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# Chapter 6

## Methods



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# Problem

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Find the sum of integers from 1 to 10, from 20 to 30, and from 35 to 45, respectively.

```
int sum = 0;
for (int i = 1; i <= 10; i++)
    sum += i;
```

```
System.out.println("Sum from 1 to 10 is " + sum);
```

```
sum = 0;
for (int i = 20; i <= 30; i++)
    sum += i;
```

```
System.out.println("Sum from 20 to 30 is " + sum);
```

```
sum = 0;
for (int i = 35; i <= 45; i++)
    sum += i;
```

```
System.out.println("Sum from 35 to 45 is " + sum);
```

# Solution

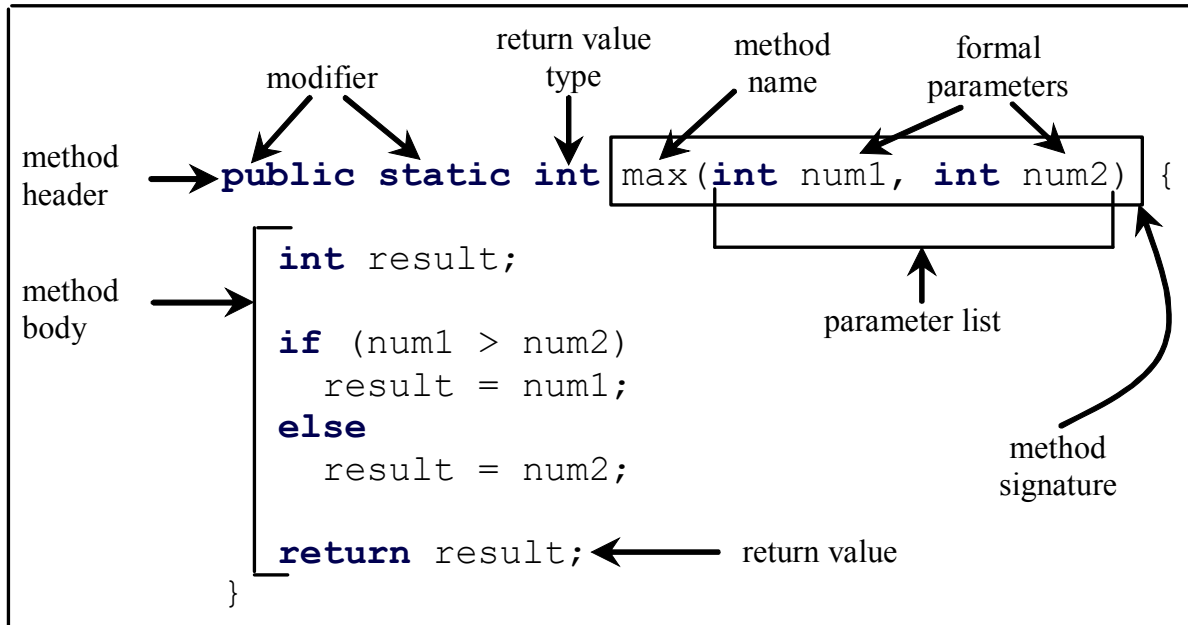
```
public static int sum(int i1, int i2) {  
    int sum = 0;  
    for (int i = i1; i <= i2; i++)  
        sum += i;  
    return sum;  
}
```

```
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 30 is " + sum(20, 30));  
    System.out.println("Sum from 35 to 45 is " + sum(35, 45));  
}
```

