Java Programming

CHAPTER 3

Language Basics

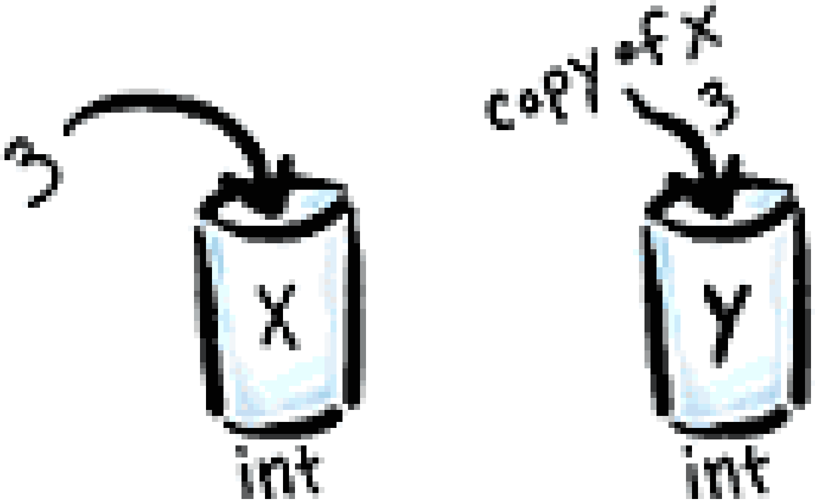
Contents

- Variables
- Operators
- Expressions, Statements, and Blocks
- Control Flow Statements

Variables

- You can imagine that a Java variable is a cup, with a value in it.
- What does it mean to say:

```
int x = 3;
int y = x;
```



Variables

- Variables in Java are very much like in C:
  - int cadence;   // variable: type + name
  - float speed = 20.0f;
  - long gear = 10L;
- Fields (or attributes) are variables that are used by an object to store its state:

```
class AA {
   int field = 4;          // an instance variable
   static char = ‘a’;    // a class variable is shared
}
```

Kinds of Variables

- Instance variables (or non-static fields) are used by an object to store its state.

```
class Bicycle {          // fields or attributes
        int cadence = 0; // instance variables
        int speed = 0;
        int gear = 1;
…
```

See the Implementation of a Bicycle, Lecture 1, sl. 21

- Class variables (or static fields) – there is only 1 copy per class, i.e., all the objects share that class variable (i.e., static field).

```
class Bicycle {          // fields or attributes
        int cadence = 0;
        int speed = 0;
        int gear = 1;
       static int numGears = 6; // class variable
…
```

Kinds of Variables

- Local variables are used by methods to store temporary values.

```
void method( … ) {
   int localVariable = 0;
. . .
}
```

- Parameters are the variables passed to a method.

```
void method(int parameter)  {   …   }
```

method signature   method body

```
void changeGear(int newValue) { // See the Bicycle class,
                                //  Lecture 1, sl. 21
        gear = newValue;
 }
```

Naming Conventions

Identifier Type	Rules for Naming	Examples

Variables	Variable names are in mixed case with a lowercase first letter. Internal words start with capital letters. Variable names should not start with underscore _ or dollar sign $ characters.	char c;
		float myWidth;

Constants	The names of variables declared class constants and of ANSI constants should be all uppercase with words separated by underscores ("_").	static final int MAX_WIDTH = 999;
		static final int GET_THE_CPU = 1;

Methods	Methods should be verbs, in mixed case with the first letter lowercase, with the first letter of each internal word capitalized.	run();
		runFast();

Naming Conventions

Identifier Type	Rules for Naming	Examples

Classes	Class names should be nouns, in mixed case with the first letter of each internal word capitalized.	class Raster;
		class ImageSprite;

Interfaces	Interface names should be capitalized like class names.	interface RasterDelegate;
		interface Storing;

Packages	The prefix of a unique package name is always written in all-lowercase ASCII letters and should be one of the top-level domain names, currently com, edu, gov, mil, net, org, or one of the English two-letter codes identifying countries. Subsequent components of the package name vary according to an organization's own internal naming conventions.	com.sun.eng edu.cmu.cs.bovik.cheese

Primitive Data Types

- Java is a strongly typed language:
  - All variables must be defined before use;
  - The variable's type and name must be stated.
- The compiler assigns a *default value* to an *uninitialized field*.
- The compiler never assigns a default value to an uninitialized local variable.
- Using an uninitialized local variable will result in a compile-time error.

