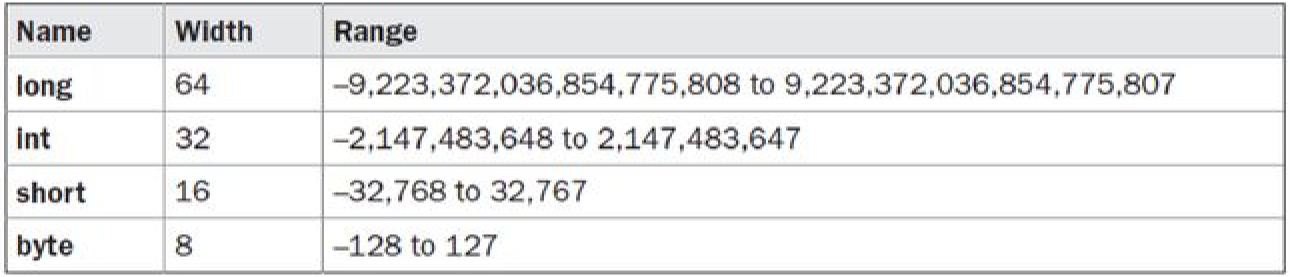
Java - Data Types, Variables, and Arrays

The Primitive Types

- Java defines eight *primitive* types of data: **byte**, **short**, **int**, **long**, **char**, **float**, **double**, and **boolean**.
- These can be put in four groups:
  - Integers This group includes **byte**, **short**, **int**, and **long**, which are for whole-valued signed numbers.
  - Floating-point numbers This group includes **float** and **double**, which represent numbers with fractional precision.
  - Characters This group includes **char**, which represents symbols in a character set, like letters and numbers.
  - Boolean This group includes **boolean**, which is a special type for representing true/false values.

Integers

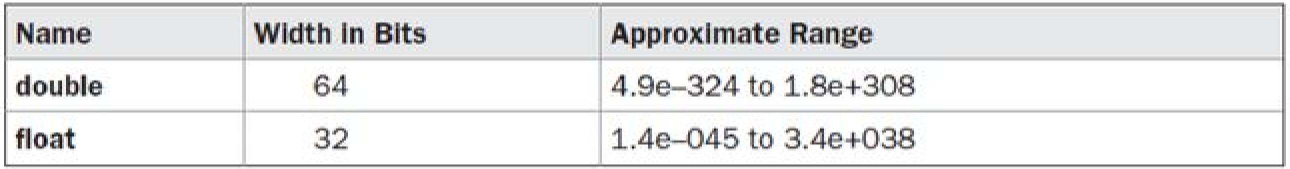
- Java defines four integer types: **byte**, **short**, **int**, and **long**.
  - byte b, c;
  - short s;
  - short t;
  - int lightspeed;
  - long days;



Name	Width	Range
long	64	–9,223,372,036,854,775,808 to 9,223,372,036,854,775,807
int	32	–2,147,483,648 to 2,147,483,647
short	16	–32,768 to 32,767
byte	8	–128 to 127

Floating-Point Types

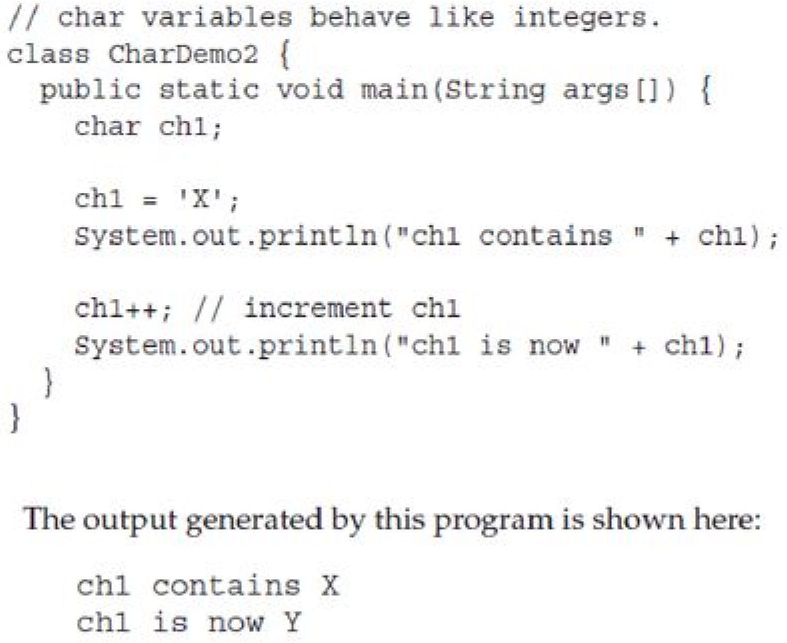
- Floating-point numbers, also known as *real* numbers, are used when evaluating expressions that require fractional precision.
  - float hightemp, lowtemp;
  - double pi, r, a;
- The type **float** specifies a *single-precision* value that uses 32 bits of storage.
- Double precision, as denoted by the **double** keyword, uses 64 bits to store a value.
- When you need to maintain accuracy over many iterative calculations, or are manipulating large-valued numbers, **double** is the best choice.



Name	Width in Bits	Approximate Range
double	64	4.9e–324 to 1.8e+308
float	32	1.4e–045 to 3.4e+038

Characters

- In Java, the data type used to store characters is **char**.
- In C/C++, **char** is 8 bits wide. This is *not* the case in Java.
- Java uses Unicode to represent characters. *Unicode* defines a fully international character set that can represent all of the characters found in all human languages.
- It is a unification of dozens of character sets, such as Latin, Greek, Arabic, Cyrillic, Hebrew, Katakana, Hangul, and many more. For this purpose, it requires 16 bits.
- The range of a **char** is 0 to 65,536.



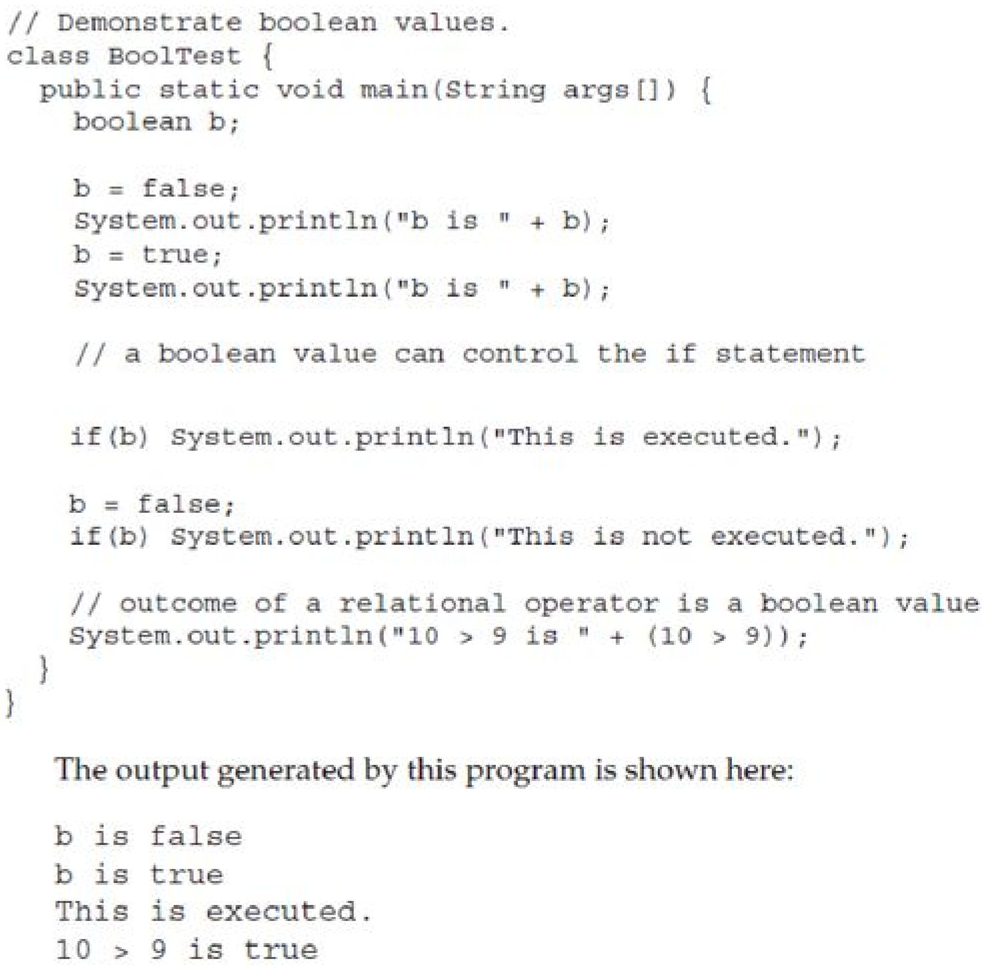
```
// char variables behave like integers.
class CharDemo2 {
  public static void main(String args[]) {
    char ch1;

    ch1 = 'X';
    System.out.println("ch1 contains " + ch1);

    ch1++; // increment ch1
    System.out.println("ch1 is now " + ch1);
  }
}
```

The output generated by this program is shown here:

```
ch1 contains X
ch1 is now Y
```

Booleans

- Java has a primitive type, called **boolean**, for logical values.
- It can have only one of two possible values, **true** or **false**.
- This is the type returned by all relational operators.

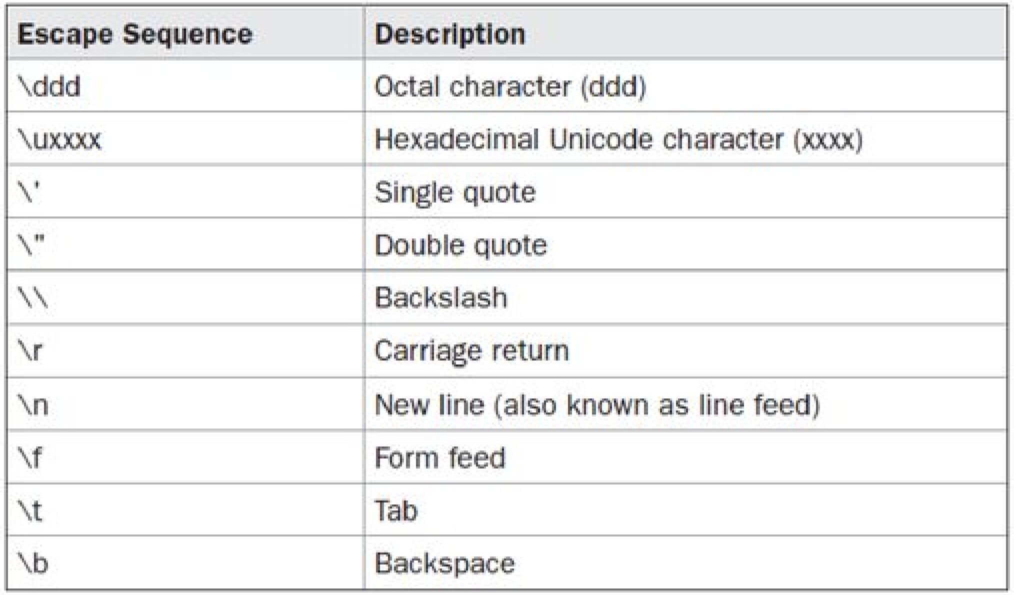


```
// Demonstrate boolean values.
class BoolTest {
  public static void main(String args[]) {
    boolean b;

    b = false;
    System.out.println("b is " + b);
    b = true;
    System.out.println("b is " + b);

    // a boolean value can control the if statement

    if(b) System.out.println("This is executed.");

    b = false;
    if(b) System.out.println("This is not executed.");

    // outcome of a relational operator is a boolean value
    System.out.println("10 > 9 is " + (10 > 9));
  }
}
```

The output generated by this program is shown here:

```
b is false
b is true
This is executed.
10 > 9 is true
```

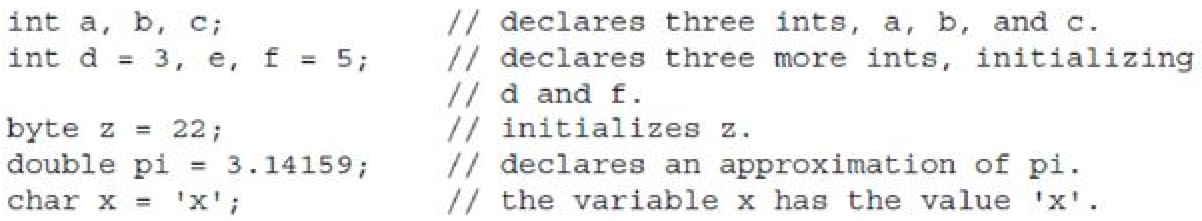
TABLE 3-1
Character Escape Sequences



Escape Sequence	Description
\ddd	Octal character (ddd)
\uxxxx	Hexadecimal Unicode character (xxxx)
\'	Single quote
\"	Double quote
\\	Backslash
\r	Carriage return
\n	New line (also known as line feed)
\f	Form feed
\t	Tab
\b	Backspace

Variables

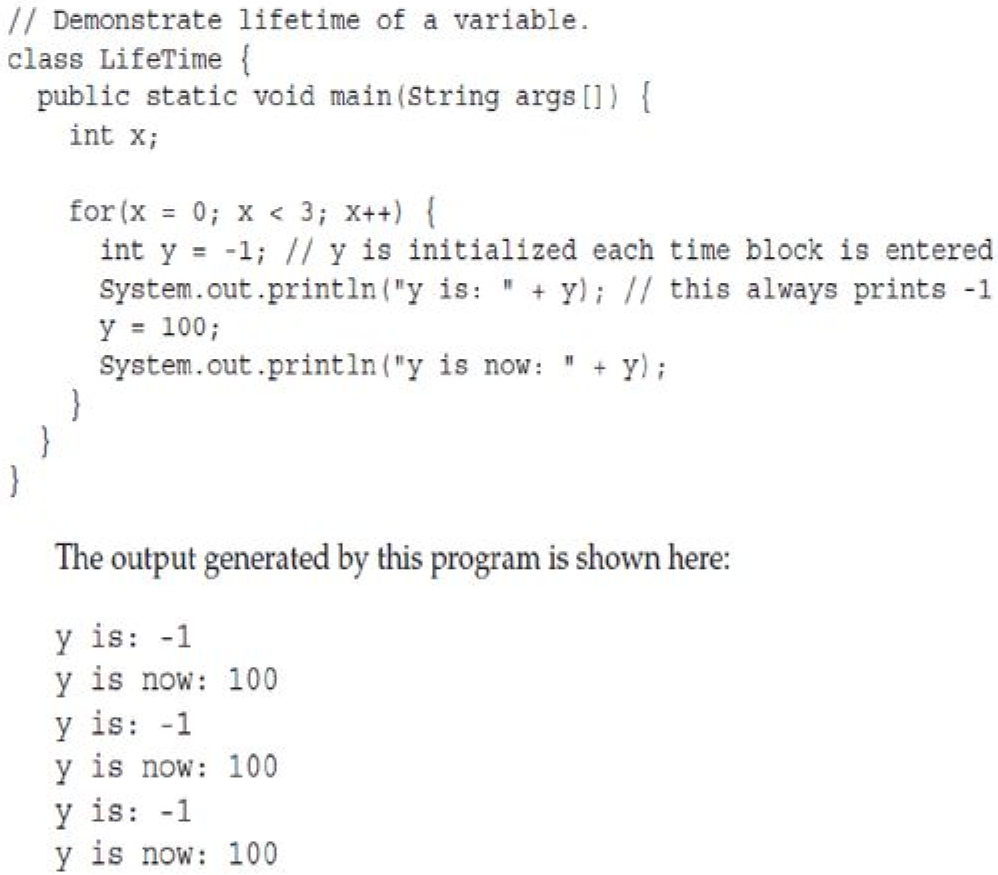
- The variable is the basic unit of storage in a Java program.
- A variable is defined by the combination of an identifier, a type, and an optional initializer.
- In addition, all variables have a scope, which defines their visibility, and a lifetime.
- **Declaring a Variable**
- *type identifier* [= *value*][, *identifier* [= *value*] ...] ;
- The *type* is one of Java's atomic types, or the name of a class or interface.
- The *identifier* is the name of the variable.



```
int a, b, c;            // declares three ints, a, b, and c.
int d = 3, e, f = 5;    // declares three more ints, initializing
                        // d and f.
byte z = 22;            // initializes z.
double pi = 3.14159;    // declares an approximation of pi.
char x = 'x';           // the variable x has the value 'x'.
```