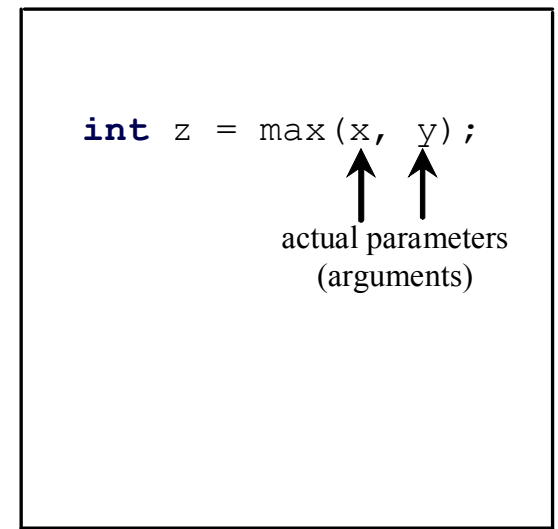
# Defining Methods

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

Define a method



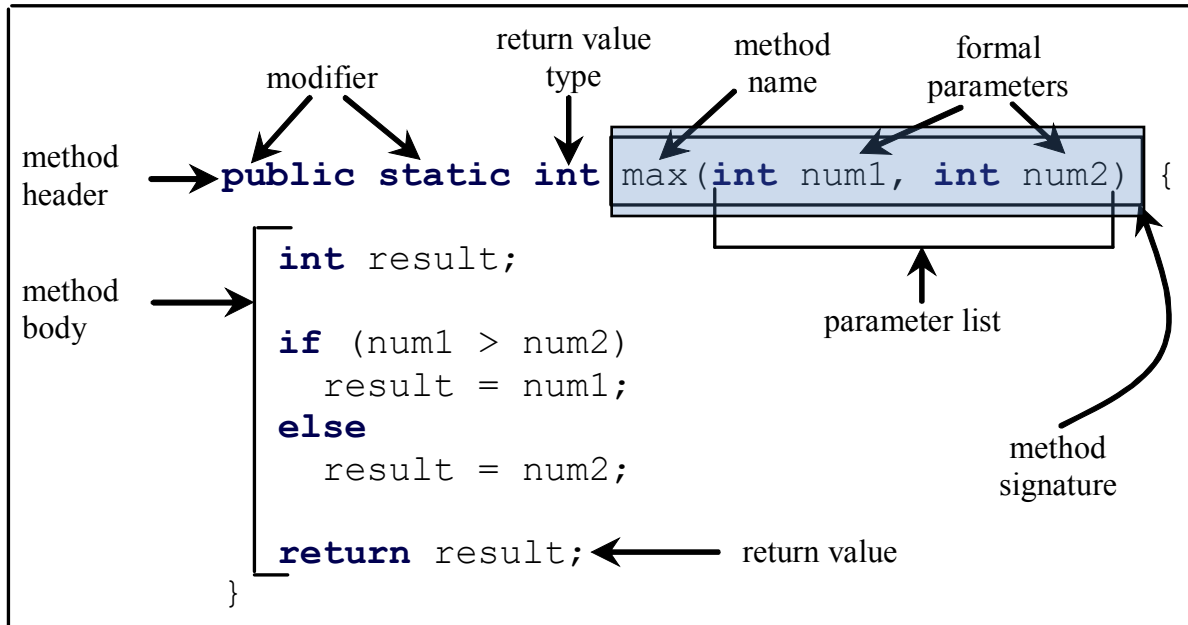
Invoke a method



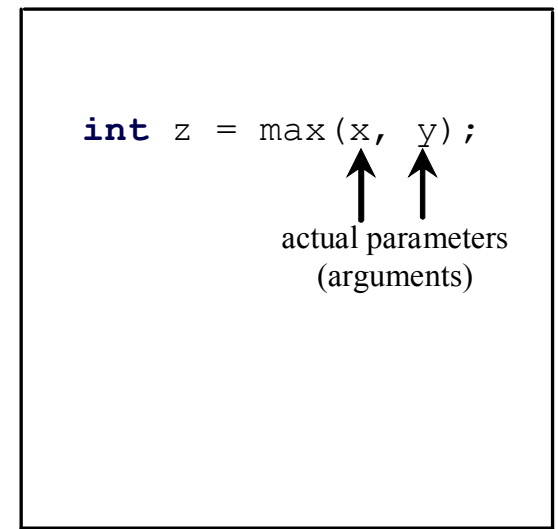
# Method Signature

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

Define a method



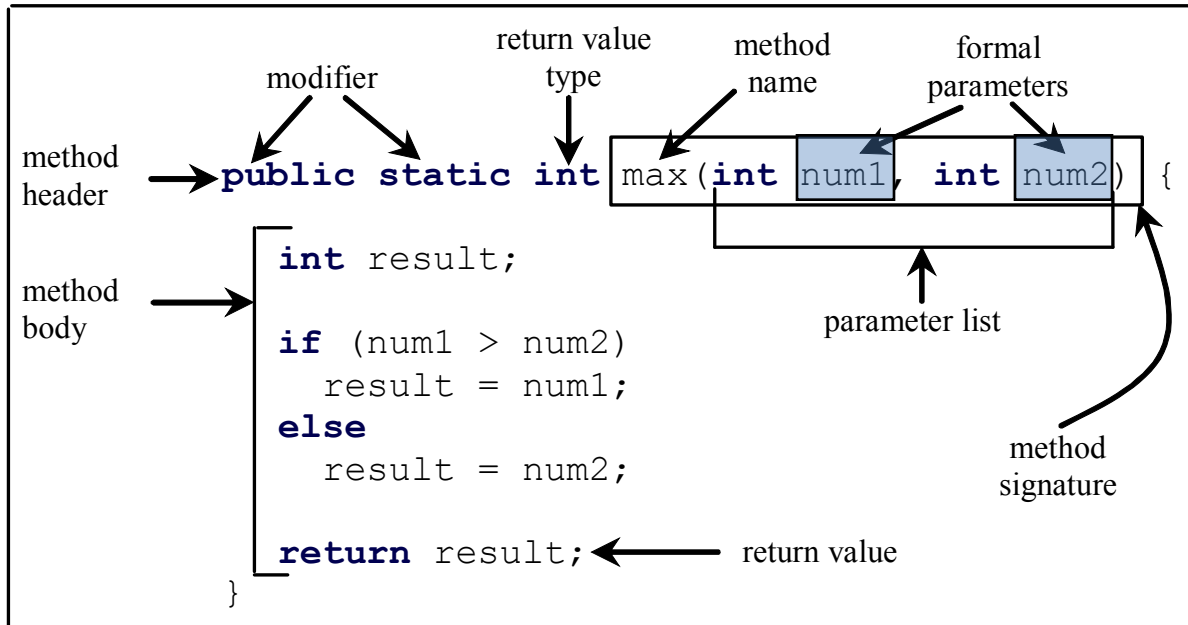
Invoke a method



