

Lesson 2

Introduction to Classes and Objects

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OBJECTIVES

In this Chapter you'll learn:

- To write simple Java applications.
- To use input and output statements.
- Java's primitive types.
- Basic memory concepts.
- To use arithmetic operators.
- The precedence of arithmetic operators.
- To write decision-making statements.
- To use relational and equality operators.

- 2.1 Introduction
- 2.2 Our First Program in Java: Printing a Line of Text
- 2.3 Modifying Our First Java Program
- 2.4 Displaying Text with `printf`
- 2.5 Another Application: Adding Integers
- 2.6 Memory Concepts
- 2.7 Arithmetic
- 2.8 Decision Making: Equality and Relational Operators
- 2.9 Wrap-Up

2.2 Our First Program in Java: Printing a Line of Text

- ▶ Java **application**
 - A computer program that executes when you use the **java command** to launch the Java Virtual Machine (JVM).
- ▶ Sample program in Fig. 2.1 displays a line of text.

```
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    } // end method main
11 } // end class Welcome1
```

Welcome to Java Programming!

Fig. 2.1 | Text-printing program.

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

▶ Comments

```
// Fig. 2.1: welcome1.java
```

- `//` indicates that the line is a **comment**.
 - Used to **document programs** and improve their readability.
 - Compiler **ignores** comments.
 - A comment that begins with `//` is an **end-of-line comment**—it terminates at the end of the line on which it appears.
- ▶ **Traditional comment**, can be spread over several lines as in

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

- This type of comment begins with `/*` and ends with `*/`.
- All text between the delimiters is ignored by the compiler.

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

- ▶ Class declaration

```
public class welcome1
```

- Every Java program consists of at least one class that you define.
- `class` keyword introduces a class declaration and is immediately followed by the `class name`.
- **Keywords** (Appendix C) are reserved for use by Java and are always spelled with all lowercase letters.

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

▶ Class names

- By convention, begin with a **capital letter** and capitalize the first letter of each word they include (e.g., `SampleClassName`).
- A class name is an **identifier**—a series of characters consisting of letters, digits, underscores (`_`) and dollar signs (`$`) that does not begin with a digit and does not contain spaces.
- Java is **case sensitive**—uppercase and lowercase letters are distinct—so `a1` and `A1` are different (but both valid) identifiers.



Common Programming Error 2.3

A public class must be placed in a file that has the same name as the class (in terms of both spelling and capitalization) plus the .java extension; otherwise, a compilation error occurs. For example, public class Welcome must be placed in a file named Welcome.java.

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

▶ Braces

- A **left brace**, {, begins the **body** of every class declaration.
- A corresponding **right brace**, }, must end each class declaration.
- Code between braces should be **indented**.
- This indentation is one of the spacing conventions mentioned earlier.



Error-Prevention Tip 2.1

When you type an opening left brace, {, immediately type the closing right brace, }, then reposition the cursor between the braces and indent to begin typing the body. This practice helps prevent errors due to missing braces. Many IDEs insert the braces for you.



Common Programming Error 2.4

It's a syntax error if braces do not occur in matching pairs.

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

▶ Declaring the `main` Method

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

- **Starting point** of every Java application.
- **Parentheses** after the identifier `main` indicate that it's a program building block called a **method**.
- Java class declarations normally contain one or more methods.
- `main` must be defined as shown; otherwise, the JVM **will not execute** the application.
- Methods **perform** tasks and can **return** information when they complete their tasks.
- Keyword `void` indicates that this method will not return any information.

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

- ▶ Body of the method declaration

- Enclosed in left and right braces.

- ▶ Statement

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

- Instructs the computer to perform an action
 - Print the **string** of characters contained between the double quotation marks.
- A string is sometimes called a **character string** or a **string literal**.
- White-space characters in strings are **not ignored** by the compiler.

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

- ▶ `System.out` object
 - Standard output object.
 - Allows Java applications to display strings in the **command window** from which the Java application executes.
- ▶ `System.out.println` method
 - Displays (or prints) a line of text in the command window.
 - The string in the parentheses is the **argument** to the method.
 - Positions the output cursor at the beginning of the next line in the command window.
- ▶ Most statements end with a semicolon.



