

5.3 for Iteration Statement

Section 5.2 presented the essentials of counter-controlled iteration. The `while` statement can be used to implement any counter-controlled loop. Java also provides the **for iteration statement**, which specifies the counter-controlled-iteration details in a single line of code. [Figure 5.2](#) reimplements the application of [Fig. 5.1](#) using `for`.

```
1 // Fig. 5.2: ForCounter.java
2 // Counter-controlled iteration with the for iteration statement
3
4 public class ForCounter {
5     public static void main(String[] args) {
6         // for statement header includes initialization, loop-continuation
7         // loop-continuation condition and increment
8         for (int counter = 1; counter <= 10; counter++)
9             System.out.printf("%d ", counter);
10        }
11
12        System.out.println();
13    }
14 }
```

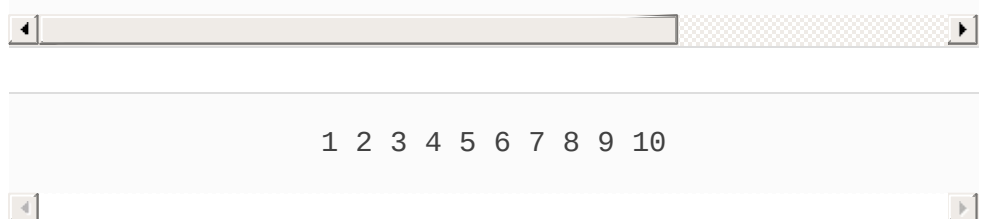


Fig. 5.2

Counter-controlled iteration with the `for` iteration statement.

When the `for` statement (lines 8–10) begins executing, the control variable `counter` is *declared* and *initialized* to 1. (Recall from [Section 5.2](#) that the first two elements of counter-controlled iteration are the *control variable* and its *initial value*.) Next, the program checks the *loop-continuation condition*, `counter <= 10`, which is between the two required semicolons. Because the initial value of `counter` is 1, the condition initially is `true`. Therefore, the body statement (line 9) displays control variable `counter`'s value, namely 1. After executing the loop's body, the program increments `counter` in the expression `counter++`, which appears to the right of the second semicolon. Then the loop-continuation test is performed again to determine whether the program should continue with the next iteration of the loop. At this point, the control variable's value is 2, so the condition is still `true` (the *final value* is not exceeded)—thus, the program performs the body statement again (i.e., the next iteration of the loop). This process continues until the numbers 1 through 10 have been displayed and the `counter`'s value becomes 11, causing the loop-continuation test to fail and iteration to terminate (after 10 iterations of the loop body). Then the program performs the first statement after the `for`—in this case, line 12.

[Figure 5.2](#) uses (in line 8) the loop-continuation condition `counter <= 10`. If you incorrectly specified `counter <`

10 as the condition, the loop would iterate only nine times. This is a common *logic error* called an **off-by-one error**.



Common Programming Error 5.2

Using an incorrect relational operator or an incorrect final value of a loop counter in the loop-continuation condition of an iteration statement can cause an off-by-one error.



Error-Prevention Tip 5.2

Using the final value and operator `<=` in a loop's condition helps avoid off-by-one errors. For a loop that outputs 1 to 10, the loop-continuation condition should be `counter <= 10` rather than `counter < 10` (which causes an off-by-one error) or `counter < 11` (which is correct). Many programmers prefer so-called zero-based counting, in which to count 10 times, `counter` would be initialized to zero and the loop-continuation test would be `counter < 10`.



Error-Prevention Tip 5.3

As Chapter 4 mentioned, integers can overflow, causing logic

errors. A loop's control variable also could overflow. Write your loop conditions carefully to prevent this.

A Closer Look at the for Statement's Header

Figure 5.3 takes a closer look at the `for` statement in Fig. 5.2. The first line—including the keyword `for` and everything in parentheses after `for` (line 8 in Fig. 5.2)—is sometimes called the **for statement header**. The `for` header “does it all”—it specifies each item needed for counter-controlled iteration with a control variable. If there's more than one statement in the body of the `for`, braces are required to define the body of the loop.