The Scope and Lifetime of Variables

- Java allows variables to be declared within any block.
- A block is begun with an opening curly brace and ended by a closing curly brace. A block defines a *scope.*
- A scope determines what objects are visible to other parts of your program.
- It also determines the lifetime of those objects.
- Scopes can be nested.
- Variables are created when their scope is entered, and destroyed when their scope is left.
- The lifetime of a variable is confined to its scope.



```
// Demonstrate lifetime of a variable.
class LifeTime {
  public static void main(String args[]) {
    int x;

    for(x = 0; x < 3; x++) {
      int y = -1; // y is initialized each time block is entered
      System.out.println("y is: " + y); // this always prints -1
      y = 100;
      System.out.println("y is now: " + y);
    }
  }
}
```

The output generated by this program is shown here:

```
y is: -1
y is now: 100
y is: -1
y is now: 100
y is: -1
y is now: 100
```

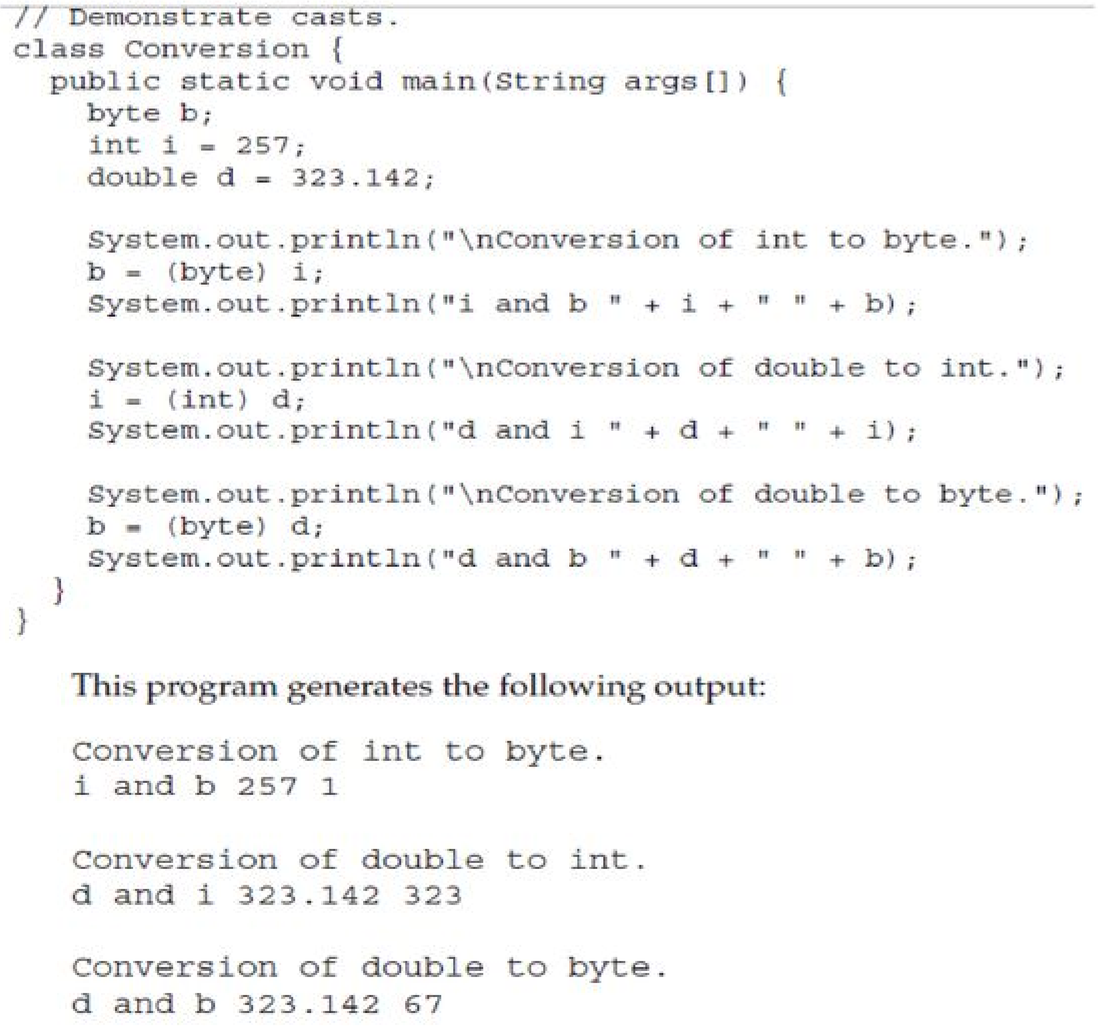
Type Conversion and Casting

- **Java’s Automatic Conversions**
- When one type of data is assigned to another type of variable, an *automatic type conversion* will take place if the following two conditions are met:
  - The two types are compatible.
  - The destination type is larger than the source type.
- When these two conditions are met, a *widening conversion* takes place.
- There are no automatic conversions from the numeric types to **char** or **boolean**.

Casting Incompatible Types

- To create a conversion between two incompatible types, you must use a cast.
- A *cast* is simply an explicit type conversion. It has this general form:

  (*target-type*) *value*



```
// Demonstrate casts.
class Conversion {
  public static void main(String args[]) {
    byte b;
    int i = 257;
    double d = 323.142;

    System.out.println("\nConversion of int to byte.");
    b = (byte) i;
    System.out.println("i and b " + i + " " + b);

    System.out.println("\nConversion of double to int.");
    i = (int) d;
    System.out.println("d and i " + d + " " + i);

    System.out.println("\nConversion of double to byte.");
    b = (byte) d;
    System.out.println("d and b " + d + " " + b);
  }
}
```

This program generates the following output:

```
Conversion of int to byte.
i and b 257 1

Conversion of double to int.
d and i 323.142 323

Conversion of double to byte.
d and b 323.142 67
```

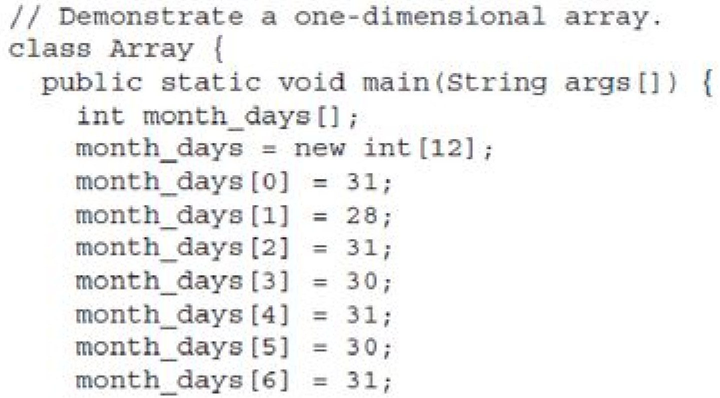
Arrays

- An *array* is a group of like-typed variables that are referred to by a common name.
- Arrays of any type can be created and may have one or more dimensions.
- A specific element in an array is accessed by its index.
- **One-Dimensional Arrays**
- A *one-dimensional array* is, essentially, a list of like-typed variables.

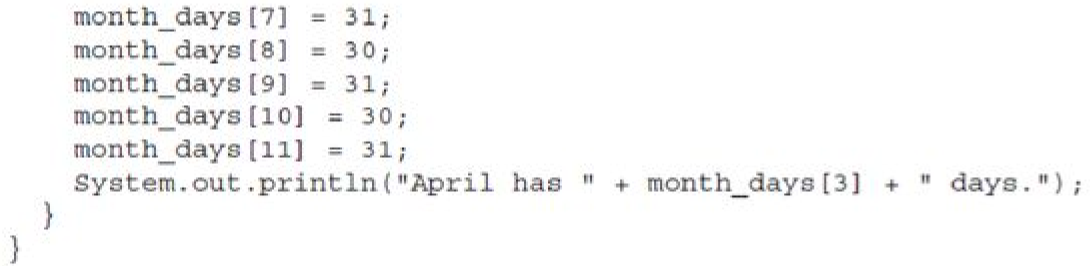
  type var-name[ ];
- The general form of **new** as it applies to one-dimensional arrays appears as follows:

  array-var = new *type*[*size*];

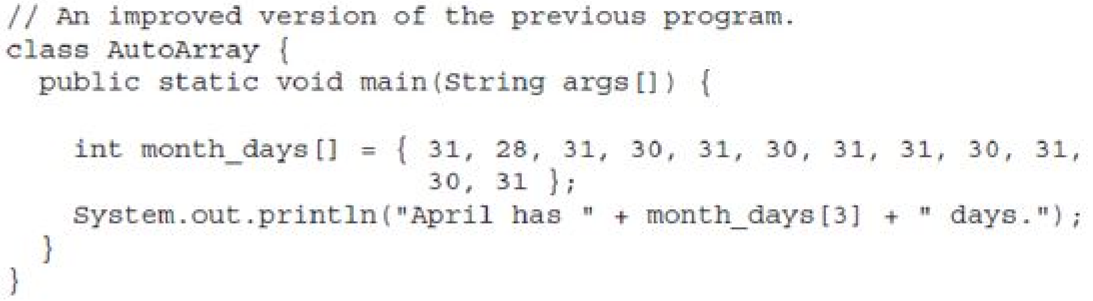
- Array Initialization



```
// Demonstrate a one-dimensional array.
class Array {
  public static void main(String args[]) {
    int month_days[];
    month_days = new int[12];
    month_days[0] = 31;
    month_days[1] = 28;
    month_days[2] = 31;
    month_days[3] = 30;
    month_days[4] = 31;
    month_days[5] = 30;
    month_days[6] = 31;
```



```
    month_days[7] = 31;
    month_days[8] = 30;
    month_days[9] = 31;
    month_days[10] = 30;
    month_days[11] = 31;
    System.out.println("April has " + month_days[3] + " days.");
  }
}
```

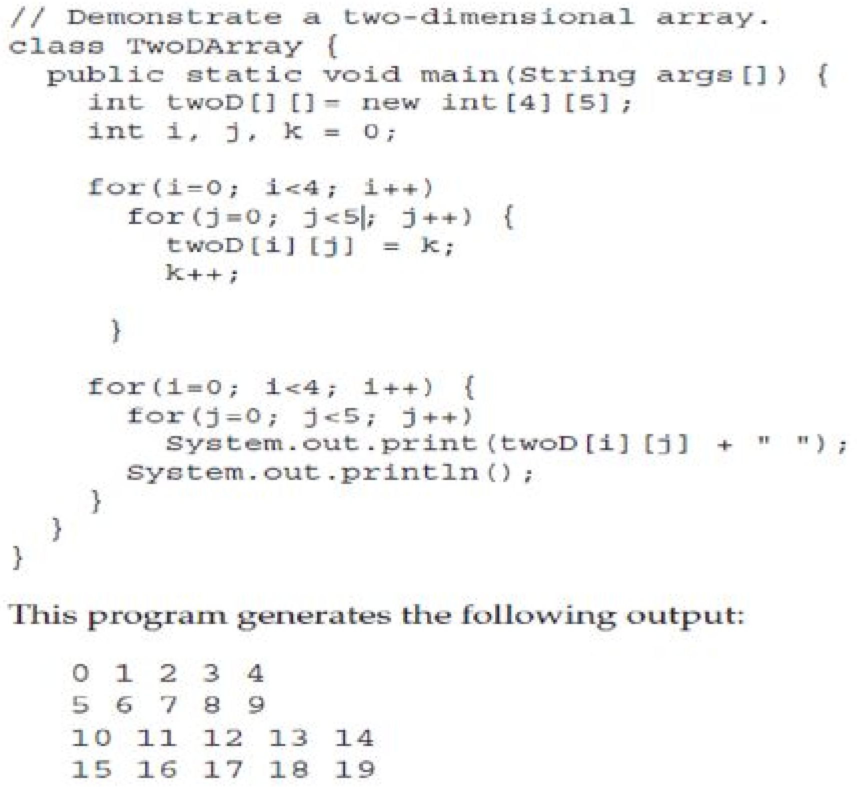


```
// An improved version of the previous program.
class AutoArray {
  public static void main(String args[]) {

    int month_days[] = { 31, 28, 31, 30, 31, 30, 31, 31, 30, 31,
                         30, 31 };
    System.out.println("April has " + month_days[3] + " days.");
  }
}
```

Multidimensional Arrays

- In Java, *multidimensional arrays* are actually arrays of arrays.

  int twoD[][] = new int[4][5];



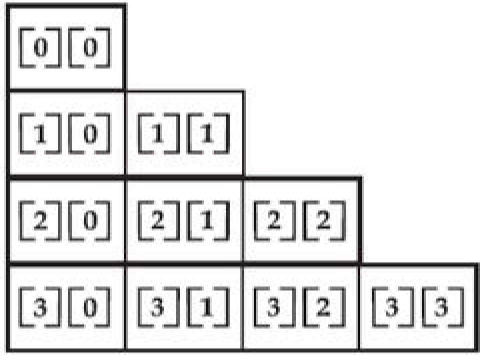
```
// Demonstrate a two-dimensional array.
class TwoDArray {
  public static void main(String args[]) {
    int twoD[][]= new int[4][5];
    int i, j, k = 0;

    for(i=0; i<4; i++)
      for(j=0; j<5; j++) {
        twoD[i][j] = k;
        k++;

     }

    for(i=0; i<4; i++) {
      for(j=0; j<5; j++)
        System.out.print(twoD[i][j] + " ");
      System.out.println();
    }
  }
}
```

This program generates the following output:

```
0 1 2 3 4
5 6 7 8 9
10 11 12 13 14
15 16 17 18 19
```

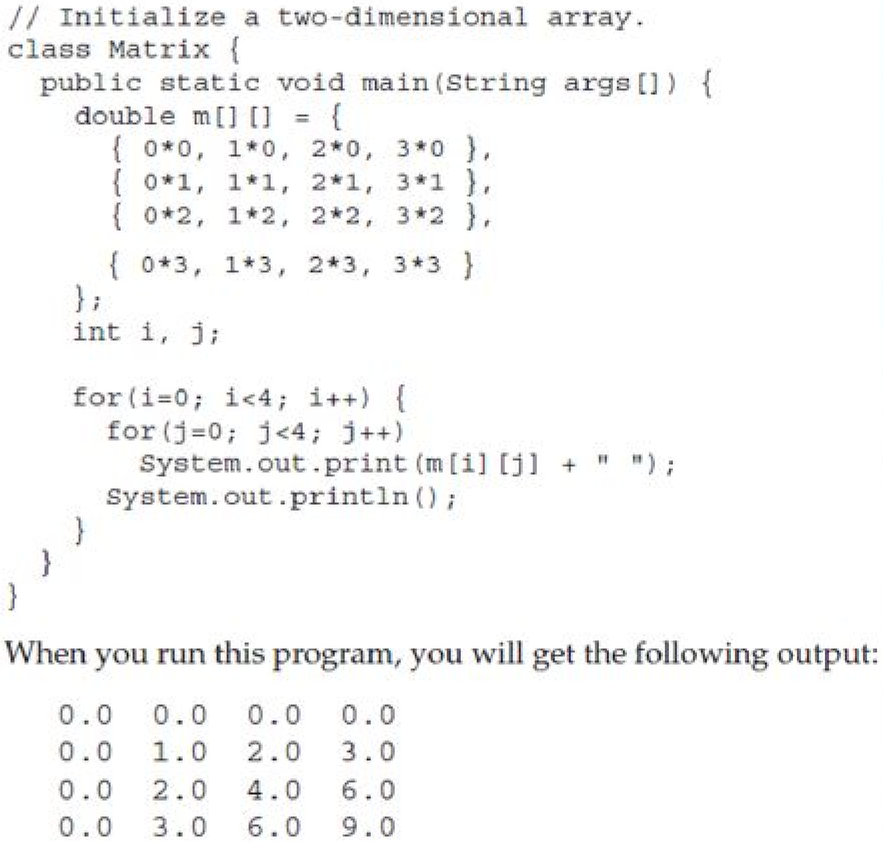
```
// Manually allocate differing size second dimensions.
class TwoDAgain {
  public static void main(String args[]) {
    int twoD[][] = new int[4][];
    twoD[0] = new int[1];
    twoD[1] = new int[2];
    twoD[2] = new int[3];
    twoD[3] = new int[4];

    int i, j, k = 0;

    for(i=0; i<4; i++)
      for(j=0; j<i+1; j++) {
        twoD[i][j] = k;
        k++;
      }

    for(i=0; i<4; i++) {
      for(j=0; j<i+1; j++)
        System.out.print(twoD[i][j] + " ");
      System.out.println();
    }
  }
}
```

