

Methods

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

Problem

```
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);
```

Problem

```
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

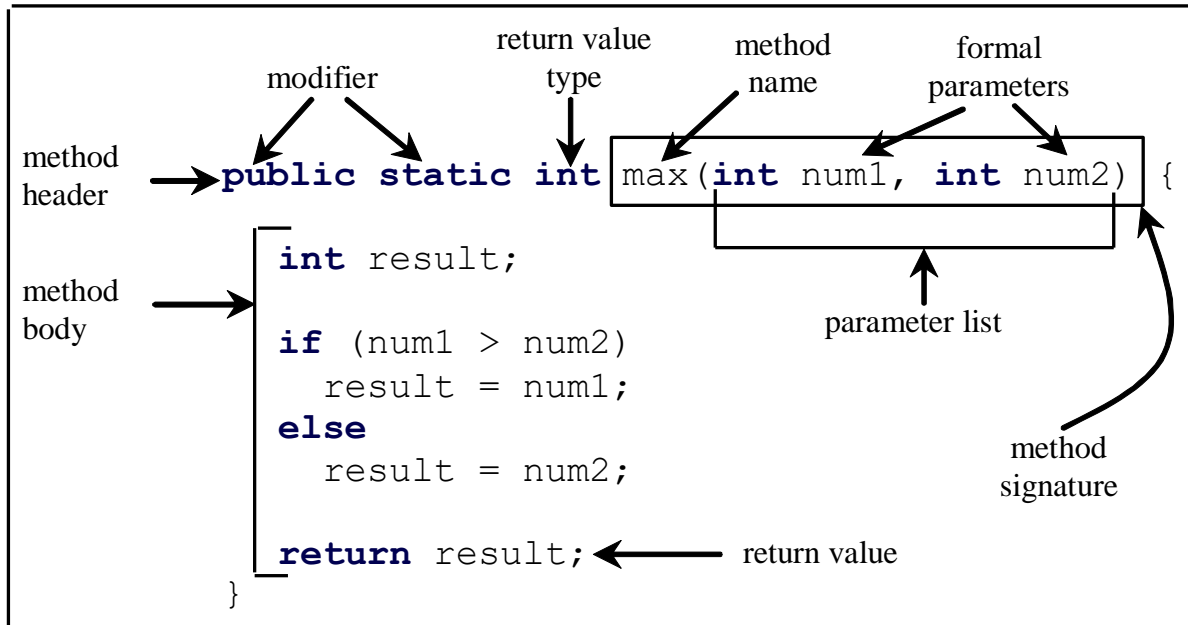
```
public static int sum(int i1, int i2) {  
    int sum = 0;  
    for (int i = i1; i <= i2; i++)  
        sum += i;  
    return sum;  
}
```