Good Programming Practice 2.6

Indent the entire body of each method declaration one “level” between the braces that define the body of the method. This makes the structure of the method stand out and makes the method declaration easier to read.



Common Programming Error 2.5

When a semicolon is required to end a statement, omitting the semicolon is a syntax error.

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

- ▶ **Compiling and Executing** Your First Java Application
 - Open a command window and change to the directory where the program is stored.
 - Many operating systems use the command `cd` to change directories.
 - To compile the program, type

```
javac welcome1.java
```
 - If the program contains no syntax errors, preceding command creates a `.class` file (known as the **class file**) containing the platform-independent Java bytecodes that represent the application.
 - When we use the `java` command to execute the application on a given platform, these bytecodes will be translated by the JVM into instructions that are understood by the underlying operating system.



Error-Prevention Tip 2.4

When attempting to compile a program, if you receive a message such as “bad command or filename,” “javac: command not found” or “'javac' is not recognized as an internal or external command, operable program or batch file,” then your Java software installation was not completed properly. If you are using the JDK, this indicates that the system’s PATH environment variable was not set properly. Please carefully review the installation instructions in the Before You Begin section of this book. On some systems, after correcting the PATH, you may need to reboot your computer or open a new command window for these settings to take effect.



Error-Prevention Tip 2.5

Each syntax-error message contains the file name and line number where the error occurred. For example, `Welcome1.java:6` indicates that an error occurred in the file `Welcome1.java` at line 6. The remainder of the error message provides information about the syntax error.



Error-Prevention Tip 2.6

The compiler error message “class Welcome1 is public, should be declared in a file named Welcome1.java” indicates that the file name does not exactly match the name of the public class in the file or that you typed the class name incorrectly when compiling the class.

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

- ▶ To **execute** the program, type `java welcome1`.
- ▶ Launches the JVM, which loads the `.class` file for class `welcome1`.
- ▶ Note that the `.class` file-name extension is omitted from the preceding command; otherwise, the JVM will not execute the program.
- ▶ The JVM calls method `main` to execute the program.

2.3 Modifying Our First Java Program

- ▶ Class `Welcome2`, shown in Fig. 2.3, uses two statements to produce the same output as that shown in Fig. 2.1.
- ▶ New and key features in each code listing are highlighted.
- ▶ `System.out`'s method `print` displays a string.
- ▶ Unlike `println`, `print` **does not position** the output cursor at the beginning of the next line in the command window.
 - The next character the program displays will **appear immediately** after the last character that `print` displays.

```
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    } // end method main
12 } // end class Welcome2
```

Prints Welcome to and leaves cursor on same line

Prints Java Programming! starting where the cursor was positioned previously, then outputs a newline character

Welcome to Java Programming!

Fig. 2.3 | Printing a line of text with multiple statements.

2.3 Modifying Our First Java Program (Cont.)

- ▶ **Newline characters** indicate to `System.out`'s `print` and `println` methods when to position the output cursor at the beginning of the next line in the command window.
- ▶ Newline characters are white-space characters.
- ▶ The **backslash** (`\`) is called an **escape character**.
 - Indicates a “special character”
- ▶ Backslash is combined with the next character to form an **escape sequence**.
- ▶ The escape sequence `\n` represents the newline character.
- ▶ Complete list of escape sequences
java.sun.com/docs/books/jls/third_edition/html/lexical.html#3.10.6.

```
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\n\tto\n\tJava\n\tProgramming!" );
10    } // end method main
11 } // end class Welcome3
```

Each \n moves the output cursor to the next line, where output continues

```
Welcome
to
Java
Programming!
```

Fig. 2.4 | Printing multiple lines of text with a single statement.