The array created by this program looks like this:



This program generates the following output:

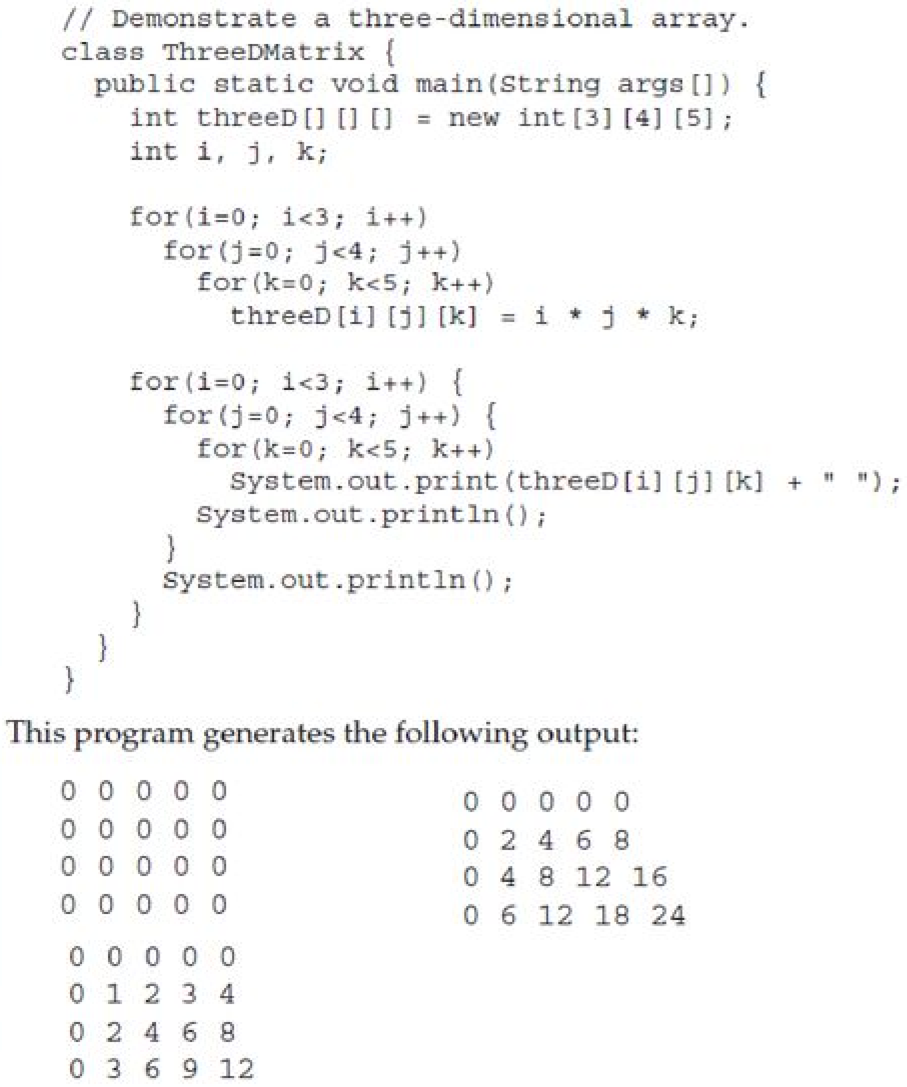
```
0
1 2
3 4 5
6 7 8 9
```



```
// Initialize a two-dimensional array.
class Matrix {
  public static void main(String args[]) {
    double m[][] = {
      { 0*0, 1*0, 2*0, 3*0 },
      { 0*1, 1*1, 2*1, 3*1 },
      { 0*2, 1*2, 2*2, 3*2 },
      { 0*3, 1*3, 2*3, 3*3 }
    };
    int i, j;

    for(i=0; i<4; i++) {
      for(j=0; j<4; j++)
        System.out.print(m[i][j] + " ");
      System.out.println();
    }
  }
}
```

When you run this program, you will get the following output:

```
0.0  0.0  0.0  0.0
0.0  1.0  2.0  3.0
0.0  2.0  4.0  6.0
0.0  3.0  6.0  9.0
```



```
// Demonstrate a three-dimensional array.
class ThreeDMatrix {
  public static void main(String args[]) {
    int threeD[][][] = new int[3][4][5];
    int i, j, k;

    for(i=0; i<3; i++)
      for(j=0; j<4; j++)
        for(k=0; k<5; k++)
          threeD[i][j][k] = i * j * k;

    for(i=0; i<3; i++) {
      for(j=0; j<4; j++) {
        for(k=0; k<5; k++)
          System.out.print(threeD[i][j][k] + " ");
        System.out.println();
      }
      System.out.println();
    }
  }
}
```

This program generates the following output:

```
0 0 0 0 0
0 0 0 0 0
0 0 0 0 0
0 0 0 0 0

0 0 0 0 0
0 1 2 3 4
0 2 4 6 8
0 3 6 9 12

0 0 0 0 0
0 2 4 6 8
0 4 8 12 16
0 6 12 18 24
```

Alternative Array Declaration Syntax

- There is a second form that may be used to declare an array:

  type[ ] *var-name;*

- For example, the following two declarations are equivalent:

```
int al[] = new int[3];
int[] a2 = new int[3];
```

- The following declarations are also equivalent:

```
char twod1[][] = new char[3][4];
char[][] twod2 = new char[3][4];
```

- This alternative declaration form offers convenience when declaring several arrays at the same time.

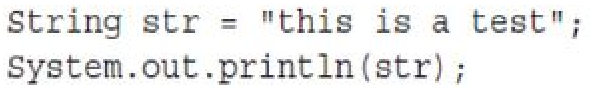
```
int[] nums, nums2, nums3; // create three arrays.
```

  This is similar to

```
int nums[], nums2[], nums3[]; // create three arrays
```

Strings

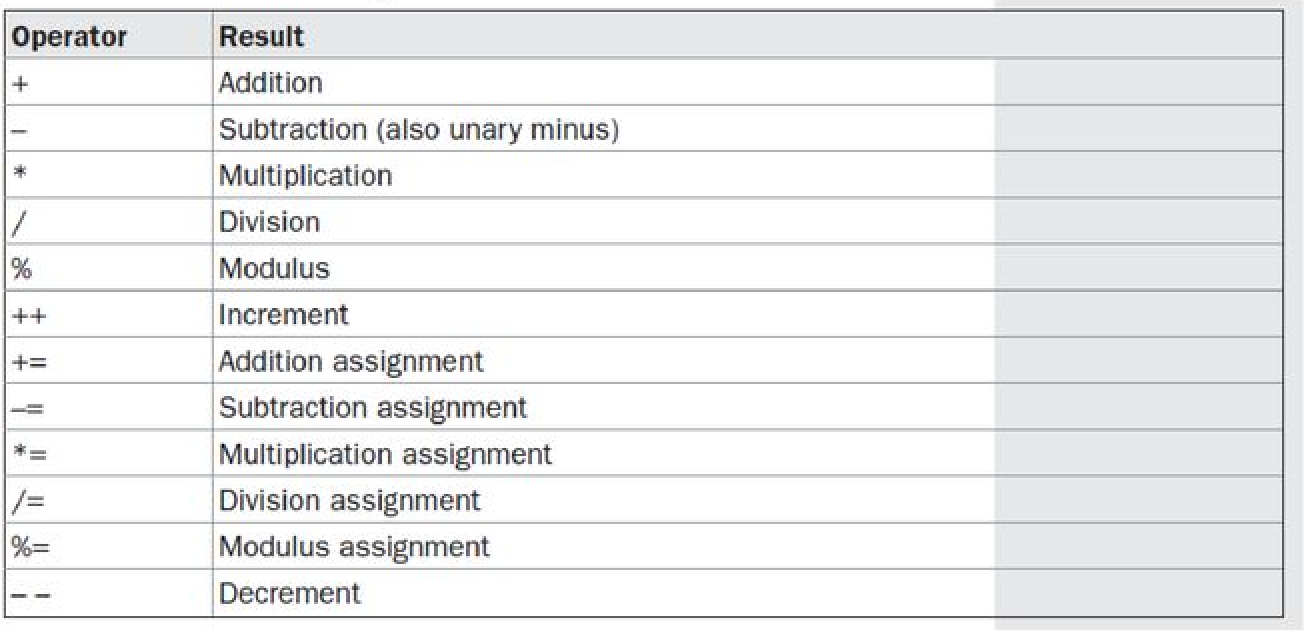
- The **String** type is used to declare string variables.
- You can also declare arrays of strings.
- A quoted string constant can be assigned to a **String** variable.
- A variable of type **String** can be assigned to another variable of type **String**.
- You can use an object of type **String** as an argument to **println( )**.



```
String str = "this is a test";
System.out.println(str);
```

Operators

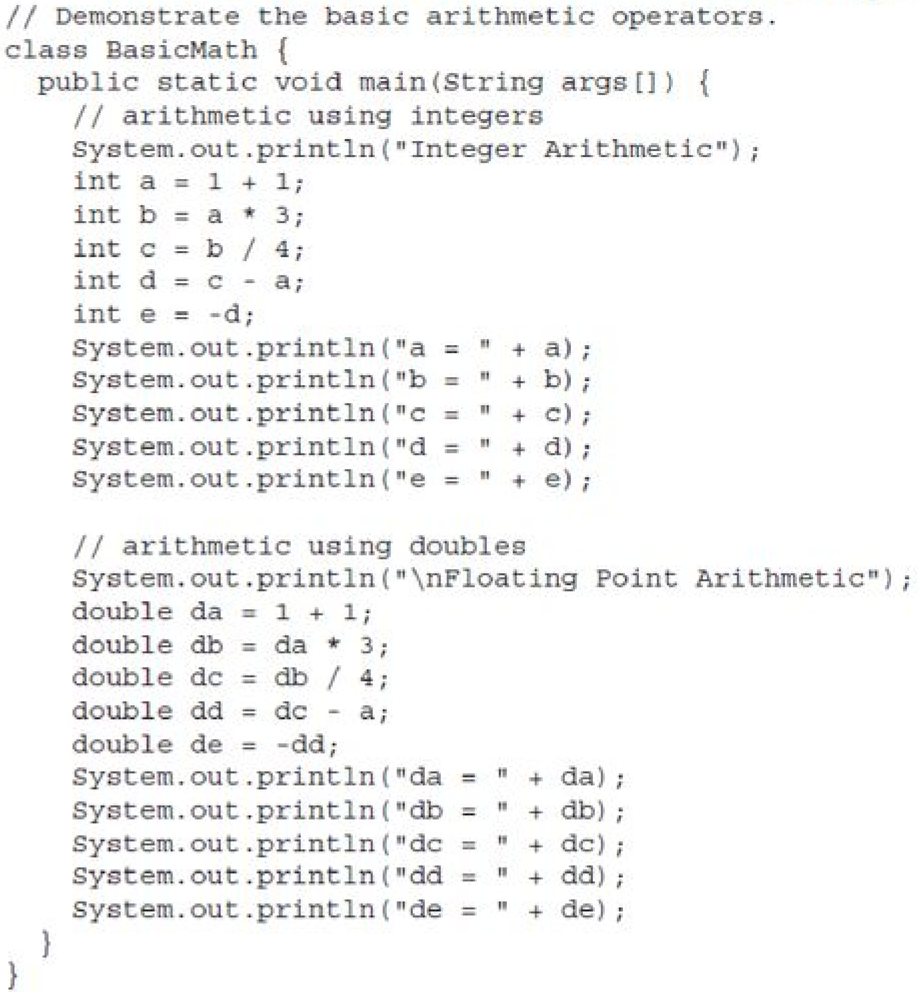
Arithmetic Operators



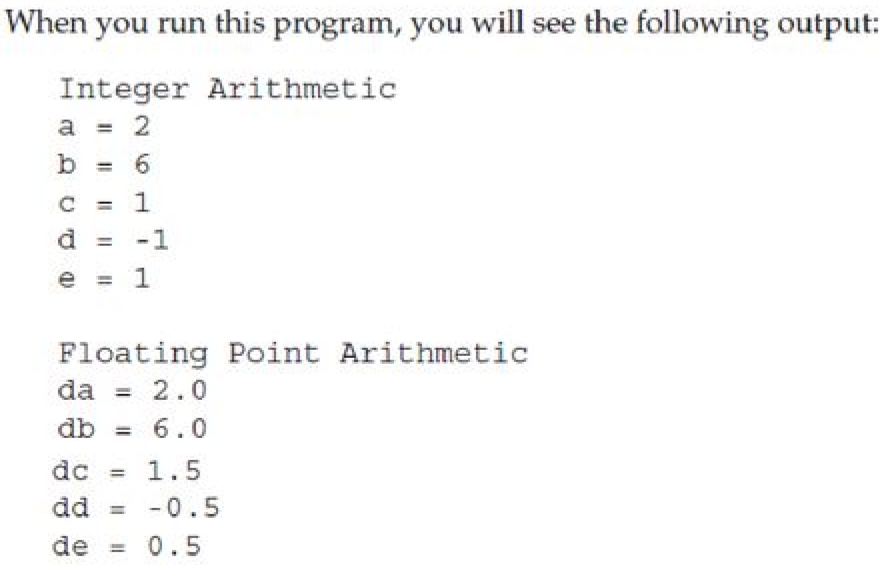
Operator	Result
+	Addition
–	Subtraction (also unary minus)
*	Multiplication
/	Division
%	Modulus
++	Increment
+=	Addition assignment
–=	Subtraction assignment
*=	Multiplication assignment
/=	Division assignment
%=	Modulus assignment
– –	Decrement

- The operands of the arithmetic operators must be of a numeric type.
- You cannot use them on **boolean** types, but you can use them on **char** types, since the **char** type in Java is, essentially, a subset of **int**.

