Chapter 5 Loops

Motivations

Suppose that you need to print a string (e.g., "Welcome to Java!") a hundred times. It would be tedious to have to write the following statement a hundred times:

```
System.out.println("Welcome to Java!");
```

So, how do you solve this problem?

Opening Problem

Problem:

100 times

```
System.out.println("Welcome to Java!");
System.out.println("Welcome to Java!");
System.out.println("Welcome to Java!");
System.out.println("Welcome to Java!");
System.out.println("Welcome to Java!");
System.out.println("Welcome to Java!");

...

...

...
System.out.println("Welcome to Java!");
System.out.println("Welcome to Java!");
System.out.println("Welcome to Java!");
```

Introducing while Loops

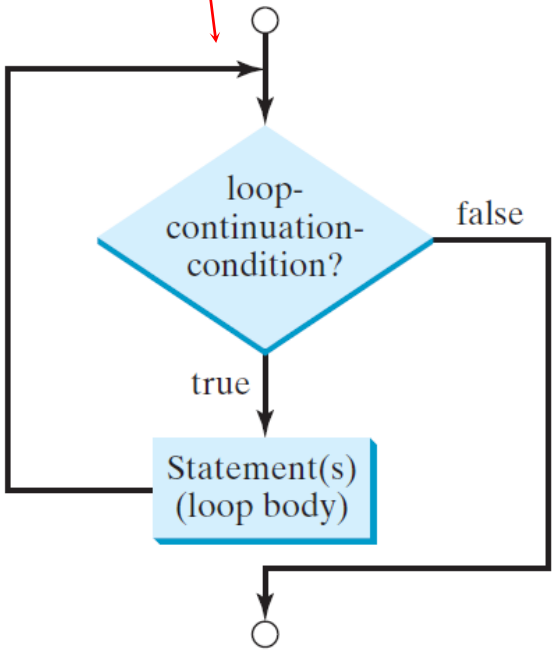
```
int count = 0;
while (count < 100) {
  System.out.println("Welcome to Java");
  count++;
}
```

Objectives

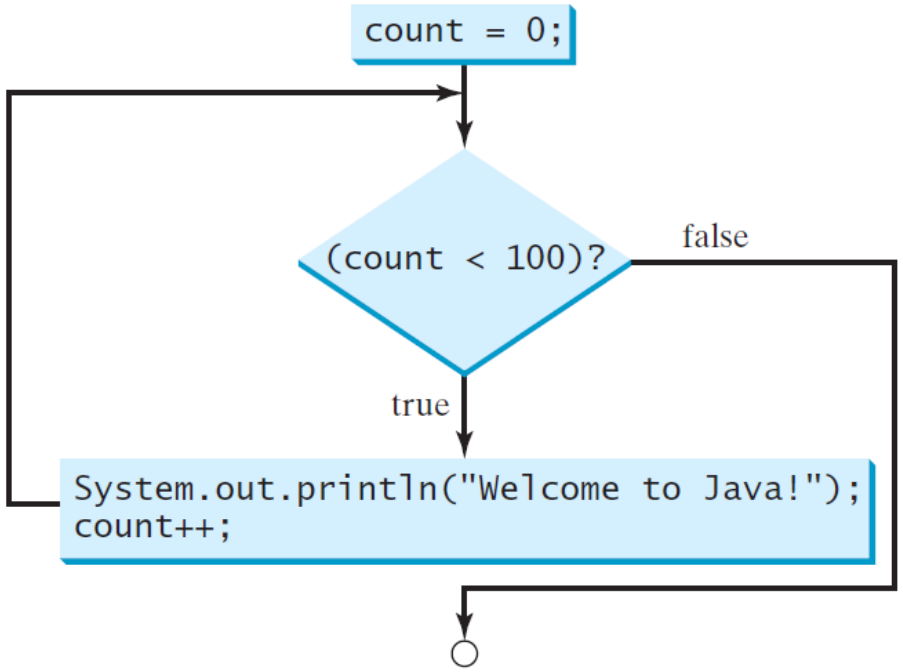
- To write programs for executing statements repeatedly using a **while** loop (§5.2).
- To follow the loop design strategy to develop loops (§§5.2.1–5.2.3).
- To control a loop with a sentinel value (§5.2.4).
- To obtain large input from a file using input redirection rather than typing from the keyboard (§5.2.5).
- To write loops using **do-while** statements (§5.3).
- To write loops using **for** statements (§5.4).
- To discover the similarities and differences of three types of loop statements (§5.5).
- To write nested loops (§5.6).
- To learn the techniques for minimizing numerical errors (§5.7).
- To learn loops from a variety of examples (**GCD**, **FutureTuition**, **Dec2Hex**) (§5.8).
- To implement program control with **break** and **continue** (§5.9).
- To write a program that displays prime numbers (§5.11).