Escape sequence	Description
<code>\n</code>	Newline. Position the screen cursor at the beginning of the next line.
<code>\t</code>	Horizontal tab. Move the screen cursor to the next tab stop.
<code>\r</code>	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.
<code>\\</code>	Backslash. Used to print a backslash character.
<code>\"</code>	Double quote. Used to print a double-quote character. For example, <pre>System.out.println("\"in quotes\"");</pre> displays <code>"in quotes"</code>

Fig. 2.5 | Some common escape sequences.

2.4 Displaying Text with `printf`

- ▶ `System.out.printf` method
 - `f` means “formatted”
 - displays formatted data
- ▶ Multiple method arguments are placed in a **comma-separated list**.
- ▶ Java allows large statements to be split over many lines.
 - Cannot split a statement in the middle of an identifier or string.
- ▶ Method `printf`'s first argument is a **format string**
 - May consist of **fixed text** and **format specifiers**.
 - Fixed text is output as it would be by `print` or `println`.
 - Each format specifier is a placeholder for a value and specifies the type of data to output.
- ▶ Format specifiers begin with a percent sign (%) and are followed by a character that represents the data type.
- ▶ Format specifier `%s` is a placeholder for a string.

```
1 // Fig. 2.6: Welcome4.java
2 // Displaying multiple lines with method System.out.printf.
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     } // end method main
12 } // end class Welcome4
```

Each %s is a placeholder for a `String` that comes later in the argument list

Statements can be split over multiple lines.

```
Welcome to
Java Programming!
```

Fig. 2.6 | Displaying multiple lines with method `System.out.printf`.

2.5 Another Application: Adding Integers

- ▶ **Integers**
 - Whole numbers, like -22 , 7 , 0 and 1024)
- ▶ Programs remember numbers and other data in the computer's memory and access that data through program elements called **variables**.
- ▶ The program of Fig. 2.7 demonstrates these concepts.