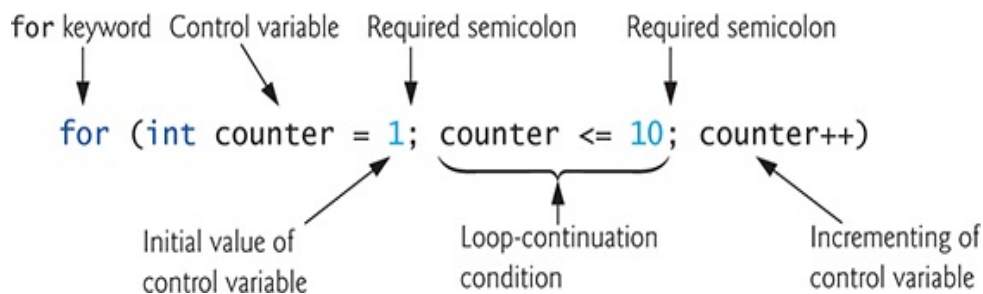


Fig. 5.3

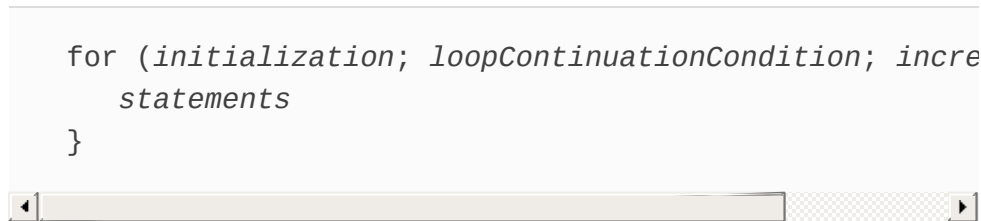
`for` statement header components.

Description

General Format of a for Statement

The general format of the `for` statement is

```
for (initialization; loopContinuationCondition; increment  
    statements  
    )  
{  
      
}
```



where the *initialization* expression names the loop's control variable and *optionally* provides its initial value, *loopContinuationCondition* determines whether the loop should continue executing and *increment* modifies the control variable's value, so that the loop-continuation condition eventually becomes `false`. The two semicolons in the `for` header are required. If the loop-continuation condition is initially `false`, the program does *not* execute the body. Instead, execution proceeds with the statement following the `for`.

Representing a for Statement with an Equivalent while Statement

The `for` statement often can be represented with an equivalent `while` statement as follows:

```
    initialization;  
    while (loopContinuationCondition) {  
        statements  
        increment;  
    }
```

In [Section 5.8](#), we show a case in which a `for` statement cannot be represented with an equivalent `while` statement. Typically, `for` statements are used for counter-controlled iteration and `while` statements for sentinel-controlled iteration. However, `while` and `for` can each be used for either iteration type.

Scope of a `for` Statement's Control Variable

If the *initialization* expression in the `for` header declares the control variable (i.e., the control variable's type is specified before the variable name, as in [Fig. 5.2](#)), the control variable can be used *only* in that `for` statement—it will not exist outside it. This restricted use is known as the variable's **scope**. The scope of a variable defines where it can be used in a program. For example, a *local variable* can be used *only* in the method that declares it and *only* from the point of declaration through the next right brace (`}`), which is often the brace that

closes the method body. Scope is discussed in detail in [Chapter 6, Methods: A Deeper Look](#).



Common Programming Error 5.3

When a `for` statement's control variable is declared in the initialization section of the `for`'s header, using the control variable after the `for`'s body is a compilation error.

Expressions in a `for` Statement's Header Are Optional

The three expressions in a `for` header are optional. If the *loopContinuationCondition* is omitted, Java assumes that it's *always true*, thus creating an *infinite loop*. You might omit the *initialization* expression if the program initializes the control variable *before* the loop. You might omit the *increment* expression if the program calculates the increment with statements in the loop's body or if no increment is needed. The increment expression in a `for` acts as if it were a standalone statement at the end of the `for`'s body. So, the expressions

```
counter = counter + 1
```

```
counter += 1  
++counter  
counter++
```

are equivalent increment expressions in a `for` statement. Many programmers prefer `counter++` because it's concise and because a `for` loop evaluates its increment expression *after* its body executes, so the postfix increment form seems more natural. In this case, the variable being incremented does not appear in a larger expression, so preincrementing and postincrementing actually have the *same* effect.