The Basic Arithmetic Operators



```
// Demonstrate the basic arithmetic operators.
class BasicMath {
  public static void main(String args[]) {
    // arithmetic using integers
    System.out.println("Integer Arithmetic");
    int a = 1 + 1;
    int b = a * 3;
    int c = b / 4;
    int d = c - a;
    int e = -d;
    System.out.println("a = " + a);
    System.out.println("b = " + b);
    System.out.println("c = " + c);
    System.out.println("d = " + d);
    System.out.println("e = " + e);

    // arithmetic using doubles
    System.out.println("\nFloating Point Arithmetic");
    double da = 1 + 1;
    double db = da * 3;
    double dc = db / 4;
    double dd = dc - a;
    double de = -dd;
    System.out.println("da = " + da);
    System.out.println("db = " + db);
    System.out.println("dc = " + dc);
    System.out.println("dd = " + dd);
    System.out.println("de = " + de);
  }
}
```

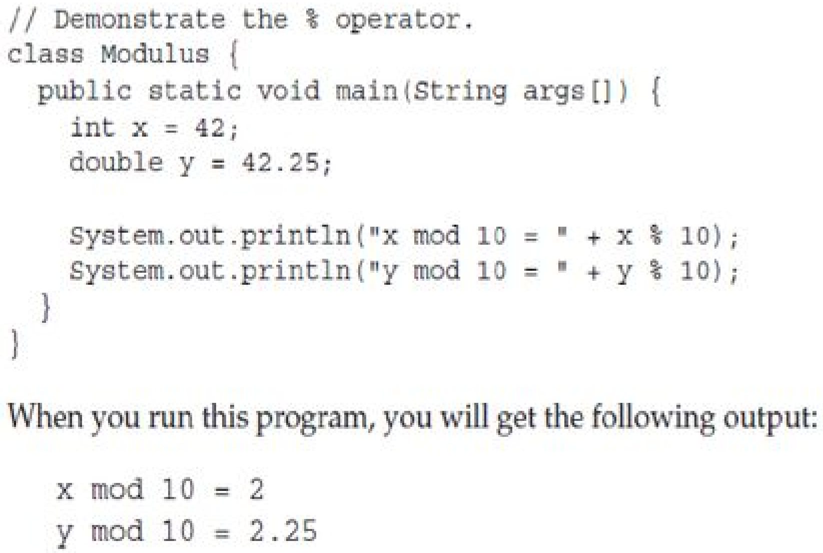


When you run this program, you will see the following output:

```
Integer Arithmetic
a = 2
b = 6
c = 1
d = -1
e = 1

Floating Point Arithmetic
da = 2.0
db = 6.0
dc = 1.5
dd = -0.5
de = 0.5
```

The Modulus Operator

- The modulus operator, %, returns the remainder of a division operation.
- It can be applied to floating-point types as well as integer types.



```
// Demonstrate the % operator.
class Modulus {
  public static void main(String args[]) {
    int x = 42;
    double y = 42.25;

    System.out.println("x mod 10 = " + x % 10);
    System.out.println("y mod 10 = " + y % 10);
  }
}
```

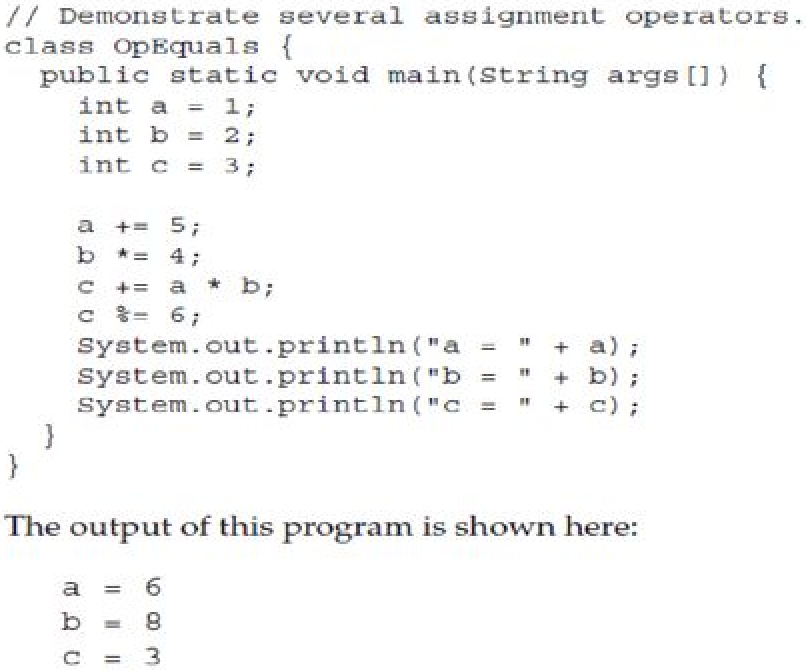
When you run this program, you will get the following output:

```
x mod 10 = 2
y mod 10 = 2.25
```

Arithmetic Compound Assignment Operators

- There are compound assignment operators for all of the arithmetic, binary operators.
- Any statement of the form ***var = var op expression;***

can be rewritten as ***var op= expression;***

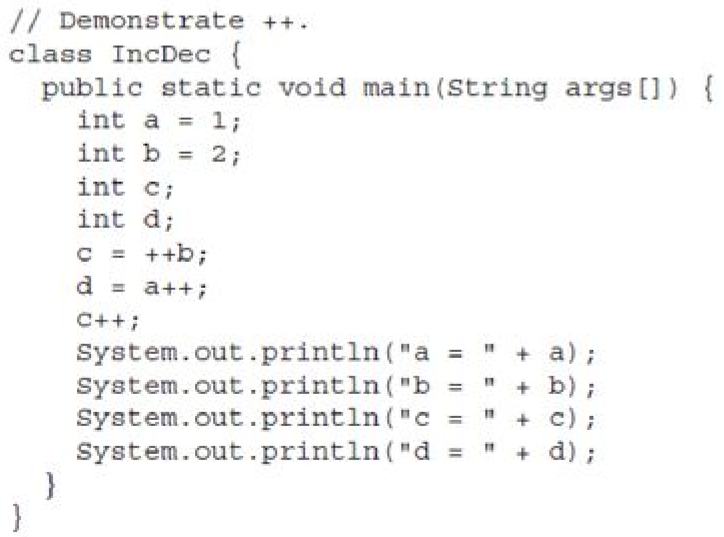


```
// Demonstrate several assignment operators.
class OpEquals {
  public static void main(String args[]) {
    int a = 1;
    int b = 2;
    int c = 3;

    a += 5;
    b *= 4;
    c += a * b;
    c %= 6;
    System.out.println("a = " + a);
    System.out.println("b = " + b);
    System.out.println("c = " + c);
  }
}
```

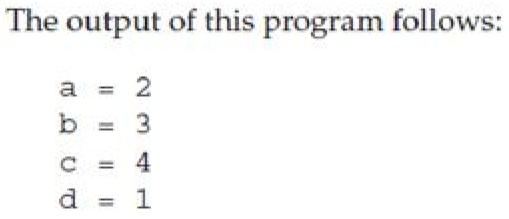
The output of this program is shown here:

```
a = 6
b = 8
c = 3
```

Increment and Decrement



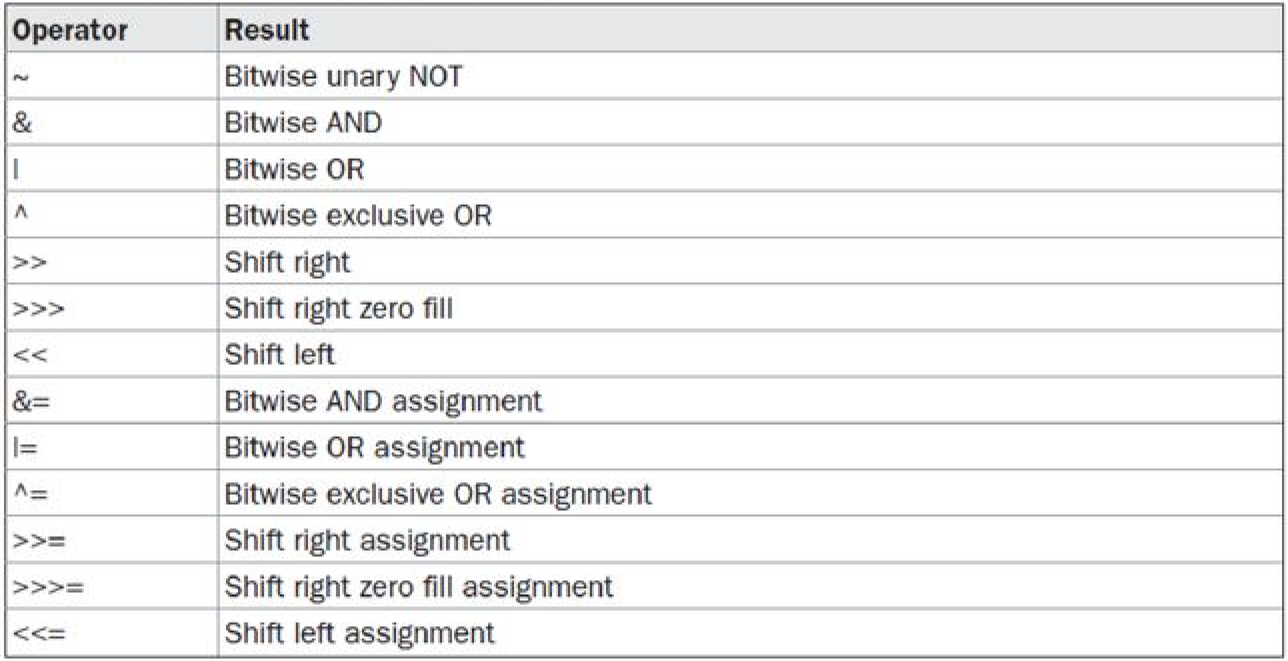
```
// Demonstrate ++.
class IncDec {
  public static void main(String args[]) {
    int a = 1;
    int b = 2;
    int c;
    int d;
    c = ++b;
    d = a++;
    c++;
    System.out.println("a = " + a);
    System.out.println("b = " + b);
    System.out.println("c = " + c);
    System.out.println("d = " + d);
  }
}
```



The output of this program follows:

```
a = 2
b = 3
c = 4
d = 1
```

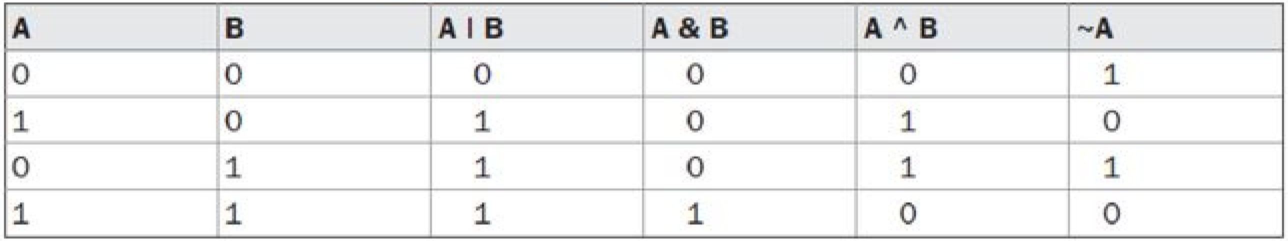
The Bitwise Operators



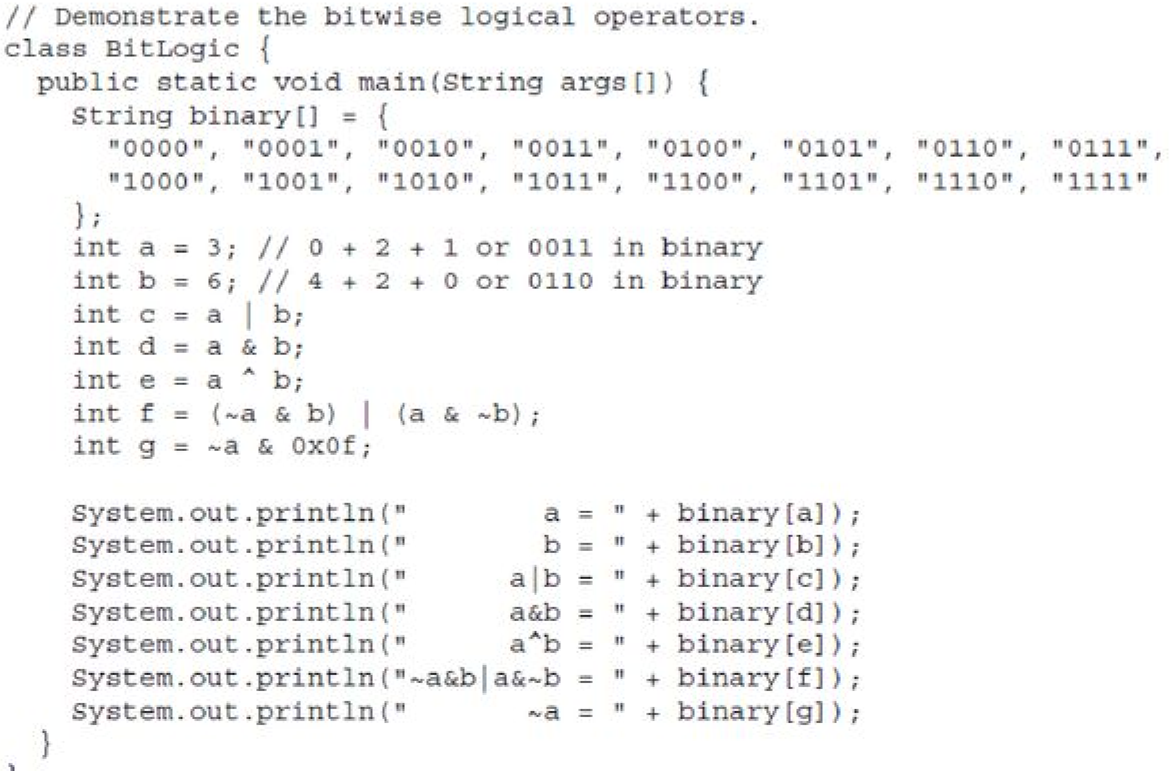
Operator	Result
~	Bitwise unary NOT
&	Bitwise AND
|	Bitwise OR
^	Bitwise exclusive OR
>>	Shift right
>>>	Shift right zero fill
<<	Shift left
&=	Bitwise AND assignment
|=	Bitwise OR assignment
^=	Bitwise exclusive OR assignment
>>=	Shift right assignment
>>>=	Shift right zero fill assignment
<<=	Shift left assignment

- Java defines several *bitwise operators* that can be applied to the integer types, **long**, **int**, **short**, **char**, and **byte**.
- These operators act upon the individual bits of their operands.