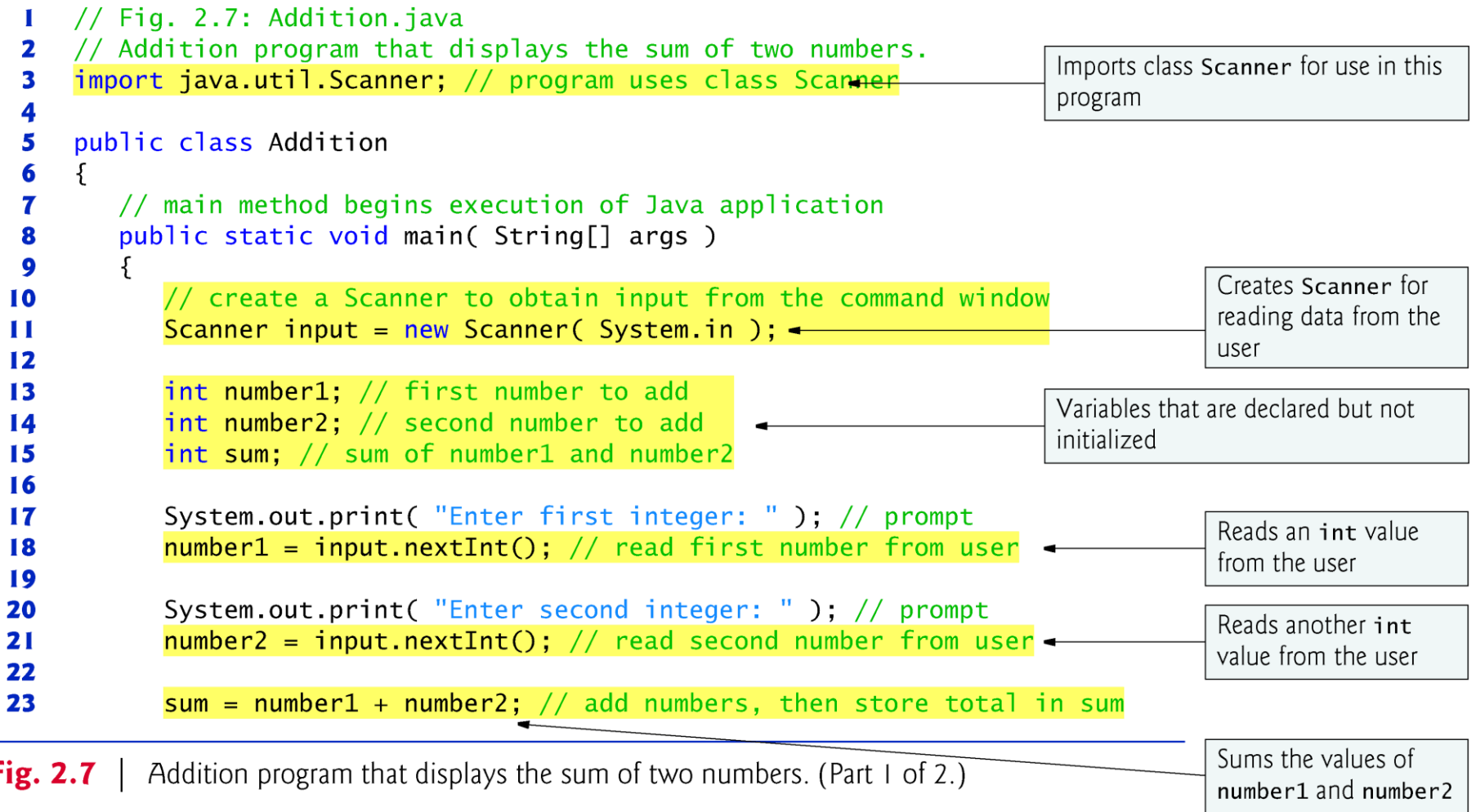


Fig. 2.7 | Addition program that displays the sum of two numbers. (Part 1 of 2.)

```
24
25     System.out.printf( "Sum is %d\n", sum ); // display sum
26 } // end method main
27 } // end class Addition
```

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

Fig. 2.7 | Addition program that displays the sum of two numbers. (Part 2 of 2.)

2.5 Another Application: Adding Integers (Cont.)

▶ `import` declaration

- Helps the compiler locate a class that is used in this program.
- Rich set of predefined classes that you can reuse rather than “reinventing the wheel.”
- Classes are grouped into `packages`—named groups of related classes—and are collectively referred to as the `Java class library`, or the `Java Application Programming Interface (Java API)`.
- You use `import` declarations to identify the predefined classes used in a Java program.



Common Programming Error 2.7

All import declarations must appear before the first class declaration in the file. Placing an import declaration inside a class declaration's body or after a class declaration is a syntax error.



Error-Prevention Tip 2.8

Forgetting to include an import declaration for a class used in your program typically results in a compilation error containing a message such as "cannot find symbol." When this occurs, check that you provided the proper import declarations and that the names in the import declarations are spelled correctly, including proper use of uppercase and lowercase letters.

2.5 Another Application: Adding Integers (Cont.)

▶ Variable declaration statement

```
Scanner input = new Scanner( System.in );
```

- Specifies the name (`input`) and type (`Scanner`) of a variable that is used in this program.

▶ Variable

- A location in the computer's memory where a value can be stored for use later in a program.
- Must be declared with a **name** and a **type** before they can be used.
- A variable's name enables the program to **access the value** of the variable in memory.
- The name can be **any valid identifier**.
- A **variable's type** specifies what kind of information is stored at that location in memory.

2.5 Another Application: Adding Integers (Cont.)

- ▶ **Scanner**
 - Enables a program to read data for use in a program.
 - Data can come from many sources, such as the user at the keyboard or a file on disk.
 - Before using a **Scanner**, you must create it and **specify the source of the data**.
- ▶ The equals sign (=) in a declaration indicates that the variable should be **initialized** (i.e., prepared for use in the program) with the result of the expression to the right of the equals sign.
- ▶ The **new** keyword creates an object.
- ▶ **Standard input object**, `System.in`, enables applications to read bytes of information typed by the user.
- ▶ **Scanner** object **translates** these bytes into types that can be used in a program.