`while` Loop Flow Chart

```
while (loop-continuation-condition) {
  // loop-body;
  Statement(s);
}
```




```
int count = 0;
while (count < 100) {
  System.out.println("Welcome to Java!");
  count++;
}
```



animation

Trace while Loop

Initialize count

```
int count = 0;

while (count < 2) {
  System.out.println("Welcome to Java!");
  count++;
}
```

animation

Trace while Loop, cont.

(count < 2) is true

```
int count = 0;

while (count < 2) {
  System.out.println("Welcome to Java!");
  count++;
}
```

animation

Trace while Loop, cont.

```
int count = 0;
while (count < 2) {
  System.out.println("Welcome to Java!");
  count++;
}
```

Print Welcome to Java

animation

Trace while Loop, cont.

```
int count = 0;
while (count < 2) {
  System.out.println("Welcome to Java!");
  count++;
}
```

Increase count by 1
count is 1 now

animation

Trace while Loop, cont.

```
int count = 0;

while (count < 2) {
  System.out.println("Welcome to Java!");
  count++;
}
```

(count < 2) is still true since count is 1

animation

Trace while Loop, cont.

```
int count = 0;
while (count < 2) {
  System.out.println("Welcome to Java!");
  count++;
}
```

Print Welcome to Java

animation

Trace while Loop, cont.

```
int count = 0;
while (count < 2) {
  System.out.println("Welcome to Java!");
  count++;
}
```

Increase count by 1
count is 2 now

animation

Trace while Loop, cont.

```
int count = 0;

while (count < 2) {
  System.out.println("Welcome to Java!");
  count++;
}
```

(count < 2) is false since count is 2 now

animation

Trace while Loop

```
int count = 0;
while (count < 2) {
  System.out.println("Welcome to Java!");
  count++;
}
```

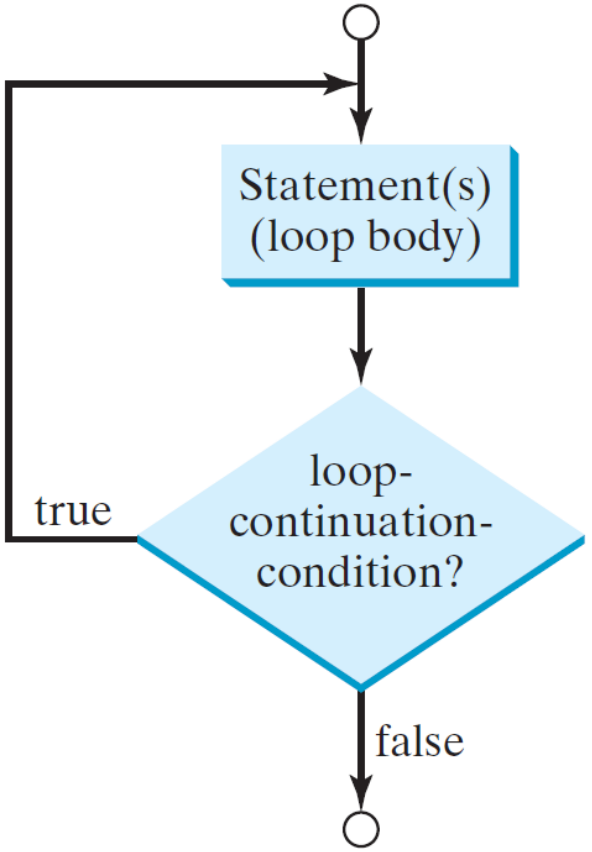
The loop exits. Execute the next statement after the loop.