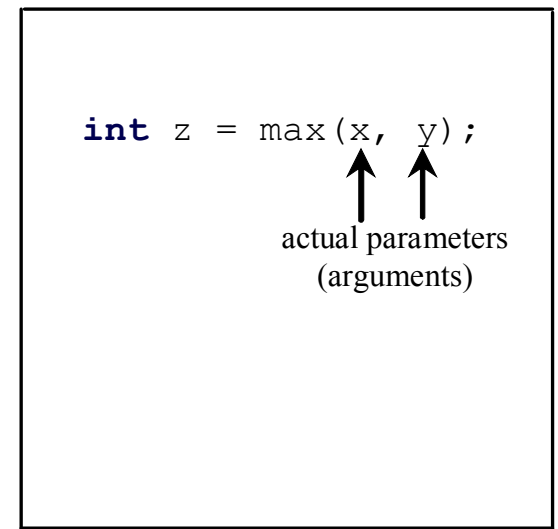
# Formal Parameters

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

Define a method



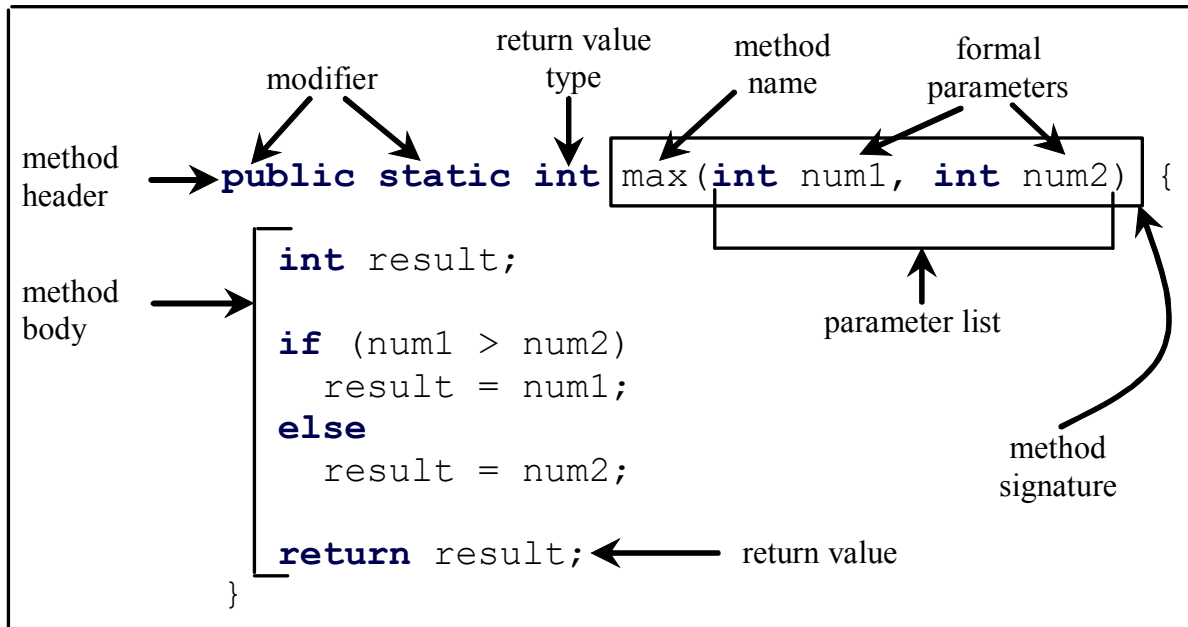
Invoke a method



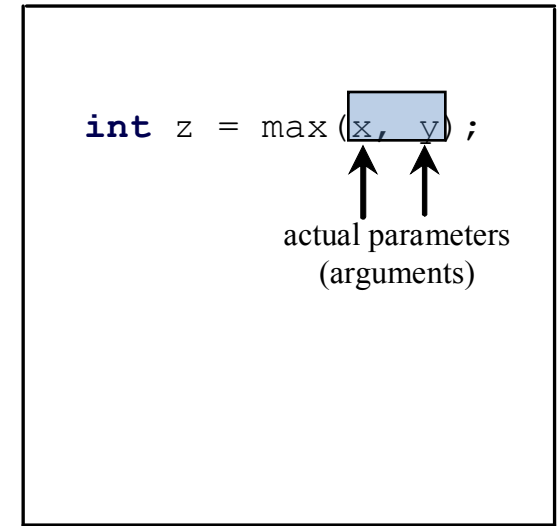
# Actual Parameters

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

Define a method



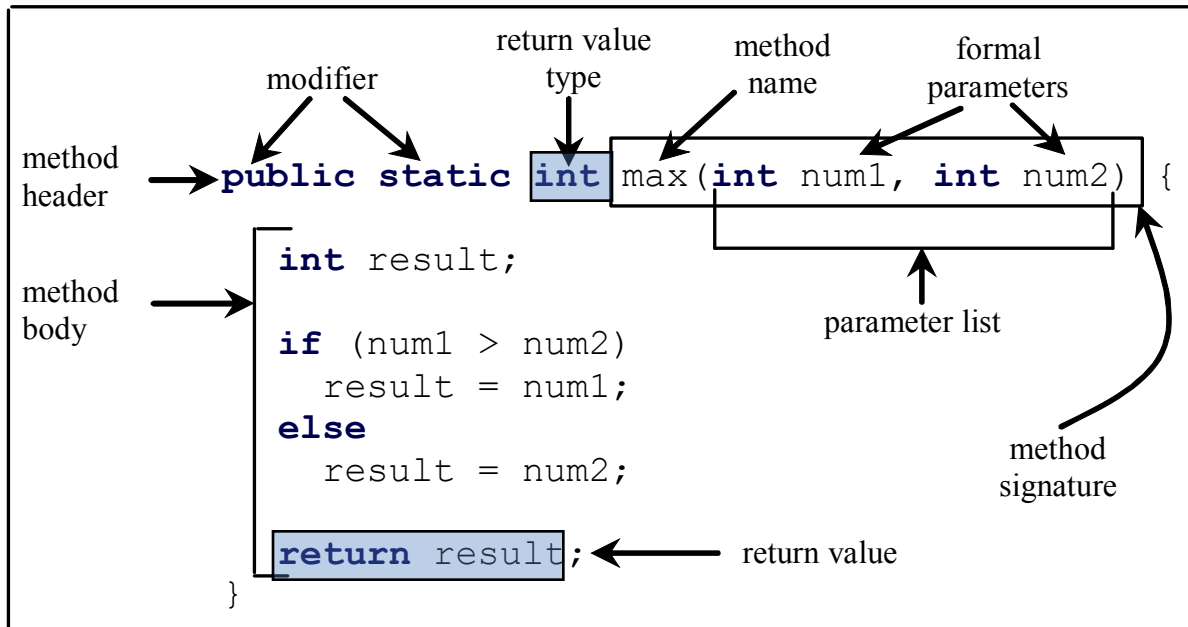
Invoke a method