```
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));  
}
```

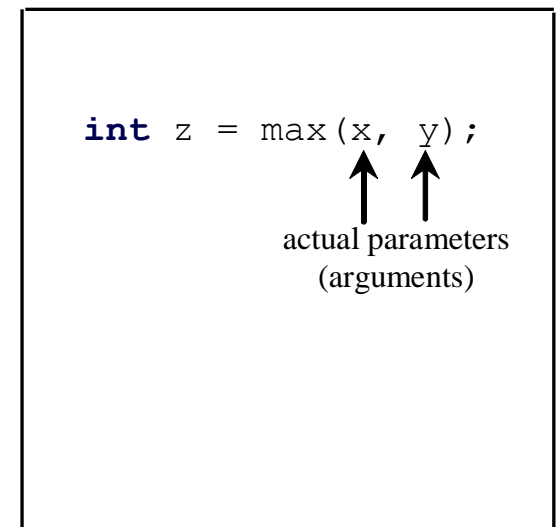
Defining Methods

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

Define a method



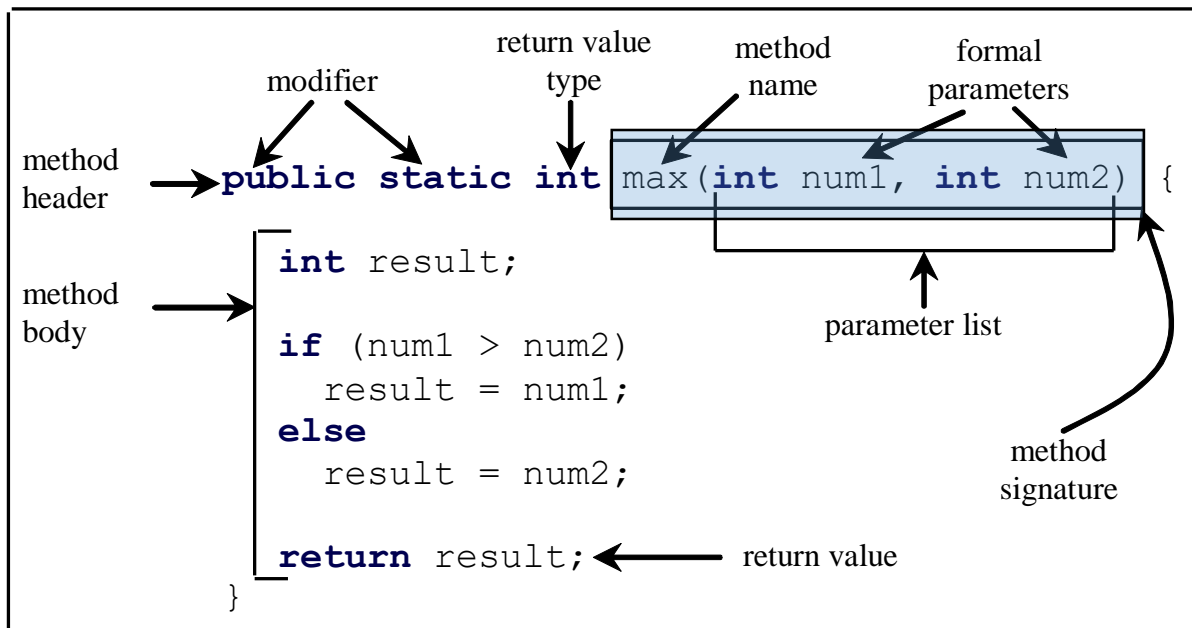
Invoke a method



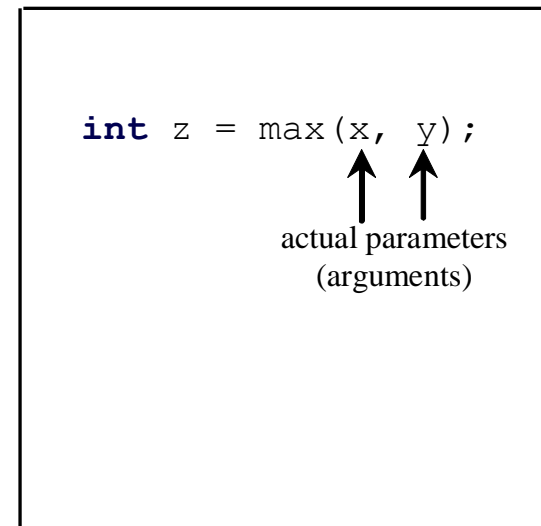
Method Signature

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