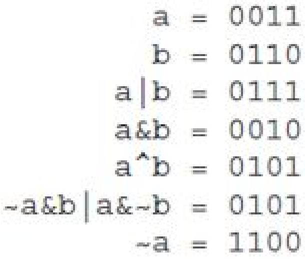
The Bitwise Logical Operators



A	B	A I B	A & B	A ^ B	~A
0	0	0	0	0	1
1	0	1	0	1	0
0	1	1	0	1	1
1	1	1	1	0	0



```
// Demonstrate the bitwise logical operators.
class BitLogic {
  public static void main(String args[]) {
    String binary[] = {
      "0000", "0001", "0010", "0011", "0100", "0101", "0110", "0111",
      "1000", "1001", "1010", "1011", "1100", "1101", "1110", "1111"
    };
    int a = 3; // 0 + 2 + 1 or 0011 in binary
    int b = 6; // 4 + 2 + 0 or 0110 in binary
    int c = a | b;
    int d = a & b;
    int e = a ^ b;
    int f = (~a & b) | (a & ~b);
    int g = ~a & 0x0f;

    System.out.println("        a = " + binary[a]);
    System.out.println("        b = " + binary[b]);
    System.out.println("      a|b = " + binary[c]);
    System.out.println("      a&b = " + binary[d]);
    System.out.println("      a^b = " + binary[e]);
    System.out.println("~a&b|a&~b = " + binary[f]);
    System.out.println("       ~a = " + binary[g]);
  }
}
```



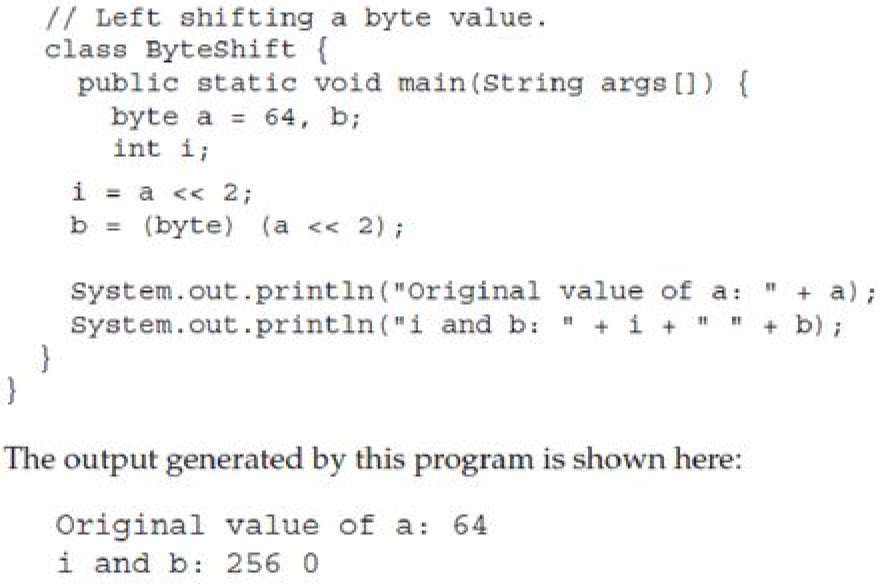
```
        a = 0011
        b = 0110
      a|b = 0111
      a&b = 0010
      a^b = 0101
~a&b|a&~b = 0101
       ~a = 1100
```

The Left Shift

- The left shift operator, **<<**, shifts all of the bits in a value to the left a specified number of times.
- It has this general form:

value << num

- *num* specifies the number of positions to left-shift the value in *value.*
- The outcome of a left shift on a **byte** or **short** value will be an **int**, and the bits shifted left will not be lost until they shift past bit position 31.
- Each left shift has the effect of doubling the original value



```
 // Left shifting a byte value.
 class ByteShift {
   public static void main(String args[]) {
     byte a = 64, b;
     int i;

   i = a << 2;
   b = (byte) (a << 2);

   System.out.println("Original value of a: " + a);
   System.out.println("i and b: " + i + " " + b);
 }
}
```

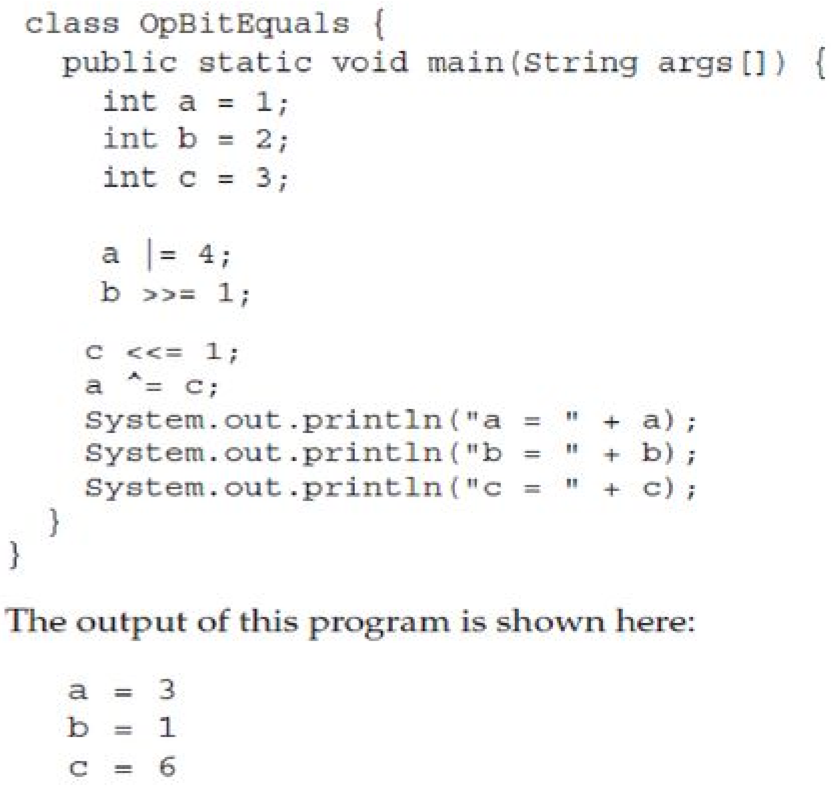
The output generated by this program is shown here:

```
 Original value of a: 64
 i and b: 256 0
```

The Right Shift

- The right shift operator, **>>**, shifts all of the bits in a value to the right a specified number of times. Its general form is shown here: *value >> num*
- *num* specifies the number of positions to right-shift the value in *value.*
- Each time you shift a value to the right, it divides that value by two—and discards any remainder.

Bitwise Operator Compound Assignments



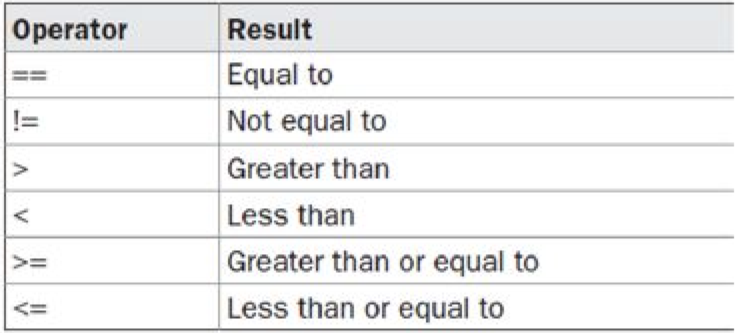
```
class OpBitEquals {
  public static void main(String args[]) {
    int a = 1;
    int b = 2;
    int c = 3;

    a |= 4;
    b >>= 1;
    c <<= 1;
    a ^= c;
    System.out.println("a = " + a);
    System.out.println("b = " + b);
    System.out.println("c = " + c);
  }
}
```

The output of this program is shown here:

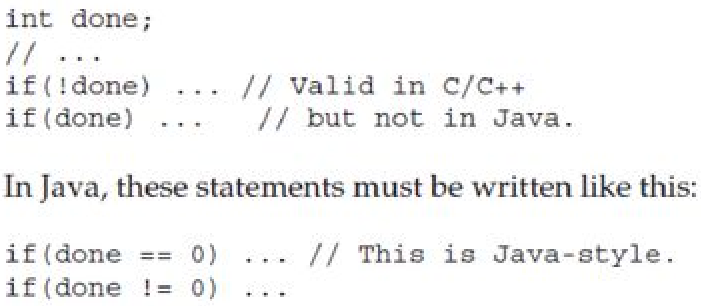
```
a = 3
b = 1
c = 6
```

Relational Operators

- The *relational operators* determine the relationship that one operand has to the other.
- Specifically, they determine equality and ordering.



Operator	Result
==	Equal to
!=	Not equal to
>	Greater than
<	Less than
>=	Greater than or equal to
<=	Less than or equal to



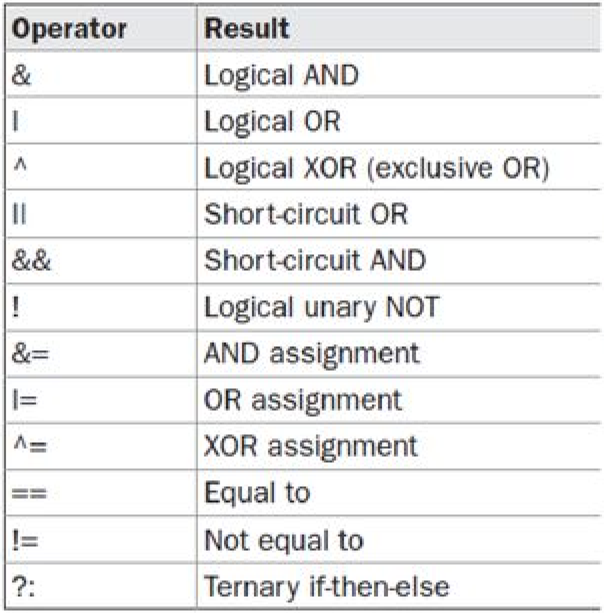
```
int done;
// ...
if(!done) ... // Valid in C/C++
if(done) ...   // but not in Java.
```

In Java, these statements must be written like this:

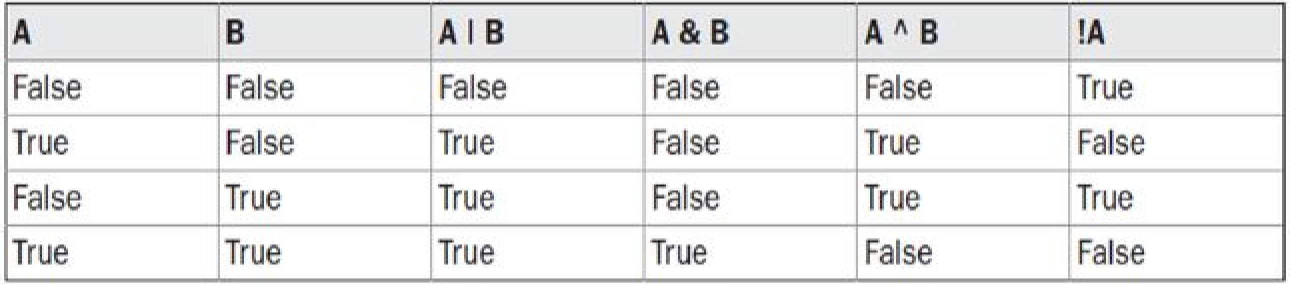
```
if(done == 0) ... // This is Java-style.
if(done != 0) ...
```

Boolean Logical Operators

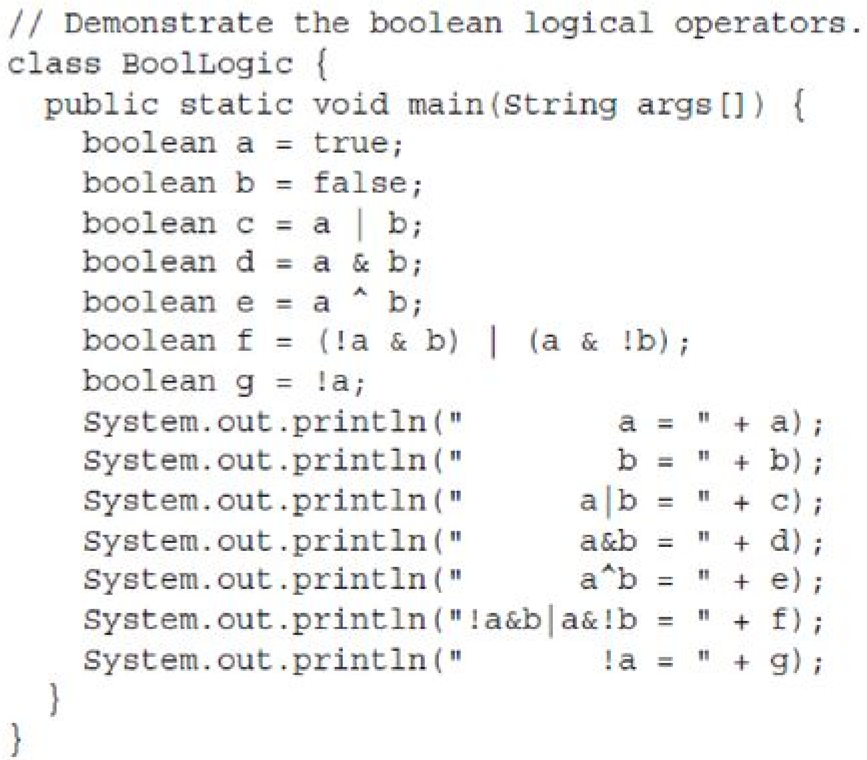
- All of the binary logical operators combine two **boolean** values to form a resultant **boolean** value.



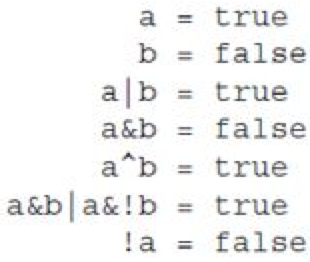
Operator	Result
&	Logical AND
|	Logical OR
^	Logical XOR (exclusive OR)
||	Short-circuit OR
&&	Short-circuit AND
!	Logical unary NOT
&=	AND assignment
|=	OR assignment
^=	XOR assignment
==	Equal to
!=	Not equal to
?:	Ternary if-then-else



A	B	A | B	A & B	A ^ B	!A
False	False	False	False	False	True
True	False	True	False	True	False
False	True	True	False	True	True
True	True	True	True	False	False



```
// Demonstrate the boolean logical operators.
class BoolLogic {
  public static void main(String args[]) {
    boolean a = true;
    boolean b = false;
    boolean c = a | b;
    boolean d = a & b;
    boolean e = a ^ b;
    boolean f = (!a & b) | (a & !b);
    boolean g = !a;
    System.out.println("        a = " + a);
    System.out.println("        b = " + b);
    System.out.println("      a|b = " + c);
    System.out.println("      a&b = " + d);
    System.out.println("      a^b = " + e);
    System.out.println("!a&b|a&!b = " + f);
    System.out.println("       !a = " + g);
  }
}
```

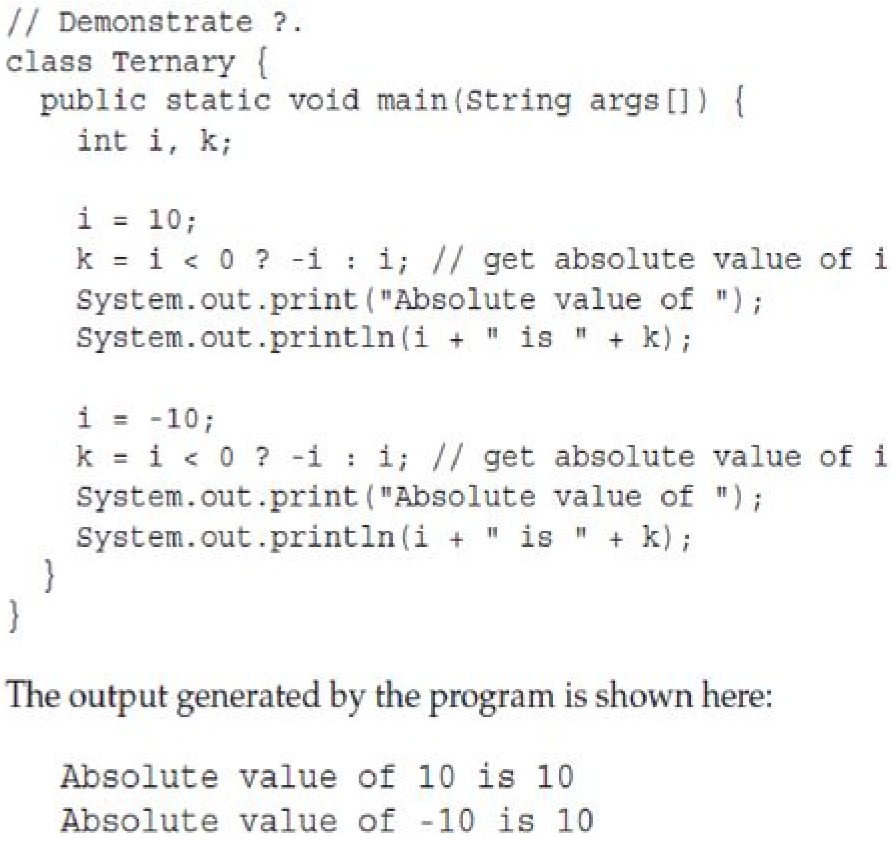


```
       a = true
       b = false
     a|b = true
     a&b = false
     a^b = true
a&b|a&!b = true
      !a = false
```

- **The Assignment Operator**
  - The *assignment operator* is the single equal sign, =.
  - It has this general form: *var = expression*;
  - Here, the type of *var* must be compatible with the type of *expression.*
- **The ? Operator**
- Java includes a special *ternary* (three-way) *operator* that can replace certain types of if-then-else statements.
- The **?** has this general form:

expression1 **?** *expression2* **:** *expression3*

  - Here, *expression1* can be any expression that evaluates to a **boolean** value.
  - If *expression1* is **true**, then *expression2* is evaluated; otherwise, *expression3* is evaluated.

