Chapter 2 Introduction to C Programming

C How to Program, 7/e

OBJECTIVES

In this chapter, you'll:

- Write simple computer programs in C.
- Use simple input and output statements.
- Use the fundamental data types.
- Learn computer memory concepts.
- Use arithmetic operators.
- Learn the precedence of arithmetic operators.
- Write simple decision-making statements.

2.1 Introduction

- The C language facilitates a structured and disciplined approach to computer program design.
- In this chapter we introduce C programming and present several examples that illustrate many important features of C.
- In Chapters 3 and 4 we present an introduction to structured programming in C.

2.2 A Simple C Program: Printing a Line of Text

- We begin by considering a simple C program.
- Our first example prints a line of text (Fig. 2.1).

```c
// Fig. 2.1: fig02_01.c
// A first program in C.
#include <stdio.h>

// function main begins program execution
int main( void )
{
   printf( "Welcome to C!\n" );
} // end function main
```

```
Welcome to C!
```

Fig. 2.1 | A first program in C.

2.2 A Simple C Program: Printing a Line of Text (Cont.)

- Lines 1 and 2

  -
    ```
    // Fig. 2.1: fig02_01.c
       A first program in C
    ```
- begin with `//`, indicating that these two lines are comments.
- You insert comments to document programs and improve program readability.
- Comments do not cause the computer to perform any action when the program is run.

2.2 A Simple C Program: Printing a Line of Text (Cont.)

- Comments are ignored by the C compiler and do not cause any machine-language object code to be generated.
- Comments also help other people read and understand your program.

2.2 A Simple C Program: Printing a Line of Text (Cont.)

- You can also use /*…*/ multi-line comments in which everything from /* on the first line to */ at the end of the line is a comment.
- We prefer // comments because they're shorter and they eliminate the common programming errors that occur with /*…*/ comments, especially when the closing */ is omitted.

***#include* Preprocessor Directive**

- Line 3
  - `#include <stdio.h>`
- is a directive to the C preprocessor.

2.2 A Simple C Program: Printing a Line of Text (Cont.)

- Lines beginning with # are processed by the preprocessor before compilation.
- Line 3 tells the preprocessor to include the contents of the standard input/output header (`<stdio.h>`) in the program.
- This header contains information used by the compiler when compiling calls to standard input/output library functions such as `printf`.

Blank Lines and White Space

- Line 4 is simply a blank line. 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.

2.2 A Simple C Program: Printing a Line of Text (Cont.)

The `main` Function

- Line 6
  - `int main( void )`
- is a part of every C program.
- The parentheses after `main` indicate that `main` is a program building block called a function.

2.2 A Simple C Program: Printing a Line of Text (Cont.)

- C programs contain one or more functions, one of which *must* be `main`.
- Every program in C begins executing at the function `main`.
- The keyword `int` to the left of `main` indicates that `main` "returns" an integer (whole number) value.
- We'll explain what it means for a function to "return a value" when we demonstrate how to create your own functions in Chapter 5.

2.2 A Simple C Program: Printing a Line of Text (Cont.)

- For now, simply include the keyword `int` to the left of `main` in each of your programs.
- Functions also can receive information when they're called upon to execute.
- The `void` in parentheses here means that `main` does not receive any information.

Good Programming Practice 2.1

Every function should be preceded by a comment describing the purpose of the function.

2.2 A Simple C Program: Printing a Line of Text (Cont.)

- A left brace, {, begins the body of every function (line 7).
- A corresponding right brace ends each function (line 11).
- This pair of braces and the portion of the program between the braces is called a block.

An Output Statement

- Line 8
  - `printf( "Welcome to C!\n" );`
- instructs the computer to perform an action, namely to print on the screen the string of characters marked by the quotation marks.
- A string is sometimes called a character string, a message or a literal.

2.2 A Simple C Program: Printing a Line of Text (Cont.)

- The entire line, including the `printf` function (the “f” stands for “formatted”), its argument within the parentheses and the semicolon `(;)`, is called a statement.
- Every statement must end with a semicolon (also known as the statement terminator).
- When the preceding `printf` statement is executed, it prints the message `Welcome to C!` on the screen.
- The characters normally print exactly as they appear between the double quotes in the `printf` statement.

