Chapter 6
Methods

Problem

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);
```

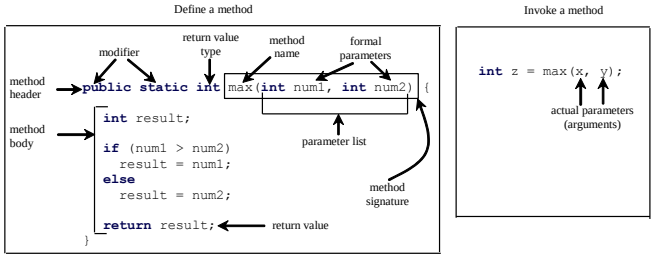
Solution

```
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));
}
```

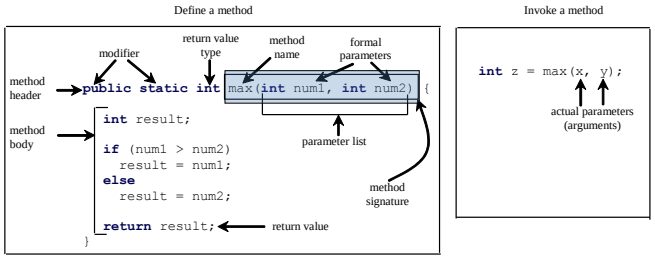

Defining Methods

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



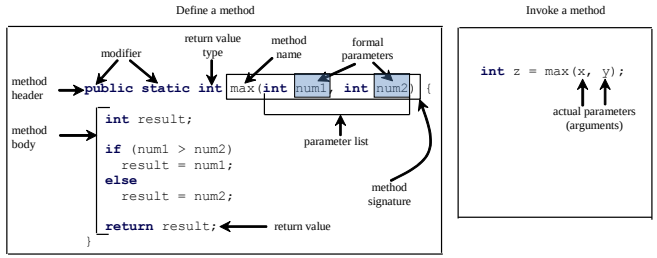
Method Signature

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



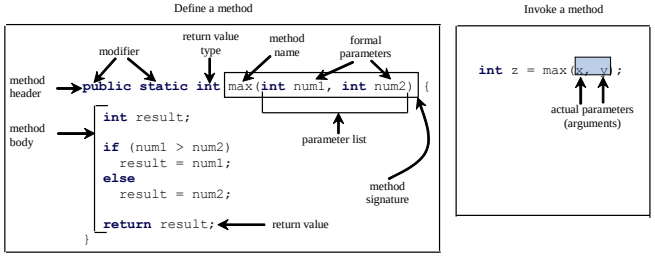
Formal Parameters

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



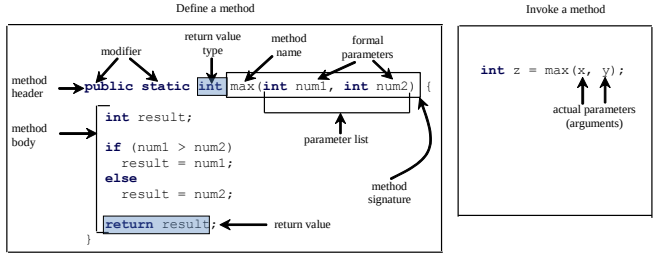
Actual Parameters

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



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.

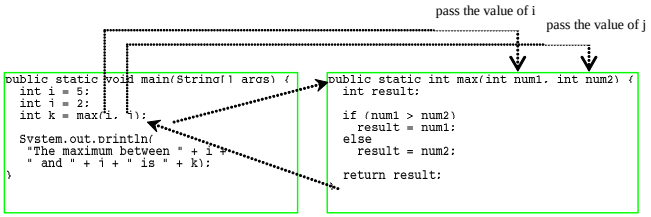


Calling Methods

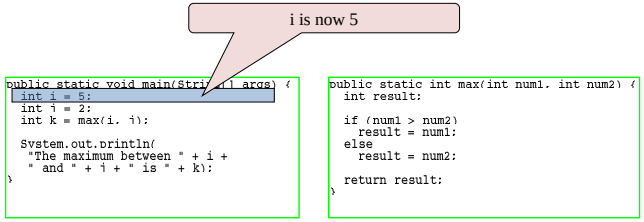
Testing the `max` method

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

