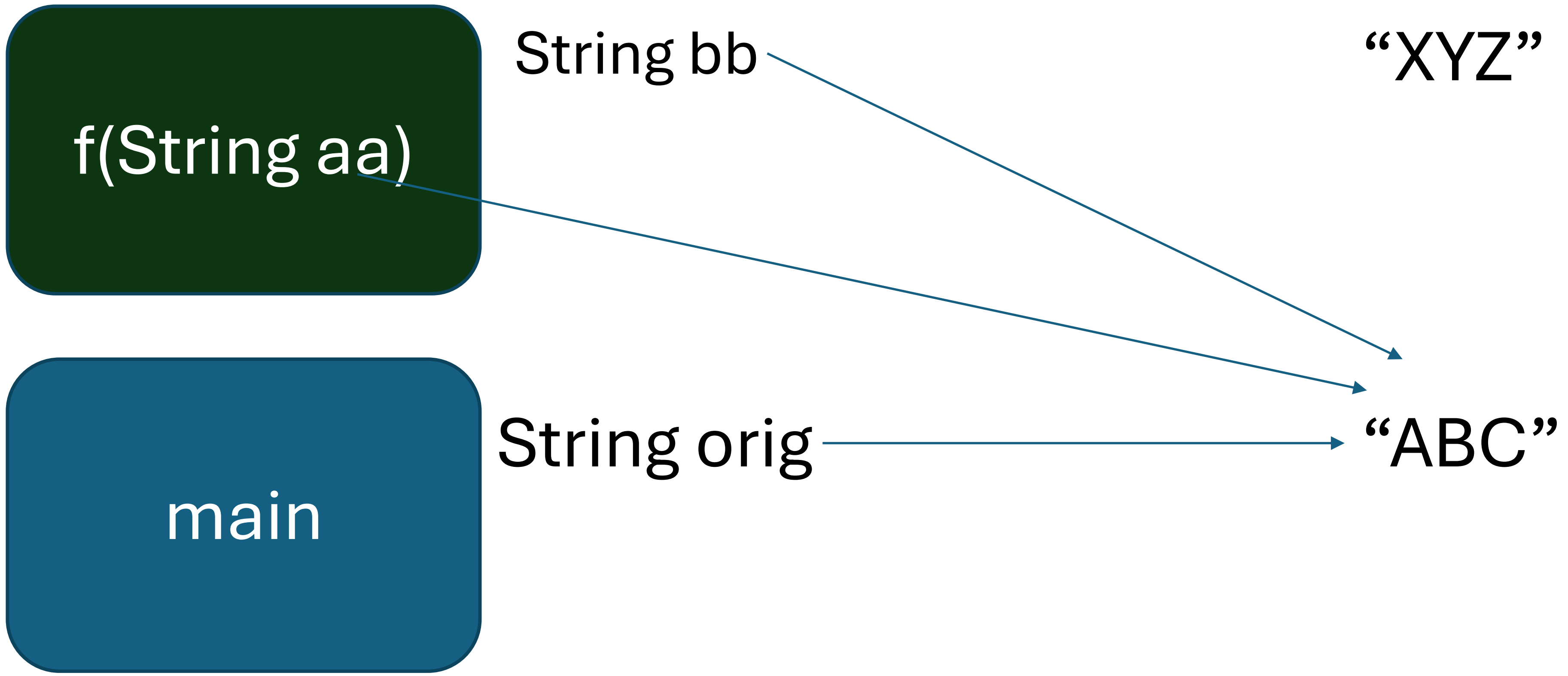
Java is pass-by-value only. Even reference data type is passing reference **VALUE**

- String is passing the reference value (still pass-by-value, in this case the address of string body)

