Programming Languages: Java

Lecture 1
Introduction to Java

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Outline

Course Information
History of Java
Introduction
First Program in Java: Printing a Line of Text
Modifying Our First Java Program
Displaying Text with `printf`
Another Java Application: Adding Integers
Memory Concepts
Arithmetic
Decision Making: Equality and Relational Operators
Introduction to Object-oriented Programming

Course Information

- Six Lectures
- Teaches “Java Standart Edition 6”
- No midterm or final
- Six assignments (5,10,15,20,25,25)
- http://www.omerboyaci.com/
- Textbook
  - Java How to Program, 8th Edition, Deitel & Deitel

Introduction

- Java Standard Edition (Java SE) 6
- Sun’s implementation called the Java Development Kit (JDK)
- Object-Oriented Programming
- Java is language of choice for networked applications
- Open Source
- Write Once Run Everywhere

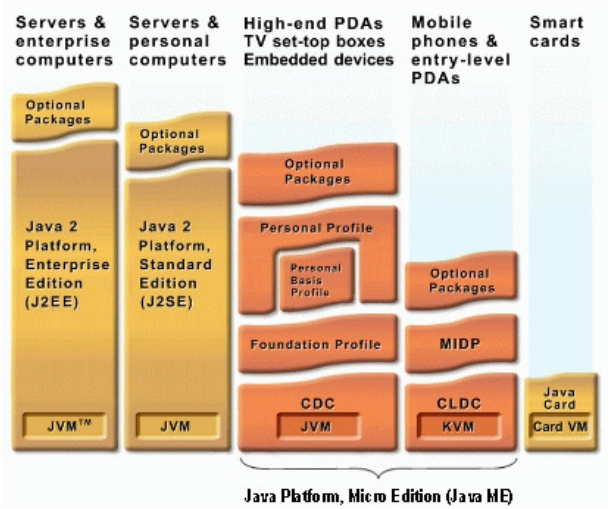
Machine Languages, Assembly Languages and High-Level Languages

- Machine language
  - "Natural language" of computer component
  - Machine dependent
- Assembly language
  - English-like abbreviations represent computer operations
  - Translator programs (assemblers) convert to machine language
- High-level language
  - Allows for writing more "English-like" instructions
    - Contains commonly used mathematical operations
  - Compiler converts to machine language
- Interpreter
  - Execute high-level language programs without compilation

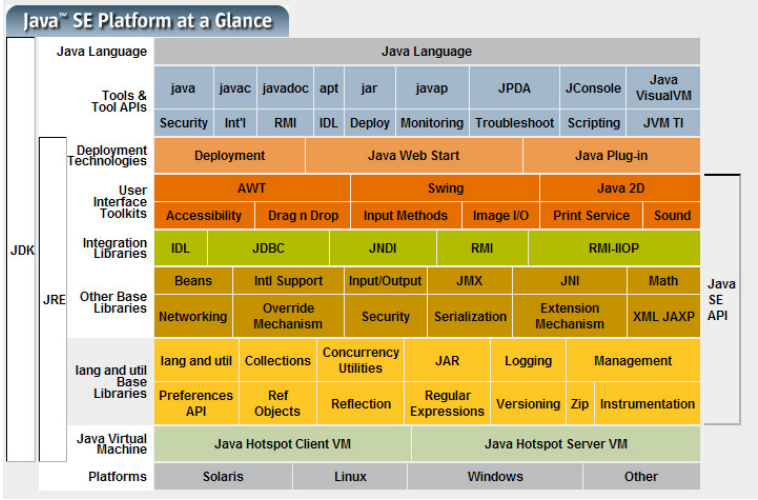
History of Java

- Java
  - Originally for intelligent consumer-electronic devices
  - Then used for creating web pages with dynamic content
  - Now also used to:
    - Develop large-scale enterprise applications
    - Enhance web server functionality
    - Provide applications for consumer devices (cell phones, etc.)

Java Platform



Java Standart Edition (SE)



Java Enterprise Edition (EE)

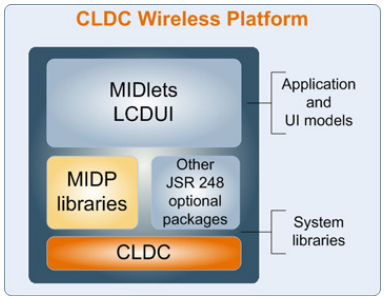
geared toward large-scale distributed applications and web applications

- **Enterprise JavaBeans (EJB)**
- **Servlets**
- **Java Server Pages (JSP)**
- **Java Server Faces (JSF)**
- **JavaMail**
- **Java Transaction API (JTA)**

Java Micro Edition (ME)

geared toward applications for small, memory constrained devices

- **Midlets**
  - **Google Maps Mobile**
  - **Opera Mini**



Java Class Libraries

- **Java programs consist of classes**
  - **Include methods that perform tasks**
    - **Return information after task completion**
- **Java provides class libraries**
  - **Known as Java APIs (Application Programming Interfaces)**
- **To use Java effectively, you must know**
  - **Java programming language**
  - **Extensive class libraries**

Use Java API classes

Improve program performance
Shorten program development time
Prevent software bugs
Improve program portability

Typical Java Development Environment

- Java programs go through five phases
  - Edit
    - Programmer writes program using an editor; stores program on disk with the `.java` file name extension
  - Compile
    - Use javac (the Java compiler) to create bytecodes from source code program; bytecodes stored in `.class` files
  - Load
    - Class loader reads bytecodes from `.class` files into memory
  - Verify
    - Bytecode verifier examines bytecodes to ensure that they are valid and do not violate security restrictions
  - Execute
    - Java Virtual Machine (JVM) uses a combination of interpretation and just-in-time compilation to translate bytecodes into machine language

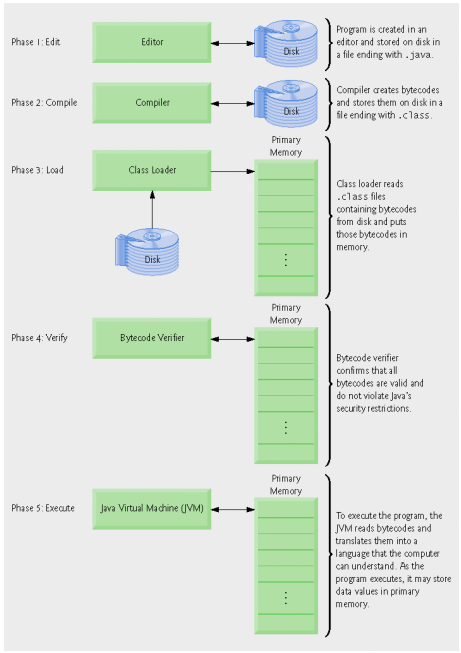
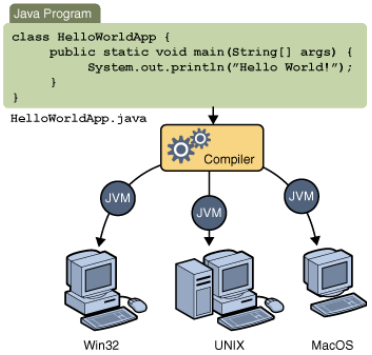


Fig. 1.1 | Typical Java development environment.