2.5 Another Application: Adding Integers (Cont.)

- ▶ Variable declaration statements

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

declare that variables `number1`, `number2` and `sum` hold data of type `int`

- They can hold integer.
 - Range of values for an `int` is $-2,147,483,648$ to $+2,147,483,647$.
 - Actual `int` values may not contain commas.
- ▶ Several variables of the same type may be declared in one declaration with the variable names separated by commas.



Good Programming Practice 2.9

Declare each variable on a separate line. This format allows a descriptive comment to be easily inserted next to each declaration.



Good Programming Practice 2.10

*Choosing meaningful variable names helps a program to be **self-documenting** (i.e., one can understand the program simply by reading it rather than by reading manuals or viewing an excessive number of comments).*



Good Programming Practice 2.11

By convention, variable-name identifiers begin with a lowercase letter, and every word in the name after the first word begins with a capital letter. For example, variable-name identifier `firstNumber` starts its second word, `Number`, with a capital N.

2.5 Another Application: Adding Integers (Cont.)

▶ Prompt

- Output statement that directs the user to take a specific action.

▶ System is a class.

- Part of package `java.lang`.
- Class `System` is not imported with an `import` declaration at the beginning of the program.



Software Engineering Observation 2.1

By default, package `java.lang` is imported in every Java program; thus, classes in `java.lang` are the only ones in the Java API that do not require an `import` declaration.

2.5 Another Application: Adding Integers (Cont.)

▶ Scanner method `nextInt`

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

- Obtains an integer from the user at the keyboard.
 - Program waits for the user to type the number and press the Enter key to submit the number to the program.
- ▶ The result of the call to method `nextInt` is placed in variable `number1` by using the **assignment operator**, `=`.
- “`number1` gets the value of `input.nextInt()`.”
 - Operator `=` is called a **binary operator**—it has two **operands**.
 - Everything to the right of the assignment operator, `=`, is always evaluated before the assignment is performed.

2.5 Another Application: Adding Integers (Cont.)

▶ Arithmetic

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

- Assignment statement that calculates the sum of the variables `number1` and `number2` then assigns the result to variable `sum` by using the assignment operator, `=`.
- “`sum` gets the value of `number1 + number2`.”
- In general, calculations are performed in assignment statements.
- Portions of statements that contain calculations are called **expressions**.
- An expression is any portion of a statement that has a value associated with it.

2.5 Another Application: Adding Integers (Cont.)

- ▶ Integer formatted output

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

- Format specifier `%d` is a placeholder for an `int` value
- The letter `d` stands for “decimal integer.”

2.6 Memory Concepts

▶ Variables

- Every variable has a **name**, a **type**, a **size** (in bytes) and a **value**.
- When a new value is placed into a variable, the new value replaces the previous value (if any)
- The previous value is lost.



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`.

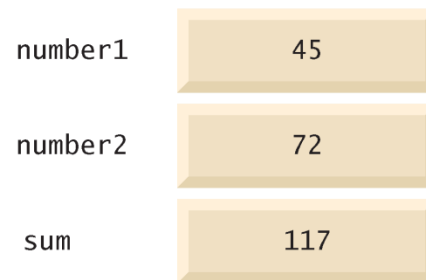


Fig. 2.10 | Memory locations after storing the sum of `number1` and `number2`.

2.7 Arithmetic

- ▶ **Arithmetic operators** are summarized in Fig. 2.11.
- ▶ The **asterisk** ($*$) indicates multiplication
- ▶ The percent sign ($\%$) is the **remainder operator**
- ▶ The arithmetic operators are binary operators because they each operate on two operands.
- ▶ **Integer division** yields an integer quotient.
 - Any fractional part in integer division is simply discarded (i.e., truncated)—no rounding occurs.
- ▶ The remainder operator, $\%$, yields the remainder after division.

Java operation	Operator	Algebraic expression	Java expression
Addition	+	$f + 7$	<code>f + 7</code>
Subtraction	-	$p - c$	<code>p - c</code>
Multiplication	*	bm	<code>b * m</code>
Division	/	x / y or $\frac{x}{y}$ or $x \div y$	<code>x / y</code>
Remainder	%	$r \text{ mod } s$	<code>r % s</code>

Fig. 2.11 | Arithmetic operators.