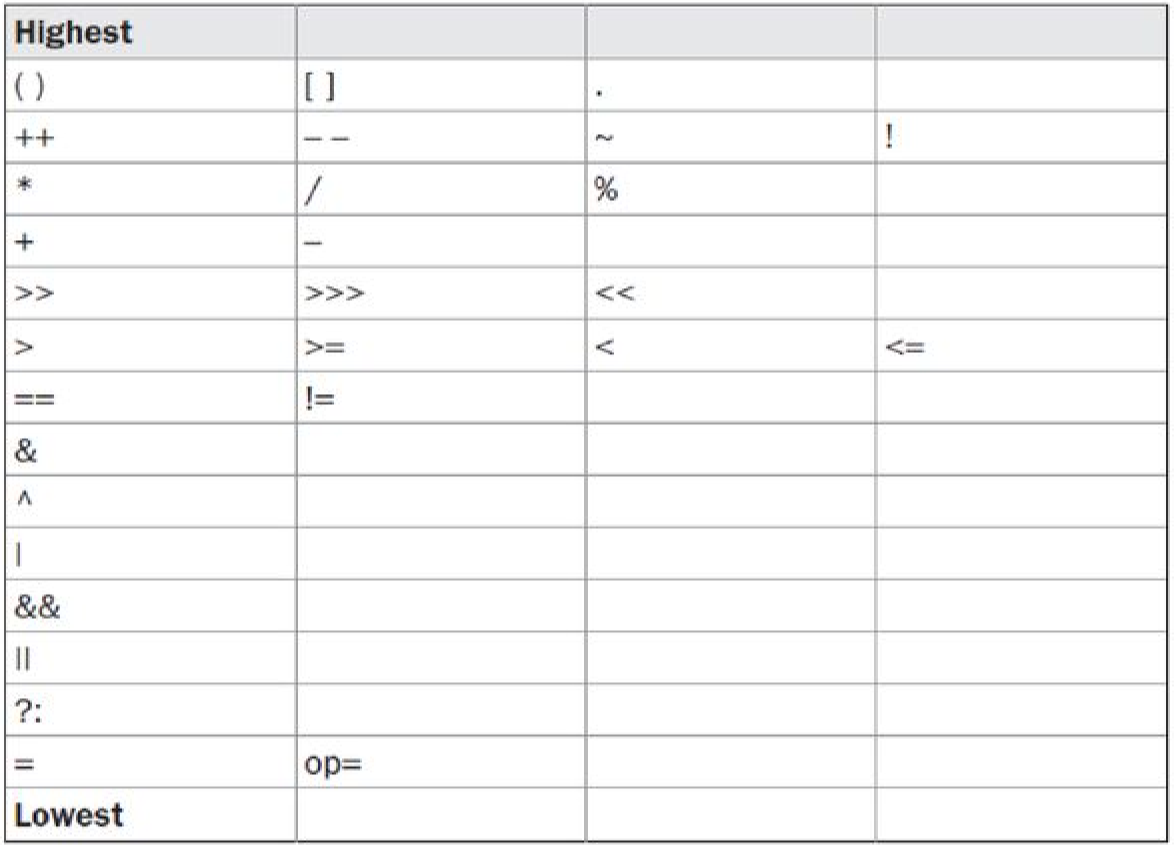


```
// Demonstrate ?.
class Ternary {
  public static void main(String args[]) {
    int i, k;

    i = 10;
    k = i < 0 ? -i : i; // get absolute value of i
    System.out.print("Absolute value of ");
    System.out.println(i + " is " + k);

    i = -10;
    k = i < 0 ? -i : i; // get absolute value of i
    System.out.print("Absolute value of ");
    System.out.println(i + " is " + k);
  }
}
```

The output generated by the program is shown here:

```
Absolute value of 10 is 10
Absolute value of -10 is 10
```

Operator Precedence



Highest			
( )	[ ]	.	
++	– –	~	!
*	/	%	
+	–		
>>	>>>	<<	
>	>=	<	<=
==	!=		
&			
^			
|			
&&			
||			
?:			
=	op=		
Lowest			

Control Statements

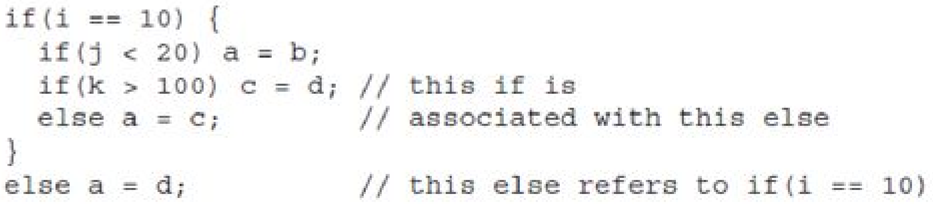
Java’s Selection Statements

- Java supports two selection statements: **if** and **switch**.
- These statements allow you to control the flow of your program’s execution based upon conditions known only during run time.
- **If**
  - The **if** statement is Java’s conditional branch statement.
  - The general form of the **if** statement:

    if (*condition*) *statement1*;

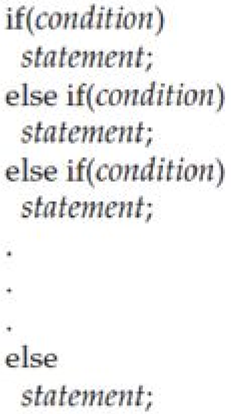
    else *statement2*;
  - Here, each *statement* may be a single statement or a compound statement enclosed in curly braces (that is, a *block*).
  - The *condition* is any expression that returns a **boolean** value.
  - The **else** clause is optional.

- **Nested ifs**
- A *nested* **if** is an **if** statement that is the target of another **if** or **else**.
- When you nest **if**s, the main thing to remember is that an **else** statement always refers to the nearest **if** statement that is within the same block as the **else** and that is not already associated with an **else**.

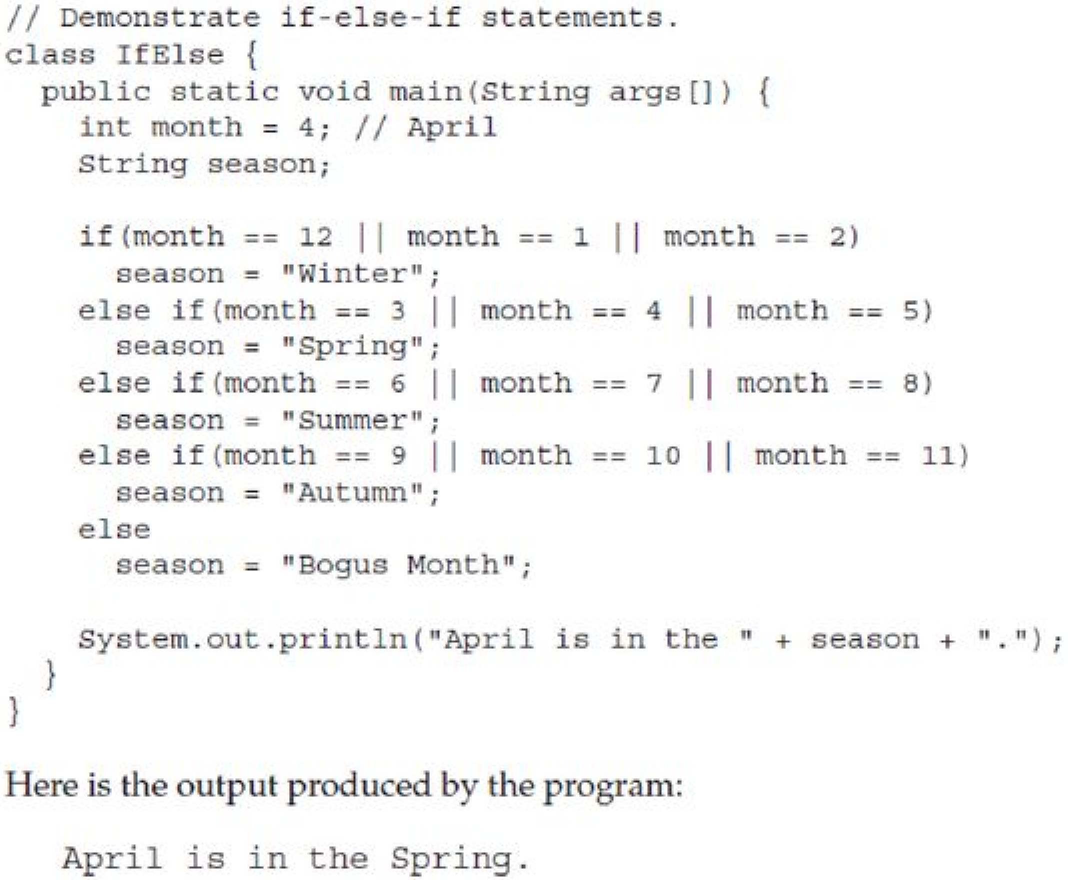


```
if(i == 10) {
  if(j < 20) a = b;
  if(k > 100) c = d; // this if is
  else a = c;        // associated with this else
}
else a = d;          // this else refers to if(i == 10)
```

- **The if-else-if Ladder**



```
if(condition)
 statement;
else if(condition)
 statement;
else if(condition)
 statement;
.
.
.
else
 statement;
```



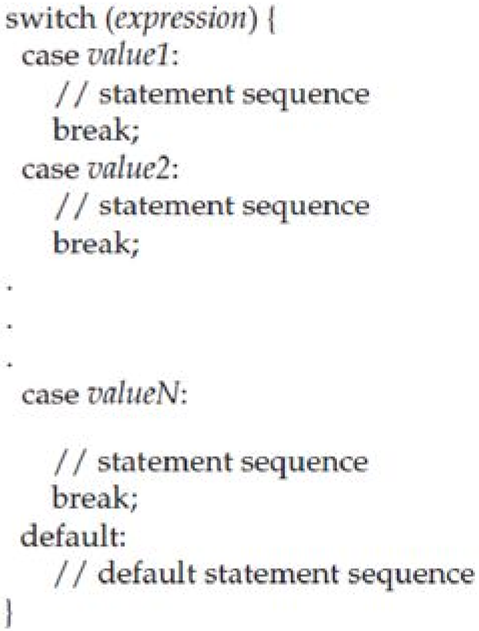
```
// Demonstrate if-else-if statements.
class IfElse {
  public static void main(String args[]) {
    int month = 4; // April
    String season;

    if(month == 12 || month == 1 || month == 2)
      season = "Winter";
    else if(month == 3 || month == 4 || month == 5)
      season = "Spring";
    else if(month == 6 || month == 7 || month == 8)
      season = "Summer";
    else if(month == 9 || month == 10 || month == 11)
      season = "Autumn";
    else
      season = "Bogus Month";

    System.out.println("April is in the " + season + ".");
  }
}
```

Here is the output produced by the program:

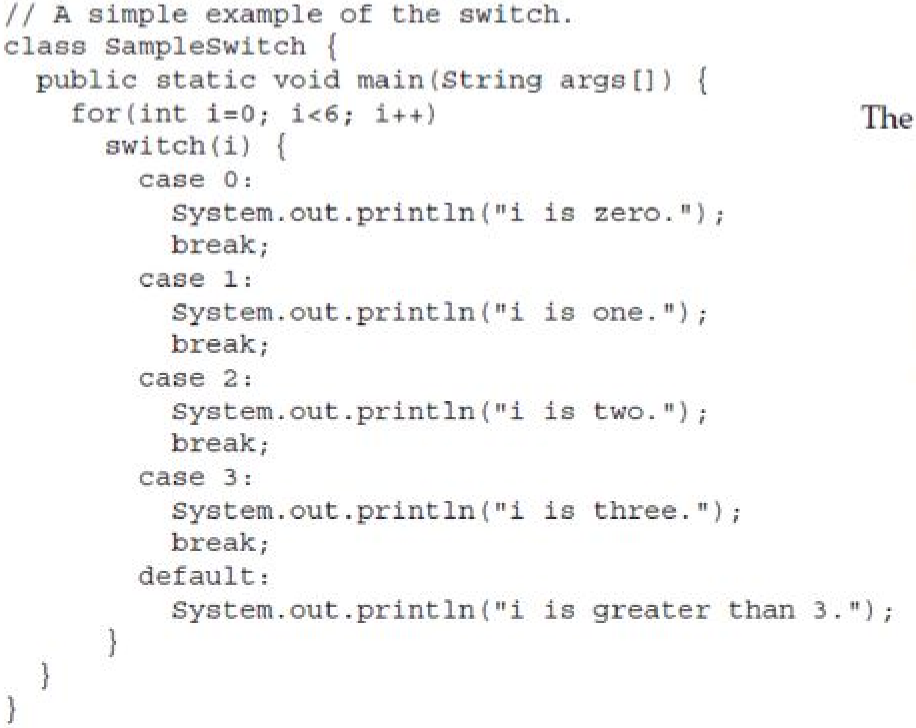
```
April is in the Spring.
```

switch

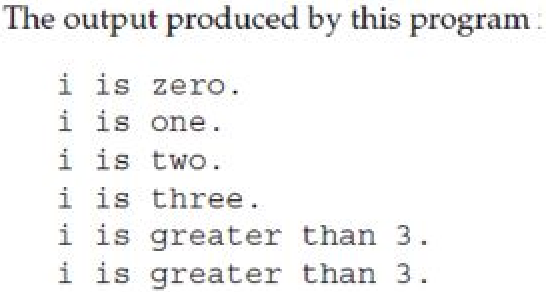
- The **switch** statement is Java’s multiway branch statement.
- It provides an easy way to dispatch execution to different parts of your code based on the value of an expression.



```
switch (expression) {
  case value1:
    // statement sequence
    break;
  case value2:
    // statement sequence
    break;
.
.
.
  case valueN:

    // statement sequence
    break;
  default:
    // default statement sequence
}
```



```
// A simple example of the switch.
class SampleSwitch {
  public static void main(String args[]) {
    for(int i=0; i<6; i++)
      switch(i) {
        case 0:
          System.out.println("i is zero.");
          break;
        case 1:
          System.out.println("i is one.");
          break;
        case 2:
          System.out.println("i is two.");
          break;
        case 3:
          System.out.println("i is three.");
          break;
        default:
          System.out.println("i is greater than 3.");
      }
    }
}
```



The output produced by this program :

```
i is zero.
i is one.
i is two.
i is three.
i is greater than 3.
i is greater than 3.
```

```
// In a switch, break statements are optional.
class MissingBreak {
  public static void main(String args[]) {
    for(int i=0; i<12; i++)
      switch(i) {
        case 0:
        case 1:
        case 2:
        case 3:
        case 4:
          System.out.println("i is less than 5");
          break;
        case 5:
        case 6:
        case 7:
        case 8:
        case 9:
          System.out.println("i is less than 10");
          break;
        default:
          System.out.println("i is 10 or more");
      }
  }
}
```