Primitive Type	**Definition**	**Default Value for Fields**
boolean	either *true* or *false*	false
byte	8-bit signed integer	0
char	16-bit Unicode UTF-16 character	'u0000'
short	16-bit signed integer	0
int	32-bit signed integer	0
long	64-bit signed integer	0L
float	32-bit signed floating point	0.0F
double	64-bit signed floating point	0.0D

Character Strings

- Java provides special support for character strings via the *String* class.
- A String is an immutable sequence of characters (it cannot be changed after it is created):
  - String s1 = new String(“this is a String”);
  - String s2 = “this is another String”;
  - String s2 = null;   // no String object assigned
- The String class is defined in the *java.lang* package, i.e., *java.lang.String.*

Literals

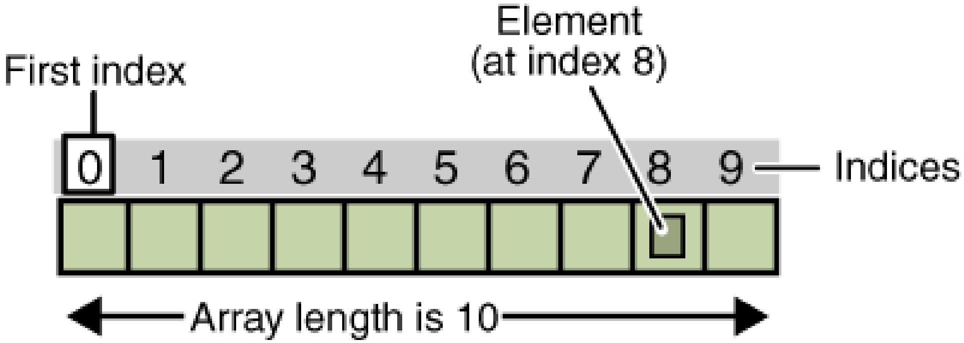
- A literal is the source code representation of a fixed value.
- Literals do not require computation.
- Java supports special escape sequences for char and String literals:
  - \b – backspace
  - \t – tab
  - \n – line feed
  - \f – form feed
  - \r – carriage return
  - \” – double quote
  - \’ – single quote
  - \\ – backslash

```
boolean result = true;
char capitalC = ‘C’;

int decVal = 26;
int octVal = 032;
int hexVal = 0x1a;

double d1 = 123.4;
double d2 = 1.234e2;
float fl = 123.4f;
```

- *null* is a special literal that can be assigned to any variable that is **not** a primitive type:

```
String s2 = null;
byte b = null; // error
```

An array of ten elements



```
class ArrayDemo {
    public static void main(String[] args) {
        int[] anArray;                  // declares an array of integers
        anArray = new int[10];   // allocates memory for 10 integers

        anArray[0] = 100; // initialize first element
        anArray[1] = 200; // initialize second element
        System.out.println("Element at index 0: " + anArray[0]);
        System.out.println("Element at index 1: " + anArray[1]);
         // prints values of the first and the second element
    }
}
```

Arrays

- An array is a container that holds a fixed number of values of a single type.
- The length of an array is defined upon its creation, and it cannot be changed.
- Each item in an array is called an *element.*
- Each element is accessed by its numerical *index* (from *0* to *length-1*).

```
int[] a1 = new int[5];
int[] a2 = { 1,2,3,4,5 };

int aL = a1.length    // = 5
a2.length = 6;        // error

a1[0] = 1;
a2[a2.length-1] = 5;
a1[5] = 6;            // error
a2[-1]  = -1;         // error
```

Arrays of Objects

- Java supports arrays of objects.

```
String[] a1 = new String[5];
String[] a2 = { “1”,”2” };
String[] a3 = { new String(“1”), “2” };
```

- The elements/objects in an array must belong to the same type/class.

```
a1[1] = “str”;
a2[0] = a1[1];
a1[0] = 444;    // error
```

- An array can be print out one element at a time.

```
System.out.println(a3[0]);
System.out.println(a3[1]);
```

Multidimensional Arrays

- A multidimensional array is simply an array whose components are themselves arrays.
- This is unlike arrays in C or Fortran. A consequence of this is that the rows are allowed to vary in length (ragged arrays).

```
class MultiDimArrayDemo {
    public static void main(String[] args) {
        String[][] names = {{"Mr. ", "Mrs. ", "Ms. "},
                            {"Smith", "Jones"}};
        System.out.println(names[0][0] + names[1][0]); //Mr. Smith
        System.out.println(names[0][2] + names[1][1]); //Ms. Jones
    }
}
```

Summary of Variables

- The term *instance variable* is another name for a non-static field (or attribute).
- The term *class variable* is another name for a static field.
- A local variable is declared inside a method. It stores temporary state.
- A *parameter* is a variable declared within the parentheses of a method signature.
- The 8 primitive (or *native*) data types are: *byte, char, short, int, long, float, double,* and *boolean*.
- Character strings are represented by the class String
- An array is a *container object* that holds a fixed number of values of a single type.
- *null* is the only literal object reference. It represents an invalid object or one that has not been created yet.