Calling Methods, cont.



Trace Method Invocation



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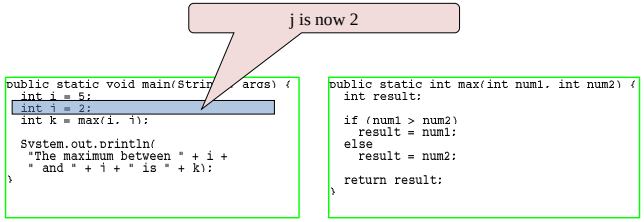

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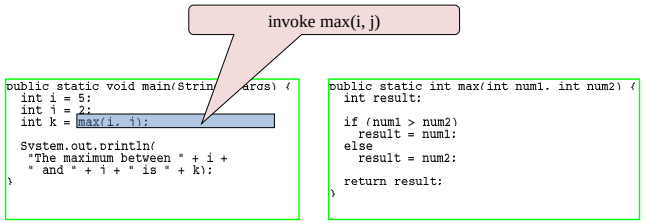

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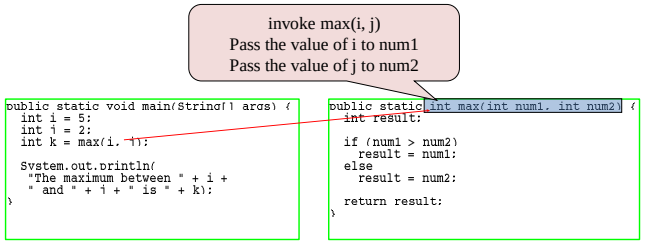

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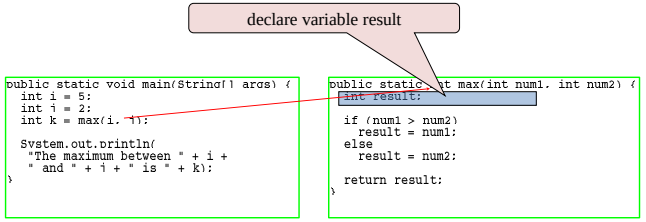

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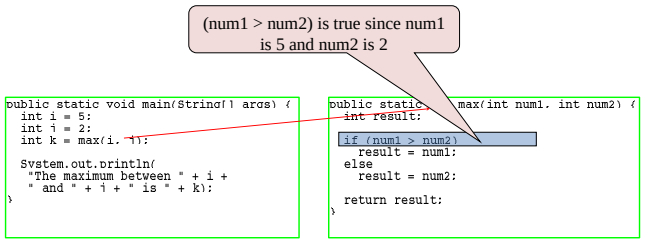
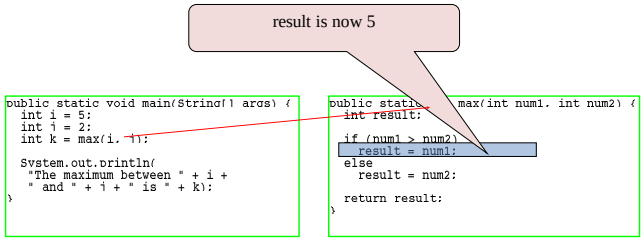
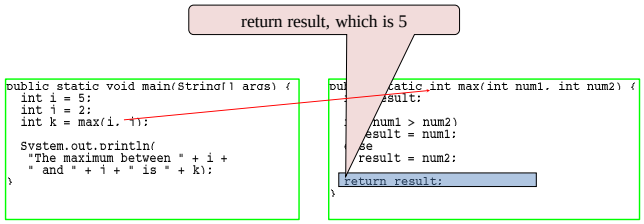


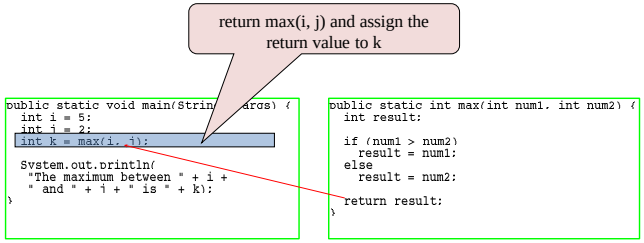
Trace Method Invocation



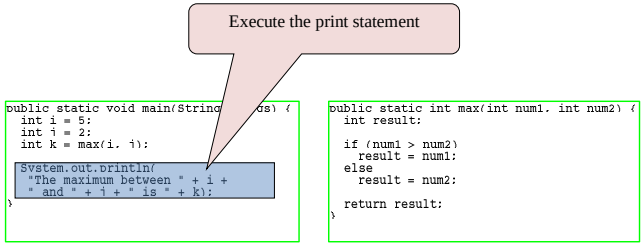
Trace Method Invocation



Trace Method Invocation



Trace Method Invocation



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;
}
```