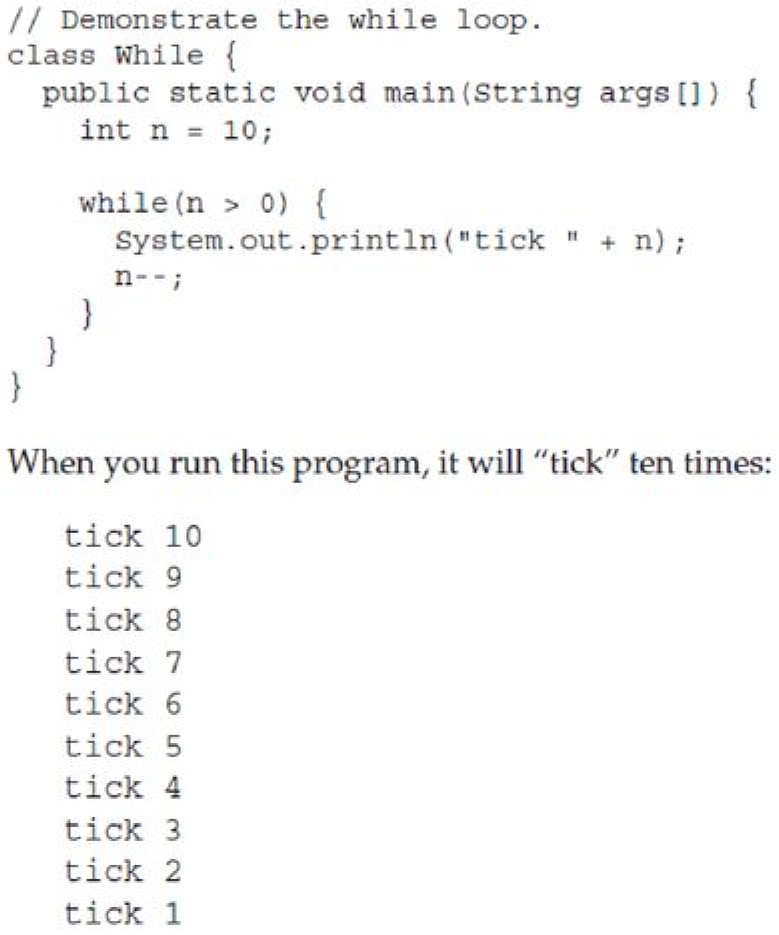
This program generates the following output:

```
i is less than 5
i is less than 5
i is less than 5
i is less than 5
i is less than 5
i is less than 10
i is less than 10
i is less than 10
i is less than 10
i is less than 10
i is 10 or more
i is 10 or more
```

Iteration Statements

- Java’s iteration statements are **for**, **while**, and **do-while**.
- These statements create what we commonly call *loops.*
- **While**
  - It repeats a statement or block while its controlling expression is true. Here is its general form:

    ```
    while(condition) {
    // body of loop
    }
    ```
  - The *condition* can be any Boolean expression.
  - The body of the loop will be executed as long as the conditional expression is true.
  - When *condition* becomes false, control passes to the next line of code immediately following the loop.
  - The curly braces are unnecessary if only a single statement is being repeated.

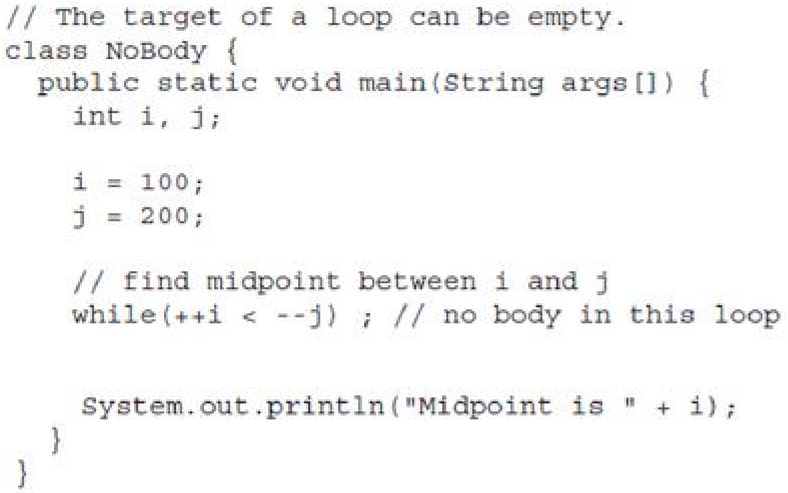


```
// Demonstrate the while loop.
class While {
  public static void main(String args[]) {
    int n = 10;

    while(n > 0) {
      System.out.println("tick " + n);
      n--;
    }
  }
}
```

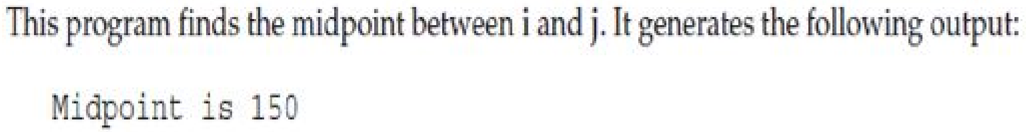
When you run this program, it will "tick" ten times:

```
tick 10
tick 9
tick 8
tick 7
tick 6
tick 5
tick 4
tick 3
tick 2
tick 1
```

- The body of the while (or any other of Java's loops) can be empty.
- This is because a null statement (one that consists only of a semicolon) is syntactically valid in Java.



```
// The target of a loop can be empty.
class NoBody {
  public static void main(String args[]) {
    int i, j;

    i = 100;
    j = 200;

    // find midpoint between i and j
    while(++i < --j) ; // no body in this loop


     System.out.println("Midpoint is " + i);
  }
}
```



This program finds the midpoint between i and j. It generates the following output:

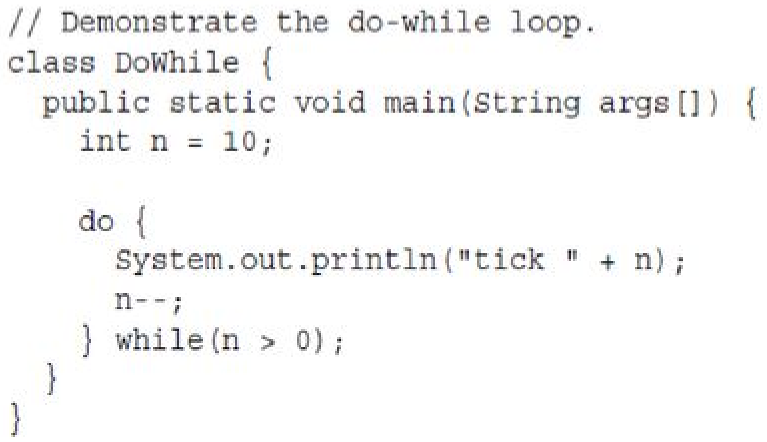
```
Midpoint is 150
```

- **do-while**
  - The **do-while** loop always executes its body at least once, because its conditional expression is at the bottom of the loop. Its general form is

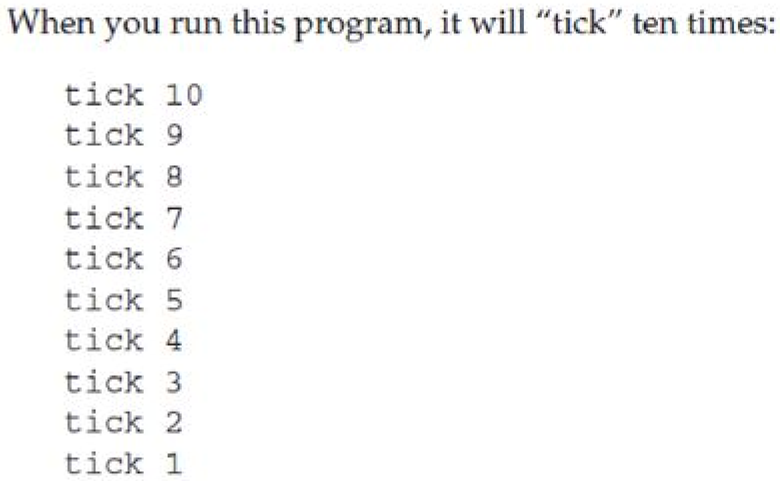
    do {

    // body of loop

    } while (*condition*);
  - Each iteration of the **do-while** loop first executes the body of the loop and then evaluates the conditional expression.
  - If this expression is true, the loop will repeat. Otherwise, the loop terminates.



```
// Demonstrate the do-while loop.
class DoWhile {
  public static void main(String args[]) {
    int n = 10;

    do {
      System.out.println("tick " + n);
      n--;
    } while(n > 0);
  }
}
```

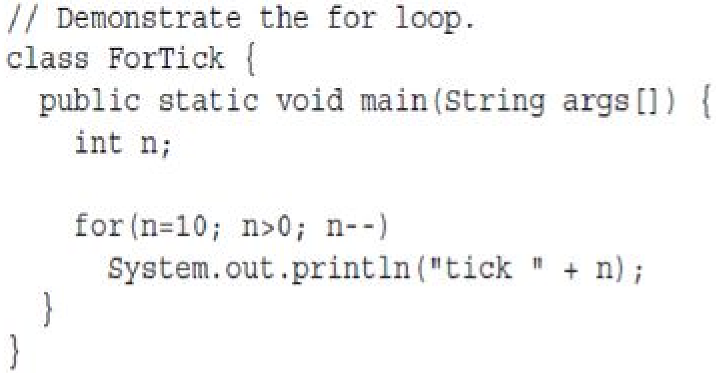


When you run this program, it will "tick" ten times:

```
tick 10
tick 9
tick 8
tick 7
tick 6
tick 5
tick 4
tick 3
tick 2
tick 1
```

- **for**
  - The general form of the traditional **for** statement:

    for(*initialization*; *condition*; *iteration*) {
    // body
    }
  - If only one statement is being repeated, there is no need for the curly braces.
  - When the loop first starts, the *initialization* portion of the loop is executed.
  - Generally, this is an expression that sets the value of the *loop control variable*, which acts as a counter that controls the loop.
  - Next, *condition* is evaluated. This must be a Boolean expression.
  - It usually tests the loop control variable against a target value.
  - If this expression is true, then the body of the loop is executed. If it is false, the loop terminates.
  - Next, the *iteration* portion of the loop is executed. This is usually an expression that increments or decrements the loop control variable.



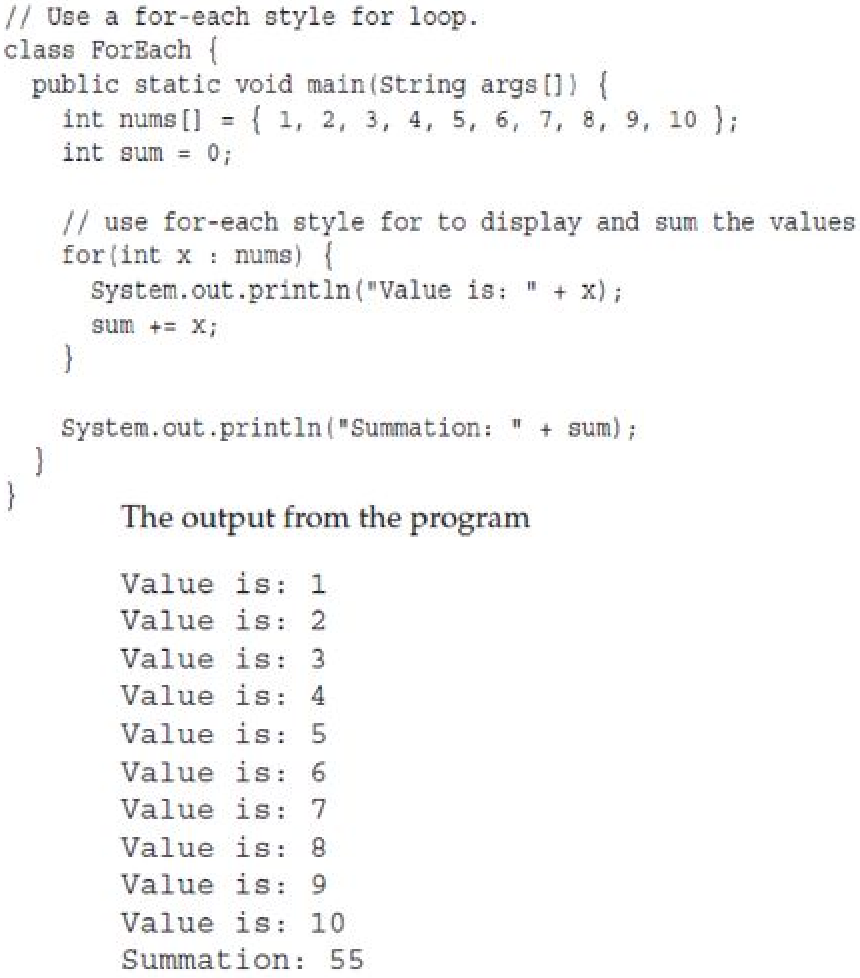
```
// Demonstrate the for loop.
class ForTick {
  public static void main(String args[]) {
    int n;

    for(n=10; n>0; n--)
      System.out.println("tick " + n);
  }
}
```

The For-Each Version of the for Loop

- Java adds the for-each capability by enhancing the **for** statement.
- The advantage of this approach is that no new keyword is required, and no preexisting code is broken.
- The for-each style of **for** is also referred to as the *enhanced* **for** loop.
- The general form of the for-each version of the **for** is:

  for(*type itr-var : collection*) *statement-block*

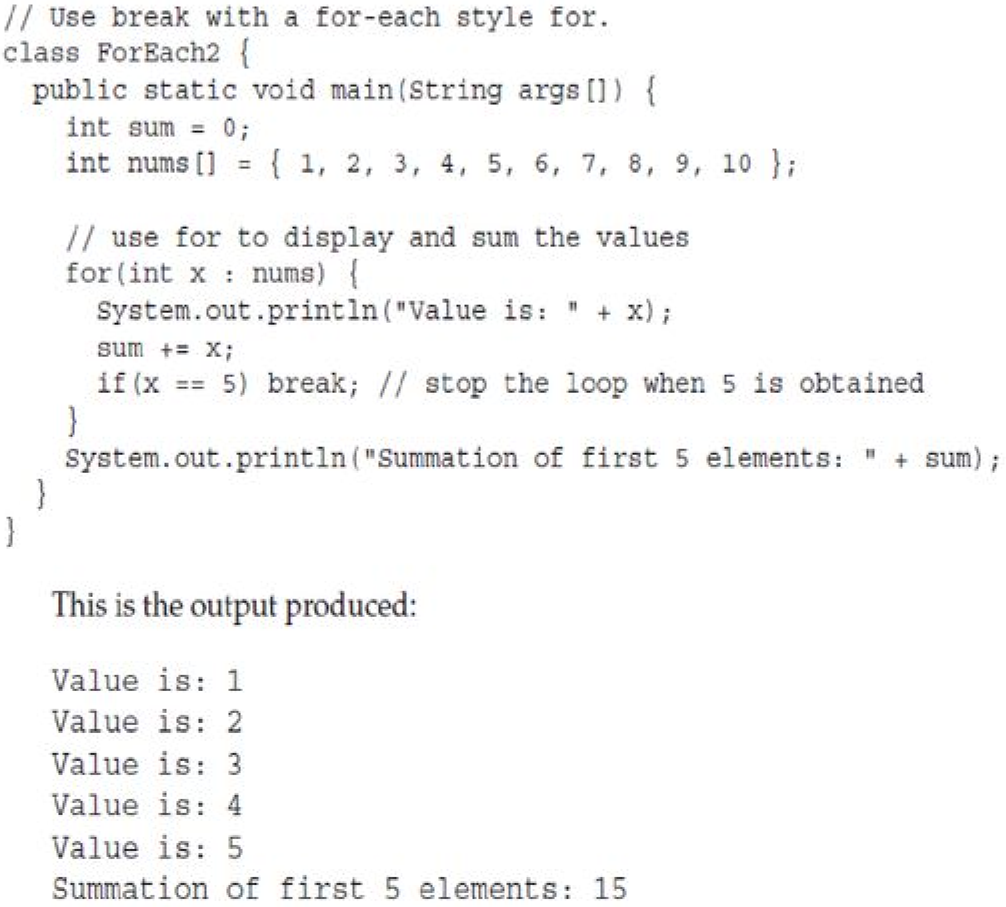
- Here, *type* specifies the type and *itr-var* specifies the name of an *iteration variable* that will receive the elements from a collection, one at a time, from beginning to end.
- With each iteration of the loop, the next element in the collection is retrieved and stored in *itr-var*.
- The loop repeats until all elements in the collection have been obtained.



```
// Use a for-each style for loop.
class ForEach {
  public static void main(String args[]) {
    int nums[] = { 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 };
    int sum = 0;

    // use for-each style for to display and sum the values
    for(int x : nums) {
      System.out.println("Value is: " + x);
      sum += x;
    }

    System.out.println("Summation: " + sum);
  }
}
```