Operator Precedence

high

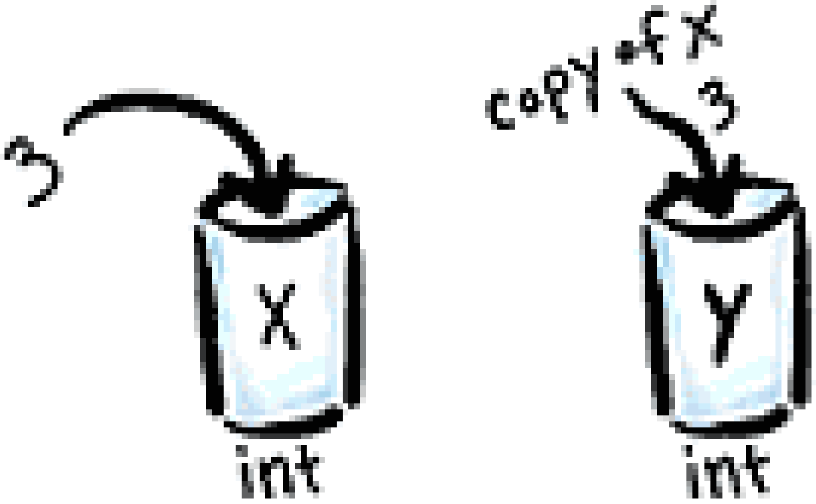
Operator	Precedence
postfix	expr++ expr--
unary	++expr --expr +expr -expr ~ !
multiplicative	* / %
additive	+ –
shift	<< >> >>>
relational	< > <= >= instanceof
equality	== !=
bitwise AND	&
bitwise exclusive OR	^
bitwise inclusive OR	|
logical AND	&&
logical OR	||
ternary	? :
assignment	= += –= *= /= %= &= ^= |= <<= >>= >>>=

low

The Assignment Operator

- The most common operator is the assignment operator '='

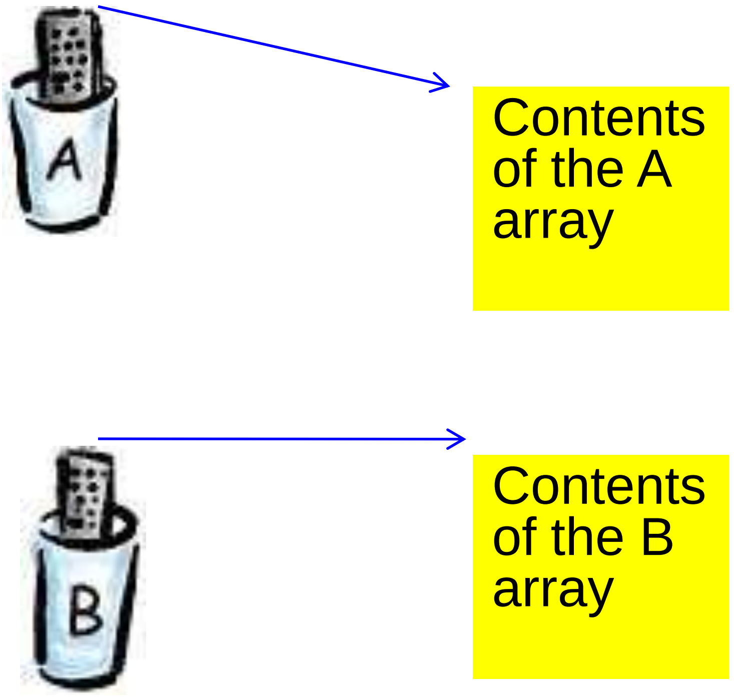
```
int x = 3;
int y = x;
```



```
boolean  b = true;
float  speed = 120.0f;
```

Copying Arrays

- Two arrays:
  - int[] a = {1, 2, 3, 4, 5};
  - int[] b = {15,16,17, 18, 19};

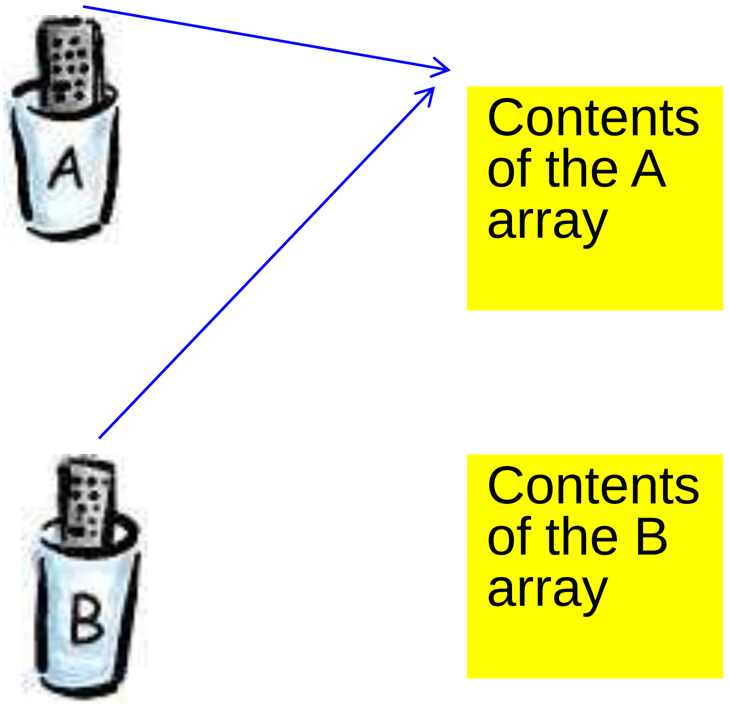


Contents of the A array

Contents of the B array

- The picture above: Before assignment
  - b = a;