2.7 Arithmetic (Cont.)

- ▶ Arithmetic expressions in Java must be written in **straight-line form** to facilitate entering programs into the computer.
- ▶ Expressions such as “a divided by b” must be written as a / b , so that all constants, variables and operators appear in a straight line.
- ▶ Parentheses are used to group terms in expressions in the same manner as in algebraic expressions.
- ▶ If an expression contains **nested parentheses**, the expression in the innermost set of parentheses is evaluated first.

2.7 Arithmetic (Cont.)

▶ Rules of operator precedence

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

Fig. 2.12 | Precedence of arithmetic operators.

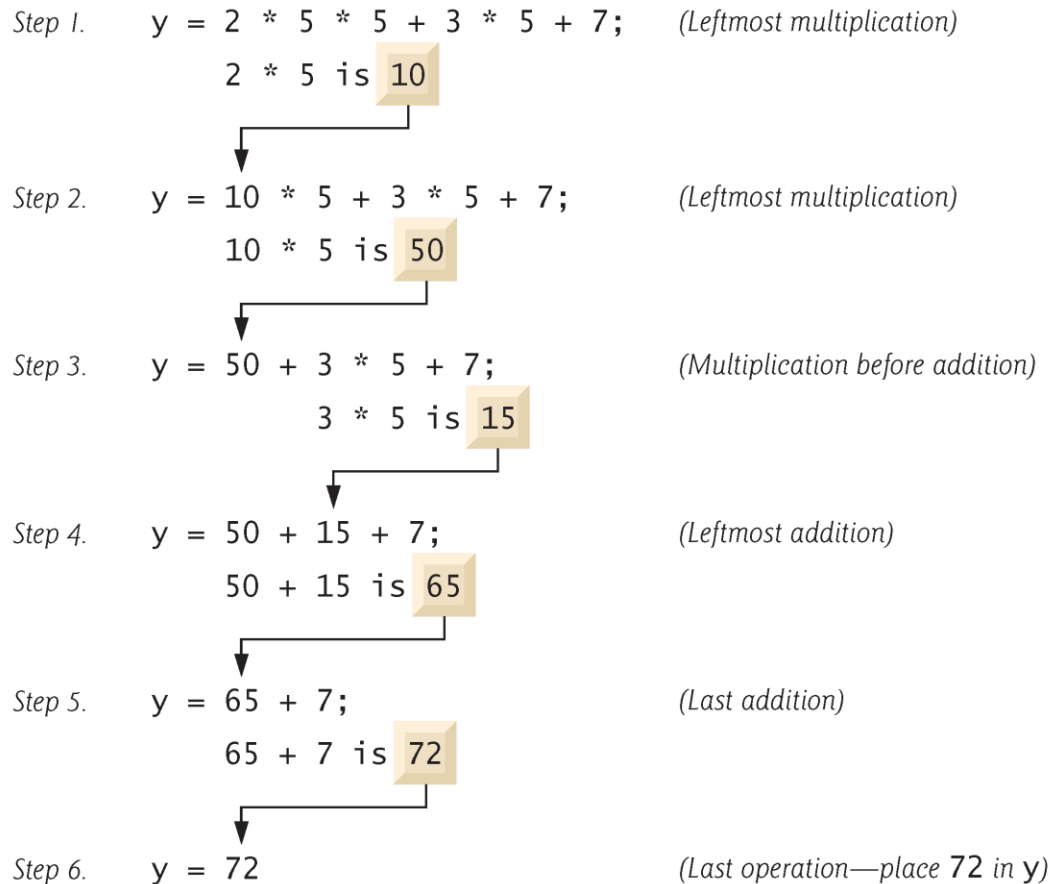


Fig. 2.13 | Order in which a second-degree polynomial is evaluated.

2.7 Arithmetic (Cont.)

- ▶ As in algebra, it's acceptable to place **redundant parentheses** (unnecessary parentheses) in an expression to make the expression clearer.