The output from the program

```
Value is: 1
Value is: 2
Value is: 3
Value is: 4
Value is: 5
Value is: 6
Value is: 7
Value is: 8
Value is: 9
Value is: 10
Summation: 55
```



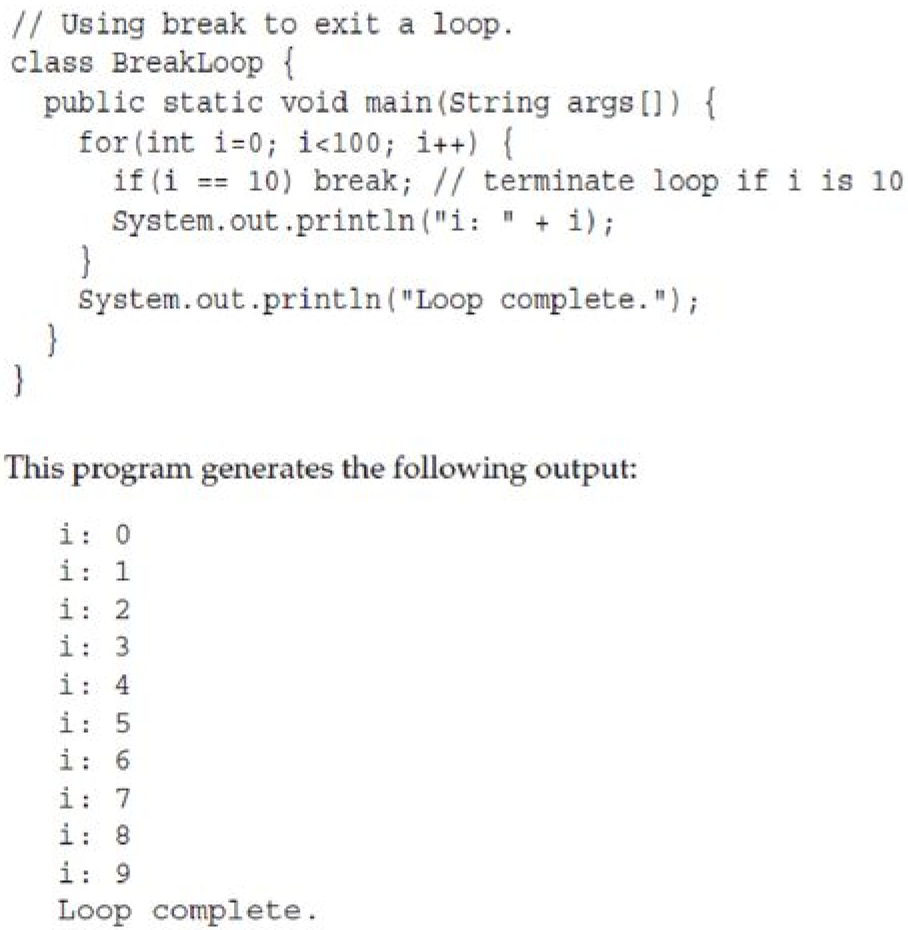
```
// Use break with a for-each style for.
class ForEach2 {
  public static void main(String args[]) {
    int sum = 0;
    int nums[] = { 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 };

    // use for to display and sum the values
    for(int x : nums) {
      System.out.println("Value is: " + x);
      sum += x;
      if(x == 5) break; // stop the loop when 5 is obtained
    }
    System.out.println("Summation of first 5 elements: " + sum);
  }
}
```

This is the output produced:

```
Value is: 1
Value is: 2
Value is: 3
Value is: 4
Value is: 5
Summation of first 5 elements: 15
```

Jump Statements

- Java supports three jump statements: **break**, **continue**, and **return**.
- These statements transfer control to another part of your program.
- **Using break**
  - By using **break**, you can force immediate termination of a loop, bypassing the conditional expression and any remaining code in the body of the loop.
  - When a **break** statement is encountered inside a loop, the loop is terminated and program control resumes at the next statement following the loop.

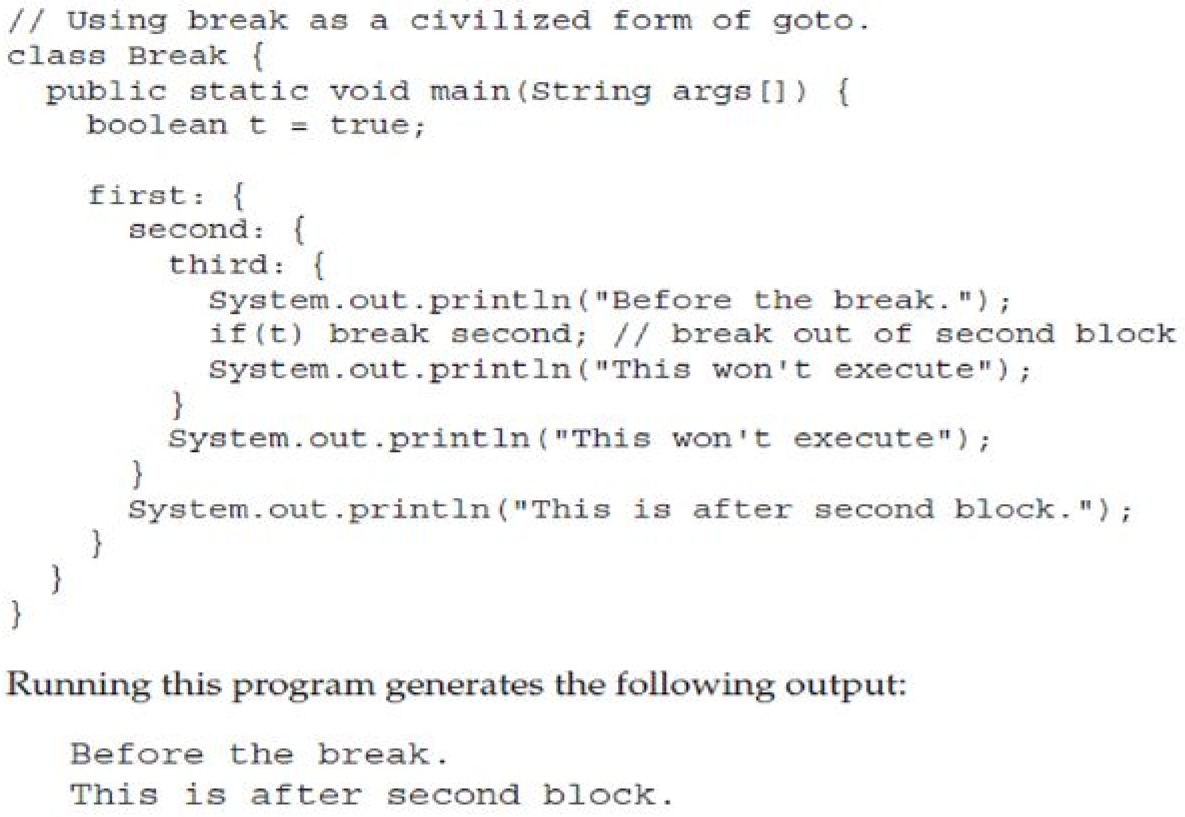


```
// Using break to exit a loop.
class BreakLoop {
  public static void main(String args[]) {
    for(int i=0; i<100; i++) {
      if(i == 10) break; // terminate loop if i is 10
      System.out.println("i: " + i);
    }
    System.out.println("Loop complete.");
  }
}
```

This program generates the following output:

```
i: 0
i: 1
i: 2
i: 3
i: 4
i: 5
i: 6
i: 7
i: 8
i: 9
Loop complete.
```

- **Using break as a Form of Goto**
  - The general form of the labeled **break** statement is shown here:
    break *label*;
  - *label* is the name of a label that identifies a block of code.

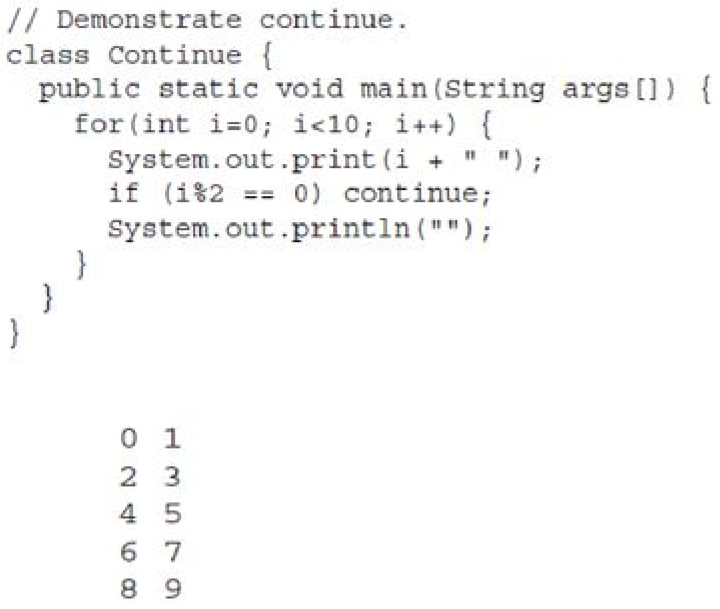


```
// Using break as a civilized form of goto.
class Break {
  public static void main(String args[]) {
    boolean t = true;

    first: {
      second: {
        third: {
          System.out.println("Before the break.");
          if(t) break second; // break out of second block
          System.out.println("This won't execute");
        }
        System.out.println("This won't execute");
      }
      System.out.println("This is after second block.");
    }
  }
}
```

Running this program generates the following output:

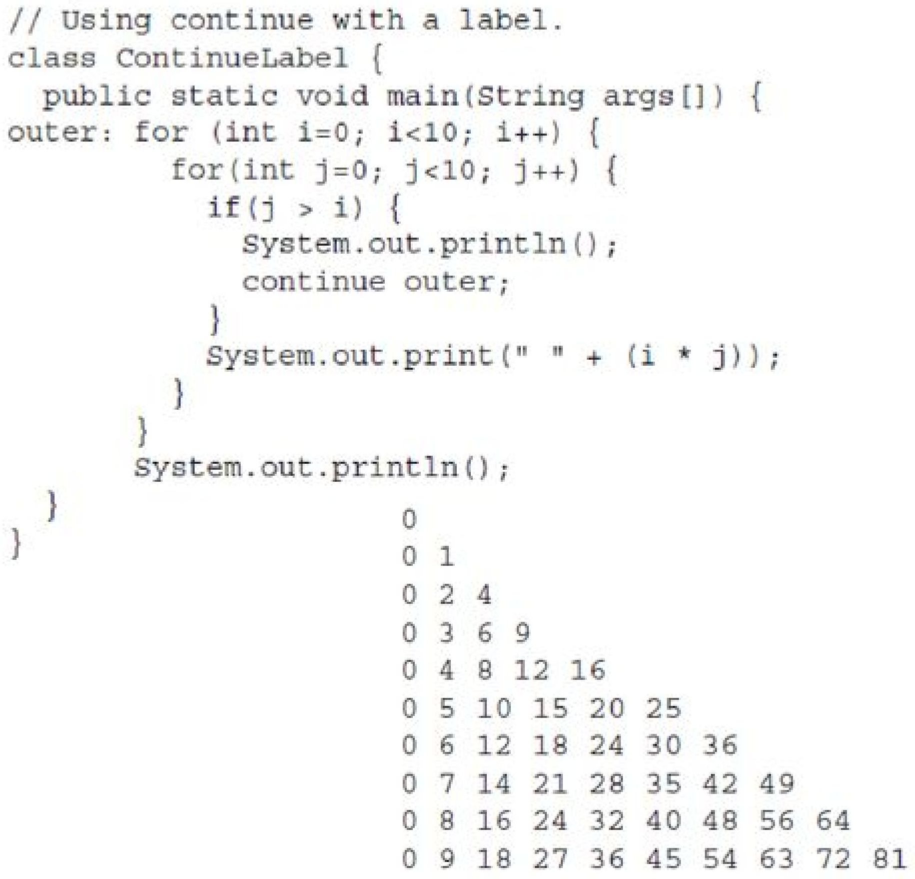
```
Before the break.
This is after second block.
```

- **Using continue**
  - A **continue** statement causes control to be transferred directly to the conditional expression that controls the loop.



```
// Demonstrate continue.
class Continue {
  public static void main(String args[]) {
    for(int i=0; i<10; i++) {
      System.out.print(i + " ");
      if (i%2 == 0) continue;
      System.out.println("");
    }
  }
}
```

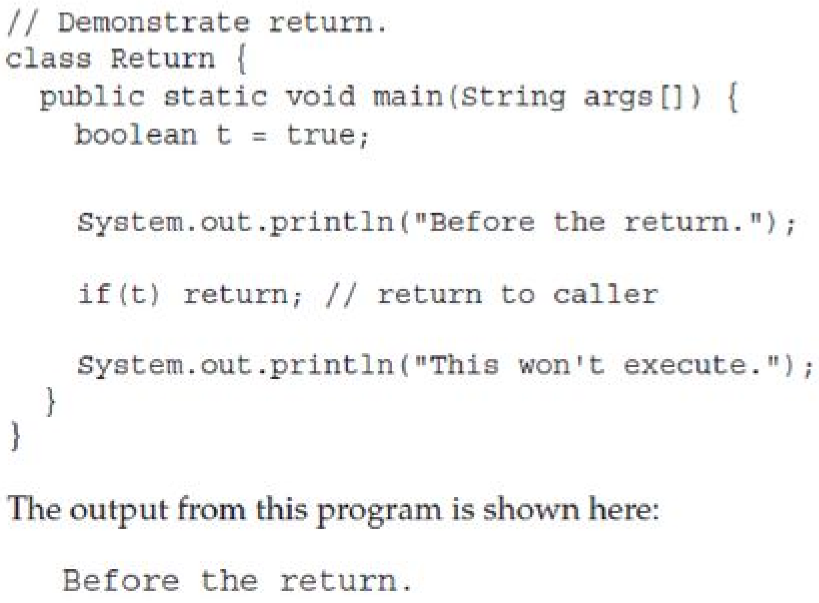
```
0 1
2 3
4 5
6 7
8 9
```



```
// Using continue with a label.
class ContinueLabel {
  public static void main(String args[]) {
outer: for (int i=0; i<10; i++) {
          for(int j=0; j<10; j++) {
            if(j > i) {
              System.out.println();
              continue outer;
            }
            System.out.print(" " + (i * j));
          }
        }
        System.out.println();
  }
}
```

```
0
0 1
0 2 4
0 3 6 9
0 4 8 12 16
0 5 10 15 20 25
0 6 12 18 24 30 36
0 7 14 21 28 35 42 49
0 8 16 24 32 40 48 56 64
0 9 18 27 36 45 54 63 72 81
```

- **return**
  - The **return** statement is used to explicitly return from a method.
  - It causes program control to transfer back to the caller of the method.
  - At any time in a method the **return** statement can be used to cause execution to branch back to the caller of the method.
  - Thus, the **return** statement immediately terminates the method in which it is executed.



```
// Demonstrate return.
class Return {
  public static void main(String args[]) {
    boolean t = true;


    System.out.println("Before the return.");

    if(t) return; // return to caller

    System.out.println("This won't execute.");
  }
}
```

The output from this program is shown here:

```
   Before the return.
```