



Chapter 2, Introduction to C++ Programming

C++ How to Program,
Late Objects Version, 7/e



OBJECTIVES

In this chapter you'll learn:

- To write simple computer programs in C++.
- To read data from the keyboard and write data to the screen.
- To use fundamental types.
- Basic computer memory concepts.
- To use arithmetic operators.
- Operator precedence.
- To write simple decision-making statements.



- 2.1 Introduction
- 2.2 First Program in C++: Printing a Line of Text
- 2.3 Modifying Our First C++ Program
- 2.4 Another C++ Program: Adding Integers
- 2.5 Memory Concepts
- 2.6 Arithmetic
- 2.7 Decision Making: Equality and Relational Operators
- 2.8 Wrap-Up



2.1 Introduction

- ▶ We now introduce C++ programming, which facilitates a disciplined approach to program design.
- ▶ Most of the C++ programs you'll study in this book process information and display results.

2.2 First Program in C++: Printing a Line of Text



- ▶ Simple program that prints a line of text (Fig. 2.1).



```
1 // Fig. 2.1: fig02_01.cpp
2 // Text-printing program.
3 #include <iostream> // allows program to output data to the screen
4
5 // function main begins program execution
6 int main()
7 {
8     std::cout << "Welcome to C++!\n"; // display message
9
10    return 0; // indicate that program ended successfully
11 }
```

Welcome to C++!

Fig. 2.1 | Text-printing program.



2.2 First Program in C++: Printing a Line of Text (cont.)

- ▶ `//` indicates that the remainder of each line is a **comment**.
 - You insert comments to document your programs and to help other people read and understand them.
 - Comments are ignored by the C++ compiler and do not cause any machine-language object code to be generated.
- ▶ A comment beginning with `//` is called a **single-line comment** because it terminates at the end of the current line.
- ▶ You also may use C's style in which a comment—possibly containing many lines—begins with `/*` and ends with `*/`.



Good Programming Practice 2.1

Begin every program with a comment that describes the purpose of the program.

2.2 First Program in C++: Printing a Line of Text (cont.)



- ▶ A **preprocessor directive** is a message to the C++ preprocessor.
- ▶ Lines that begin with **#** are processed by the preprocessor before the program is compiled.
- ▶ **#include <iostream>** notifies the preprocessor to include in the program the contents of the **input/output stream header file <iostream>**.
 - Must be included for any program that outputs data to the screen or inputs data from the keyboard using C++-style stream input/output.



Common Programming Error 2.1

Forgetting to include the `<iostream>` header file in a program that inputs data from the keyboard or outputs data to the screen causes the compiler to issue an error message, because the compiler cannot recognize references to the stream components (e.g., `cout`).

2.2 First Program in C++: Printing a Line of Text (cont.)



- ▶ You use blank lines, space characters and tab characters (i.e., “tabs”) to make programs easier to read.
 - Together, these characters are known as **white space**.
 - White-space characters are normally ignored by the compiler.



Good Programming Practice 2.2

Use blank lines, space characters and tabs to enhance program readability.



2.2 First Program in C++: Printing a Line of Text (cont.)

- ▶ `main` is a part of every C++ program.
- ▶ The parentheses after `main` indicate that `main` is a program building block called a **function**.
- ▶ C++ programs typically consist of one or more functions and classes.
- ▶ Exactly one function in every program must be named `main`.
- ▶ C++ programs begin executing at function `main`, even if `main` is not the first function in the program.
- ▶ The keyword `int` to the left of `main` indicates that `main` “returns” an integer (whole number) value.
 - A **keyword** is a word in code that is reserved by C++ for a specific use.
 - For now, simply include the keyword `int` to the left of `main` in each of your programs.



2.2 First Program in C++: Printing a Line of Text (cont.)

- ▶ A **left brace**, {, must begin the **body** of every function.
- ▶ A corresponding **right brace**, }, must end each function's body.
- ▶ A statement instructs the computer to **perform an action**.
- ▶ A string is sometimes called a **character string** or a **string literal**.
- ▶ We refer to characters between double quotation marks simply as **strings**.
 - White-space characters in strings are not ignored by the compiler.
- ▶ A statement normally ends with a **semicolon (;)**, also known as the **statement terminator**.
 - Preprocessor directives (like `#include`) do not end with a semicolon.