Good Programming Practice 2.13

Using redundant parentheses in complex arithmetic expressions can make them easier to read.

2.8 Decision Making: Equality and Relational Operators

- ▶ **Condition**
 - An expression that can be `true` or `false`.
- ▶ **if selection statement**
 - Allows a program to make a **decision** based on a condition's value.
- ▶ **Equality operators** (`==` and `!=`)
- ▶ **Relational operators** (`>`, `<`, `>=` and `<=`)
- ▶ Both equality operators have the same level of precedence, which is lower than that of the relational operators.
- ▶ The equality operators associate from left to right.
- ▶ The relational operators all have the same level of precedence and also associate from left to right.

Standard algebraic equality or relational operator	Java equality or relational operator	Sample Java condition	Meaning of Java condition
<i>Equality operators</i>			
=	==	x == y	x is equal to y
≠	!=	x != y	x is not equal to y
<i>Relational operators</i>			
>	>	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 number from user
22
```

Fig. 2.15 | Compare integers using `if` statements, relational operators and equality operators. (Part I of 3.)

```
23     if ( number1 == number2 )
24         System.out.printf( "%d == %d\n", number1, number2 );
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, number2 );
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, number2 );
37
38     if ( number1 >= number2 )
39         System.out.printf( "%d >= %d\n", number1, number2 );
40 } // end method main
41 } // end class Comparison
```

← Output statement executes only if the numbers are equal

← Output statement executes only if the numbers are not equal

← Output statement executes only if number1 is less than number2

← Output statement executes only if number1 is greater than number2

← Output statement executes only if number1 is less than or equal to number2

← Output statement executes only if number1 is greater than or equal to number2

Fig. 2.15 | Compare integers using if statements, relational operators and equality operators. (Part 2 of 3.)

```
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
```

Fig. 2.15 | Compare integers using `if` statements, relational operators and equality operators. (Part 3 of 3.)

2.8 Decision Making: Equality and Relational Operators (Cont.)

- ▶ An `if` statement always begins with keyword `if`, followed by a condition in parentheses.
 - Expects one statement in its body, but may contain **multiple statements** if they are enclosed in a set of braces (`{ }`).
 - The **indentation** of the body statement is not required, but it improves the program's readability by emphasizing that statements are part of the body.
- ▶ Note that there is **no semicolon** (`;`) at the end of the first line of each `if` statement.
 - Such a semicolon would result in a logic error at execution time.
 - Treated as the **empty statement**—semicolon by itself.



Common Programming Error 2.8

Forgetting the left and/or right parentheses for the condition in an `if` statement is a syntax error—the parentheses are required.



Common Programming Error 2.9

Confusing the equality operator, `==`, with the assignment operator, `=`, can cause a logic error or a syntax error. The equality operator should be read as “is equal to,” and the assignment operator should be read as “gets” or “gets the value of.” To avoid confusion, some people read the equality operator as “double equals” or “equals equals.”



Good Programming Practice 2.14

Placing only one statement per line in a program enhances program readability.



Common Programming Error 2.10

Placing a semicolon immediately after the right parenthesis of the condition in an `if` statement is normally a logic error.

Lab exercises

- ▶ Program that calculates the product of three integers inserted from the user.
- ▶ Program that prints the sum, product, difference and quotient of two numbers inserted from keyboard.
- ▶ Program that determines the largest of two numbers.
- ▶ Program calculates the largest and the smallest of five integers entered one at a time.
- ▶ Program that swaps two numbers using temporary or third variable
- ▶ Program accepts five numbers as input and prints the number of negatives, positives and zeros.

Take home coding exercises

1. Program that determines if the first number entered is a multiple of the second number entered. Put the program in a class called Multiple.
2. Program that determines if sum of the first two numbers entered is greater or equal than the third number entered. Put the program in a class called Sum.
3. Program that determines with four entered numbers whether the product of the first two is smaller than the division of the last two. Put the program in a class called Product.

Readings

- ▶ Java™ How to Program, 9/e
 - Chapter 2

End of class