Define a method



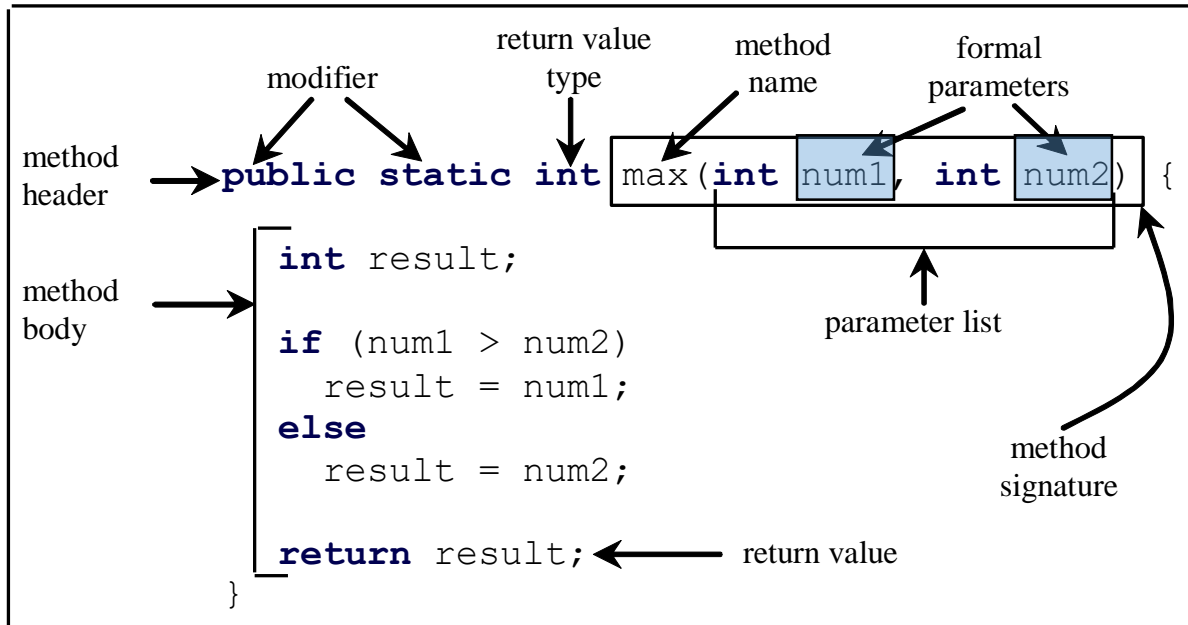
Invoke a method



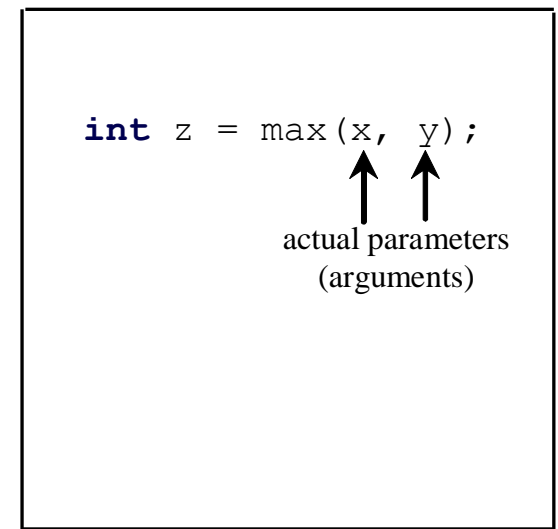
Formal Parameters

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

Define a method



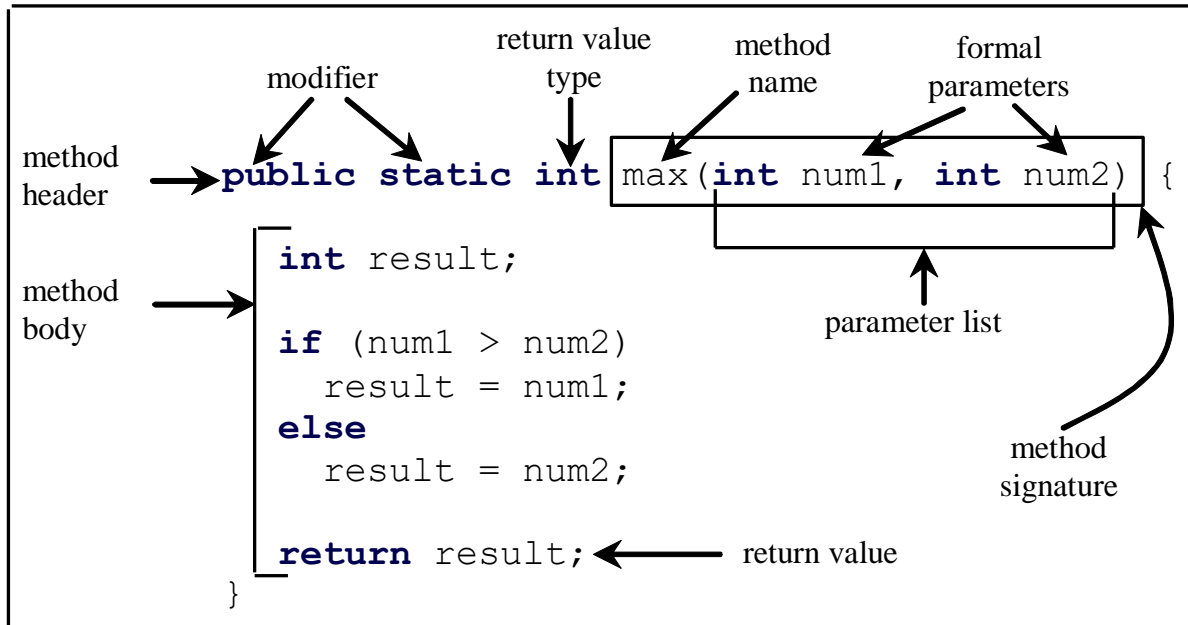
Invoke a method



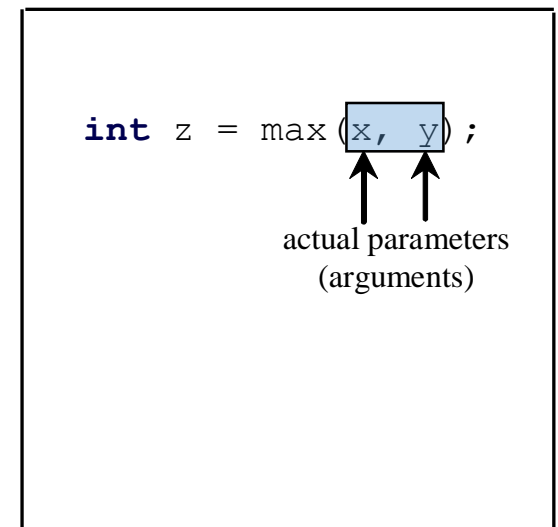
Actual Parameters

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