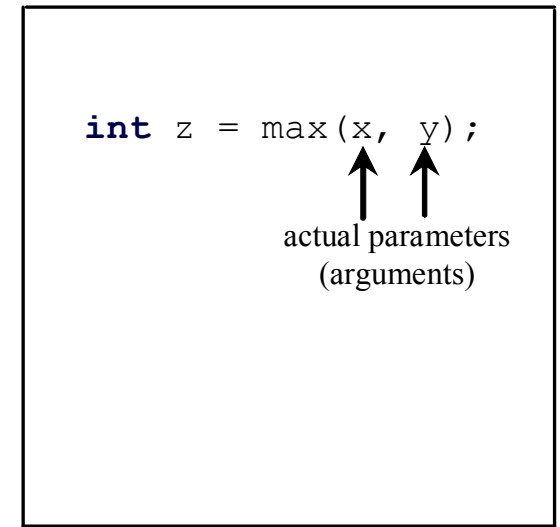
# Return Value Type

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.

Define a method



Invoke a method





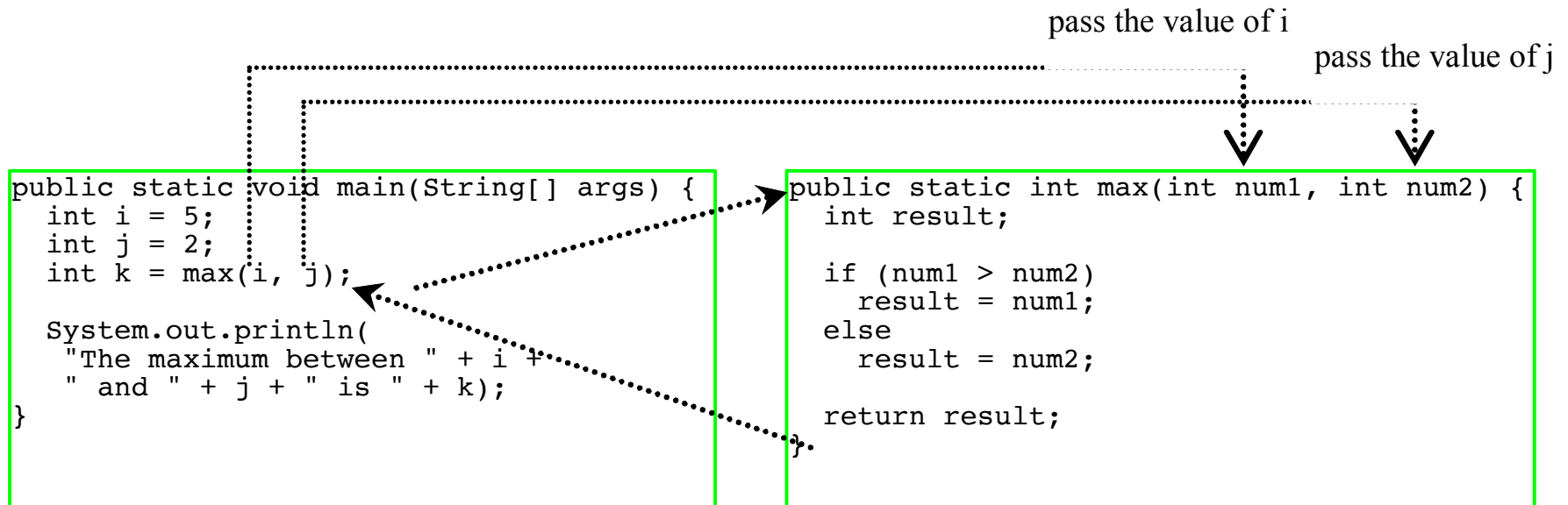
# Calling Methods

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Testing the `max` method

This program demonstrates calling a method `max` to return the largest of the `int` values