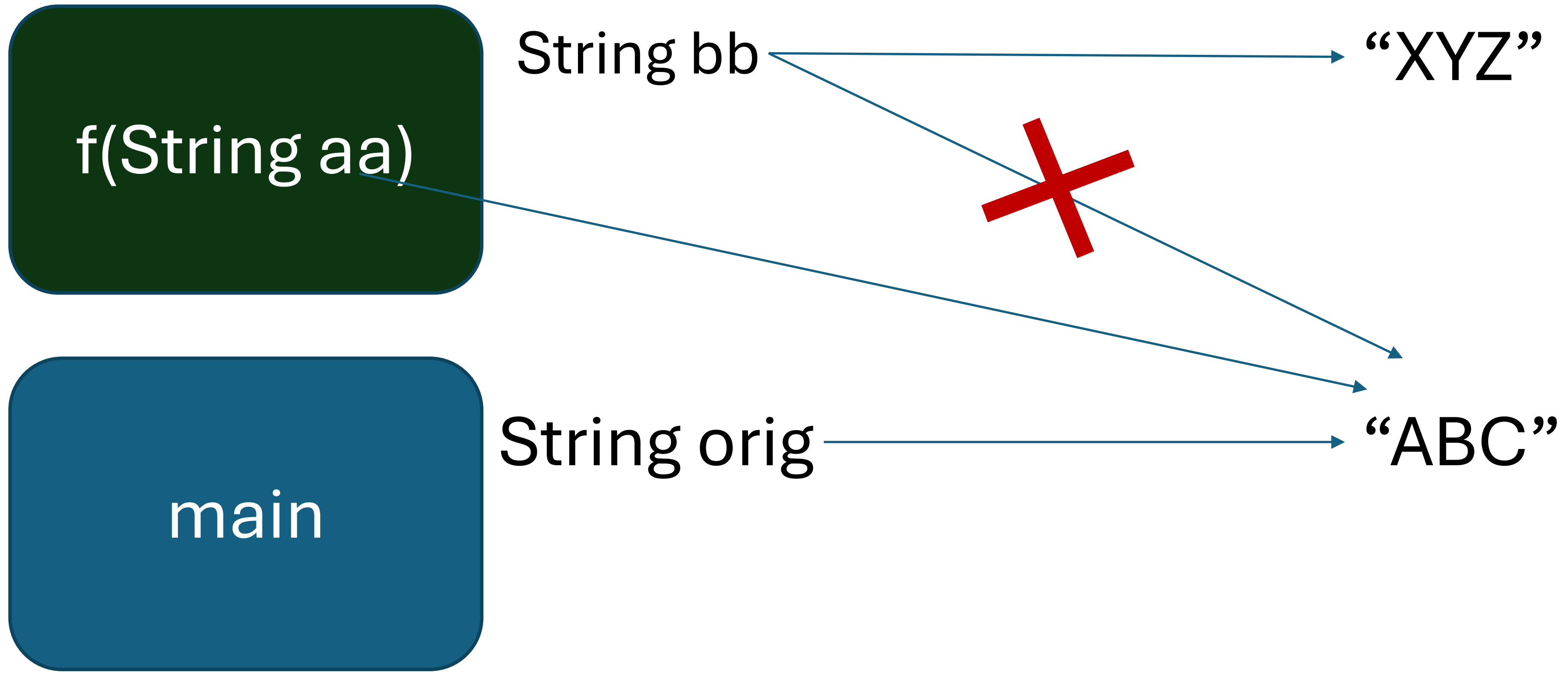
Demonstration Program

TestPassStriNG.java

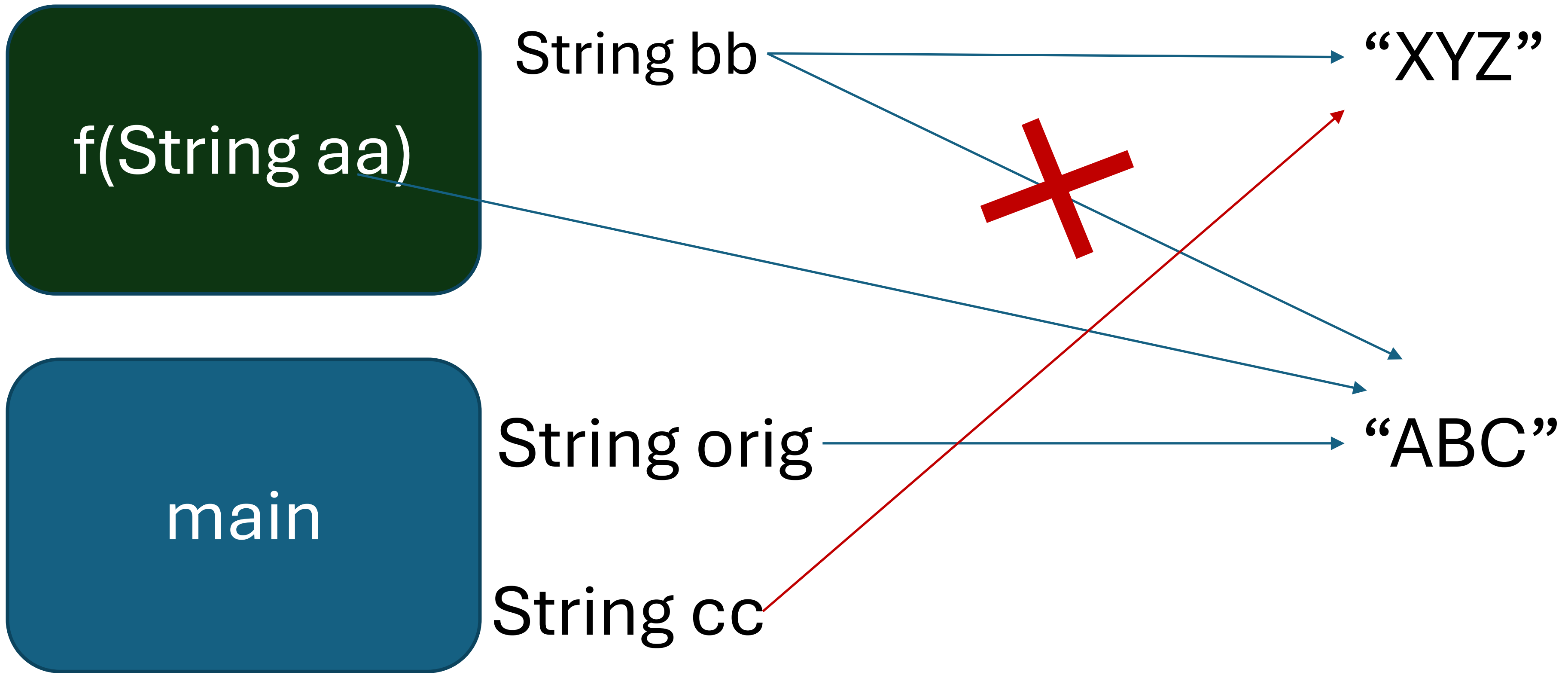
Variable value



Variable value



Variable value