- The picture below: After the assignment
  - b = a;



Contents of the A array

Contents of the B array

Copying Arrays

- The *System* class has an *arraycopy* method that you can use to copy data from one array into another:

```
class ArrayCopyDemo {
    public static void main(String[] args) {
        char[] copyFrom = { 'd', 'e', 'c', 'a', 'f', 'f', 'e',
                                    'i', 'n', 'a', 't', 'e', 'd' };
        char[] copyTo = new char[7];

        System.arraycopy(copyFrom, 2, copyTo, 0, 7);
        System.out.println(new String(copyTo));
    }
}
```

The output from this program is:

```
caffein
```

The Arithmetic Operators

- Java provides operators that perform:
  - Addition: +   the additive operator
  - Subtraction: -   the subtraction operator
  - Multiplication: *   the multiplication operator
  - Division: /   the division operator
  - Remainder: %   the remainder operator
- Examples:
  - int result = 1 + 2;   // → result = 3
  - int result = 13 % 2;   // → result = 1

Concatenating Two Strings

- The + operator can be used to join or concatenate two strings:

```
String s1 = new String(“aa”);
String s2 = “bb”;
String s3 = s1 + s2;

System.out.println(s3);     // → “aabb”
```

The Unary Operators

- The unary operators require only 1 operand:
  - + unary plus operator, indicates positive value
  - - unary minus operator, indicates negative value
  - ++ increment operator, increments a value by 1
  - -- decrement operator, decrements a value by 1
  - ! logical complement operator, inverts the value of a boolean
- Examples:

```
int result = -1;
result++;          // (postfix)     → result = 0
--result;          // (prefix)      → result = -1
++result;          //               → result = 0

boolean b = true;
b = !b;             // → b = false
```

The Equality and Relational Operators

- The equality and relational operators are:

==	equal to
!=	not equal to
>	greater than
>=	greater than or equal
<	less than
<=	less than or equal to

- Examples:

```
int m;
if (1 == 2) { m = 1; } else { m = 3; } // → false; m received 3
if (2 > 1) {m = 5;}  // → true; m received 5
int value = 1;
if (value != 0) { m = 7; } else { m = 9; } // m received 7
```

The Conditional Operators

- The conditional operators are:

&&	conditional AND
||	conditional OR
? :	ternary operator

- Examples:

```
int m = 5;
boolean b1 = true, b2 = false;
if (b1 && b2) { m = 10; } // → false; the value of m  is 5
if (b1 || b2) { m = 15; } // → true; m received 15
boolean b = 1 > 0 ? true : false; // → b = true
```

Type Comparison Operator

- The *instanceof* operator compares an object to a specified class.
- *instanceof* is used to test if an object is an instance of a class or a subclass, or an instance of (a class that implements) an interface.
- An example:

```
String str = new String(“123”);
if (str instanceof String) {          // → true
   System.out.println(“The type of str is String”);
}
```

Bitwise and Bit Shift Operators

- These operators operate on integral types.
- The bitwise operators are:
  - & bitwise AND
  - ^ bitwise XOR – exclusive OR
  - | bitwise OR
  - ~ the complement operator
- For example:
  - 0010 & 0110 // → 0010
  - 0010 | 0110 // → 0110
  - 0010 ^ 0110 // → 0100
  - ~0100 // → 1011

- The bit shift operators shift bits left or right.
- The signed bit shift operators are:
  - << shifts to the left
  - >> shifts to the right
- The unsigned bit shift operator is:
  - >>> shifts to the right and fills with 0 bits on the left
- For example:
  - 0001 << 1 // → 0010
  - 0010 >> 1 // → 0001
  - 1001 >>> 1 // → 0100

Expressions and Statements

- An expression is a construct that consists of variables, operators, and method invocations.
- Examples are in a blue color below:

```
int a = 1;
int b = 2;
int c = a * b + 3;
```

- Statements are equivalent to sentences in natural languages. A statement forms a complete unit of execution.
- Examples:

```
aValue = 4;
Car c = new Car();
double db = 4.;
```

Blocks

- A block is a group of zero or more statements between balanced braces.
- Blocks can be used anywhere a single statement is allowed.

```
class BlockDemo {
    public static void main(String[] args) {
        boolean condition = true;
        if (condition) { // begin block 1
            System.out.println("Condition is true.");
        } // end block one
        else { // begin block 2
            System.out.println("Condition is false.");
        } // end block 2
    }
}
```

Summary of Operators

- Operators may be used to build expressions that compute values.
- Expressions are the core components of statements.
- Statements may be grouped into blocks.
- Statements end with a semicolon ‘;’
- A block is a group of zero or more statements between balanced braces ‘{‘ and ‘}’.
- Blocks can be used anywhere a single statement is allowed.

