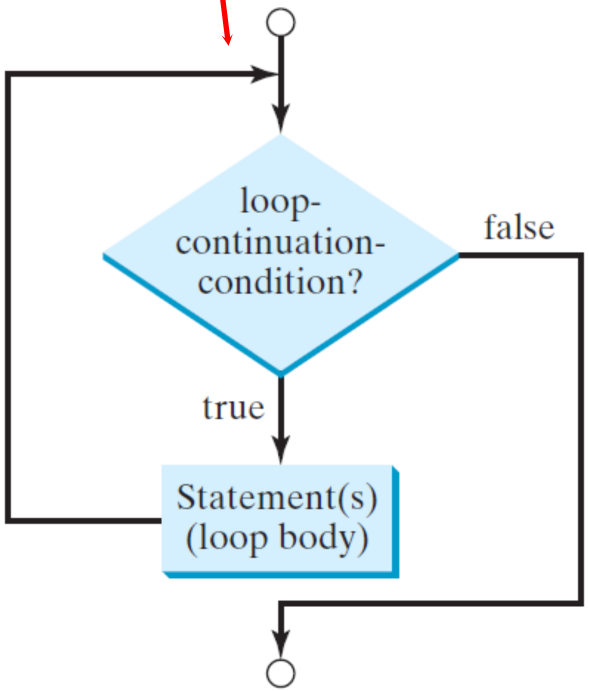
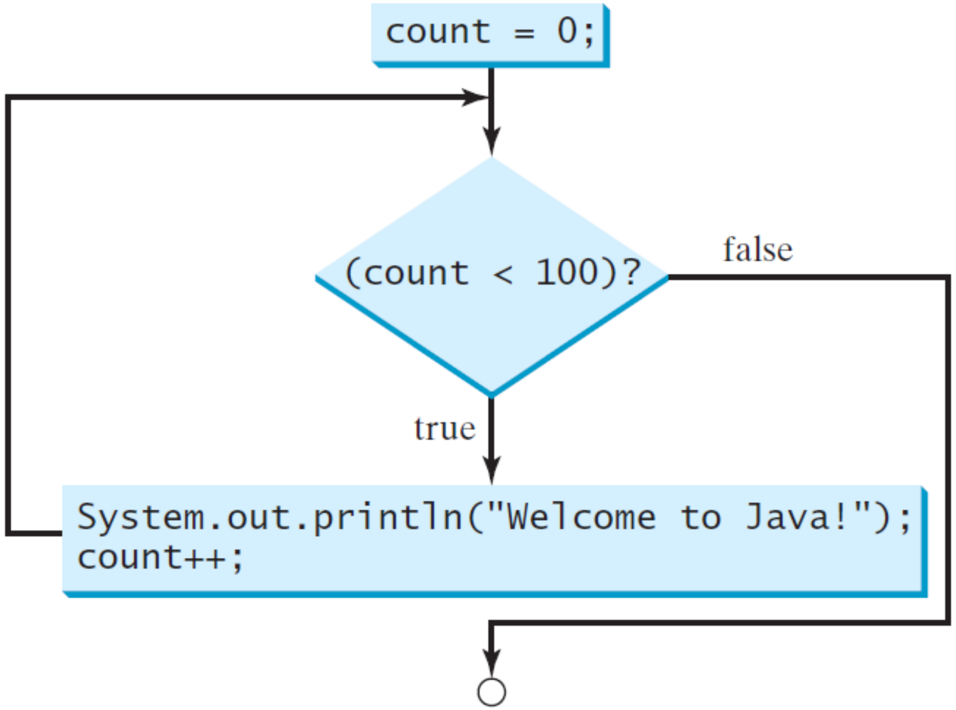
Chapter 5 Loops

`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++;
}
```



Problem: Repeat Addition Until Correct

Recall that Listing 3.1 AdditionQuiz.java gives a program that prompts the user to enter an answer for a question on addition of two single digits. Using a loop, you can now rewrite the program to let the user enter a new answer until it is correct.

ch05/RepeatAdditionQuiz.java

Problem: Guessing Numbers

Write a program that randomly generates an integer between 0 and 100, inclusive. The program prompts the user to enter a number continuously until the number matches the randomly generated number. For each user input, the program tells the user whether the input is too low or too high, so the user can choose the next input intelligently.