Common Programming Error 5.4

Placing a semicolon immediately to the right of the right parenthesis of a `for` header makes that `for`'s body an empty statement. This is normally a logic error.



Error-Prevention Tip 5.4

Infinite loops occur when the loop-continuation condition in an iteration statement never becomes `false`. To prevent this situation in a counter-controlled loop, ensure that the control variable is modified during each iteration of the loop so that the loop-continuation condition will eventually become

false. In a *sentinel-controlled loop*, ensure that the *sentinel value* is able to be input.

Placing Arithmetic Expressions in a for Statement's Header

The initialization, loop-continuation condition and increment portions of a `for` statement can contain arithmetic expressions. For example, assume that $x = 2$ and $y = 10$. If x and y are not modified in the body of the loop, the statement

```
for (int j = x; j <= 4 * x * y; j += y / x)
```

is equivalent to the statement

```
for (int j = 2; j <= 80; j += 5)
```

The increment of a `for` statement may also be *negative*, in which case it's a **decrement**, and the loop counts *downward*.

Using a for Statement's

Control Variable in the Statement's Body

Programs frequently display the control-variable value or use it in calculations in the loop body, but this use is *not* required. The control variable is commonly used to control iteration *without* being mentioned in the body of the `for`.



Error-Prevention Tip 5.5

Although the value of the control variable can be changed in the body of a `for` loop, avoid doing so, because this practice can lead to subtle errors.

UML Activity Diagram for the `for` Statement

The `for` statement's UML activity diagram is similar to that of the `while` statement ([Fig. 4.6](#)). [Figure 5.4](#) shows the activity diagram of the `for` statement in [Fig. 5.2](#). The diagram makes it clear that initialization occurs *once before* the loop-continuation test is evaluated the first time, and that incrementing occurs *each* time through the loop *after* the body statement executes.

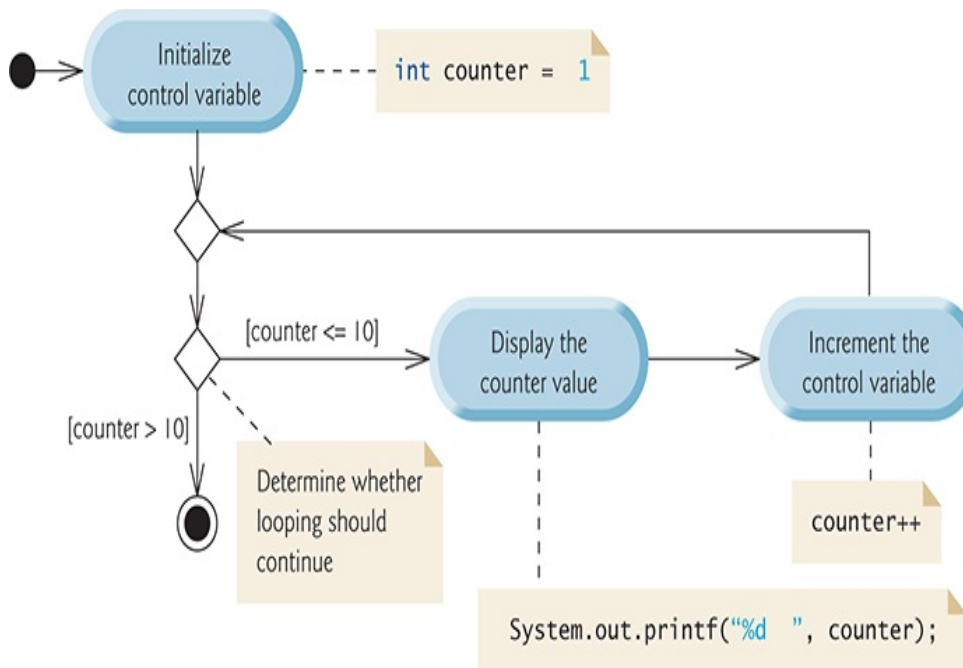


Fig. 5.4

UML activity diagram for the `for` statement in [Fig. 5.2](#).

Description