Escape Sequences

- Notice that the characters `\n` were not printed on the screen.
- The backslash (\) is called an escape character.
- It indicates that `printf` is supposed to do something out of the ordinary.

2.2 A Simple C Program: Printing a Line of Text (Cont.)

- When encountering a backslash in a string, the compiler looks ahead at the next character and combines it with the backslash to form an escape sequence.
- The escape sequence `\n` means newline.
- When a newline appears in the string output by a `printf`, the newline causes the cursor to position to the beginning of the next line on the screen.
- Some common escape sequences are listed in Fig. 2.2.

Escape sequence	Description
`\n`	Newline. Position the cursor at the beginning of the next line.
`\t`	Horizontal tab. Move the cursor to the next tab stop.
`\a`	Alert. Produces a sound or visible alert without changing the current cursor position.
`\\`	Backslash. Insert a backslash character in a string.
`\"`	Double quote. Insert a double-quote character in a string.

Fig. 2.2 | Some common escape sequences .

2.2 A Simple C Program: Printing a Line of Text (Cont.)

- Because the backslash has special meaning in a string, i.e., the compiler recognizes it as an escape character, we use a double backslash (`\\`) to place a single backslash in a string.
- Printing a double quote also presents a problem because double quotes mark the boundaries of a string—such quotes are not printed.
- By using the escape sequence `\"` in a string to be output by `printf`, we indicate that `printf` should display a double quote.
- The right brace, `}`, (line 9) indicates that the end of `main` has been reached.

Good Programming Practice 2.2

Add a comment to the line containing the right brace, `}`, that closes every function, including `main`.

2.2 A Simple C Program: Printing a Line of Text (Cont.)

- We said that `printf` causes the computer to perform an action.
- As any program executes, it performs a variety of actions and makes decisions.
- Chapter 3 discusses this action/decision model of programming in depth.

Common Programming Error 2.1

Mistyping the name of the output function `printf` as `print` in a program.

2.2 A Simple C Program: Printing a Line of Text (Cont.)

The Linker and Executables

- Standard library functions like `printf` and `scanf` are not part of the C programming language.
- For example, the compiler cannot find a spelling error in `printf` or `scanf`.
- When the compiler compiles a `printf` statement, it merely provides space in the object program for a “call” to the library function.
- But the compiler does not know where the library functions are—the linker does.
- When the linker runs, it locates the library functions and inserts the proper calls to these library functions in the object program.

2.2 A Simple C Program: Printing a Line of Text (Cont.)

- Now the object program is complete and ready to be executed.
- For this reason, the linked program is called an executable.
- If the function name is misspelled, it's the linker that will spot the error, because it will not be able to match the name in the C program with the name of any known function in the libraries.

Good Programming Practice 2.3

Indent the entire body of each function one level of indentation (we recommend three spaces) within the braces that define the body of the function. This indentation emphasizes the functional structure of programs and helps make programs easier to read.

Good Programming Practice 2.4

Set a convention for the size of indent you prefer and then uniformly apply that convention. The tab key may be used to create indents, but tab stops may vary.

2.2 A Simple C Program: Printing a Line of Text (Cont.)

Using Multiple `printf`s

- The `printf` function can print `Welcome to C!` several different ways.
- For example, the program of Fig. 2.3 produces the same output as the program of Fig. 2.1.
- This works because each `printf` resumes printing where the previous `printf` stopped printing.
- The first `printf` (line 8) prints `Welcome` followed by a space and the second `printf` (line 9) begins printing on the same line immediately following the space.

```c
// Fig. 2.3: fig02_03.c
// Printing on one line with two printf statements.
#include <stdio.h>

// function main begins program execution
int main( void )
{
   printf( "Welcome " );
   printf( "to C!\n" );
} // end function main
```

```
Welcome to C!
```

Fig. 2.3 | Printing on one line with two `printf` statements.

2.2 A Simple C Program: Printing a Line of Text (Cont.)

- One `printf` can print *several* lines by using additional newline characters as in Fig. 2.4.
- Each time the `\n` (newline) escape sequence is encountered, output continues at the beginning of the next line.