2.2 First Program in C++: Printing a Line of Text (cont.)



- ▶ When a `cout` statement executes, it sends a stream of characters to the **standard output stream object**—`std::cout`—which is normally “connected” to the screen.
- ▶ The `std::` before `cout` is required when we use names that we’ve brought into the program by the preprocessor directive `#include <iostream>`.
 - The notation `std::cout` specifies that we are using a name, in this case `cout`, that belongs to “namespace” `std`.
 - The names `cin` (the standard input stream) and `cerr` (the standard error stream) also belong to namespace `std`.
- ▶ The `<<` operator is referred to as the **stream insertion operator**.
 - The value to the operator’s right, the right **operand**, is inserted in the output stream.



2.2 First Program in C++: Printing a Line of Text (cont.)

- ▶ The characters `\n` are not printed on the screen.
- ▶ The backslash (`\`) is called an **escape character**.
 - It indicates that a “special” character is to be output.
- ▶ When a backslash is encountered in a string of characters, the next character is combined with the backslash to form an **escape sequence**.
- ▶ The escape sequence `\n` means **newline**.
 - Causes the **cursor** to move to the beginning of the next line on the screen.
- ▶ When the **return statement** is used at the end of `main` the value `0` indicates that the program has terminated successfully.
- ▶ According to the C++ standard, if program execution reaches the end of `main` without encountering a **return** statement, it’s assumed that the program terminated successfully—exactly as when the last statement in `main` is a **return** statement with the value `0`.



Escape sequence	Description
<code>\n</code>	Newline. Position the screen cursor to 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 to the beginning of the current line; do not advance to the next line.
<code>\a</code>	Alert. Sound the system bell.
<code>\\</code>	Backslash. Used to print a backslash character.
<code>\'</code>	Single quote. Use to print a single quote character.
<code>\"</code>	Double quote. Used to print a double quote character.

Fig. 2.2 | Escape sequences.



Common Programming Error 2.2

*Omitting the semicolon at the end of a C++ statement is a syntax error. (Again, preprocessor directives do not end in a semicolon.) The **syntax** of a programming language specifies the rules for creating proper programs in that language. A **syntax error** occurs when the compiler encounters code that violates C++'s language rules (i.e., its syntax). The compiler normally issues an error message to help you locate and fix the incorrect code. Syntax errors are also called **compiler errors**, **compile-time errors** or **compilation errors**, because the compiler detects them during the compilation phase. You cannot execute your program until you correct all the syntax errors in it. As you'll see, some compilation errors are not syntax errors.*



Good Programming Practice 2.3

Indent the entire body of each function one level within the braces that delimit the body of the function. This makes a program's functional structure stand out and makes the program easier to read.



Good Programming Practice 2.4

Set a convention for the size of indent you prefer, then apply it uniformly. The tab key may be used to create indents, but tab stops may vary. We recommend using either 1/4-inch tab stops or (preferably) three spaces to form a level of indent.



2.3 Modifying Our First C++ Program

- ▶ welcome to C++! can be printed several ways.



```
1 // Fig. 2.3: fig02_03.cpp
2 // Printing a line of text with multiple statements.
3 #include <iostream> // allows program to output data to the screen
4
5 // function main begins program execution
6 int main()
7 {
8     std::cout << "Welcome ";
9     std::cout << "to C++!\n";
10 }
```

```
Welcome to C++!
```

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



2.3 Modifying Our First C++ Program (cont.)

- ▶ A single statement can print multiple lines by using newline characters.
- ▶ Each time the `\n` (newline) escape sequence is encountered in the output stream, the screen cursor is positioned to the beginning of the next line.
- ▶ To get a blank line in your output, place two newline characters back to back.



```
1 // Fig. 2.4: fig02_04.cpp
2 // Printing multiple lines of text with a single statement.
3 #include <iostream> // allows program to output data to the screen
4
5 // function main begins program execution
6 int main()
7 {
8     std::cout << "Welcome\n\nC++!\n";
9 } // end function main
```

```
Welcome
to

C++!
```