Through the Java VM, the same application is capable of running on multiple platforms.



First Program in Java: Printing a Line of Text

- Application
  - Executes when you use the `java` command to launch the Java Virtual Machine (JVM)
- Sample program
  - Displays a line of text
  - Illustrates several important Java language features

```
1  // Fig. 2.1: Welcome1.java
2  // Text-printing program.
3
4  public class Welcome1
5  {
6     // main method begins execution of Java application
7     public static void main( String args[] )
8     {
9        System.out.println( "Welcome to Java Programming!" );
10
11    } // end method main
12
13 } // end clazss Welcome1
```

```
Welcome to Java Programming!
```

First Program in Java: Printing a Line of Text (Cont.)

```
1  // Fig. 2.1: Welcome1.java
```

- Comments start with: //
  - Comments ignored during program execution
  - Document and describe code
  - Provides code readability
- Traditional comments: /* ... */

```
/* This is a traditional
   comment. It can be
   split over many lines */
```

```
2  // Text-printing program.
```

- Another line of comments
- Note: line numbers not part of program, added for reference

First Program in Java: Printing a Line of Text (Cont.)

```
3
```

- Blank line
  - Makes program more readable
  - Blank lines, spaces, and tabs are white-space characters
    - Ignored by compiler

```
4  public class Welcome1
```

- Begins class declaration for class `Welcome1`
  - Every Java program has at least one user-defined class
  - Keyword: words reserved for use by Java
    - `class` keyword followed by class name
  - Naming classes: capitalize every word
    - `SampleClassName`

First Program in Java: Printing a Line of Text (Cont.)

```
4  public class Welcome1
```

- Java identifier
  - Series of characters consisting of letters, digits, underscores (_) and dollar signs ($)
  - Does not begin with a digit, has no spaces
  - Examples: `Welcome1`, `$value`, `_value`, `button7`
    - `7button` is invalid
  - Java is case sensitive (capitalization matters)
    - `a1` and `A1` are different

First Program in Java: Printing a Line of Text (Cont.)

```
4  public class Welcome1
```

- Saving files
  - File name must be class name with `.java` extension
  - `Welcome1.java`

```
5  {
```

- Left brace `{`
  - Begins body of every class
  - Right brace ends declarations (line 13)

First Program in Java: Printing a Line of Text (Cont.)

```
7     public static void main( String args[] )
```

- Part of every Java application
  - Applications begin executing at `main`
    - Parentheses indicate `main` is a method
    - Java applications contain one or more methods
  - Exactly one method must be called `main`
- Methods can perform tasks and return information
  - `void` means `main` returns no information
  - For now, mimic `main`'s first line

```
8     {
```

- Left brace begins body of method declaration
  - Ended by right brace `}` (line 11)

First Program in Java: Printing a Line of Text (Cont.)

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

- Instructs computer to perform an action
  - Prints string of characters
    - String – series of characters inside double quotes
  - White-spaces in strings are not ignored by compiler
- `System.out`
  - Standard output object
  - Print to command window (i.e., MS-DOS prompt)
- Method `System.out.println`
  - Displays line of text
- This line known as a statement
  - Statements must end with semicolon `;`

First Program in Java: Printing a Line of Text (Cont.)

```
11    } // end method main
```

- Ends method declaration

```
13 } // end class Welcome1
```

- Ends class declaration
- Can add comments to keep track of ending braces

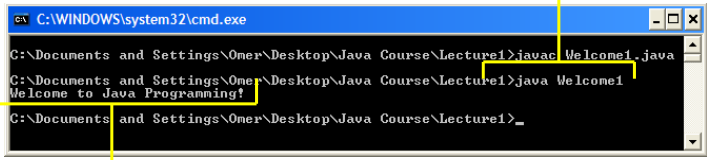
First Program in Java: Printing a Line of Text (Cont.)

- **Compiling a program**
  - **Open a command prompt window, go to directory where program is stored**
  - **Type `javac Welcome1.java`**
  - **If no syntax errors, `Welcome1.class` created**
    - **Has bytecodes that represent application**
    - **Bytecodes passed to JVM**
- **system's *PATH* environment variable for java and javac**

First Program in Java: Printing a Line of Text (Cont.)

- **Executing a program**
  - **Type `java Welcome1`**
    - **Launches JVM**
    - **JVM loads `.class` file for class `Welcome1`**
    - **`.class` extension omitted from command**
    - **JVM calls method `main`**

You type this command to execute the application



The program outputs **Welcome to Java Programming!**

Executing `Welcome1` in a Microsoft Windows XP Command Prompt **window.**

Modifying Our First Java Program

- **Modify example in Fig. 2.1 to print same contents using different code**

Modifying Our First Java Program (Cont.)

- **Modifying programs**
  - `Welcome2.java` (Fig. 2.3) produces same output as `Welcome1.java` (Fig. 2.1)
  - Using different code

```
9         System.out.print( "Welcome to " );
10        System.out.println( "Java Programming!" );
```

  - Line 9 displays "Welcome to " with cursor remaining on printed line
  - Line 10 displays "Java Programming! " on same line with cursor on next line


```
1  // Fig. 2.3: Welcome2.java
2  // Printing a line of text with multiple statements.
3
4  public class Welcome2
5  {
6     // main method begins execution of Java application
7     public static void main( String args[] )
8     {
9        System.out.print( "Welcome to " );
10       System.out.println( "Java Programming!" );
11
12    } // end method main
13
14 } // end class Welcome2
```

```
Welcome to Java Programming!
```

`System.out.print` keeps the cursor on the same line, so `System.out.println` continues on the same line.

Outline

1. Comments
2. Blank line
3. Begin class Welcome2
3.1 Method main
4. Method System.out.print
4.1 Method System.out.println
5. end main, Welcome2

Program Output

Modifying Our First Java Program (Cont.)