```
while (guess != number) { //SentinelValue
```

GuessNumber

Problem: An Advanced Math Learning Tool

The Math subtraction learning tool program generates just one question for each run. You can use a loop to generate questions repeatedly. This example gives a program that generates five questions and reports the number of the correct answers after a student answers all five questions.

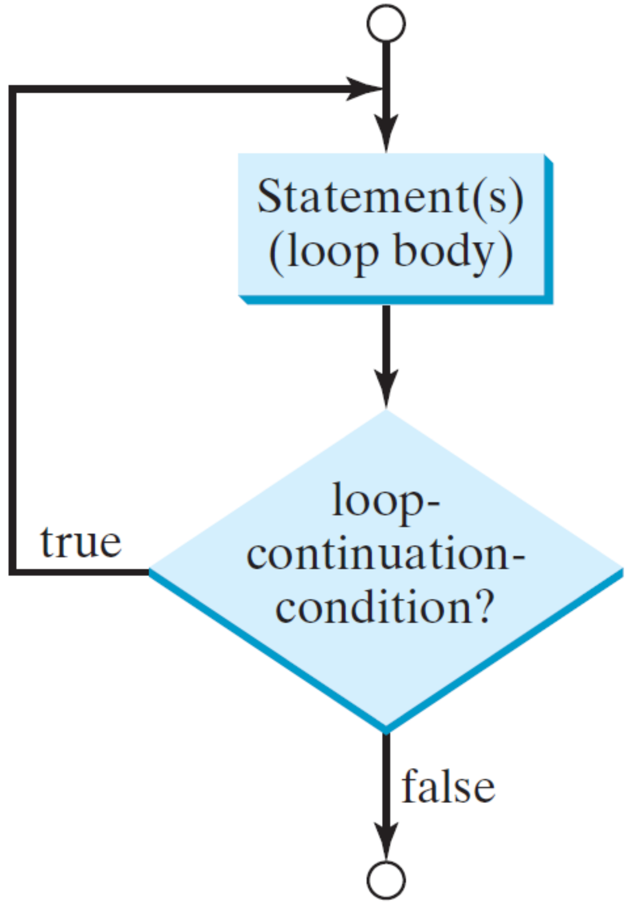
SubtractionQuizLoop

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

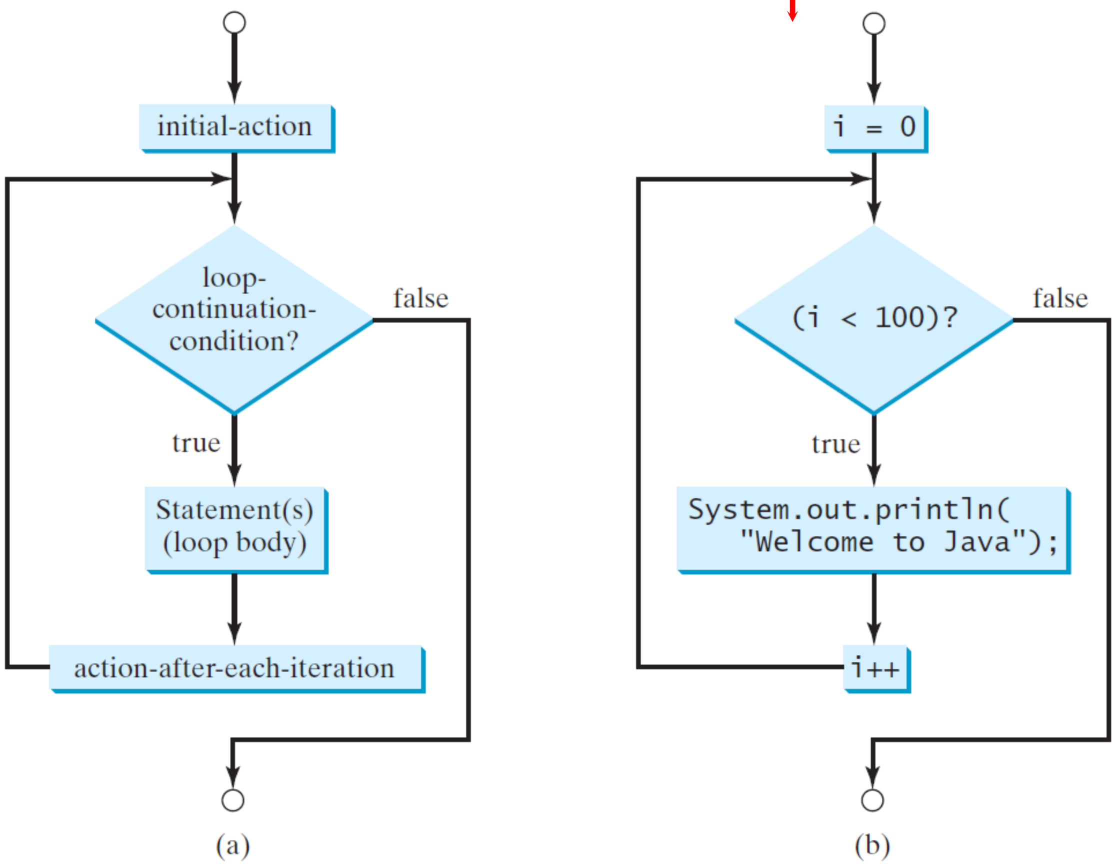