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



2.4 Another C++ Program: Adding Integers

- ▶ The input stream object `std::cin` and the stream extraction operator-, `>>`, can be used obtain data from the user at the keyboard.



```
1 // Fig. 2.5: fig02_05.cpp
2 // Addition program that displays the sum of two integers.
3 #include <iostream> // allows program to perform input and output
4
5 // function main begins program execution
6 int main()
7 {
8     // variable declarations
9     int number1; // first integer to add
10    int number2; // second integer to add
11    int sum; // sum of number1 and number2
12
13    std::cout << "Enter first integer: "; // prompt user for data
14    std::cin >> number1; // read first integer from user into number1
15
16    std::cout << "Enter second integer: "; // prompt user for data
17    std::cin >> number2; // read second integer from user into number2
18
19    sum = number1 + number2; // add the numbers; store result in sum
20
21    std::cout << "Sum is " << sum << std::endl; // display sum; end line
22 }
```

Fig. 2.5 | Addition program that displays the sum of two integers. (Part 1 of 2.)



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

Fig. 2.5 | Addition program that displays the sum of two integers. (Part 2 of 2.)



2.4 Another C++ Program: Adding Integers (cont.)

- ▶ **Declarations** introduce identifiers into programs.
- ▶ The identifiers `number1`, `number2` and `sum` are the names of **variables**.
- ▶ A variable is a location in the computer's memory where a value can be stored for use by a program.
- ▶ Variables `number1`, `number2` and `sum` are data of type `int`, meaning that these variables will hold **integer** values, i.e., whole numbers such as 7, -11, 0 and 31914.
- ▶ All variables must be declared with a name and a data type before they can be used in a program.
- ▶ If more than one name is declared in a declaration (as shown here), the names are separated by commas (,); this is referred to as a **comma-separated list**.



Good Programming Practice 2.5

Place a space after each comma (,) to make programs more readable.



2.4 Another C++ Program: Adding Integers (cont.)

- ▶ Data type `double` is for specifying real numbers, and data type `char` for specifying character data.
- ▶ Real numbers are numbers with decimal points, such as 3.4, 0.0 and -11.19.
- ▶ A `char` variable may hold only a single lowercase letter, a single uppercase letter, a single digit or a single special character (e.g., \$ or *).
- ▶ Types such as `int`, `double` and `char` are called **fundamental types**.
- ▶ Fundamental-type names are keywords and therefore must appear in all lowercase letters.
- ▶ Appendix C contains the complete list of fundamental types.



2.4 Another C++ Program: Adding Integers (cont.)

- ▶ A variable name is any valid **identifier** that is not a keyword.
- ▶ An identifier is a series of characters consisting of letters, digits and underscores (`_`) that does not begin with a digit.
- ▶ C++ is **case sensitive**—uppercase and lowercase letters are different, so `a1` and `A1` are different identifiers.



Portability Tip 2.1

C++ allows identifiers of any length, but your C++ implementation may restrict identifier lengths. Use identifiers of 31 characters or fewer to ensure portability.



Good Programming Practice 2.6

*Choosing meaningful identifiers makes a program **self-documenting**—a person can understand the program simply by reading it rather than having to refer to manuals or comments.*



Good Programming Practice 2.7

Avoid using abbreviations in identifiers. This promotes program readability.



Good Programming Practice 2.8

Avoid identifiers that begin with underscores and double underscores, because C++ compilers may use names like that for their own purposes internally. This will prevent names you choose from being confused with names the compilers choose.



Error-Prevention Tip 2.1

Languages like C++ are “moving targets.” As they evolve, more keywords could be added to the language. Avoid using “loaded” words like “object” as identifiers. Even though “object” is not currently a keyword in C++, it could become one; therefore, future compiling with new compilers could break existing code.



2.4 Another C++ Program: Adding Integers (cont.)

- ▶ Declarations of variables can be placed almost anywhere in a program, but they must appear before their corresponding variables are used in the program.