- **Escape characters**
  - Backslash (\ )
  - Indicates special characters to be output
- **Newline characters (\n)**
  - Interpreted as "special characters" by methods `System.out.print` and `System.out.println`
  - Indicates cursor should be at the beginning of the next line
  - `Welcome3.java` (Fig. 2.4)

```
9         System.out.println( "Welcome\nto\nJava\nProgramming!" );
```

  - Line breaks at \n


```
1  // Fig. 2.4: Welcome3.java
2  // Printing multiple lines of text with a single statement.
3
4  public class Welcome3
5  {
6     // main method begins execution of Java application
7     public static void main( String args[] )
8     {
9        System.out.println( "Welcome\nto\nJava\nProgramming!" );
10
11    } // end method main
12
13 } // end class Welcome3
```

```
Welcome
to
Java
Programming!
```

A new line begins after each \n escape sequence is output.

Outline

Welcome3.java

1. main
2. System.out.println (uses \n for new line)

Program Output

Escape sequence	Description
\n	Newline. Position the screen cursor at the beginning of the next line.
\t	Horizontal tab. Move the screen cursor to the next tab stop.
\r	Carriage return. Position the screen cursor at the beginning of the current line—do not advance to the next line. Any characters output after the carriage return overwrite the characters previously output on that line.
\\	Backslash. Used to print a backslash character.

\"	Double quote. Used to print a double-quote character. For example,
	`System.out.println( "\"in quotes\"" );`
	displays
	`"in quotes"`

Fig. 2.5 | Some common escape sequences.

Displaying Text with `printf`

- `System.out.printf`
  - Feature added in Java SE 5.0
  - Displays formatted data

```
9          System.out.printf( "%s\n%s\n",
10            "Welcome to", "Java Programming!" );
```

  - Format string
    - Fixed text
    - Format specifier – placeholder for a value
  - Format specifier `%s` – placeholder for a string


```
1  // Fig. 2.6: Welcome4.java
2  // Printing multiple lines in a dialog box.
3
4  public class Welcome4
5  {
6     // main method begins execution of Java application
7     public static void main( String args[] )
8     {
9        System.out.printf( "%s\n%s\n",
10          "Welcome to", "Java Programming!" );
11
12    } // end method main
13
14 } // end class Welcome4
```

System.out.printf displays formatted data.

```
Welcome to
Java Programming!
```

Outline

elcome4.java

main

printf

Program output

Another Java Application: Adding Integers

- Upcoming program
  - Use `Scanner` to read two integers from user
  - Use `printf` to display sum of the two values
  - Use packages

```
1  // Fig. 2.7: Addition.java
2  // Addition program that displays the sum of two numbers.
3  import java.util.Scanner; // program uses class Scanner
4
5  public class Addition
6  {
7     // main method begins execution of Java application
8     public static void main( String args[] )
9     {
10       // create Scanner to obtain input from command window
11       Scanner input = new Scanner( System.in );
12
13       int number1; // first number to add
14       int number2; // second number to add
15       int sum; // sum of number1 and number2
16
17       System.out.print( "Enter first integer: " ); // prompt
18       number1 = input.nextInt(); // read first number from user
19
```

Outline

Addition.java

(1 of 2)

`import` declaration imports class `Scanner` from package `java.util`.

Declare and initialize variable `input`, which is a `Scanner`.

Declare variables `number1`, `number2` and `sum`.

Read an integer from the user and assign it to `number1`.


```
20       System.out.print( "Enter second integer: " ); // prompt
21       number2 = input.nextInt(); // read second number from user
22
23       sum = number1 + number2; // add numbers
24
25       System.out.printf( "Sum is %d\n", sum ); // d
26
27    } // end method main
28
29 } // end class Addition
```

```
Enter first integer: 45
Enter second integer: 72
Sum is 117
```

Two integers entered by the user.

Read an integer from the user and assign it to `number2`.

Calculate the sum of the variables `number1` and `number2`, assign result to `sum`.

Display the sum using formatted output.

```
C:\WINDOWS\system32\cmd.exe

C:\Documents and Settings\Omer\Desktop\Java Course\Lecture1>javac Addition.java

C:\Documents and Settings\Omer\Desktop\Java Course\Lecture1>java Addition
Enter first integer: 23
Enter second integer: 17
Sum is 40

C:\Documents and Settings\Omer\Desktop\Java Course\Lecture1>
```

Outline

dition.java

(2 of 2)

4. Addition

5. `printf`

Another Java Application: Adding Integers (Cont.)

```
3  import java.util.Scanner;  // program uses class Scanner
```

- `import` declarations
  - Used by compiler to identify and locate classes used in Java programs
  - Tells compiler to load class `Scanner` from `java.util` package

```
5  public class Addition
6     {
```

- Begins `public` class `Addition`
  - Recall that file name must be `Addition.java`
- Lines 8-9: begin `main`

Another Java Application: Adding Integers (Cont.)

```
10       // create Scanner to obtain input from command window
11       Scanner input = new Scanner( System.in );
```

- Variable Declaration Statement
- Variables
  - Location in memory that stores a value
    - Declare with name and type before use
  - `Input` is of type `Scanner`
    - Enables a program to read data for use
  - Variable name: any valid identifier
- Declarations end with semicolons `;`
- Initialize variable in its declaration
  - Equal sign
  - Standard input object
    - `System.in`

Another Java Application: Adding Integers (Cont.)

```
13        int number1; // first number to add
14        int number2; // second number to add
15        int sum; // sum of number 1 and number 2
```

- Declare variable `number1`, `number2` and `sum` of type `int`
  - `int` holds integer values (whole numbers): i.e., 0, -4, 97
  - Types `float` and `double` can hold decimal numbers
  - Type `char` can hold a single character: i.e., x, $, \n, 7
  - `int`, `float`, `double` and `char` are primitive types
- Can add comments to describe purpose of variables

```
int number1, // first number to add
    number2, // second number to add
    sum; // sum of number1 and number2
```

- Can declare multiple variables of the same type in one declaration
- Use comma-separated list

Another Java Application: Adding Integers (Cont.)

```
17        System.out.print( "Enter first integer: " ); // prompt
```

- Message called a prompt - directs user to perform an action
- Package `java.lang`

```
18        number1 = input.nextInt(); // read first number from user
```

- Result of call to `nextInt` given to `number1` using assignment operator `=`
  - Assignment statement
  - `=` binary operator - takes two operands
    - Expression on right evaluated and assigned to variable on left
  - Read as: `number1` gets the value of `input.nextInt()`