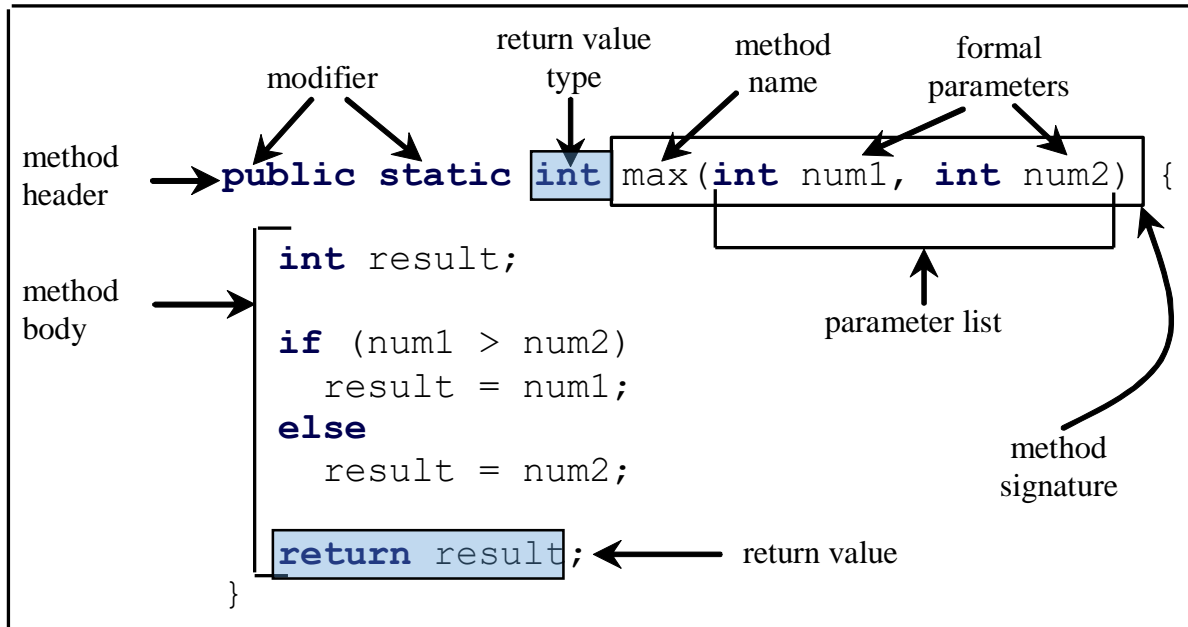
Invoke a method



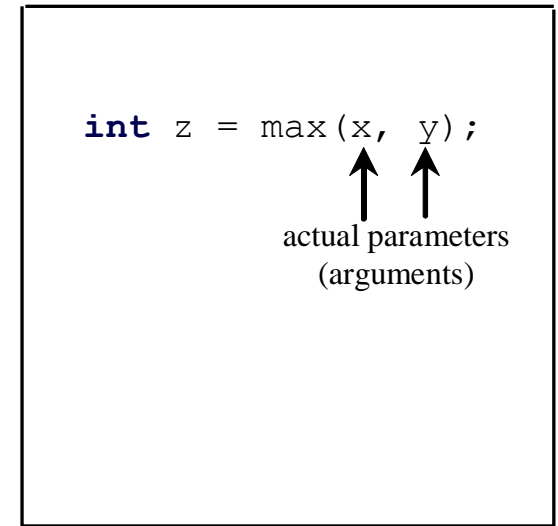
Return Value Type

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.

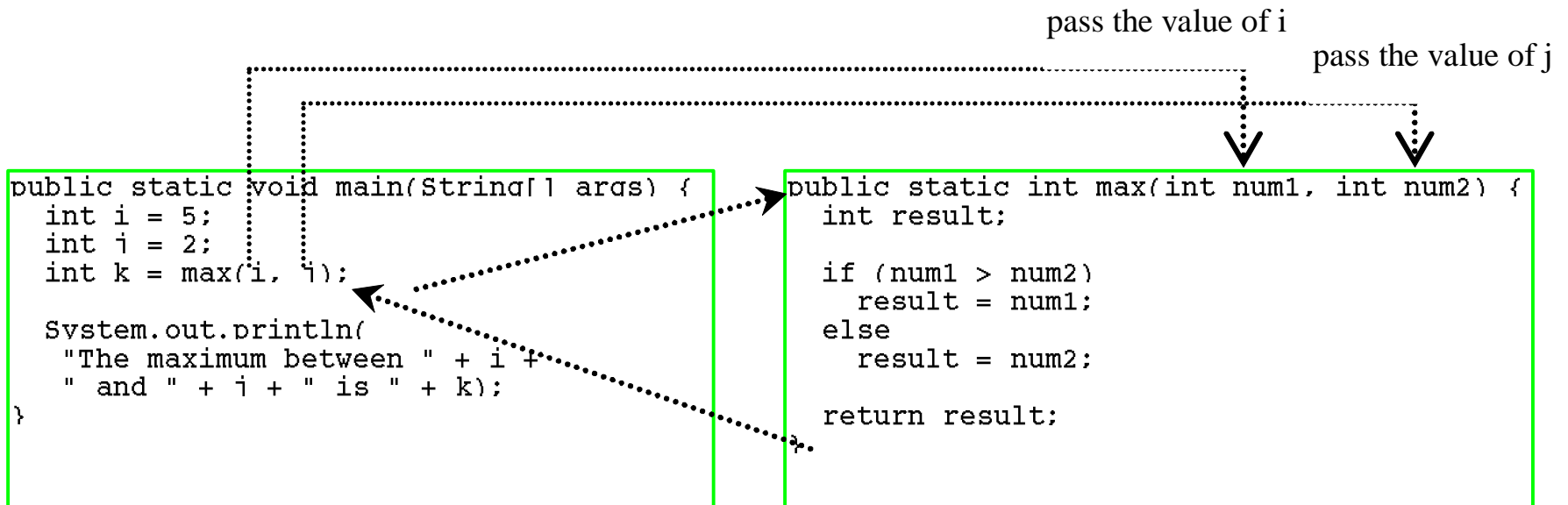
Define a method



Invoke a method



Calling Methods



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 i = 2;  
    int k = max(i, i);  
  
    System.out.println(  
        "The maximum between " + i +  
        " and " + i + " 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

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).

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?

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.

Problem: Greatest Common Divisor, Prime Number

Passing Arrays to Methods