Good Programming Practice 2.9

Always place a blank line between a declaration and adjacent executable statements. This makes the declarations stand out in the program and contributes to program clarity.



2.4 Another C++ Program: Adding Integers (cont.)

- ▶ A **prompt** it directs the user to take a specific action.
- ▶ A `cin` statement uses the **input stream object** `cin` (of namespace `std`) and the **stream extraction operator**, `>>`, to obtain a value from the keyboard.
- ▶ Using the stream extraction operator with `std::cin` takes character input from the standard input stream, which is usually the keyboard.



Error-Prevention Tip 2.2

Programs should validate the correctness of all input values to prevent erroneous information from affecting a program's calculations.



2.4 Another C++ Program: Adding Integers (cont.)

- ▶ When the computer executes an input statement that places a value in an `int` variable, it waits for the user to enter a value for variable `number1`.
- ▶ The user responds by typing the number (as characters) then pressing the *Enter* key (sometimes called the Return key) to send the characters to the computer.
- ▶ The computer converts the character representation of the number to an integer and assigns (i.e., copies) this number (or **value**) to the variable `number1`.
- ▶ Any subsequent references to `number1` in this program will use this same value.
- ▶ In this program, an assignment statement adds the values of variables `number1` and `number2` and assigns the result to variable `sum` using the **assignment operator** `=`.
 - Most calculations are performed in assignment statements.



2.4 Another C++ Program: Adding Integers (cont.)

- ▶ The = operator and the + operator are called **binary operators** because each has two operands.



Good Programming Practice 2.10

Place spaces on either side of a binary operator. This makes the operator stand out and makes the program more readable.

15



2.4 Another C++ Program: Adding Integers (cont.)

- ▶ `std::endl` is a so-called **stream manipulator**.
- ▶ The name `endl` is an abbreviation for “end line” and belongs to namespace `std`.
- ▶ The `std::endl` stream manipulator outputs a newline, then “flushes the output buffer.”
 - This simply means that, on some systems where outputs accumulate in the machine until there are enough to “make it worthwhile” to display them on the screen, `std::endl` forces any accumulated outputs to be displayed at that moment.
 - This can be important when the outputs are prompting the user for an action, such as entering data.



2.4 Another C++ Program: Adding Integers (cont.)

- ▶ Using multiple stream insertion operators (<<) in a single statement is referred to as **concatenating**, **chaining** or **cascading stream insertion operations**.
- ▶ Calculations can also be performed in output statements.



2.5 Memory Concepts

- ▶ Variable names such as `number1`, `number2` and `sum` actually correspond to **locations** in the computer's memory.
- ▶ Every variable has a name, a type, a size and a value.
- ▶ When a value is placed in a memory location, the value overwrites the previous value in that location; thus, placing a new value into a memory location is said to be **destructive**.
- ▶ When a value is read out of a memory location, the process is **nondestructive**.



number1

45

Fig. 2.6 | Memory location showing the name and value of variable `number1`.



Fig. 2.7 | Memory locations after storing values for `number1` and `number2`.



number1	45
number2	72
sum	117

Fig. 2.8 | Memory locations after calculating and storing the sum of number1 and number2.



2.6 Arithmetic

- ▶ Most programs perform arithmetic calculations.
- ▶ Figure 2.9 summarizes the C++ **arithmetic operators**.
- ▶ The **asterisk** (`*`) indicates multiplication.
- ▶ The **percent sign** (`%`) is the **modulus** operator that will be discussed shortly.
 - C++ provides the **modulus operator**, `%`, that yields the remainder after integer division.
 - The modulus operator can be used only with integer operands.
- ▶ The arithmetic operators in Fig. 2.9 are all binary operators.
- ▶ **Integer division** (i.e., where both the numerator and the denominator are integers) yields an integer quotient.
 - Any fractional part in integer division is discarded (i.e., **truncated**)—no rounding occurs.



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

Fig. 2.9 | Arithmetic operators.



Common Programming Error 2.3

Attempting to use the modulus operator (%) with noninteger operands is a compilation error.