# Calling Methods, cont.



# 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(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

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;  
}
```

# 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

declare variable 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;  
}
```

# 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 int max(int num1, int num2) {  
    int result;  
    if (num1 > num2)  
        result = num1;  
    else  
        result = num2;  
    return result;  
}
```



# Trace Method Invocation

result 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

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);  
}
```

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

# Trace Method Invocation

return max(i, j) and assign the  
return value 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;  
}
```

# Trace Method Invocation

Execute the 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;  
}
```

# 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.

```
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

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

(b)

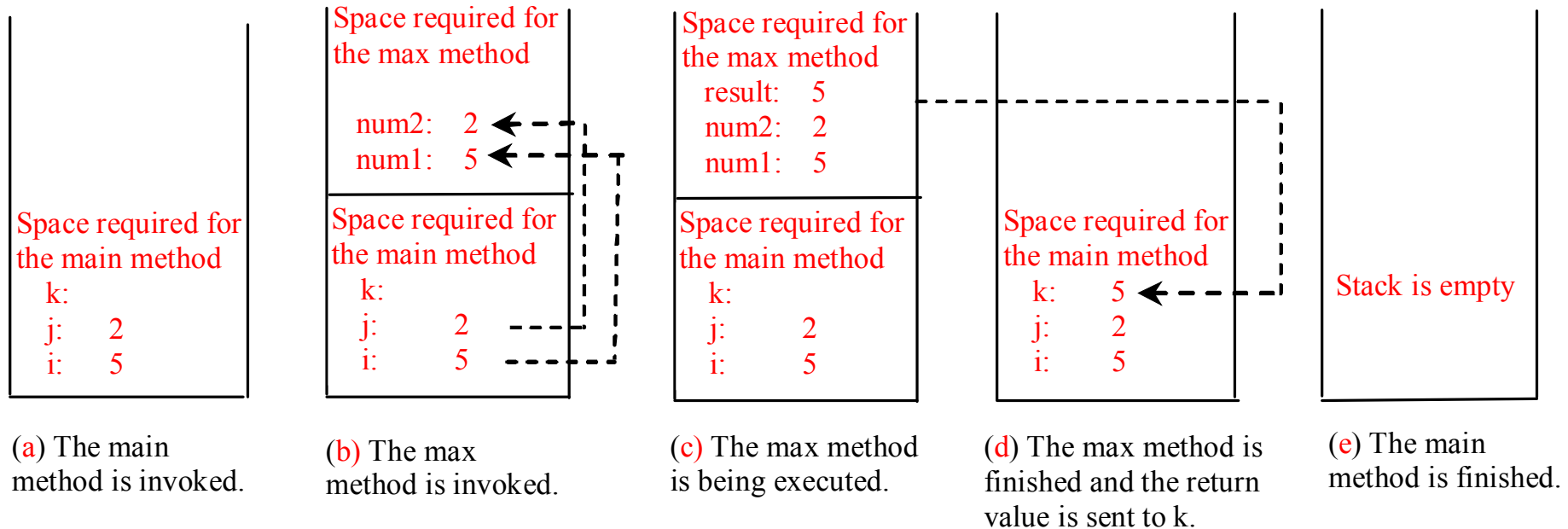
To fix this problem, delete if ( $n < 0$ ) in (a), so that the compiler will see a return statement to be reached regardless of how the if statement is evaluated.

# Reuse Methods from Other Classes

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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).

# Call Stacks



# 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;  
}
```

i: 5

The main method  
is invoked.