Another Java Application: Adding Integers (Cont.)

```
20        System.out.print( "Enter second integer: " ); // prompt
```

- Similar to previous statement
  - Prompts the user to input the second integer

```
21        number2 = input.nextInt(); // read second number from user
```

- Similar to previous statement
  - Assign variable number2 to second integer input

```
23        sum = number1 + number2; // add numbers
```

- Assignment statement
  - Calculates sum of `number1` and `number2` (right hand side)
  - Uses assignment operator `=` to assign result to variable `sum`
  - Read as: `sum` gets the value of `number1 + number2`
  - `number1` and `number2` are operands

Another Java Application: Adding Integers (Cont.)

```
25        System.out.printf( "Sum is %d\n " , sum ); // display sum
```

- Use `System.out.printf` to display results
- Format specifier `%d`
  - Placeholder for an `int` value

```
System.out.printf( "Sum is %d\n " , ( number1 + number2 ) );
```

- Calculations can also be performed inside `printf`
- Parentheses around the expression `number1 + number2` are not required

Memory Concepts

- **Variables**
  - **Every variable has a name, a type, a size and a value**
    - **Name corresponds to location in memory**
  - **When new value is placed into a variable, replaces (and destroys) previous value**
  - **Reading variables from memory does not change them**

Fig. 2.8 | Memory location showing the name and value of variable `number1`.

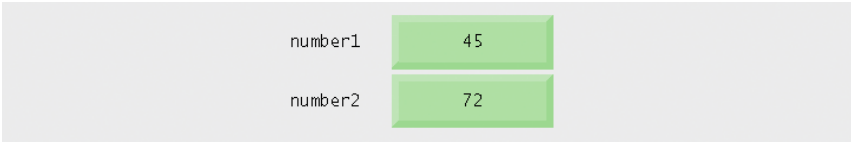


Fig. 2.9 | Memory locations after storing values for `number1` and `number2`.

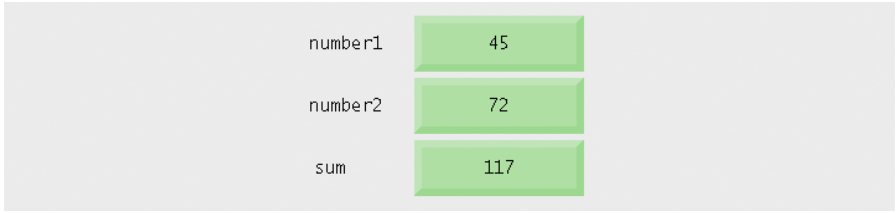


Fig. 2.10 | Memory locations after calculating and storing the sum of `number1` and `number2`.

Arithmetic

- **Arithmetic calculations used in most programs**
  - **Usage**
    - **`*` for multiplication**
    - **`/` for division**
    - **`%` for remainder**
    - **`+`, `-`**
  - **Integer division truncates remainder**

    `7 / 5` evaluates to `1`
  - **Remainder operator `%` returns the remainder**

    `7 % 5` evaluates to `2`

Java operation	Arithmetic operator	Algebraic expression	Java expression
Addition	`+`	$f + 7$	`f + 7`
Subtraction	`-`	$p - c$	`p - c`
Multiplication	`*`	bm	`b * m`
Division	`/`	x / y or $\frac{x}{y}$ or $x \div y$	`x / y`

Fig. 2.11 | Arithmetic operators.

Arithmetic (Cont.)

- **Operator precedence**
  - **Some arithmetic operators act before others (i.e., multiplication before addition)**
    - **Use parenthesis when needed**
  - **Example: Find the average of three variables `a`, `b` and `c`**
    - **Do not use: `a + b + c / 3`**
    - **Use: `( a + b + c ) / 3`**

Operator(s)	Operation(s)	Order of evaluation (precedence)
`*`	Multiplication	Evaluated first. If there are several operators of this type, they are evaluated from left to right.
`/`	Division	
`%`	Remainder	
`+`	Addition	Evaluated next. If there are several operators of this type, they are evaluated from left to right.
`-`	Subtraction	

Fig. 2.12 | Precedence of arithmetic operators.

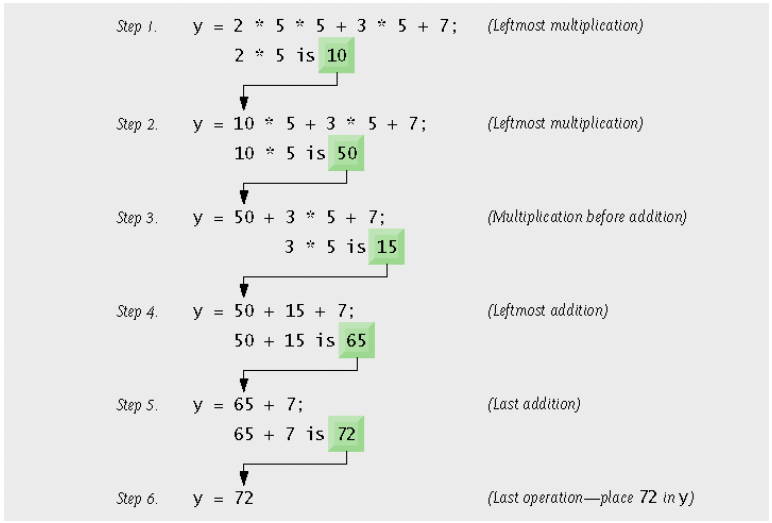


Fig. 2.13 | Order in which a second-degree polynomial is evaluated.

Decision Making: Equality and Relational Operators

- **Condition**
  - Expression can be either `true` or `false`
- **`if` statement**
  - Simple version in this section, more detail later
  - If a condition is `true`, then the body of the `if` statement executed
  - Control always resumes after the `if` statement
  - Conditions in `if` statements can be formed using equality or relational operators (next slide)

Standard algebraic equality or relational operator	Java equality or relational operator	Sample Java condition	Meaning of Java condition
Equality operators			
=	==	x == y	x is equal to y
≠	!=	x != y	x is not equal to y
Relational operators			
>	>	x > y	x is greater than y
<	<	x < y	x is less than y
≥	>=	x >= y	x is greater than or equal to y
≤	<=	x <= y	x is less than or equal to y

Fig. 2.14 | Equality and relational operators.


```
1  // Fig. 2.15: Comparison.java
2  // Compare integers using if statements, relational operators
3  // and equality operators.
4  import java.util.Scanner; // program uses class Scanner
5
6  public class Comparison
7  {
8     // main method begins execution of Java application
9     public static void main( String args[] )
10    {
11       // create Scanner to obtain input from command window
12       Scanner input = new Scanner( System.in );
13
14       int number1; // first number to compare
15       int number2; // second number to compare
16
17       System.out.print( "Enter first integer: " ); // prompt
18       number1 = input.nextInt(); // read first number from user
19
20       System.out.print( "Enter second integer: " ); // prompt
21       number2 = input.nextInt(); // read second n
22
23       if ( number1 == number2 )
24          System.out.printf( "%d == %d\n", number1,
25
26       if ( number1 != number2 )
27          System.out.printf( "%d != %d\n", number1, number2 );
28
29       if ( number1 < number2 )
30          System.out.printf( "%d < %d\n", number1,
```

Test for equality, display result using `printf`.