2.6 Arithmetic (cont.)

- ▶ Arithmetic expressions in C++ must be entered into the computer in **straight-line form**.
- ▶ 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 in C++ expressions in the same manner as in algebraic expressions.
- ▶ For example, to multiply a times the quantity $b + c$ we write $a * (b + c)$.



2.6 Arithmetic (cont.)

- ▶ C++ applies the operators in arithmetic expressions in a precise sequence determined by the following **rules of operator precedence**, which are generally the same as those followed in algebra.



Operator(s)	Operation(s)	Order of evaluation (precedence)
()	Parentheses	Evaluated first. If the parentheses are nested, the expression in the innermost pair is evaluated first. If there are several pairs of parentheses “on the same level” (i.e., not nested), they’re evaluated left to right.
*, /, %	Multiplication, Division, Modulus	Evaluated second. If there are several, they’re evaluated left to right.
+ -	Addition Subtraction	Evaluated last. If there are several, they’re evaluated left to right.

Fig. 2.10 | Precedence of arithmetic operators.



2.6 Arithmetic (cont.)

- ▶ There is no arithmetic operator for exponentiation in C++, so x^2 is represented as $x * x$.
- ▶ Figure 2.11 illustrates the order in which the operators in a second-degree polynomial are applied.
- ▶ As in algebra, it's acceptable to place unnecessary parentheses in an expression to make the expression clearer.
- ▶ These are called **redundant parentheses**.



Common Programming Error 2.4

*Some programming languages use operators $**$ or \wedge to represent exponentiation. C++ does not support these exponentiation operators; using them for exponentiation results in errors.*



Good Programming Practice 2.11

Using redundant parentheses in complex arithmetic expressions can make the expressions clearer.

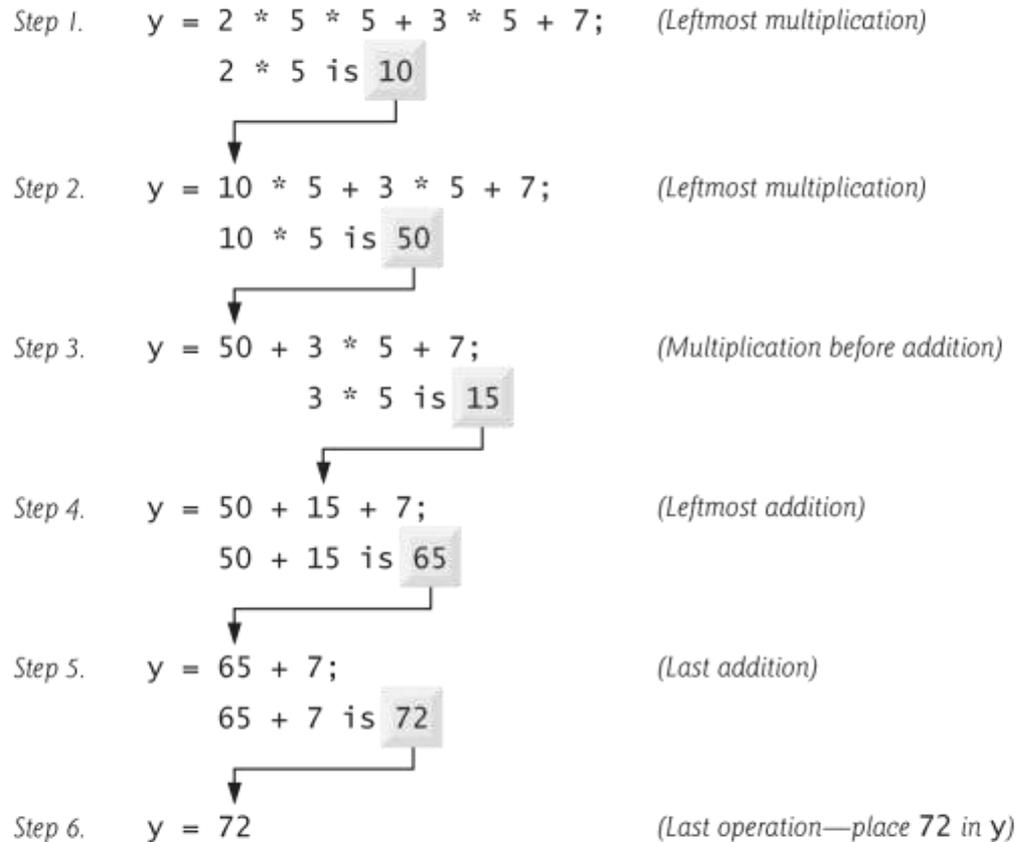


Fig. 2.11 | Order in which a second-degree polynomial is evaluated.