Control Flow Statements

- The statements inside a Java source file are generally executed from top to bottom, in the order that they appear.
- Control flow statements break up the flow of execution via:
  - Decision making – *if*, *if-else*, *switch*
  - Looping – *for*, *while*, *do-while*
  - Branching – *break*, *continue*, *return*

The *if-then* Statement

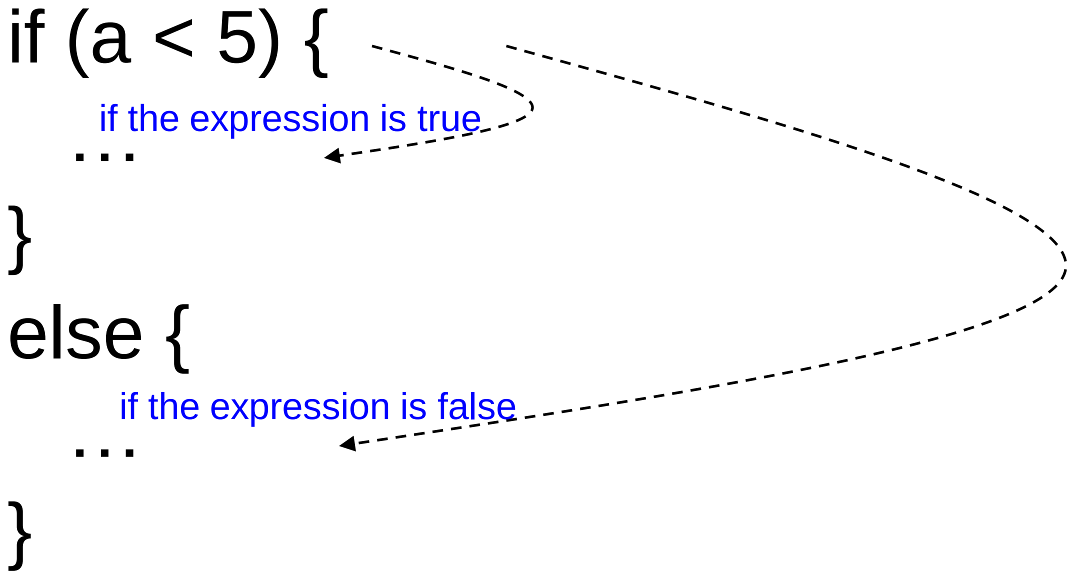
- The *if-then* statement instructs the computer to execute a certain section of code only if a particular test evaluates to true.
- An example:

```
int  a = 4;
int  c = 9;
if (a < 5) {
     a++;
     c = a + 4;
}
```

if the expression is true

The *if-else* Statement

- The *if-else* statement provides a secondary path of execution when an *if* clause evaluates to false.
- For example:



```
if (a < 5) {
    …
}
else {
    …
}
```

if the expression is true

if the expression is false

Multiple ‘else if’ blocks

- An example: Assigning a grade based on the value of testscore

```
class IfElseDemo {
    public static void main(String[] args) {
        int testscore = 76;
        char grade;
        if (testscore >= 90) { grade = 'A';
        } else if (testscore >= 80) { grade = 'B';
        } else if (testscore >= 70) { grade = 'C';
        } else if (testscore >= 60) { grade = 'D';
        } else { grade = 'F';
        }
        System.out.println("Grade = " + grade);  // Output: Grade =C
    }
}
```

The *switch* Statement

- The switch statement allows any number of possible execution paths.
- A switch works with the following data types: *byte, short, char,* and *int.*
- A switch works with some other types (e.g., Integer, Short, enumerated types, etc.):
  - Integer is a wrapper class for the type int
  - Short is a wrapper class for the type short