```
do {
  // Loop body;
  Statement(s);
} while (loop-continuation-condition);
```

`for` Loops

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

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



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.

Execute initializer
i is now 0

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

animation

Trace for Loop, cont.

(i < 2) is true
since i is 0

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

animation

Trace for Loop, cont.

Print Welcome to Java

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

animation

Trace for Loop, cont.

Execute adjustment statement
i now is 1

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

animation

Trace for Loop, cont.

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

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

animation

Trace for Loop, cont.

Print Welcome to Java

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

animation

Trace for Loop, cont.

Execute adjustment statement
i now is 2

```
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!");
}
```

(i < 2) is false
since i is 2

animation

Trace for Loop, cont.

Exit the loop. Execute the next statement after the loop

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

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 <u>loop-continuation-condition</u> in a <u>for</u> 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);          Logic Error
{
  System.out.println("i is " + i);
  i++;
}
```

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.

for-each

```
public class ForEachDemo {
     public static void main(String[] args) {
          int sum = 0;
          int a[] = new int[100];
          for (int i = 0; i < 100; i++)
               a[i] = 101 + i;
          // for-each语句的使用
          for (int e : a)
               sum = sum + e;
          System.out.println("the sum is " + sum);
     }
} // ForEachDemo.java
```

‘:’ means ‘in’

for(int e:a) “for each int e in a”,

Minimizing Numerical Errors

Numeric errors involving floating-point numbers are inevitable. This section discusses how to minimize such errors through an example.

Here is an example that sums a series that starts with 0.01 and ends with 1.0. The numbers in the series will increment by 0.01, as follows: 0.01 + 0.02 + 0.03 and so on.

TestSum

Problem:
Finding the Greatest Common Divisor

Problem: Write a program that prompts the user to enter two positive integers and finds their greatest common divisor.

Solution: Suppose you enter two integers 4 and 2, their greatest common divisor is 2. Suppose you enter two integers 16 and 24, their greatest common divisor is 8. So, how do you find the greatest common divisor? Let the two input integers be n1 and n2. You know number 1 is a common divisor, but it may not be the greatest commons divisor. So you can check whether k (for k = 2, 3, 4, and so on) is a common divisor for n1 and n2, until k is greater than n1 or n2.