# 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;  
}
```

j: 2  
i: 5

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

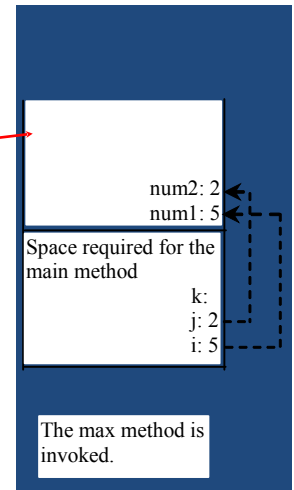
The main method  
is invoked.

# Trace Call Stack

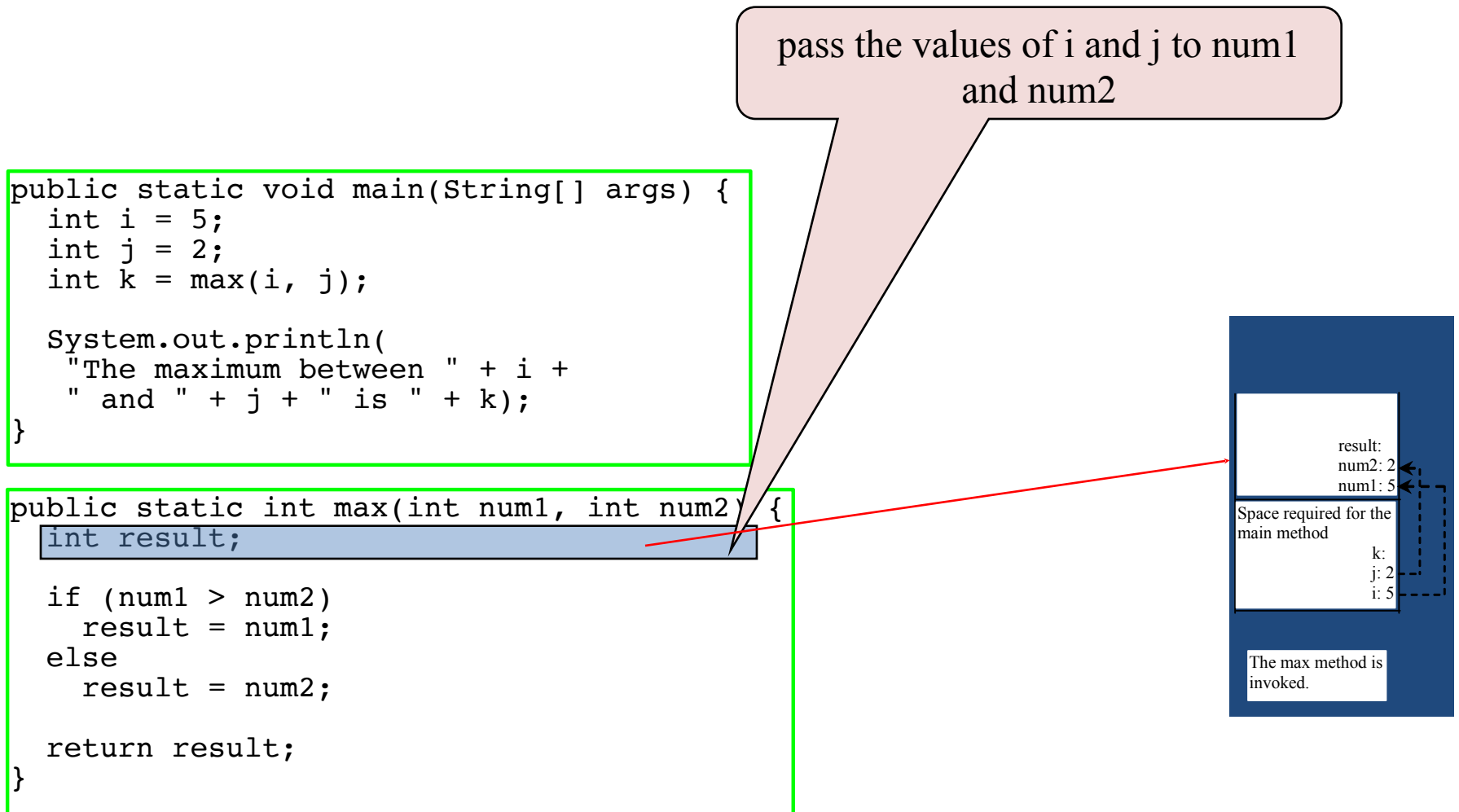
pass the values of i and j to num1  
and num2