```
public static void printArray(int[] array) {  
    for (int i = 0; i < array.length; i++) {  
        System.out.print(array[i] + " ");  
    }  
}
```

Invoke the method

```
int[] list = {3, 1, 2, 6, 4, 2};  
printArray(list);
```

Invoke the method

```
printArray(new int[]{3, 1, 2, 6, 4, 2});
```

Anonymous array

Anonymous Array

The statement

```
printArray(new int[]{3, 1, 2, 6, 4, 2});
```

creates an array using the following syntax:

```
new dataType[]{literal0, literal1, ..., literalk};
```

There is no explicit reference variable for the array. Such array is called an *anonymous array*.

Pass By Value

Java uses *pass by value* to pass arguments to a method. There are important differences between passing a value of variables of primitive data types and passing arrays.

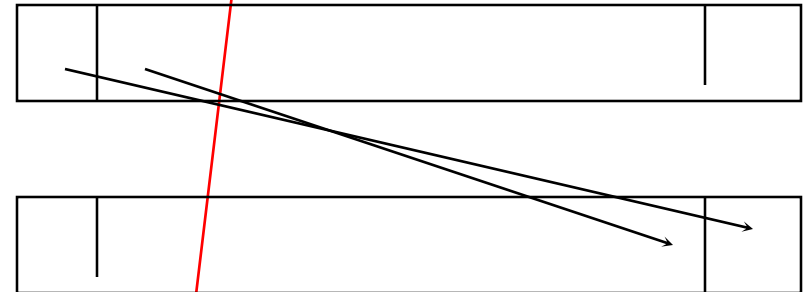
- For a parameter of a primitive type value, the actual value is passed. Changing the value of the local parameter inside the method does not affect the value of the variable outside the method.
- For a parameter of an array type, the value of the parameter contains a reference to an array; this reference is passed to the method. Any changes to the array that occur inside the method body will affect the original array that was passed as the argument.

Returning an Array from a Method

```
public static int[] reverse(int[] list) {  
    int[] result = new int[list.length];  
  
    for (int i = 0, j = result.length - 1;  
        i < list.length; i++, j--) {  
        result[j] = list[i];  
    }  
  
    return result;  
}
```

list

result



```
int[] list1 = new int[]{1, 2, 3, 4, 5, 6};  
int[] list2 = reverse(list1);
```

Passing Two-Dimensional Arrays to Methods

```
public static int sum(int[][] m) {  
    return total;  
}
```

```
int[][] m = new int[3][4];  
sum(m);
```

Overloading Methods

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;  
    }  
}
```


Problem: Converting Decimals to Hexadecimals

Write a method that converts a decimal integer to a hexadecimal.

```
public static String dec2hex(int n) {  
  
}
```

Write a method that returns an amount of currency in words. Assume the amount <10000.

```
public static String amountInWords(int n) {  
  
}
```

Handwritten, On the top page: Assignment 1,
CSE 215.1 (Sum 2018), Name & ID, Date

Problem: Converting Decimals to Hexadecimals

Write a method that converts a hexadecimal integer to a decimal.

```
public static int hex2dec(String s) {  
  
}
```

Write a method that return an amount of currency in words. Assume the amount <10000.

```
public static String amountInWords(int n) {  
  
}
```

Handwritten, On the top page: Assignment 1,
CSE 215.1 (Fall 2017), Name & ID, Date

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;  
        .  
        .  
        .  
    }  
}
```

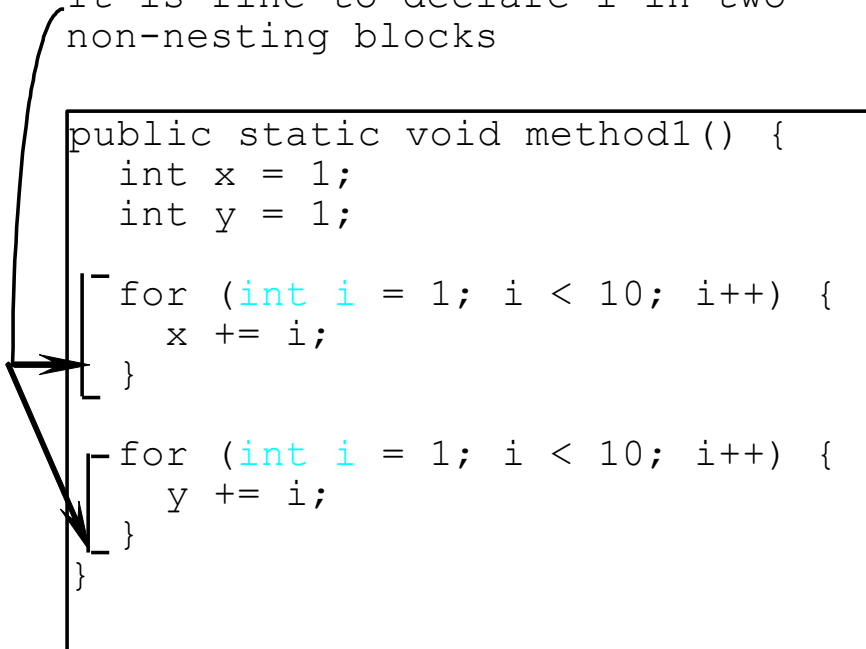
The scope of i →

The scope of j →

Scope of Local Variables, cont.

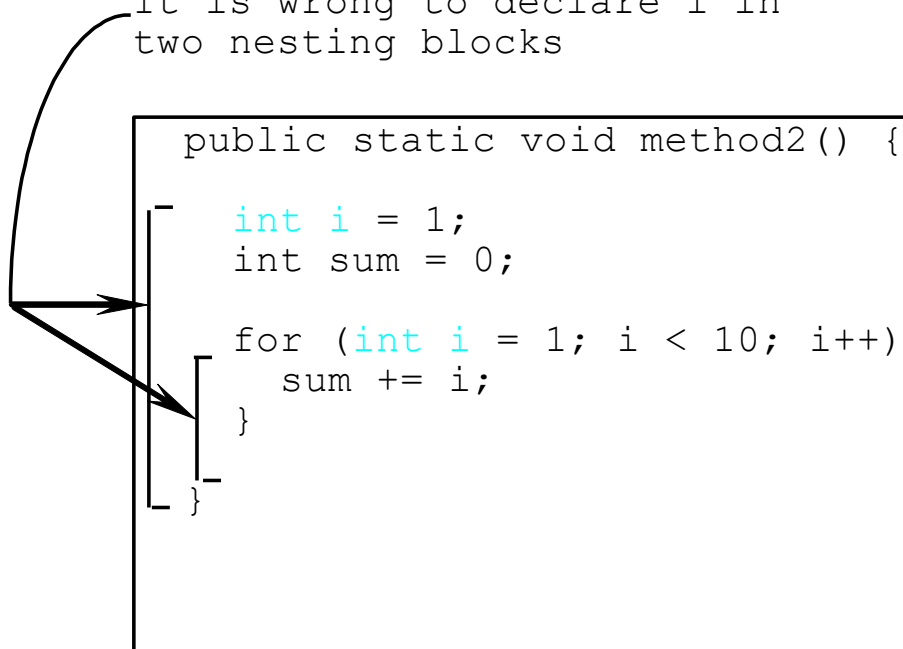
It is fine to declare `i` in two non-nesting blocks