2.7 Decision Making: Equality and Relational Operators

- ▶ The **if statement** allows a program to take alternative action based on whether a **condition** is true or false.
- ▶ If the condition is true, the statement in the body of the **if** statement is executed.
- ▶ If the condition is false, the body statement is not executed.
- ▶ Conditions in **if** statements can be formed by using the **equality operators** and **relational operators** summarized in Fig. 2.12.
- ▶ The relational operators all have the same level of precedence and associate left to right.
- ▶ The equality operators both have the same level of precedence, which is lower than that of the relational operators, and associate left to right.



Common Programming Error 2.5

A syntax error will occur if any of the operators ==, !=, >= and <= appears with spaces between its pair of symbols.



Common Programming Error 2.7

Confusing the equality operator `==` with the assignment operator `=` results in logic errors. The equality operator should be read “is equal to,” and the assignment operator should be read “gets” or “gets the value of” or “is assigned the value of.” Some people prefer to read the equality operator as “double equals.” As we discuss in Section 4.9, confusing these operators may not necessarily cause an easy-to-recognize syntax error, but may cause extremely subtle logic errors.



Standard algebraic equality or relational operator	C++ equality or relational operator	Sample C++ condition	Meaning of C++ condition
<i>Relational operators</i>			
>	>	<code>x > y</code>	x is greater than y
<	<	<code>x < y</code>	x is less than y
\geq	<code>>=</code>	<code>x >= y</code>	x is greater than or equal to y
\leq	<code><=</code>	<code>x <= y</code>	x is less than or equal to y
<i>Equality operators</i>			
=	<code>==</code>	<code>x == y</code>	x is equal to y
\neq	<code>!=</code>	<code>x != y</code>	x is not equal to y

Fig. 2.12 | Equality and relational operators.



Common Programming Error 2.7

Confusing the equality operator `==` with the assignment operator `=` results in logic errors. The equality operator should be read “is equal to,” and the assignment operator should be read “gets” or “gets the value of” or “is assigned the value of.” Some people prefer to read the equality operator as “double equals.” As we discuss in Section 5.9, confusing these operators may not necessarily cause an easy-to-recognize syntax error, but may cause extremely subtle logic errors.



2.7 Decision Making: Equality and Relational Operators (cont.)

- ▶ The following example uses six `if` statements to compare two numbers input by the user.
- ▶ If the condition in any of these `if` statements is satisfied, the output statement associated with that `if` statement is executed.
- ▶ Figure 2.13 shows the program and the input/output dialogs of three sample executions.



```
1 // Fig. 2.13: fig02_13.cpp
2 // Comparing integers using if statements, relational operators
3 // and equality operators.
4 #include <iostream> // allows program to perform input and output
5
6 using std::cout; // program uses cout
7 using std::cin; // program uses cin
8 using std::endl; // program uses endl
9
10 // function main begins program execution
11 int main()
12 {
13     int number1; // first integer to compare
14     int number2; // second integer to compare
15
16     cout << "Enter two integers to compare: "; // prompt user for data
17     cin >> number1 >> number2; // read two integers from user
18
19     if ( number1 == number2 )
20         cout << number1 << " == " << number2 << endl;
21
```