Compares two numbers using relational operator <.

Outline

`Comparison.java`

(1 of 2)

1. Class Comparison

1.1 main

1.2 Declarations

1.3 Input data (nextInt)

1.4 Compare two inputs using if statements

Outline

```
31
32      if ( number1 > number2 )
33         System.out.printf( "%d > %d\n", number1, number2 );
34
35      if ( number1 <= number2 )
36         System.out.printf( "%d <= %d\n", number1,
37
38      if ( number1 >= number2 )
39         System.out.printf( "%d >= %d\n", number1, number2 );
40
41   } // end method main
42
43 } // end class Comparison
```

Compares two numbers using relational operators >, <= and >=.

Comparison.java

(2 of 2)

Program output

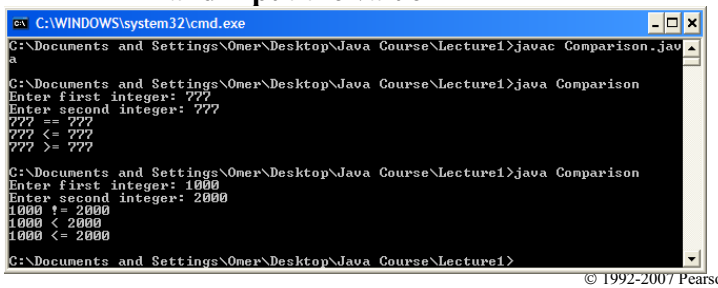
```
Enter first integer: 777
Enter second integer: 777
777 == 777
777 <= 777
777 >= 777
```

```
Enter first integer: 1000
Enter second integer: 2000
1000 != 2000
1000 < 2000
1000 <= 2000
```

```
Enter first integer: 2000
Enter second integer: 1000
2000 != 1000
2000 > 1000
2000 >= 1000
```


Decision Making: Equality and Relational Operators (Cont.)

- Line 6: begins class `Comparison` declaration
- Line 12: declares Scanner variable input and assigns it a Scanner that inputs data from the standard input
- Lines 14-15: declare `int` variables
- Lines 17-18: prompt the user to enter the first integer and input the value
- Lines 20-21: prompt the user to enter the second integer and input the value



Decision Making: Equality and Relational Operators (Cont.)

```
23       if ( number1 == number2 )
24          System.out.printf( "%d == %d\n", number1, number2 );
```

- `if` statement to test for equality using (==)
  - If variables equal (condition true)
    - Line 24 executes
  - If variables not equal, statement skipped
  - No semicolon at the end of line 23
  - Empty statement
    - No task is performed
- Lines 26-27, 29-30, 32-33, 35-36 and 38-39
  - Compare `number1` and `number2` with the operators !=, <, >, <= and >=, respectively

Operators				Associativity	Type
*	/	%		left to right	multiplicative
+	-			left to right	additive
<	<=	>	>=	left to right	relational
==	!=			left to right	equality
=				right to left	assignment

Fig. 2.16 | Precedence and associativity of operations discussed.

Object-oriented Programming

- **Objects**
  - **Reusable software components that model real-world items**
  - **Look all around you**
    - **People, animals, plants, cars, etc.**
  - **Attributes**
    - **Size, shape, color, weight, etc.**
  - **Behaviors**
    - **Babies cry, crawl, sleep, etc.**

Object-oriented Programming

- **Object-oriented design (OOD)**
  - **Models software in terms similar to those used to describe real-world objects**
  - **Class relationships**
  - **Inheritance relationships**
  - **Models communication among objects**
  - **Encapsulates attributes and operations (behaviors)**
    - **Information hiding**
    - **Communication through well-defined interfaces**
- **Object-oriented language**
  - **Programming in object-oriented languages is called *object-oriented programming* (*OOP*)**
  - **Java**

Object-oriented Programming

- **Classes are to objects as blueprints are to houses**
- **Associations**
  - **Relationships between classes**
- **Packaging software in classes facilitates reuse**

Object-oriented Programming

- **Object-Oriented Analysis and Design (OOA/D)**
  - **Essential for large programs**
  - **Analyze program requirements, then develop a design**
  - **UML**
    - **Unified Modeling Language**
    - **Standard for designing object-oriented systems**

- **History of the UML**
  - **Need developed for process with which to approach OOA/D**
  - **Brainchild of Booch, Rumbaugh and Jacobson**
  - **Object Management Group (OMG) supervised**
  - **Version 2 is current version**

- **UML**
  - **Graphical representation scheme**
  - **Enables developers to model object-oriented systems**
  - **Flexible and extensible**

Control Statements

Outline

Introduction
Algorithms
Pseudocode
Control Structures
`if` Single-Selection Statement
`if…else` Double-Selection Statement
`while` Repetition Statement
Formulating Algorithms: Counter-Controlled Repetition
Formulating Algorithms: Sentinel-Controlled Repetition
Formulating Algorithms: Nested Control Statements
Compound Assignment Operators
Increment and Decrement Operators
Primitive Types

Algorithms

- **Algorithms**
  - **The actions to execute**
  - **The order in which these actions execute**
- **Program control**
  - **Specifies the order in which actions execute in a program**

Pseudocode

- **Pseudocode**
  - **An informal language similar to English**
  - **Helps programmers develop algorithms**
  - **Does not run on computers**
  - **Should contain input, output and calculation actions**
  - **Should not contain variable declarations**

Control Structures

- **Sequential execution**
  - **Statements are normally executed one after the other in the order in which they are written**
- **Transfer of control**
  - **Specifying the next statement to execute that is not necessarily the next one in order**
  - **Can be performed by the `goto` statement**
    - **Structured programming eliminated `goto` statements**

Control Structures (Cont.)