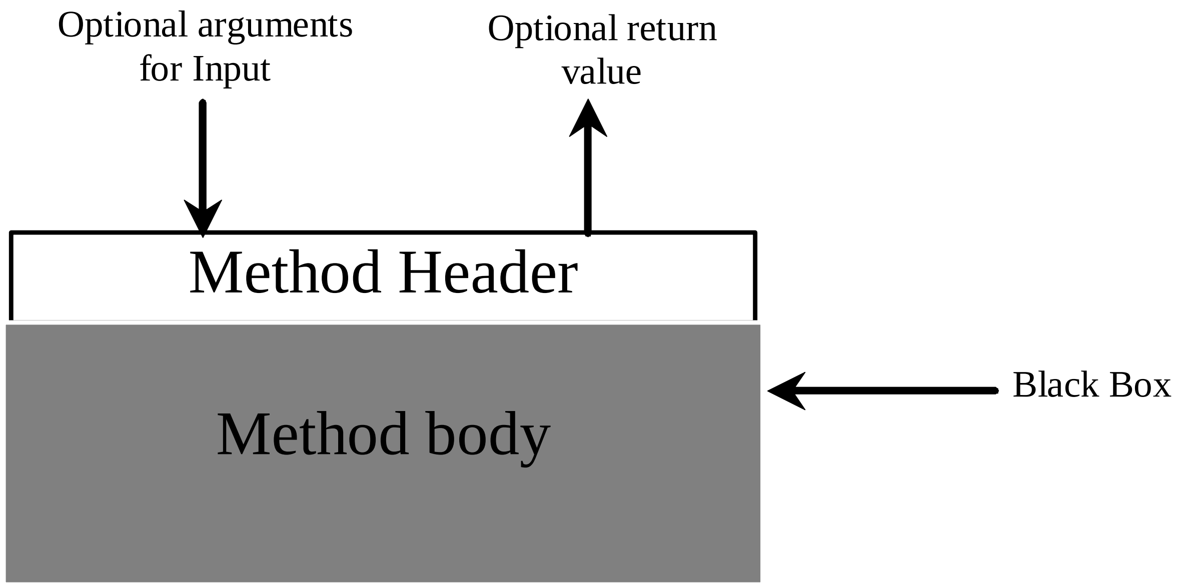


Modularizing Code

Lecture 8

Method Abstraction

- You can think of the method body as a black box that contains the detailed implementation for the method.