```c
// Fig. 2.4: fig02_04.c
// Printing multiple lines with a single printf.
#include <stdio.h>

// function main begins program execution
int main( void )
{
   printf( "Welcome\nto\nC!\n" );
} // end function main
```

```
Welcome
to
C!
```

Fig. 2.4 | Printing multiple lines with a single `printf`.

2.3 Another Simple C Program: Adding Two Integers

- Our next program (fig. 2.5) uses the Standard Library function `scanf` to obtain two integers typed by a user at the keyboard, computes the sum of these values and prints the result using `printf`.
- [In the input/output dialog of Fig. 2.5, we emphasize the numbers entered by the user in **bold.]**

```c
// Fig. 2.5: fig02_05.c
// Addition program.
#include <stdio.h>

// function main begins program execution
int main( void )
{
   int integer1; // first number to be entered by user
   int integer2; // second number to be entered by user
   int sum; // variable in which sum will be stored

   printf( "Enter first integer\n" ); // prompt
   scanf( "%d", &integer1 ); // read an integer

   printf( "Enter second integer\n" ); // prompt
   scanf( "%d", &integer2 ); // read an integer

   sum = integer1 + integer2; // assign total to sum

   printf( "Sum is %d\n", sum ); // print sum
} // end function main
```

Fig. 2.5 | Addition program. (Part 1 of 2.)

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

Fig. 2.5 | Addition program. (Part 2 of 2.)

2.3 Another Simple C Program: Adding Two Integers (Cont.)

Variables and Variable Definitions

- Lines 8–10

  -
    ```
    int integer1; /* first number to be input by user
    */
    int integer2; /* second number to be input by user
    */
    int sum; /* variable in which sum will be stored */
    ```

  are definitions.
- The names `integer1`, `integer2` and `sum` are the names of variables—locations in memory where values can be stored for use by a program.
- These definitions specify that the variables `integer1`, `integer2` and `sum` are of type `int`, which means that they'll hold integer values, i.e., whole numbers such as 7, –11, 0, 31914 and the like.

2.3 Another Simple C Program: Adding Two Integers (Cont.)

- All variables must be defined with a name and a data type before they can be used in a program.
- The preceding definitions could have been combined into a single definition statement as follows:
  - `int integer1, integer2, sum;`

  but that would have made it difficult to describe the variables with corresponding comments as we did in lines 8–10.

2.3 Another Simple C Program: Adding Two Integers (Cont.)

Identifiers and Case Sensitivity

- A variable name in C is any valid identifier.
- 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 in C, so `a1` and `A1` are different identifiers.

Common Programming Error 2.2

Using a capital letter where a lowercase letter should be used (for example, typing `Main` instead of `main`).

Error-Prevention Tip 2.1

Avoid starting identifiers with the underscore character (_) to prevent conflicts with compiler-generated identifiers and standard library identifiers.

Good Programming Practice 2.5

Choosing meaningful variable names helps make a program self-documenting—that is, fewer comments are needed.

Good Programming Practice 2.6

The first letter of an identifier used as a simple variable name should be a lowercase letter. Later in the text we'll assign special significance to identifiers that begin with a capital letter and to identifiers that use all capital letters.

Good Programming Practice 2.7

Multiple-word variable names can help make a program more readable. Separate the words with underscores as in `total_commissions`, or, if you run the words together, begin each word after the first with a capital letter as in `totalCommissions`. The latter style is preferred.

2.3 Another Simple C Program: Adding Two Integers (Cont.)

Syntax Errors

- Recall that the Microsoft Visual C++ compiler requires variable definitions to be placed *after* the left brace of a function and *before* any executable statements.
- Therefore, in the program in Fig. 2.5, inserting the definition of `integer1` *after* the first `printf` would cause a syntax error in Visual C++.

Common Programming Error 2.3

Placing variable definitions among executable statements causes syntax errors in the Microsoft Visual C++ Compiler.

2.3 Another Simple C Program: Adding Two Integers (Cont.)

Prompting Messages

- Line 12
  - `printf( "Enter first integer\n" ); /* prompt */`

  displays the literal “`Enter first integer`” and positions the cursor to the beginning of the next line.
- This message is called a prompt because it tells the user to take a specific action.

2.3 Another Simple C Program: Adding Two Integers (Cont.)

The `scanf` Function and Formatted Inputs

- The next statement
  - `scanf( "%d", &integer1 ); /* read an integer */`

  uses `scanf` to obtain a value from the user.
- The `scanf` function reads from the standard input, which is usually the keyboard.