```
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 Call Stack

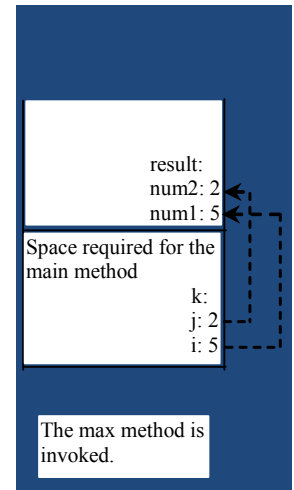


# Trace Call Stack

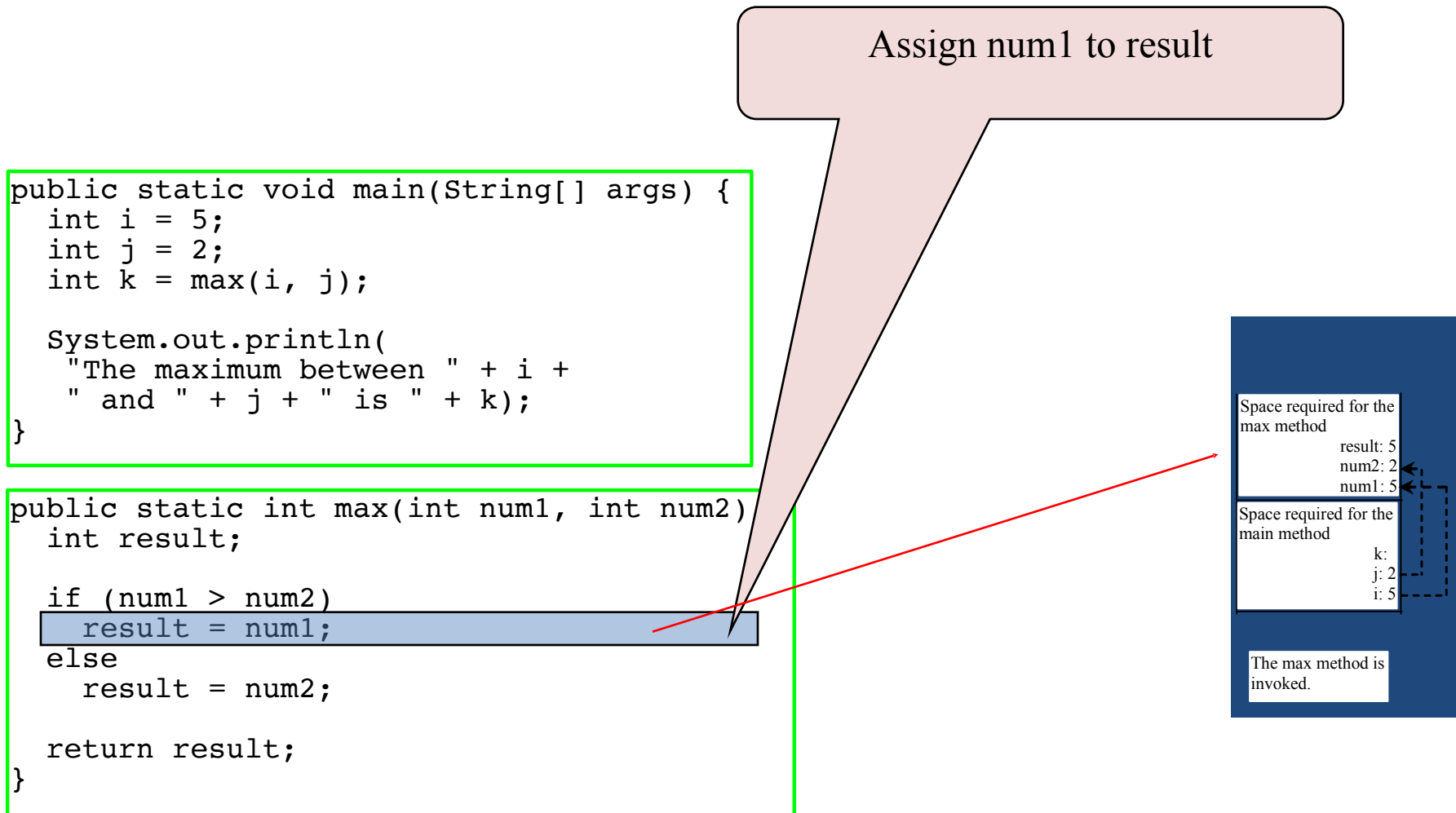
(num1 > num2) is true

```
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;  
}
```



# Trace Call Stack

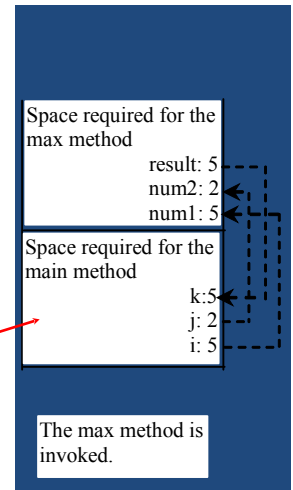


# Trace Call Stack

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;  
}
```





# 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 Example

This type of method does not return a value. The method performs some actions.

## LISTING 6.2 TestVoidMethod.java

```
1  public class TestVoidMethod {
2      public static void main(String[] args) {
3          System.out.print("The grade is ");
4          printGrade(78.5);
5
6          System.out.print("The grade is ");
7          printGrade(59.5);
8      }
9
10     public static void printGrade(double score) {
11         if (score >= 90.0) {
12             System.out.println('A');
13         }
14         else if (score >= 80.0) {
15             System.out.println('B');
16         }
17         else if (score >= 70.0) {
18             System.out.println('C');
19         }
20         else if (score >= 60.0) {
21             System.out.println('D');
22         }
23         else {
24             System.out.println('F');
25         }
26     }
27 }
```

# Passing Parameters

---

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

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?

# Pass by Value

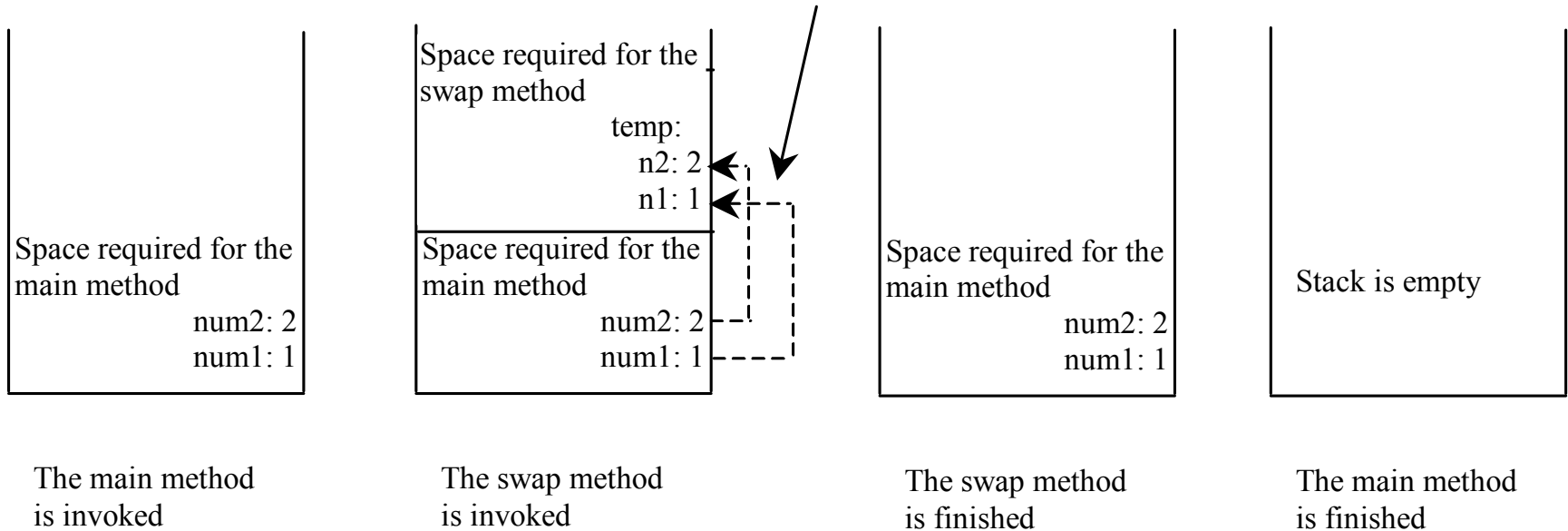
This program demonstrates passing values to the methods.

## LISTING 6.4 Increment.java