Benefits of Methods

- Write a method once and reuse it anywhere.
- Information hiding. Hide the implementation from the user.
    - Reduce complexity
    - Information hiding
    - Abstraction
    - Encapsulation

Modularizing Code

- Methods can be used to reduce redundant coding and enable code reuse. Methods can also be used to modularize code and improve the quality of the program.
- [1] GreatestCommonDivisorMethod.java
- run from 1 to min(num1, num2) to check if it is GCD
- [2] PrimeNumberMethod.java
- run from 2 to n/2 to check if a number is prime (sqrt(n) will be enough.)

Converting Hexadecimal to Decimal

- How do you convert a hexadecimal number to a decimal number? To convert a hexadecimal number to a decimal a is to find the decimal value from $h_{n,} h_{n-1,}\, h_{n-2,}\, \ldots,\, h_{2,} h_{1,}\, h_0 \rightarrow d$
- $d = h_n \times 16^n + h_{n-1} \times 16^{n-1} + \cdots + h_2 \times 16^2 + h_1 \times 16^1 + h_0 \times 16^0$
- $\quad = (((h_n \times 16^1 + h_{n-1}) \times 16^1 + \cdots + h_2) \times 16^1 + h_1) \times 16^1 + h_0 \times 16^0$
- This called Horner's Algorithm.
- int decimalValue = 0;
- for (int I = 0; I < hex.length(); i++) {
-     char hexChar = hex.charAt(i);
-     decimalValue = decimalValue * 16 + hexCharToDecimal(hexChar);
- }

Problem: Converting Hexadecimals to Decimals

- Write a method that converts a hexadecimal integer to a decimal.
- [3] Hex2Dec.java

Demonstration Program

[1] GreatestCommonDivisorMethod.java

[2] PrimeNumberMethod.java

[3] Hex2Dec.java

Modularize RandomCharacter()

Lecture 9

Static Methods

- Java static method program: static methods in Java can be called **without creating an object of class**.
- Have you noticed why we write static keyword when defining main it's because program execution begins from main and no object has been created yet.
- Consider the example below to improve your understanding of static methods.

Static Variables

- There are several kinds of variables:
- **Member variables in a class**—these are called fields.
- **Variables in a method or block of code**—these are called local variables (method level).
- **Variables in a block of code** – these are also local variables (block level).
- **Variables in method declarations—these** are called parameters.

- Static variables in a class is a **class variable** which does not need to declare any instance to access. The value of the static variable will also live as long as the class is **loaded**. No instantiation needed.

Static Methods and Static Variables

```
class Languages {
 static String message = "Java is my favorite programming language.";
 public static void main(String[] args) {
  display();
 }

 static void display() {
  System.out.println(message);
 }
}
```

Use of Math class’s staic variables

```
 Math.PI;
 Math.E;
```

Java static method vs instance method

Instance method requires an object of its class to be created before it can be called while static method doesn't require object creation.

```
class Difference {
 public static void main(String[] args) {
  display();  //calling without object
  Difference t = new Difference();
  t.show();  //calling using object
 }
 static void display() {
  System.out.println("Programming is
amazing.");
 }
 void show(){
  System.out.println("Java is awesome.");
 }
}
```

Using static method of another classes

If you wish to call static method of another class then you have to write class name while calling static method as shown in example below.

```java
import java.lang.Math;
class Another {
 public static void main(String[] args) {
   int result;
   result = Math.min(10, 20);
   //calling static method min by writing class name
   System.out.println(result);
   System.out.println(Math.max(100, 200));
 }
}
```

Output of program:

```
10
200
```

Static Methods can only Access Static Methods and Static Variables.

- Because they are class variables and class method, they do **not** belong to any instance. So, a instance won’t be able to access them. Non-static methods are not class methods and are not supposed to access them as well.

The random Method

Generates a random double value greater than or equal to 0.0 and less than 1.0 (0 <= Math.random() < 1.0).

Examples:

`(int)(Math.random() * 10)` $\longrightarrow$ Returns a random integer between 0 and 9.

`50 + (int)(Math.random() * 50)` $\longrightarrow$ Returns a random integer between 50 and 99.

In general,

`a + Math.random() * b` $\longrightarrow$ Returns a random number between a and a + b, excluding a + b.