- **Bohm and Jacopini's research**
  - **Demonstrated that `goto` statements were unnecessary**
  - **Demonstrated that all programs could be written with three control structures**
    - **The sequence structure,**
    - **The selection structure and**
    - **The repetition structure**

Control Structures (Cont.)

- **UML activity diagram (www.uml.org)**
  - **Models the workflow (or activity) of a part of a software system**
  - **Action-state symbols (rectangles with their sides replaced with outward-curving arcs)**
    - **represent action expressions specifying actions to perform**
  - **Diamonds**
    - **Decision symbols**
    - **Merge symbols**

Control Structures (Cont.)

  - **Small circles**
    - **Solid circle represents the activity's initial state**
    - **Solid circle surrounded by a hollow circle represents the activity's final state**
  - **Transition arrows**
    - **Indicate the order in which actions are performed**
  - **Notes (rectangles with the upper-right corners folded over)**
    - **Explain the purposes of symbols (like comments in Java)**
    - **Are connected to the symbols they describe by dotted lines**

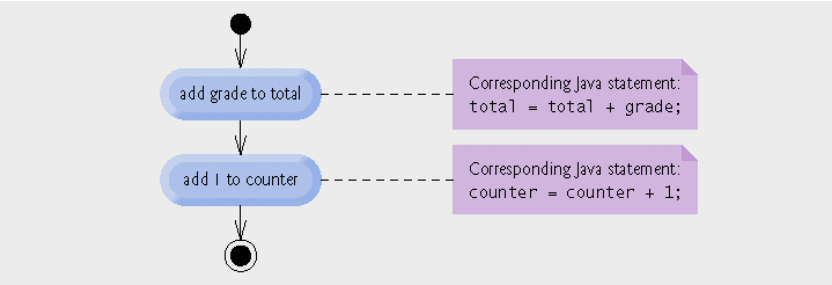


Fig. 4.1 | Sequence structure activity diagram.

Control Structures (Cont.)

- **Selection Statements**
  - **`if` statement**
    - **Single-selection statement**
  - **`if`...`else` statement**
    - **Double-selection statement**
  - **`switch` statement**
    - **Multiple-selection statement**

Control Structures (Cont.)

- Repetition statements
  - Also known as looping statements
  - Repeatedly performs an action while its loop-continuation condition remains true
  - `while` statement
    - Performs the actions in its body zero or more times
  - `do`...`while` statement
    - Performs the actions in its body one or more times
  - `for` statement
    - Performs the actions in its body zero or more times

Control Structures (Cont.)

- Java has three kinds of control structures
  - Sequence statement,
  - Selection statements (three types) and
  - Repetition statements (three types)
  - All programs are composed of these control statements
    - Control-statement stacking
      - All control statements are single-entry/single-exit
    - Control-statement nesting

`if` Single-Selection Statement

- `if` statements
  - Execute an action if the specified condition is `true`
  - Can be represented by a decision symbol (diamond) in a UML activity diagram
    - Transition arrows out of a decision symbol have guard conditions
      - Workflow follows the transition arrow whose guard condition is true

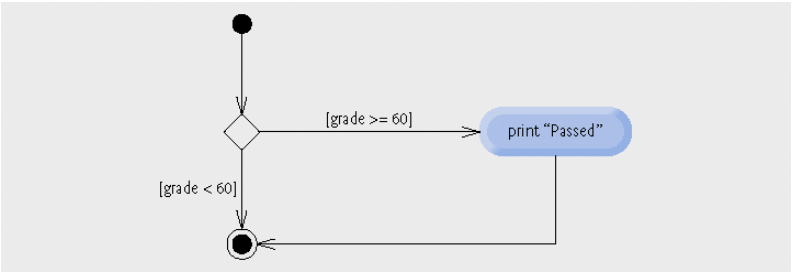


Fig. 4.2 | `if` single-selection statement UML activity diagram.

`if`...`else` Double-Selection Statement

- **`if`...`else` statement**
  - **Executes one action if the specified condition is `true` or a different action if the specified condition is `false`**
- **Conditional Operator (`?` `:`)**
  - **Java's only ternary operator (takes three operands)**
  - **`?` `:` and its three operands form a conditional expression**
    - **Entire conditional expression evaluates to the second operand if the first operand is `true`**
    - **Entire conditional expression evaluates to the third operand if the first operand is `false`**

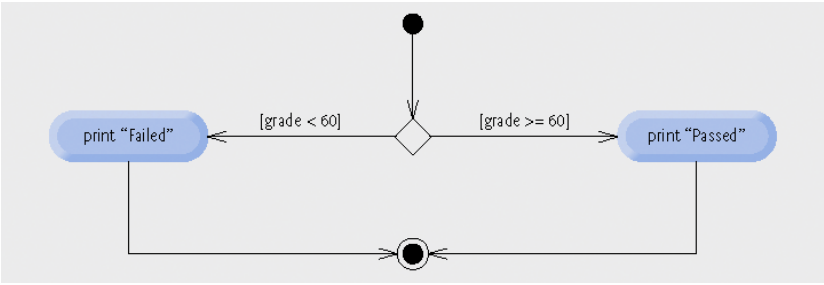


Fig. 4.3 | `if`...`else` double-selection statement UML activity diagram.

`if`...`else` Double-Selection Statement (Cont.)

- **Nested `if`...`else` statements**
  - **`if`...`else` statements can be put inside other `if`...`else` statements**
- **Dangling-`else` problem**
  - **`else`s are always associated with the immediately preceding `if` unless otherwise specified by braces `{ }`**
- **Blocks**
  - **Braces `{ }` associate statements into blocks**
  - **Blocks can replace individual statements as an `if` body**

`if`...`else` Double-Selection Statement (Cont.)

- **Logic errors**
  - **Fatal logic errors cause a program to fail and terminate prematurely**
  - **Nonfatal logic errors cause a program to produce incorrect results**
- **Empty statements**
  - **Represented by placing a semicolon (`;`) where a statement would normally be**
  - **Can be used as an `if` body**

Good Programming Practice 4.4

Always using braces in an `if...else` (or other) statement helps prevent their accidental omission, especially when adding statements to the `if`-part or the `else`-part at a later time. To avoid omitting one or both of the braces, some programmers type the beginning and ending braces of blocks before typing the individual statements within the braces.