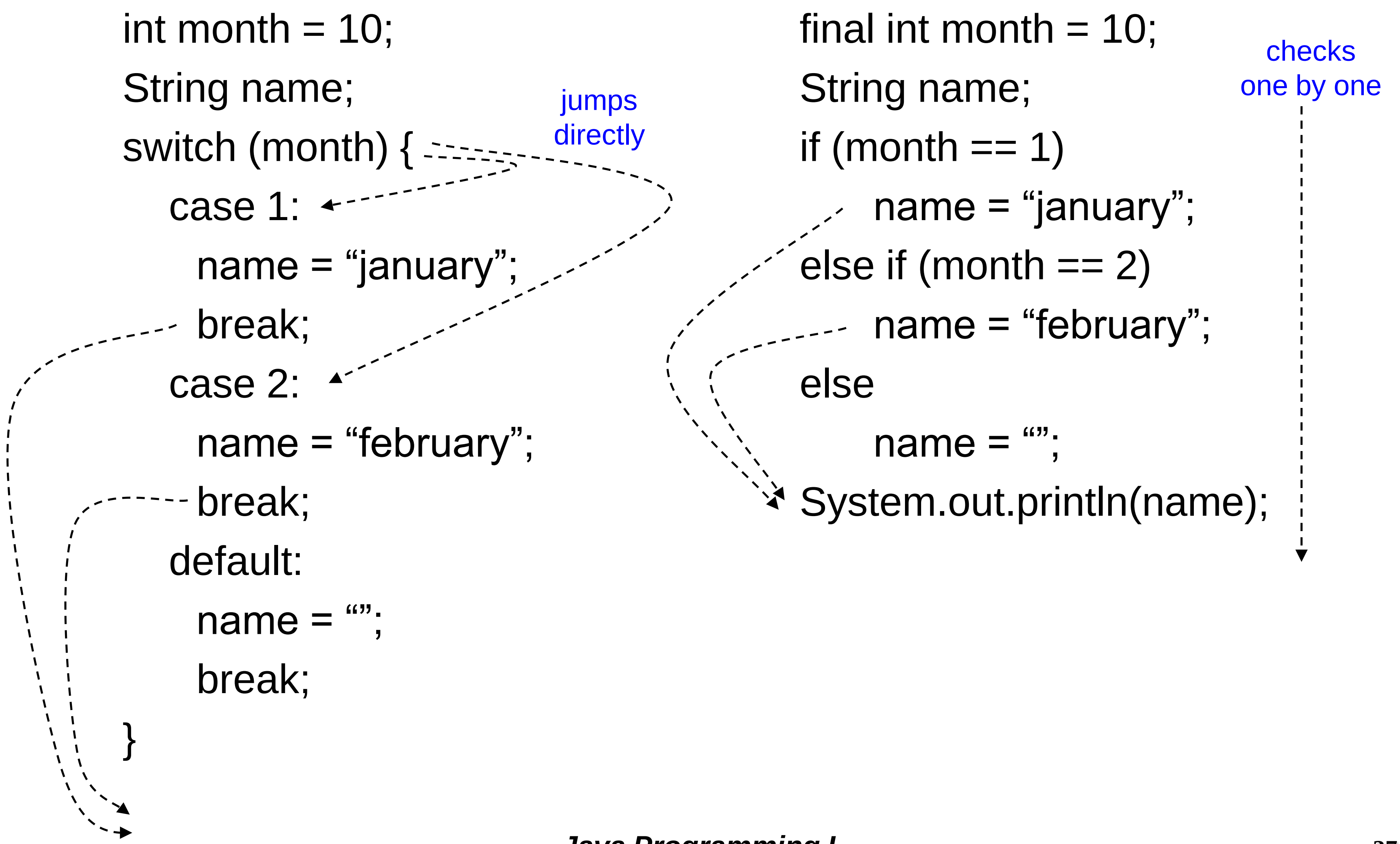
```
final int month = 2;
String name;
switch (month) {
   case 1:
     name = “january”;
     break;
   case 2:
     name = “february”;
     break;
   default:
     name = “”;
     break;
}
System.out.println(name);
// output: february
```

Example: switch

```
final Integer month = 4;
String name;

switch (month) {
    case 1:
      name = “january”;
      break;
    case 2:
      name = “february”;
      break;
    default:
      name = “”;
      break;
}
System.out.println(name);
// output: an empty string
```

```
Short month = new Short(2);
String name;

switch (month) {
    case 1:
      name = “january”;
      break;
    case 2:
      name = “february”;
      break;
    default:
      name = “”;
      break;
}
System.out.println(name);
// output february
```

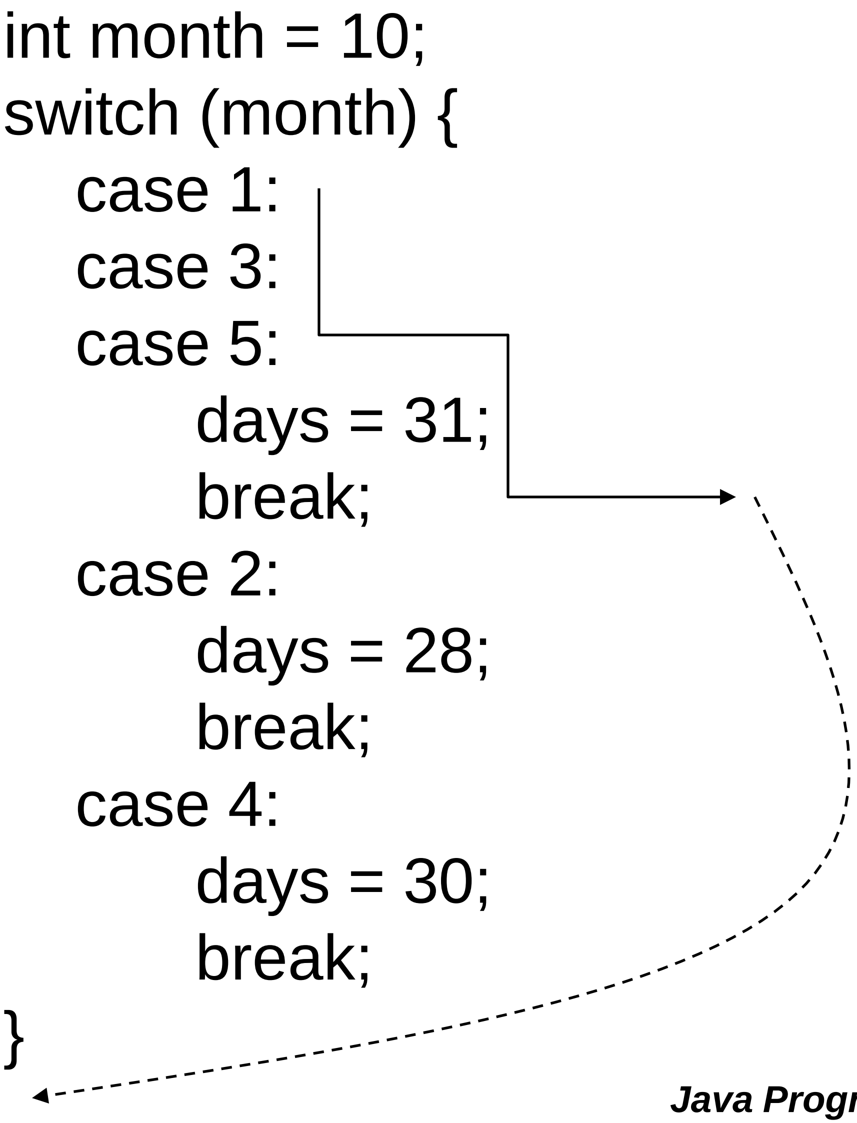
Example: switch And if-else if



```
int month = 10;
String name;
switch (month) {
    case 1:
      name = “january”;
      break;
    case 2:
      name = “february”;
      break;
    default:
      name = “”;
      break;
}
```

```
final int month = 10;
String name;
if (month == 1)
      name = “january”;
else if (month == 2)
      name = “february”;
else
      name = “”;
System.out.println(name);
```