GreatestCommonDivisor

Problem: Predicting the Future Tuition

Problem: Suppose that the tuition for a university is $10,000 this year and tuition increases 7% every year. In how many years will the tuition be doubled?

FutureTuition

Problem: Predicating the Future Tuition

```
double tuition = 10000;   int year = 0  // Year 0
tuition = tuition * 1.07; year++;       // Year 1
tuition = tuition * 1.07; year++;       // Year 2
tuition = tuition * 1.07; year++;       // Year 3
...
```

Case Study: *Converting Decimals to Hexadecimals*

Hexadecimals are often used in computer systems programming (see Appendix F for an introduction to number systems). How do you convert a decimal number to a hexadecimal number? To convert a decimal number *d* to a hexadecimal number is to find the hexadecimal digits h_n, h_{n-1}, h_{n-2}, ... , h_2, h_1, and h_0 such that

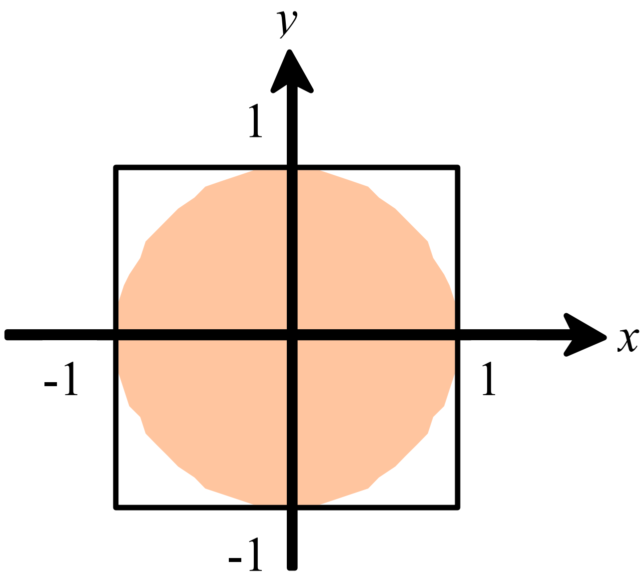
$$d = h_n \times 16^n + h_{n-1} \times 16^{n-1} + h_{n-2} \times 16^{n-2} + ... + h_2 \times 16^2 + h_1 \times 16^1 + h_0 \times 16^0$$

These hexadecimal digits can be found by successively dividing *d* by 16 until the quotient is 0. The remainders are h_0, h_1, h_2, ... , h_{n-2}, h_{n-1}, and h_n.

Dec2Hex

Problem: *Monte Carlo Simulation*

The Monte Carlo simulation refers to a technique that uses random numbers and probability to solve problems. This method has a wide range of applications in computational mathematics, physics, chemistry, and finance. This section gives an example of using the Monto Carlo simulation for estimating π.



circleArea / squareArea = π / 4.

π can be approximated as 4 * numberOfHits / numberOfTrials

MonteCarloSimulation

Using `break` and `continue`

Examples for using the `break` and `continue` keywords:

- TestBreak.java

  TestBreak

- TestContinue.java

  TestContinue

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);
  }
}
```

Tips: If possible, do not use *continue* and *break*

如果出现了 continue，你往往只需要把 continue 的条件反向，就可以消除 continue。
如果出现了 break，你往往可以把 break 的条件，合并到循环头部的终止条件里，从而去掉 break。
有时候你可以把 break 替换成 return，从而去掉 break。
如果以上都失败了，你也许可以把循环里面复杂的部分提取出来，做成函数调用，之后 continue 或者 break 就可以去掉了。

Guessing Number Problem Revisited

Here is a program for guessing a number. You can rewrite it using a break statement.

GuessNumberUsingBreak.java