Caution

Don’t use floating-point values for equality checking in a loop control. Since floating-point values are approximations for some values, using them could result in imprecise counter values and inaccurate results. Consider the following code for computing 1 + 0.9 + 0.8 + ... + 0.1:

```
double item = 1; double sum = 0;
while (item != 0) { // No guarantee item will be 0
  sum += item;
  item -= 0.1;
}
System.out.println(sum);
```

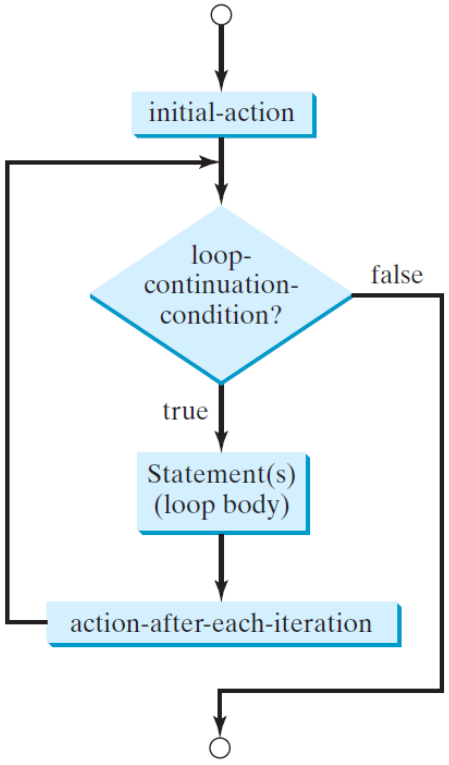
do-while Loop




```
do {
  // Loop body;
  Statement(s);
} while (loop-continuation-condition);
```

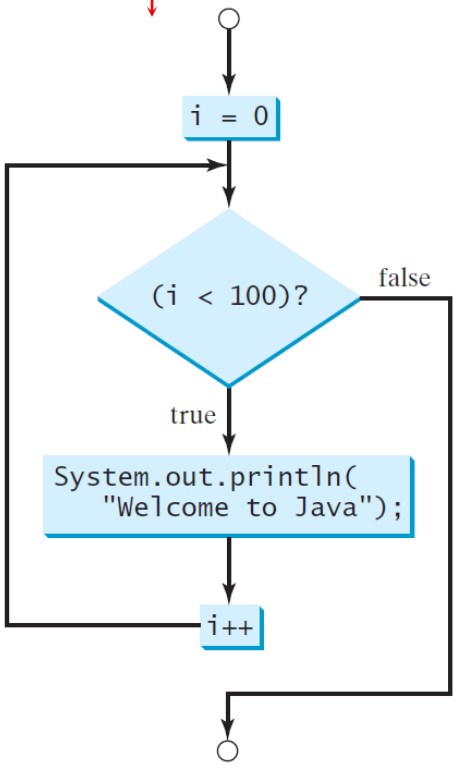
`for` Loops

```
for (initial-action; loop-
    continuation-condition; action-
    after-each-iteration) {
  // loop body;
  Statement(s);
}
```



(a)

```
int i;
for (i = 0; i < 100; i++) {
  System.out.println(
    "Welcome to Java!");
}
```



(b)

animation

Trace for Loop

Declare i

```
int i;
for (i = 0; i < 2; i++) {
  System.out.println(
    "Welcome to Java!");
}
```

animation

Trace for Loop, cont.

```
int i;
for (i = 0; i < 2; i++) {
  System.out.println(
    "Welcome to Java!");
}
```

Execute initializer
i is now 0

animation

Trace for Loop, cont.

```
int i;
for (i = 0; i < 2; i++) {
  System.out.println( "Welcome to Java!");
}
```

(i < 2) is true
since i is 0

animation

Trace for Loop, cont.

```
int i;
for (i = 0; i < 2; i++) {
  System.out.println("Welcome to Java!");
}
```

Print Welcome to Java

animation

Trace for Loop, cont.

```
int i;
for (i = 0; i < 2; i++) {
  System.out.println("Welcome to Java!");
}
```