Case Study: Generating Random Characters

- Computer programs process numerical data and characters. You have seen many examples that involve numerical data. It is also important to understand characters and how to process them.
- Each character has a unique Unicode between 0 and FFFF in hexadecimal (65535 in decimal). To generate a random character is to generate a random integer between 0 and 65535 using the following expression: (note that since 0 <= Math.random() < 1.0, you have to add 1 to 65535.)

```
(int)(Math.random() * (65535 + 1))
```

Case Study: Generating Random Characters

- Now let us consider how to generate a random lowercase letter. The Unicode for lowercase letters are consecutive integers starting from the Unicode for 'a', then for 'b', 'c', ..., and 'z'. The Unicode for 'a' is

```
(int) 'a'
```

- So, a random integer between (int)'a' and (int)'z' is

```
(int)(Math.random() * ((int)'z' - (int)'a' + 1) + (int) ’a’)
```

Case Study: Generating Random Characters

- Now let us consider how to generate a random lowercase letter. The Unicode for lowercase letters are consecutive integers starting from the Unicode for 'a', then for 'b', 'c', ..., and 'z'.
- The Unicode for 'a' is (int) 'a'
- So, a random integer between (int)'a' and (int)'z’ is

(int)(Math.random() * ((int)'z' - (int)'a' + 1) + ‘a’)

Case Study: Generating Random Characters

- All numeric operators can be applied to the char operands. The char operand is cast into a number if the other operand is a number or a character. So, the preceding expression can be simplified as follows:

  ```
  Math.random() * ('z' - 'a' + 1) + ‘a’
  ```

- So a random lowercase letter is

  ```
  (char)(Math.random() * ('z' - 'a' + 1) + ‘a’)
  ```

Case Study: Generating Random Characters

- To generalize the foregoing discussion, a random character between any two characters ch1 and ch2 with ch1 < ch2 can be generated as follows:

```
(char)(Math.random() * (ch2 – ch1 + 1) + ch1)
```

Demonstration Program

The RandomCharacter Class

[1] RandomCharacter.java

[2] TestRandomCharacter.java

[3] StrongPasswordMethod.java

Overloading of Methods

Lecture 10

Overloading Methods

- Overloading the max Method
- public static double max(double num1, double num2) {
- if (num1 > num2)
-   return num1;
- else
-   return num2;
- }

Demonstration Program

Overloading

[1] TestOverloading.java

Ambiguous Invocation

- Sometimes there may be two or more possible matches for an invocation of a method, but the compiler cannot determine the most specific match.
- This is referred to as **ambiguous invocation**. Ambiguous invocation is a **compilation** error.

Ambiguous Invocation

(Compilation Error: Neither is better. max(int num1, int num2) will win.)

```
public class AmbiguousOverloading {
  public static void main(String[] args) {
    System.out.println(max(1, 2));
  }

  public static double max(int num1, double num2) {
    if (num1 > num2)
      return num1;
    else
      return num2;
  }

  public static double max(double num1, int num2) {
    if (num1 > num2)
      return num1;
    else
      return num2;
  }
}
```

Scope of Variables (Local Variables)