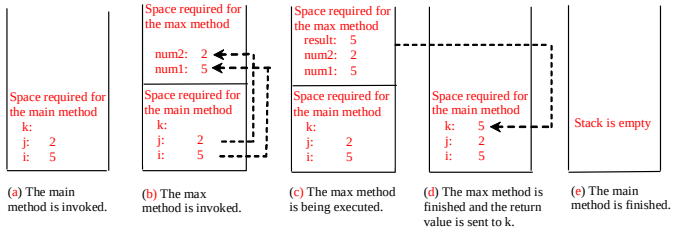
(b)

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

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



(a) The main method is invoked.

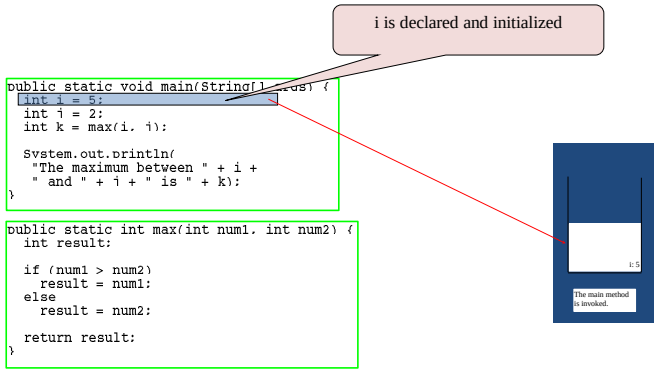
(b) The max method is invoked.

(c) The max method is being executed.

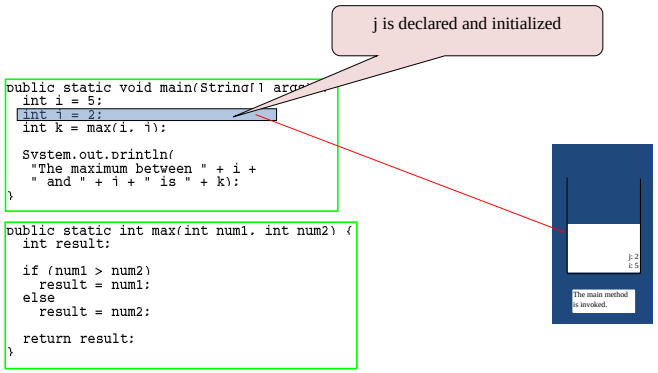
(d) The max method is finished and the return value is sent to k.

(e) The main method is finished.

Trace Call Stack



Trace Call Stack



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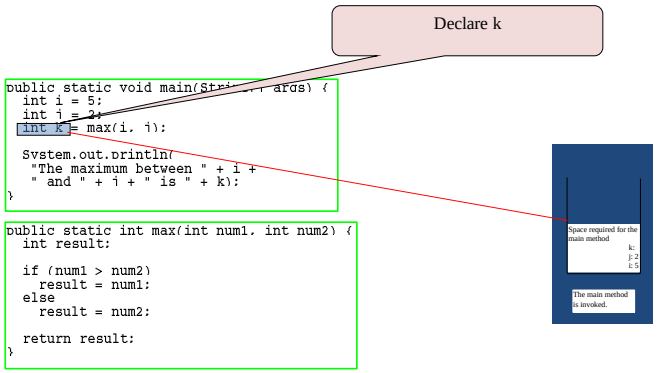
Trace Call Stack