Fig. 2.13 | Comparing integers using if statements, relational operators and equality operators. (Part I of 3.)



```
22  if ( number1 != number2 )
23      cout << number1 << " != " << number2 << endl;
24
25  if ( number1 < number2 )
26      cout << number1 << " < " << number2 << endl;
27
28  if ( number1 > number2 )
29      cout << number1 << " > " << number2 << endl;
30
31  if ( number1 <= number2 )
32      cout << number1 << " <= " << number2 << endl;
33
34  if ( number1 >= number2 )
35      cout << number1 << " >= " << number2 << endl;
36  } // end function main
```

```
Enter two integers to compare: 3 7
3 != 7
3 < 7
3 <= 7
```

Fig. 2.13 | Comparing integers using if statements, relational operators and equality operators. (Part 2 of 3.)



```
Enter two integers to compare: 22 12
22 != 12
22 > 12
22 >= 12
```

```
Enter two integers to compare: 7 7
7 == 7
7 <= 7
7 >= 7
```

Fig. 2.13 | Comparing integers using `if` statements, relational operators and equality operators. (Part 3 of 3.)



2.7 Decision Making: Equality and Relational Operators (cont.)

- ▶ `using declarations` that eliminate the need to repeat the `std::` prefix as we did in earlier programs.
- ▶ Once we insert these `using` declarations, we can write `cout` instead of `std::cout`, `cin` instead of `std::cin` and `endl` instead of `std::endl`, respectively, in the remainder of the program.
- ▶ Many programmers prefer to use the declaration `using namespace std;` which enables a program to use all the names in any standard C++ header file (such as `<iostream>`) that a program might include.
- ▶ From this point forward in the book, we'll use the preceding declaration in our programs.



2.7 Decision Making: Equality and Relational Operators (cont.)

- ▶ Each `if` statement in Fig. 2.13 has a single statement in its body and each body statement is indented.
- ▶ In Chapter 3 we show how to specify `if` statements with multiple-statement bodies (by enclosing the body statements in a pair of braces, `{ }`, creating what's called a **compound statement** or a **block**).



Good Programming Practice 2.12

Indent the statement(s) in the body of an `if` statement to enhance readability.



Good Programming Practice 2.13

For readability, there should be no more than one statement per line in a program.





Common Programming Error 2.8

Placing a semicolon immediately after the right parenthesis after the condition in an `if` statement is often a logic error (although not a syntax error). The semicolon causes the body of the `if` statement to be empty, so the `if` statement performs no action, regardless of whether or not its condition is true. Worse yet, the original body statement of the `if` statement now becomes a statement in sequence with the `if` statement and always executes, often causing the program to produce incorrect results.



2.7 Decision Making: Equality and Relational Operators (cont.)

- ▶ Statements may be split over several lines and may be spaced according to your preferences.
- ▶ It's a syntax error to split identifiers, strings (such as "hello") and constants (such as the number 1000) over several lines.



Common Programming Error 2.9

It's a syntax error to split an identifier by inserting white-space characters (e.g., writing `main` as `ma in`).



Good Programming Practice 2.14

A lengthy statement may be spread over several lines. If a single statement must be split across lines, choose meaningful breaking points, such as after a comma in a comma-separated list, or after an operator in a lengthy expression. If a statement is split across two or more lines, indent all subsequent lines and left-align the group of indented lines.



2.7 Decision Making: Equality and Relational Operators (cont.)

- ▶ Figure 2.14 shows the precedence and associativity of the operators introduced in this chapter.
- ▶ The operators are shown top to bottom in decreasing order of precedence.
- ▶ All these operators, with the exception of the assignment operator `=`, associate from left to right.



Operators	Associativity	Type
()	left to right	parentheses
* / %	left to right	multiplicative
+ -	left to right	additive
<< >>	left to right	stream insertion/extraction
< <= > >=	left to right	relational
== !=	left to right	equality
=	right to left	assignment

Fig. 2.14 | Precedence and associativity of the operators discussed so far.



Good Programming Practice 2.15

Refer to the operator precedence and associativity chart when writing expressions containing many operators. Confirm that the operators in the expression are performed in the order you expect. If you're uncertain about the order of evaluation in a complex expression, break the expression into smaller statements or use parentheses to force the order of evaluation, exactly as you'd do in an algebraic expression. Be sure to observe that some operators such as assignment (=) associate right to left rather than left to right.