2.3 Another Simple C Program: Adding Two Integers (Cont.)

- This `scanf` has two arguments, `"%d"` and `&integer1`.
- The first, the format control string, indicates the type of data that should be input by the user.
- The `%d` conversion specifier indicates that the data should be an integer (the letter `d` stands for “decimal integer”).
- The % in this context is treated by `scanf` (and `printf` as we’ll see) as a special character that begins a conversion specifier.
- The second argument of `scanf` begins with an ampersand (&)—called the address operator in C—followed by the variable name.

2.3 Another Simple C Program: Adding Two Integers (Cont.)

- The &, when combined with the variable name, tells `scanf` the location (or address) in memory at which the variable `integer1` is stored.
- The computer then stores the value that the user enters for `integer1` at that location.
- The use of ampersand (&) is often confusing to novice programmers or to people who have programmed in other languages that do not require this notation.
- For now, just remember to precede each variable in every call to `scanf` with an ampersand.

Good Programming Practice 2.8

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

2.3 Another Simple C Program: Adding Two Integers (Cont.)

- When the computer executes the preceding `scanf`, it waits for the user to enter a value for variable `integer1`.
- The user responds by typing an integer, then pressing the *Enter* key to send the number to the computer.
- The computer then assigns this number, or value, to the variable `integer1`.
- Any subsequent references to `integer1` in this program will use this same value.
- Functions `printf` and `scanf` facilitate interaction between the user and the computer.
- Because this interaction resembles a dialogue, it's often called interactive computing.

2.3 Another Simple C Program: Adding Two Integers (Cont.)

- Line 15
  - `printf( "Enter second integer\n" ); /* prompt */`

  displays the message `Enter second integer` on the screen, then positions the cursor to the beginning of the next line.
- This `printf` also prompts the user to take action.
- Line 16
  - `scanf( "%d", &integer2 ); /* read an integer */`

  obtains a value for variable `integer2` from the user.

2.3 Another Simple C Program: Adding Two Integers (Cont.)

Assignment Statement

- The assignment statement in line 18
  - `sum = integer1 + integer2; /* assign total to sum */`

  calculates the total of variables `integer1` and `integer2` and assigns the result to variable `sum` using the assignment operator `=`.
- The statement is read as, "`sum` *gets* the value of `integer1 + integer2`." Most calculations are performed in assignments.
- The `=` operator and the `+` operator are called binary operators because each has two operands.
- The `+` operator's two operands are `integer1` and `integer2`.
- The `=` operator's two operands are `sum` and the value of the expression `integer1 + integer2`.

Good Programming Practice 2.9

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

Common Programming Error 2.4

A calculation in an assignment statement must be on the right side of the `=` operator. It's a compilation error to place a calculation on the left side of an assignment operator.

2.3 Another Simple C Program: Adding Two Integers (Cont.)

Printing with a Format Control String

- Line 20
  - `printf( "Sum is %d\n", sum ); /* print sum */`

  calls function `printf` to print the literal `Sum is` followed by the numerical value of variable `sum` on the screen.
- This `printf` has two arguments, `"Sum is %d\n"` and `sum`.
- The first argument is the format control string.
- It contains some literal characters to be displayed, and it contains the conversion specifier `%d` indicating that an integer will be printed.
- The second argument specifies the value to be printed.
- Notice that the conversion specifier for an integer is the same in both `printf` and `scanf`.

2.3 Another Simple C Program: Adding Two Integers (Cont.)

Calculations in `printf` Statements

- We could have combined the previous two statements into the statement
  - `printf( "Sum is %d\n", integer1 + integer2 );`
- The right brace, `}`, at line 21 indicates that the end of function `main` has been reached.

Common Programming Error 2.5

Forgetting to precede a variable in a `scanf` statement with an ampersand when that variable should, in fact, be preceded by an ampersand results in an execution-time error. On many systems, this causes a "segmentation fault" or "access violation." Such an error occurs when a user's program attempts to access a part of the computer's memory to which it does not have access privileges. The precise cause of this error will be explained in Chapter 7.