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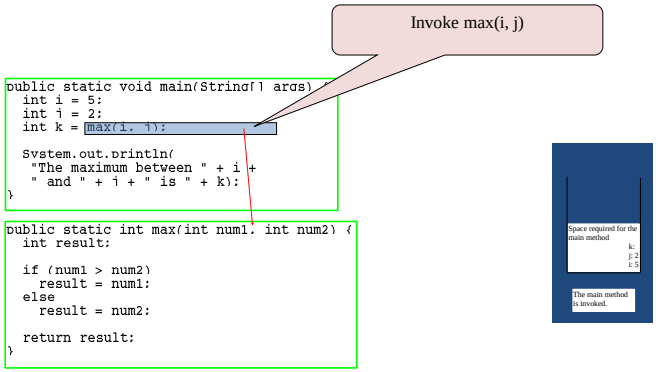
Trace Call Stack



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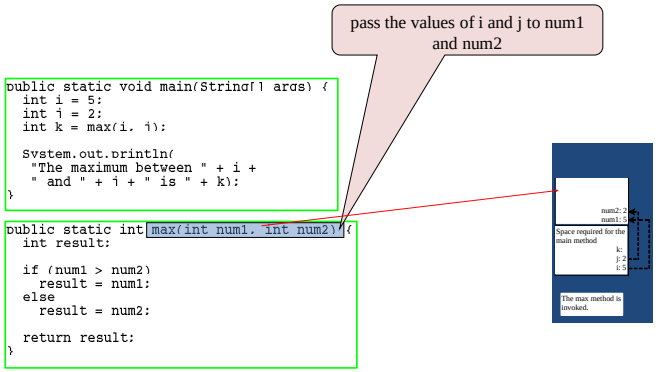
Trace Call Stack



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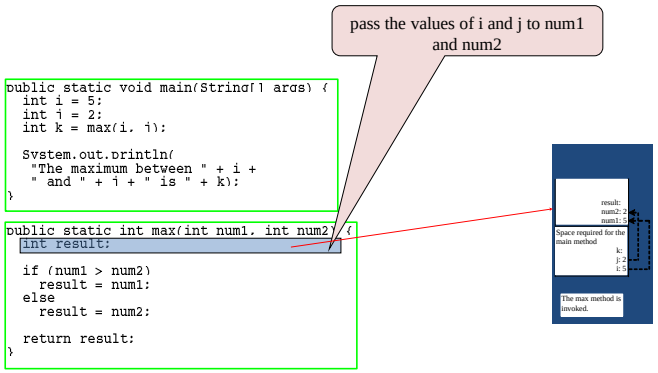
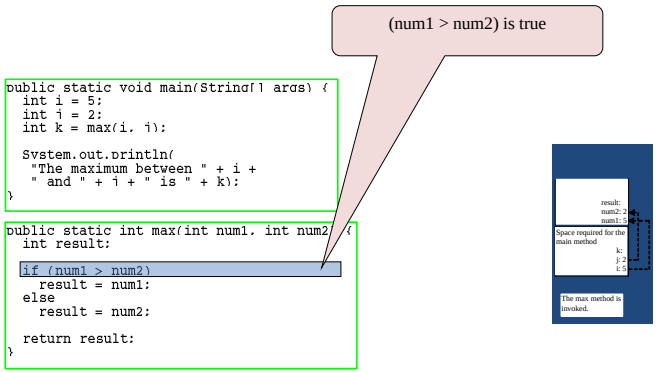
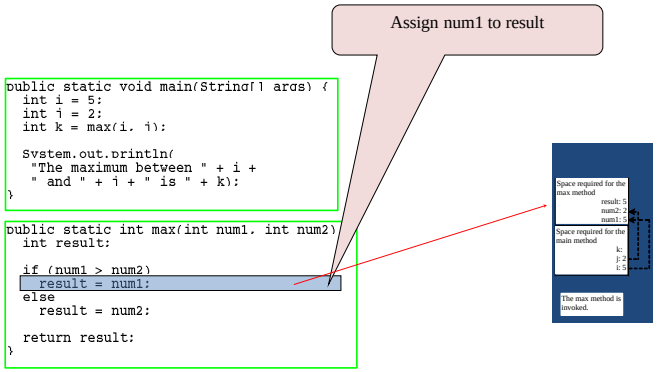
Trace Call Stack