Execute adjustment statement
i now is 1

animation

Trace for Loop, cont.

```
int i;
for (i = 0; i < 2; i++) {
  System.out.println("Welcome to Java!");
}
```

(i < 2) is still true
since i is 1

animation

Trace for Loop, cont.

```
int i;
for (i = 0; i < 2; i++) {
  System.out.println("Welcome to Java!");
}
```

Print Welcome to Java

animation

Trace for Loop, cont.

```
int i;
for (i = 0; i < 2; i++) {
  System.out.println("Welcome to Java!");
}
```

Execute adjustment statement
i now is 2

animation

Trace for Loop, cont.

```
int i;
for (i = 0; i < 2; i++) {
  System.out.println("Welcome to Java!");
}
```

(i < 2) is false
since i is 2

animation

Trace for Loop, cont.

```
int i;
for (i = 0; i < 2; i++) {
  System.out.println("Welcome to Java!");
}
```

Exit the loop. Execute the next statement after the loop

Note

The initial-action in a for loop can be a list of zero or more comma-separated expressions. The action-after-each-iteration in a for loop can be a list of zero or more comma-separated statements. Therefore, the following two for loops are correct. They are rarely used in practice, however.

```
for (int i = 1; i < 100; System.out.println(i++));


for (int i = 0, j = 0; (i + j < 10); i++, j++) {
  // Do something
}
```

Note

If the loop-continuation-condition in a for loop is omitted, it is implicitly true. Thus the statement given below in (a), which is an infinite loop, is correct. Nevertheless, it is better to use the equivalent loop in (b) to avoid confusion:

```
for ( ; ; ) {
  // Do something
}
```

(a)

Equivalent

```
while (true) {
  // Do something
}
```

(b)

Caution

Adding a semicolon at the end of the for clause before the loop body is a common mistake, as shown below:

Logic Error

```
for (int i=0; i<10; i++);
{
  System.out.println("i is " + i);
}
```

Caution, cont.

Similarly, the following loop is also wrong:

```
int i=0;
while (i < 10);
{
  System.out.println("i is " + i);
  i++;
}
```

Logic Error

In the case of the do loop, the following semicolon is needed to end the loop.

```
int i=0;
do {
  System.out.println("i is " + i);
  i++;
} while (i<10);
```

Correct

Which Loop to Use?

The three forms of loop statements, while, do-while, and for, are expressively equivalent; that is, you can write a loop in any of these three forms. For example, a while loop in (a) in the following figure can always be converted into the following for loop in (b):

```
while (loop-continuation-condition) {
  // Loop body
}
```

(a)

Equivalent

```
for ( ; loop-continuation-condition; )
  // Loop body
}
```

(b)

A for loop in (a) in the following figure can generally be converted into the following while loop in (b) except in certain special cases (see Review Question 3.19 for one of them):

```
for (initial-action;
     loop-continuation-condition;
     action-after-each-iteration) {
  // Loop body;
}
```

(a)

Equivalent

```
initial-action;
while (loop-continuation-condition) {
  // Loop body;
  action-after-each-iteration;
}
```

(b)

Recommendations

Use the one that is most intuitive and comfortable for you. In general, a for loop may be used if the number of repetitions is known, as, for example, when you need to print a message 100 times. A while loop may be used if the number of repetitions is not known, as in the case of reading the numbers until the input is 0. A do-while loop can be used to replace a while loop if the loop body has to be executed before testing the continuation condition.

Nested Loops

Problem: Write a program that uses nested for loops to print a multiplication table.

MultiplicationTable

Run

break

```
public class TestBreak {
  public static void main(String[] args) {
    int sum = 0;
    int number = 0;

    while (number < 20) {
      number++;
      sum += number;
      if (sum >= 100)
        break;
    }

    System.out.println("The number is " + number);
    System.out.println("The sum is " + sum);
  }
}
```

continue

```
public class TestContinue {
  public static void main(String[] args) {
    int sum = 0;
    int number = 0;

    while (number < 20) {
      number++;
      if (number == 10 || number == 11)
        continue;
      sum += number;
    }

    System.out.println("The sum is " + sum);
  }
}
```