Lecture 11

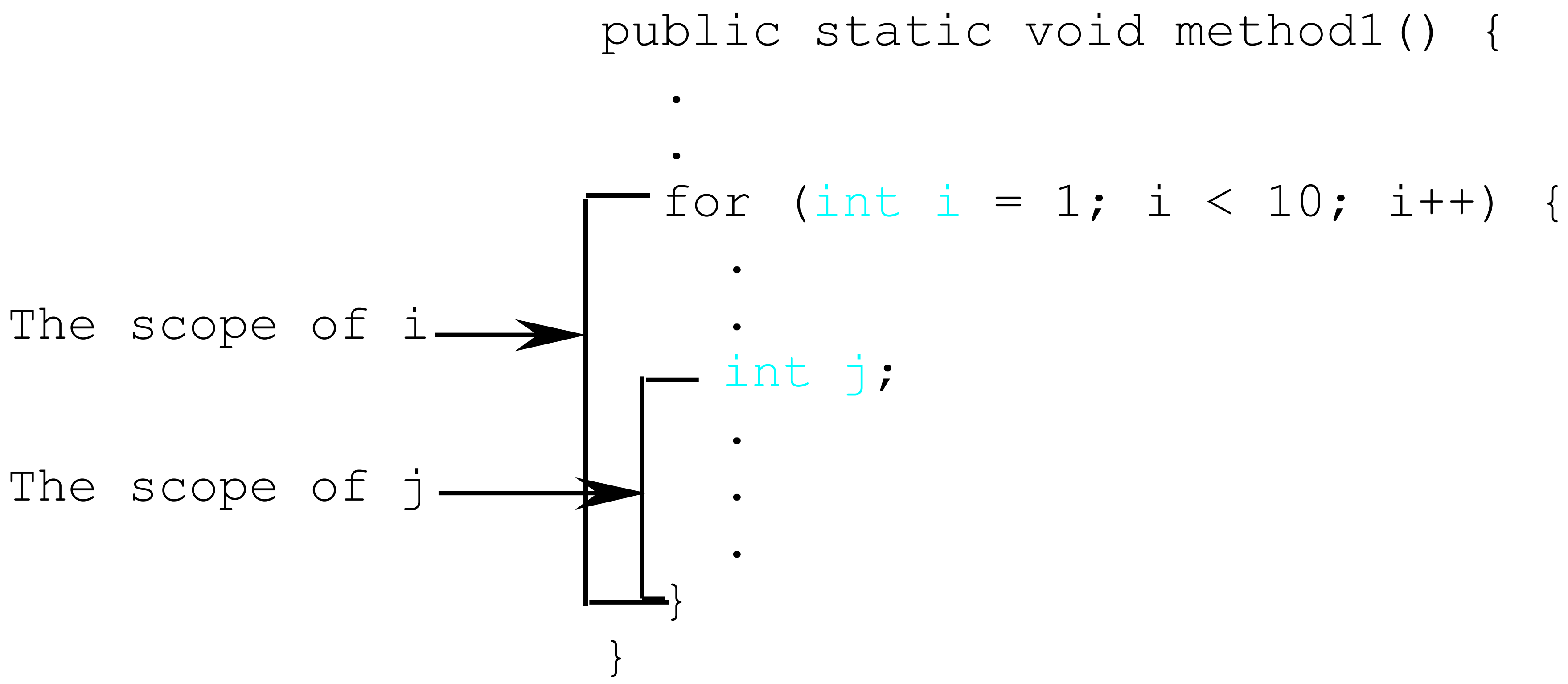
Scope of Local Variables (method/block)

- **A local variable:** a variable defined inside a method or block.
- **Scope:** the part of the program where the variable can be referenced.
- 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 before it can be used.

Scope of Local Variables (method/block)

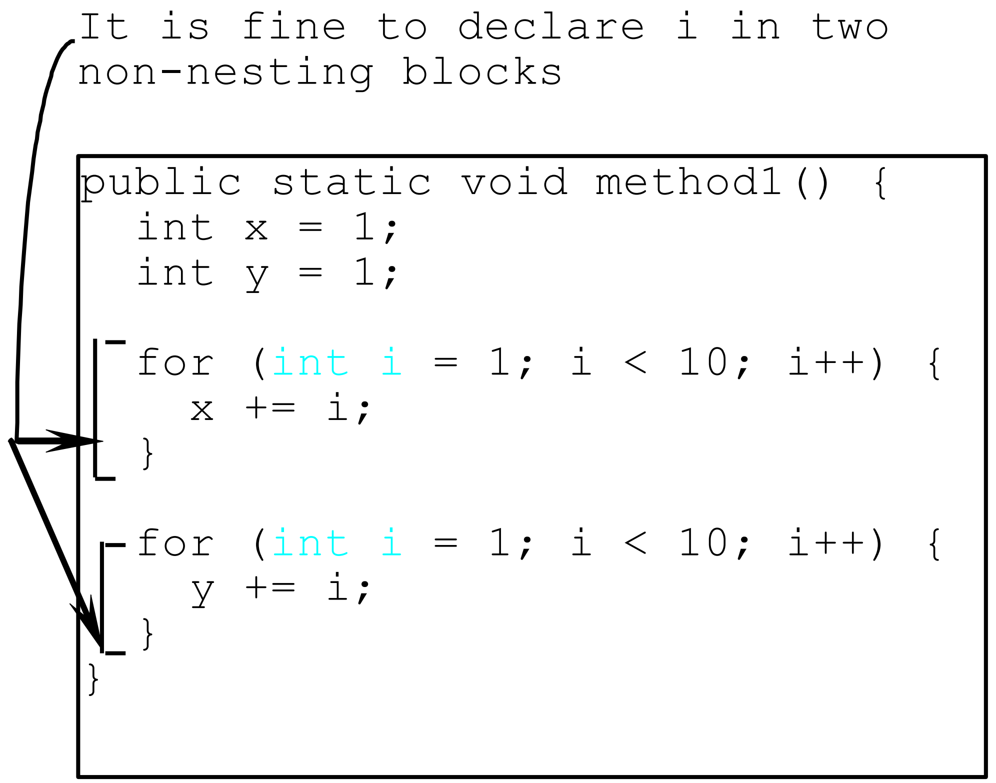
- You can declare a local variable with the same name multiple times in different non-nesting blocks in a method, but you cannot declare a local variable twice in nested blocks.
- A variable declared in the initial action part of a <u>for</u> loop header has its scope in the entire loop. But a variable declared inside a <u>for</u> loop body has its scope limited in the loop body from its declaration and to the end of the block that contains the variable.