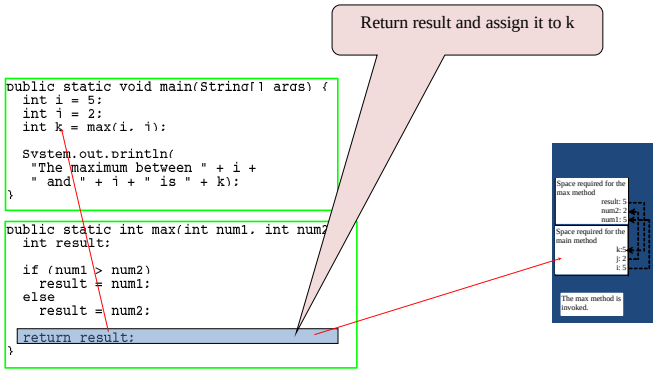
Trace Call Stack



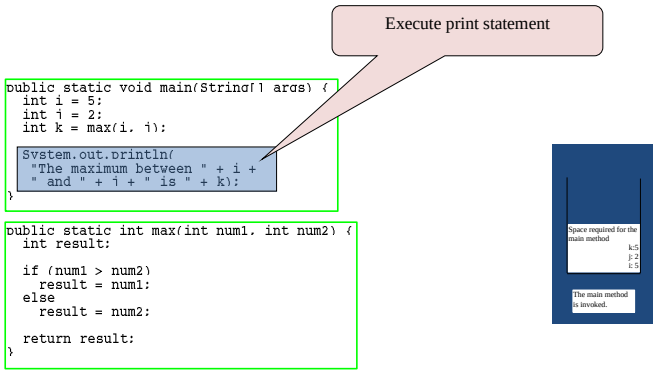
Trace Call Stack



Trace Call Stack



Trace Call Stack



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?

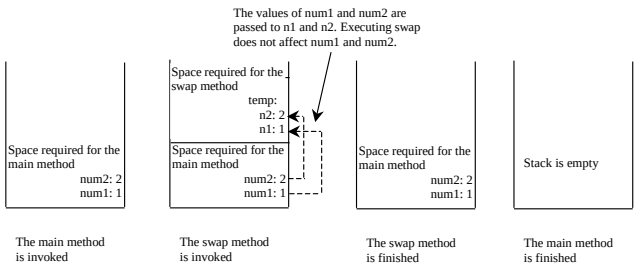
Pass by Value

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.



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.

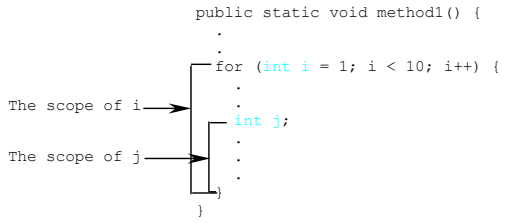
The scope of a local variable starts from its declaration and continues to the end of the block that contains the variable. A local variable must be declared before it can be used.

Scope of Local Variables, cont.

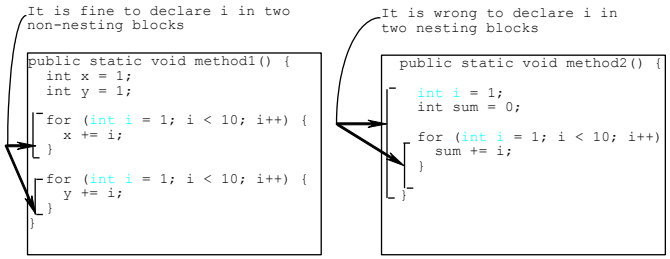
You can declare a local variable with the same name multiple times in different non-nesting blocks in a method, but you cannot declare a local variable twice in nested blocks.

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.



Scope of Local Variables, cont.



Scope of Local Variables, cont.