Example: A *fall-through* switch



```
int month = 10;
switch (month) {
    case 1:
    case 3:
    case 5:
        days = 31;
        break;
    case 2:
        days = 28;
        break;
    case 4:
        days = 30;
        break;
}
```

The *while* Statement

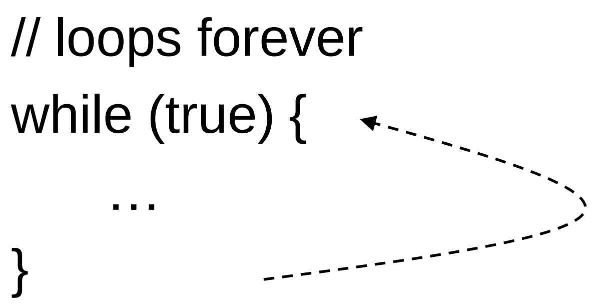
- The *while* loop continually executes a block of statements as long as a particular condition is true:

```
while (condition is true) {
        …
}
```

- An example:

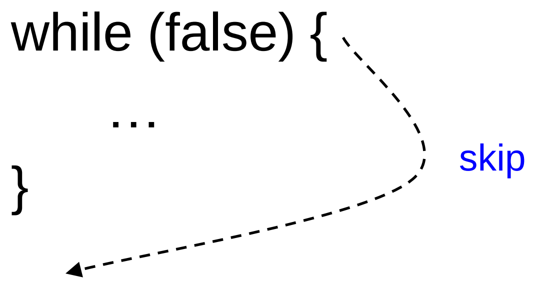
```
int i = 1;
while (i < 5) {
    System.out.println(i++);
}
```

- An infinite loop as a *while* block:



```
// loops forever
while (true) {
        …
}
```

- This loop never runs:



```
while (false) {
        …
}
```

The *do-while* Statement

- The *do-while* loop checks its *condition* of termination after its block has executed:

```
do {
     …      // statements
} while (condition);
```

loops while the condition is true

- A *do-while* loop executes at least once
- A *while* loop may or may not execute

Example: do-while

- Correct:

```
int[] array = new int[2];
int i = 0;

do {
   array[i] = i;
   ++i;
} while (i < array.length);
```

- Incorrect:

```
int[] array = new int[2];
int i = array.length;

do {
   array[i] = i;// error: i = 2
   --i;
} while (i >= 0);
```

The *for* Statement

- The *for* loop executes repeatedly until a termination condition is not satisfied:

```
for (initialization ; condition_of_termination ; increment) {
    …
}
```

- For example:

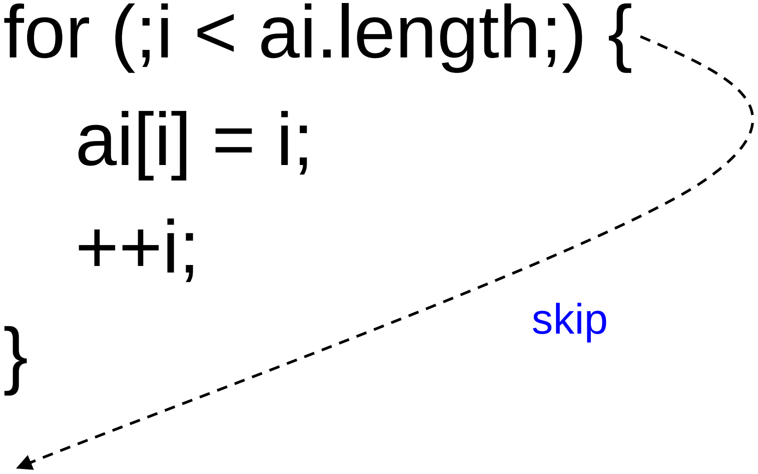
```
for (int i = 0;i < 10;++i) {
        System.out.println(i); // prints 10 lines
}
```