Scope of Local Variables



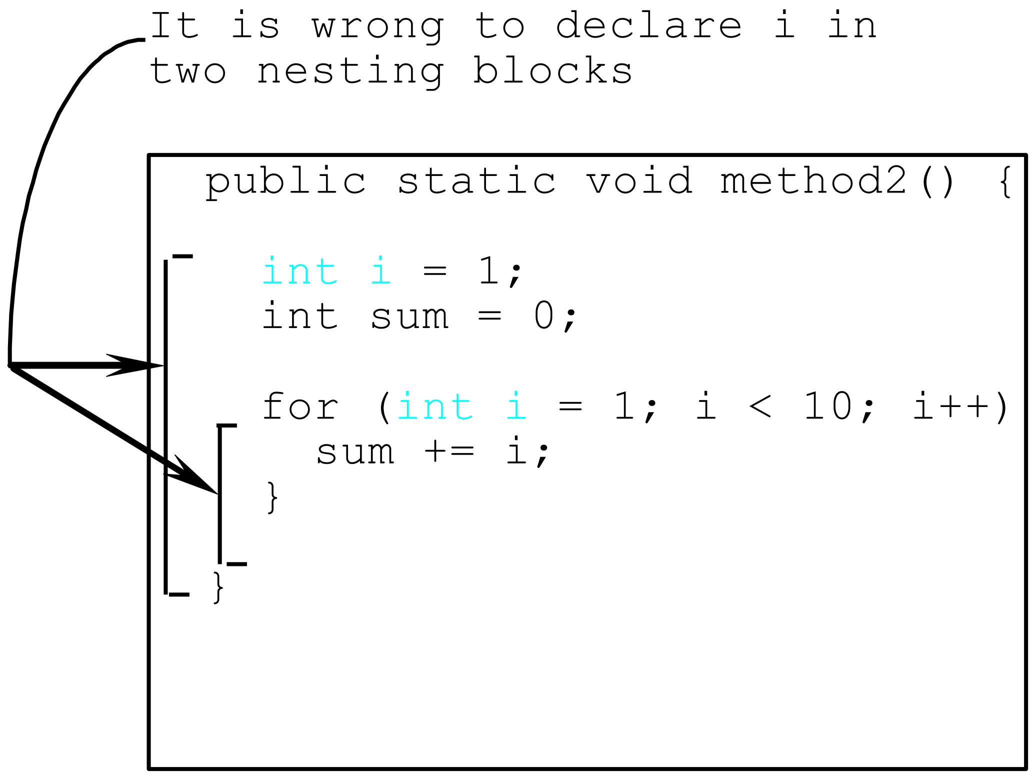
```
public static void method1() {
  .
  .
  for (int i = 1; i < 10; i++) {
    .
    .
    int j;
    .
    .
    .
  }
}
```

Scope of Local Variables



It is fine to declare i in two non-nesting blocks

```
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;
  }
}
```



It is wrong to declare i in two nesting blocks

```
  public static void method2() {

    int i = 1;
    int sum = 0;

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

Scope of Local Variables

```
// Fine with no errors
public static void correctMethod() {
  int x = 1;
  int y = 1;
  // i is declared
  for (int i = 1; i < 10; i++) {
    x += i;
  }
  // i is declared again
  for (int i = 1; i < 10; i++) {
    y += i;
  }
}
```

Scope of Local Variables

```
// With errors
public static void incorrectMethod() {
  int x = 1;
  int y = 1;
  for (int i = 1; i < 10; i++) {
    int x = 0;
    x += i;
  }
}
```