`while` Repetition Statement

- **`while` statement**
  - Repeats an action while its loop-continuation condition remains true
  - Uses a merge symbol in its UML activity diagram
    - Merges two or more workflows
    - Represented by a diamond (like decision symbols) but has:
      - Multiple incoming transition arrows,
      - Only one outgoing transition arrow and
      - No guard conditions on any transition arrows

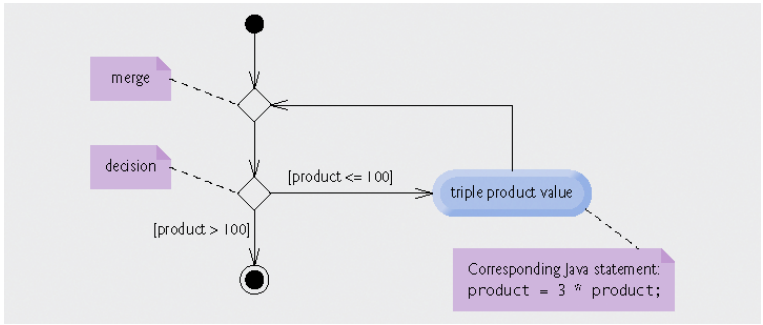


Fig. 4.4 | `while` repetition statement UML activity diagram.

Formulating Algorithms: Counter-Controlled Repetition

- **Counter-controlled repetition**
  - Use a counter variable to count the number of times a loop is iterated
- **Integer division**
  - The fractional part of an integer division calculation is truncated (thrown away)

```
1     Set total to zero
2     Set grade counter to one
3
4     While grade counter is less than or equal to ten
5           Prompt the user to enter the next grade
6           Input the next grade
7           Add the grade into the total
8           Add one to the grade counter
9
10    Set the class average to the total divided by ten
11    Print the class average
```

Fig. 4.5 | Pseudocode algorithm that uses counter-controlled repetition to solve the class-average problem.


```
import java.util.Scanner; // program uses class Scanner.
public class GradeBook .
{.
   public static void main(String[] args) .
   {.
      // create Scanner to obtain input from command window.
      Scanner input = new Scanner( System.in );.
.
      int total; // sum of grades entered by user.
      int gradeCounter; // number of the grade to be entered next.
      int grade; // grade value entered by user.
      int average; // average of grades.
.
      // initialization phase.
      total = 0; // initialize total.
      gradeCounter = 1; // initialize loop counter.
      while ( gradeCounter <= 10 ) // loop 10 times.
      {.
         System.out.print( "Enter grade: " ); // prompt .
         grade = input.nextInt(); // input next grade.
         total = total + grade; // add grade to total.
         gradeCounter = gradeCounter + 1; // increment counter by 1.
      } // end while.
   .
      // termination phase.
      average = total / 10; // integer division yields integer result.
.
      // display total and average of grades.
      System.out.printf( "\nTotal of all 10 grades is %d\n", total );.
      System.out.printf( "Class average is %d\n", average );.
   } // end method determineClassAverage.
} // end class GradeBook.
```

•GradeBook.java


```
C:\Documents and Settings\Omer\Desktop\Java Course\Lecture1>java GradeBook
Enter grade: 12
Enter grade: 8
Enter grade: 12
Enter grade: 12
Enter grade: 3
Enter grade: 5
Enter grade: 6
Enter grade: 8
Enter grade: 9
Enter grade: 6

Total of all 10 grades is 81
Class average is 8

C:\Documents and Settings\Omer\Desktop\Java Course\Lecture1>
```

Common Programming Error 4.5

Assuming that integer division rounds (rather than truncates) can lead to incorrect results. For example, 7 ÷ 4, which yields 1.75 in conventional arithmetic, truncates to 1 in integer arithmetic, rather than rounding to 2.

Formulating Algorithms: Sentinel-Controlled Repetition

- **Sentinel-controlled repetition**
  - **Also known as indefinite repetition**
  - **Use a sentinel value (also known as a signal, dummy or flag value)**
    - **A sentinel value cannot also be a valid input value**

Common Programming Error 4.6

Choosing a sentinel value that is also a legitimate data value is a logic error.

Error-Prevention Tip 4.2

When performing division by an expression whose value could be zero, explicitly test for this possibility and handle it appropriately in your program (e.g., by printing an error message) rather than allow the error to occur


```
1    Initialize total to zero
2    Initialize counter to zero
3
4    Prompt the user to enter the first grade
5    Input the first grade (possibly the sentinel)
6
7    While the user has not yet entered the sentinel
8        Add this grade into the running total
9        Add one to the grade counter
10       Prompt the user to enter the next grade
11       Input the next grade (possibly the sentinel)
12
13   If the counter is not equal to zero
14       Set the average to the total divided by the counter
15       Print the average
16   else
17       Print "No grades were entered"
```

Fig. 4.8 | Class-average problem pseudocode algorithm with sentinel-controlled repetition.

```
import java.util.Scanner; // program uses class Scanner.
public class GradeBookWhile .
{.
   public static void main(String[] args) .
   {.
      // create Scanner to obtain input from command window.
      Scanner input = new Scanner( System.in );.
.
      int total; // sum of grades entered by user.
      int gradeCounter; // number of the grade to be entered next.
      int grade; // grade value entered by user.
      double average; // average of grades.
.
      // initialization phase.
      total = 0; // initialize total.
      gradeCounter = 0; // initialize loop counter.
      .
      System.out.print( "Enter grade or -1 to quit: " ); // prompt .
      grade = input.nextInt(); // input next grade.
         .
      while ( grade != -1 ) {.
         total = total + grade; // add grade to total.
         gradeCounter = gradeCounter + 1; // increment counter by 1.
         System.out.print( "Enter grade or -1 to quit: " ); // prompt
         grade = input.nextInt(); // input next grade.
      } // end while.
   .
      // termination phase.
      average = (double) total / gradeCounter; .
      System.out.printf( "\nTotal of all 10 grades is %d\n", total );.
      System.out.printf( "Class average is %.2f\n", average );.
   } // end method determineClassAverage.
} // end class GradeBook.
```



```
C:\Documents and Settings\Omer\Desktop\Java Course\Lecture1>java GradeBookWhile
Enter grade or -1 to quit: 34
Enter grade or -1 to quit: 16
Enter grade or -1 to quit: 5
Enter grade or -1 to quit: -1

Total of all 10 grades is 55
Class average is 18.33

C:\Documents and Settings\Omer\Desktop\Java Course\Lecture1>
```


Formulating Algorithms: Sentinel-Controlled Repetition (Cont.)