- An infinite loop can be expressed as:

```
for (;;) {
    …
}
```

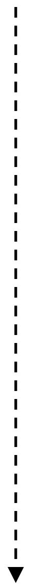
Example: for And do-while

```
int[] array = new int[2];
int i = array.length;

for (;i < ai.length;) {
    ai[i] = i;
    ++i;
}
```



skip

```
int[] array = new int[2];
int i = array.length;

do {
    --I;
    ai[i] = i;
} while (i < ai.length);
```



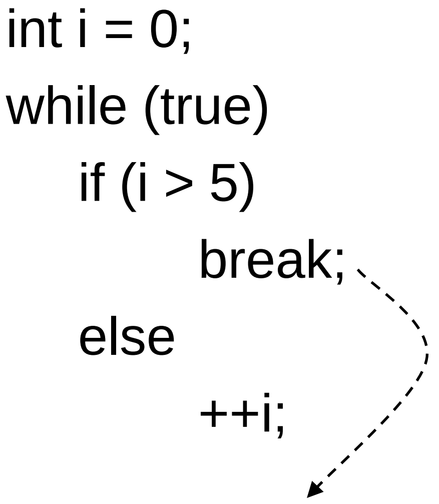
no skip

The *break* Statements

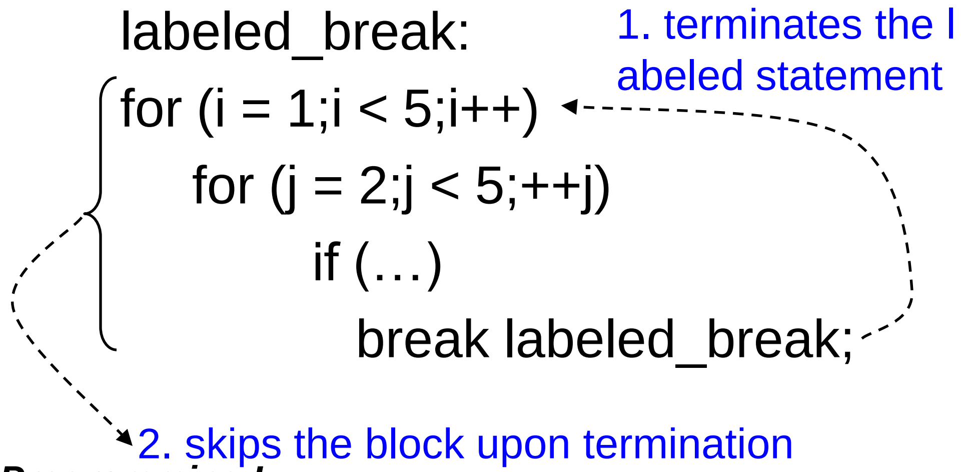
- The *break* statement has two forms: labeled, and unlabeled

- An unlabeled break can be used to terminate a for, while, or do-while loop, and a switch

- A labeled break statement terminates an outer statement



```
int i = 0;
while (true)
    if (i > 5)
        break;
    else
        ++i;
```



```
labeled_break:
for (i = 1;i < 5;i++)
    for (j = 2;j < 5;++j)
        if (…)
            break labeled_break;
```

1. terminates the l
abeled statement

2. skips the block upon termination

The *continue* Statement

- It skips the current iteration of a for, while, or do-while loop.
- The unlabeled form skips to the end of the innermost loop’s body.
- A labeled continue statement skips the current iteration of an outer loop marked with the given label.

```
for (int i = 1;i < 10;++i) {
    if (i > 5)
        continue;
    System.out.println(i);
}
```

```
label :
for (int i = 1;i < 10;++i) {
    for (int j = 0;j < 5;j++)
        if (i > 5)
            continue label;
    System.out.println(i);
}
```

The *return* Statement

- The return statement exits from the current method, and control flow returns to where the method was invoked.
- A return statement may or may not return a value, for example:

```
 return;
 return 5;
```

```
void method1()
{
    int i =  method2();
    return; // no return value
}

int method2()
{
    int i = 0;
    i += 5;
    return i; // must return an int
}
```

Summary of Control Flow Statements

- The *if-then* statement tells your program to execute a certain section of code *only if* a particular test evaluates to true.
- The *if-then-else* statement provides a secondary path of execution when an "if" clause evaluates to false.
- The *switch* statement allows for any number of possible execution paths.
- The *while* and *do-while* statements continually execute a block of statements while a particular condition is true.
- The *for* statement provides a compact way to iterate over a range of values.