```
1  public class Increment {
2      public static void main(String[] args) {
3          int x = 1;
4          System.out.println("Before the call, x is " + x);
5          increment(x);
6          System.out.println("After the call, x is " + x);
7      }
8
9      public static void increment(int n) {
10         n++;
11         System.out.println("n inside the method is " + n);
12     }
13 }
```

# Pass by Value, cont.

The values of num1 and num2 are passed to n1 and n2. Executing swap does not affect num1 and num2.



# Overloading Methods

---

*Overloading methods enables you to define the methods with the same name as long as their signatures are different.*

## Overloading the `max` Method

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

# 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

---

```
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 Local Variables

---

A local variable: a variable defined inside a method.

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, cont.

---

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.

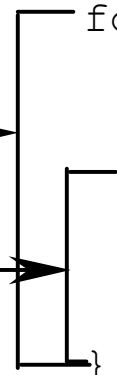
## Scope of Local Variables, cont.

A variable declared in the initial action part of a for loop header has its scope in the entire loop. But a variable declared inside a for loop body has its scope limited in the loop body from its declaration and to the end of the block that contains the variable.

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

The scope of i →

The scope of j →



# Scope of Local Variables, cont.

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, cont.

---

```
// 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, cont.

---

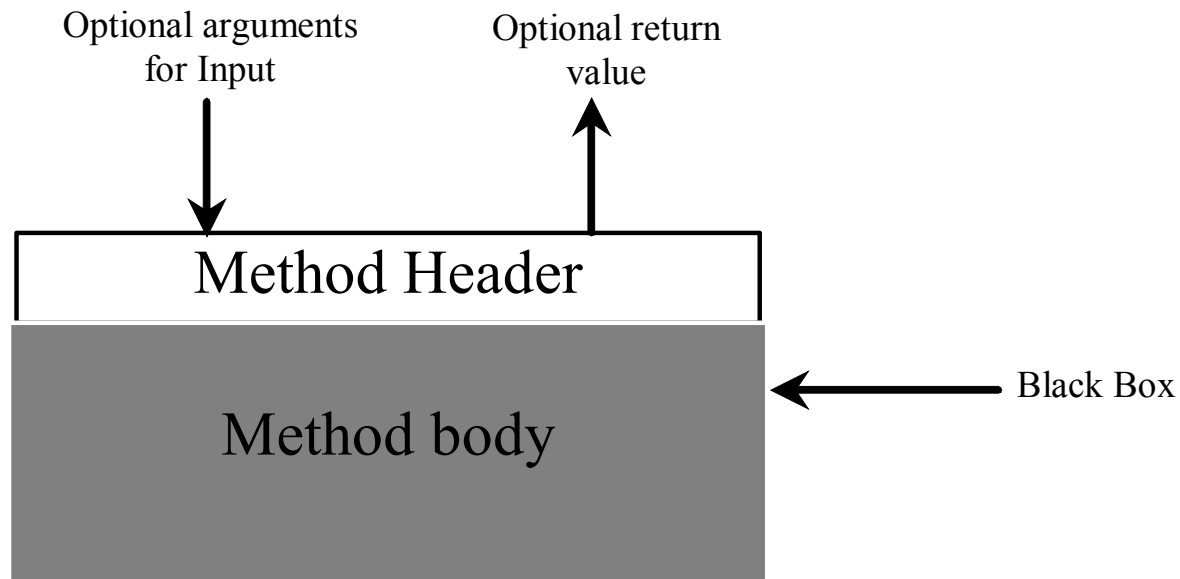
// With errors

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

# 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.