- **Unary cast operator**
  - **Creates a temporary copy of its operand with a different data type**
    - **example: `(double)` will create a temporary floating-point copy of its operand**
  - **Explicit conversion**
- **Promotion**
  - **Converting a value (e.g. `int`) to another data type (e.g. `double`) to perform a calculation**
  - **Implicit conversion**

Formulating Algorithms: Nested Control Statements

- **Control statements can be nested within one another**
  - **Place one control statement inside the body of the other**

```
Initialize passes to zero
Initialize failures to zero
Initialize student counter to one

While student counter is less than or equal to 10
   Prompt the user to enter the next exam result
   Input the next exam result

   If the student passed
      Add one to passes
   Else
      Add one to failures

   Add one to student counter

Print the number of passes
Print the number of failures

If more than eight students passed
   Print "Raise tuition"
```

Fig. 4.11 | **Pseudocode for examination-results problem.**


```
import java.util.Scanner; // class uses class Scanner.
public class Analysis .
{.
   public static void main(String[] args) .
   {.
      // create Scanner to obtain input from command window.
      Scanner input = new Scanner( System.in );.
      // initializing variables in declarations .
      int passes = 0; // number of passes        .
      int failures = 0; // number of failures    .
      int studentCounter = 1; // student counter.
      int result; // one exam result (obtains value from user).
      // process 10 students using counter-controlled loop.
      while ( studentCounter <= 10 ) .
      {.
         // prompt user for input and obtain value from user.
         System.out.print( "Enter result (1 = pass, 2 = fail): " );.
         result = input.nextInt();.
         // if...else nested in while                          .
         if ( result == 1 )          // if result 1,           .
            passes = passes + 1;     // increment passes;      .
         else                        // else result is not 1, so.
            failures = failures + 1; // increment failures     .
.
         // increment studentCounter so loop eventually terminates.
         studentCounter = studentCounter + 1;  .
      } // end while.
      System.out.printf( "Passed: %d\nFailed: %d\n", passes, failures );
      // determine whether more than 8 students passed.
      if ( passes > 8 ).
         System.out.println( "Hardworking class." );.
   } // end method.
} // end class Analysis.
```


```
C:\Documents and Settings\Omer\Desktop\Java Course\Lecture1>java Analysis
Enter result (1 = pass, 2 = fail): 1
Enter result (1 = pass, 2 = fail): 2
Enter result (1 = pass, 2 = fail): 1
Enter result (1 = pass, 2 = fail): 1
Enter result (1 = pass, 2 = fail): 1
Enter result (1 = pass, 2 = fail): 1
Enter result (1 = pass, 2 = fail): 1
Enter result (1 = pass, 2 = fail): 1
Enter result (1 = pass, 2 = fail): 1
Enter result (1 = pass, 2 = fail): 1
Passed: 9
Failed: 1
Hardworking class.

C:\Documents and Settings\Omer\Desktop\Java Course\Lecture1>
```

Compound Assignment Operators

- **Compound assignment operators**
  - **An assignment statement of the form:**
    ***variable* = *variable operator expression* ;**
    where *operator* is +, -, *, / or % can be written as:
    ***variable operator= expression* ;**
  - **example: `c = c + 3 ;` can be written as `c += 3 ;`**
    - **This statement adds 3 to the value in variable `c` and stores the result in variable `c`**

Assignment operator	Sample expression	Explanation	Assigns
Assume: `int c = 3, d = 5, e = 4, f = 6, g = 12;`			
`+=`	`c += 7`	`C = c + 7`	10 to `c`
`-=`	`d -= 4`	`d = d - 4`	1 to `d`
`*=`	`e *= 5`	`e = e * 5`	20 to `e`
`/=`	`f /= 3`	`f = f / 3`	2 to `f`
`%=`	`g %= 9`	`g = g % 9`	3 to `g`

Fig. 4.14 | Arithmetic compound assignment operators.

Increment and Decrement Operators

- **Unary increment and decrement operators**
  - **Unary increment operator (++) adds one to its operand**
  - **Unary decrement operator (--) subtracts one from its operand**
  - **Prefix increment (and decrement) operator**
    - **Changes the value of its operand, then uses the new value of the operand in the expression in which the operation appears**
  - **Postfix increment (and decrement) operator**
    - **Uses the current value of its operand in the expression in which the operation appears, then changes the value of the operand**

Operator	Called	Sample expression	Explanation
`++`	prefix increment	`++a`	Increment `a` by 1, then use the new value of `a` in the expression in which `a` resides.
`++`	postfix increment	`a++`	Use the current value of `a` in the expression in which `a` resides, then increment `a` by 1.
`--`	prefix decrement	`--b`	Decrement `b` by 1, then use the new value of `b` in the expression in which `b` resides.
`--`	postfix decrement	`b--`	Use the current value of `b` in the expression in which `b` resides, then decrement `b` by 1.

Fig. 4.15 | Increment and decrement operators.


```
1  // Fig. 4.16: Increment.java
2  // Prefix increment and postfix increment operators.
3
4  public class Increment
5  {
6     public static void main( String args[] )
7     {
8        int c;
9
10       // demonstrate postfix increment operator
11       c = 5; // assign 5 to c
12       System.out.println( c );   // print 5
13       System.out.println( c++ ); // print 5 then postincrement
14       System.out.println( c );   // print 6
15
16       System.out.println(); // skip a line
17
18       // demonstrate prefix increment operator
19       c = 5; // assign 5 to c
20       System.out.println( c );   // print 5
21       System.out.println( ++c ); // preincrement then print 6
22       System.out.println( c );   // print 6
23
24    } // end main
25
26 } // end class Increment
```

Postincrementing the `c` variable

Preincrementing the `c` variable

```
5
5
6

5
6
6
```

•Increment.java

Operators						Associativity	Type
++	--					right to left	unary postfix
++	--	+	-	(*type*)		right to left	unary prefix
*	/	%				left to right	Multiplicative
+	-					left to right	Additive
<	<=	>	>=			left to right	Relational
==	!=					left to right	Equality
?:						right to left	Conditional
=	+=	-=	*=	/=	%=	right to left	assignment

Fig. 4.17 | Precedence and associativity of the operators discussed so far.

Primitive Types

- Java is a strongly typed language
  - All variables have a type
- Primitive types in Java are portable across all platforms that support Java

Portability Tip 4.1

Unlike C and C++, the primitive types in Java are portable across all computer platforms that support Java. Thanks to this and Java's many other portability features, a programmer can write a program once and be certain that it will execute on any computer platform that supports Java. This capability is sometimes referred to as *WORA* (Write Once, Run Anywhere).