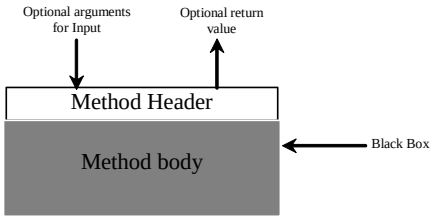
```
// Fine with no errors
public static void correctMethod() {
  int x = 1;
  int y = 1;
  // i is declared
  for (int i = 1; i < 10; i++) {
    x += i;
  }
  // i is declared again
  for (int i = 1; i < 10; i++) {
    y += i;
  }
}
```


Scope of Local Variables, cont.

```
// With no 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.

The `Math` Class

- Class constants:
  - `PI`
  - `E`
- Class methods:
  - Trigonometric Methods
  - Exponent Methods
  - Rounding Methods
  - min, max, abs, and random Methods

Trigonometric Methods

- `sin(double a)`
- `cos(double a)`
- `tan(double a)`
- `acos(double a)`
- `asin(double a)`
- `atan(double a)`

Radians

toRadians(90)

```
Examples:

Math.sin(0) returns 0.0
Math.sin(Math.PI / 6)
  returns 0.5
Math.sin(Math.PI / 2)
  returns 1.0
Math.cos(0) returns 1.0
Math.cos(Math.PI / 6)
  returns 0.866
Math.cos(Math.PI / 2)
  returns 0
```


Exponent Methods

- `exp(double a)`
  Returns `e` raised to the power of `a`.
- `log(double a)`
  Returns the natural logarithm of `a`.
- `log10(double a)`
  Returns the 10-based logarithm of `a`.
- `pow(double a, double b)`
  Returns `a` raised to the power of `b`.
- `sqrt(double a)`
  Returns the square root of `a`.

```
Examples:

Math.exp(1) returns 2.71
Math.log(2.71) returns 1.0
Math.pow(2, 3) returns 8.0
Math.pow(3, 2) returns 9.0
Math.pow(3.5, 2.5) returns
   22.91765
Math.sqrt(4) returns 2.0
Math.sqrt(10.5) returns 3.24
```


Rounding Methods

- `double ceil(double x)`
  x rounded up to its nearest integer. This integer is returned as a double value.
- `double floor(double x)`
  x is rounded down to its nearest integer. This integer is returned as a double value.
- `double rint(double x)`
  x is rounded to its nearest integer. If x is equally close to two integers, the even one is returned as a double.
- `int round(float x)`
  Return (int)Math.floor(x+0.5).
- `long round(double x)`
  Return (long)Math.floor(x+0.5).

Rounding Methods Examples

```
Math.ceil(2.1) returns 3.0
Math.ceil(2.0) returns 2.0
Math.ceil(-2.0) returns -2.0
Math.ceil(-2.1) returns -2.0
Math.floor(2.1) returns 2.0
Math.floor(2.0) returns 2.0
Math.floor(-2.0) returns -2.0
Math.floor(-2.1) returns -3.0
Math.rint(2.1) returns 2.0
Math.rint(2.0) returns 2.0
Math.rint(-2.0) returns -2.0
Math.rint(-2.1) returns -2.0
Math.rint(2.5) returns 2.0
Math.rint(-2.5) returns -2.0
Math.round(2.6f) returns 3
Math.round(2.0) returns 2
Math.round(-2.0f) returns -2
Math.round(-2.6) returns -3
```


min, max, and abs

- `max(a, b)` and `min(a, b)`

  Returns the maximum or minimum of two parameters.
- `abs(a)`

  Returns the absolute value of the parameter.
- `random()`

  Returns a random `double` value in the range [0.0, 1.0).

```
Examples:

Math.max(2, 3) returns 3
Math.max(2.5, 3) returns
  3.0
Math.min(2.5, 3.6)
  returns 2.5
Math.abs(-2) returns 2
Math.abs(-2.1) returns
  2.1
```


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)  ──→  Returns a random integer
                                between 0 and 9.

50 + (int)(Math.random() * 50)  ──→  Returns a random integer
                                     between 50 and 99.
```

In general,

```
a + Math.random() * b  ──→  Returns a random number between
                            a and a + b, excluding a + b.
```