```
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;
    }
}
```

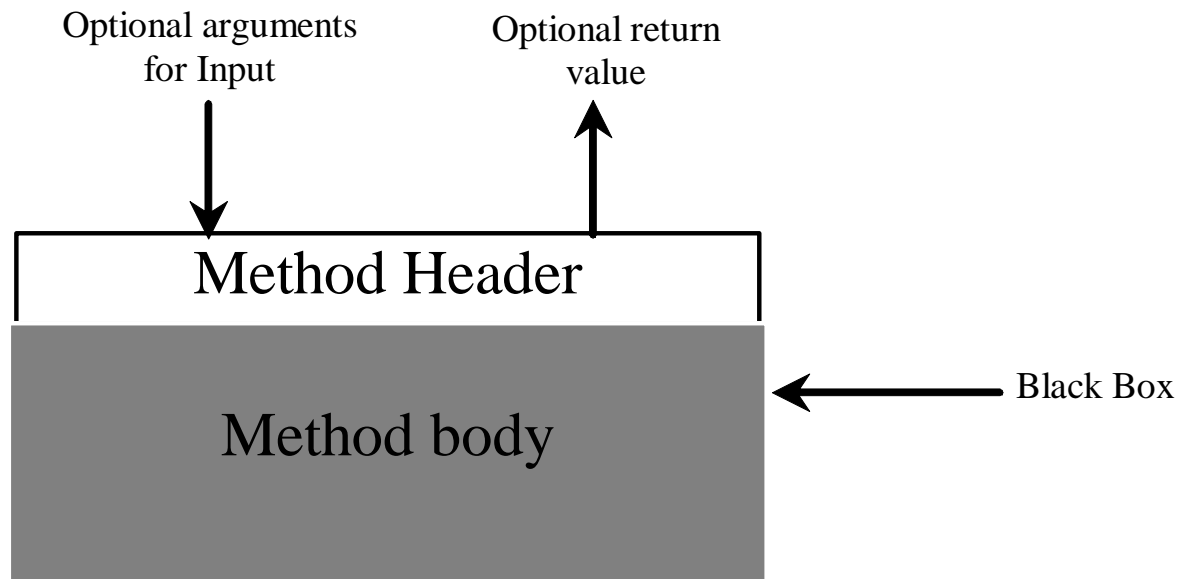
Scope of Local Variables, cont.

// With errors

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

Finish!

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 ($0 \leq \text{Math.random()} < 1.0$).

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

As discussed in Chapter 2., 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:

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

So a random lowercase letter is

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