Common Programming Error 2.6

Preceding a variable included in a `printf` statement with an ampersand when, in fact, that variable should not be preceded by an ampersand.

2.4 Memory Concepts

- Variable names such as `integer1`, `integer2` and `sum` actually correspond to locations in the computer's memory.
- Every variable has a name, a type and a value.
- In the addition program of Fig. 2.5, when the statement (line 13)
  - `scanf( "%d", &integer1 ); /* read an integer */`
- is executed, the value entered by the user is placed into a memory location to which the name `integer1` has been assigned.
- Suppose the user enters the number `45` as the value for `integer1`.
- The computer will place `45` into location `integer1` as shown in Fig. 2.6.

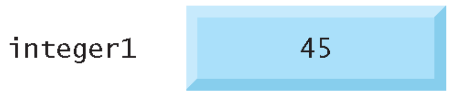


Fig. 2.6 | Memory location showing the name and value of a variable.

2.4 Memory Concepts (Cont.)

- Whenever a value is placed in a memory location, the value replaces the previous value in that location; thus, this process is said to be destructive.
- Returning to our addition program again, when the statement (line 16)
  - `scanf( "%d", &integer2 ); /* read an integer */`

  executes, suppose the user enters the value `72`.
- This value is placed into location `integer2`, and memory appears as in Fig. 2.7.
- These locations are not necessarily adjacent in memory.

2.4 Memory Concepts (Cont.)

- Once the program has obtained values for `integer1` and `integer2`, it adds these values and places the total into variable `sum`.
- The statement (line 18)
  - `sum = integer1 + integer2; /* assign total to sum */`
- that performs the addition also replaces whatever value was stored in `sum`.

2.4 Memory Concepts (Cont.)

- This occurs when the calculated total of `integer1` and `integer2` is placed into location `sum` (destroying the value already in `sum`).
- After `sum` is calculated, memory appears as in Fig. 2.8.
- The values of `integer1` and `integer2` appear exactly as they did before they were used in the calculation.

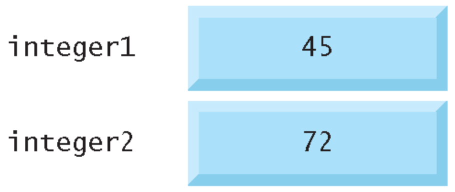


Fig. 2.7 | Memory locations after both variables are input.

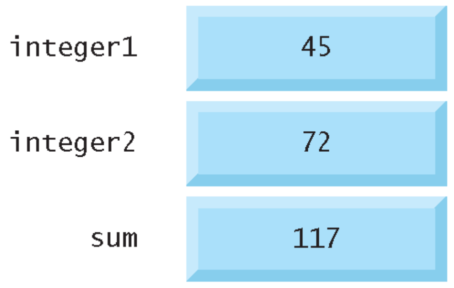


Fig. 2.8 | Memory locations after a calculation.

2.4 Memory Concepts (Cont.)

- They were used, but not destroyed, as the computer performed the calculation.
- Thus, when a value is read from a memory location, the process is said to be nondestructive.

2.5 Arithmetic in C

- Most C programs perform calculations using the C arithmetic operators (Fig. 2.9).
- Note the use of various special symbols not used in algebra.
- The asterisk (`*`) indicates multiplication and the percent sign (`%`) denotes the remainder operator, which is introduced below.
- In algebra, to multiply *a* times *b*, we simply place these single-letter variable names side by side as in *ab*.
- In C, however, if we were to do this, `ab` would be interpreted as a single, two-letter name (or identifier).
- Therefore, C requires that multiplication be explicitly denoted by using the `*` operator as in `a * b`.
- The arithmetic operators are all binary operators.
- For example, the expression `3 + 7` contains the binary operator `+` and the operands `3` and `7`.

C operation	Arithmetic operator	Algebraic expression	C 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`
Remainder	%	$r \bmod s$	`r % s`

Fig. 2.9 | Arithmetic operators.

2.5 Arithmetic in C (Cont.)

Integer Division and the Remainder Operator

- Integer division yields an integer result.
- For example, the expression `7 / 4` evaluates to `1` and the expression `17 / 5` evaluates to `3`.
- C provides the remainder operator, `%`, which yields the remainder after integer division.
- The remainder operator is an integer operator that can be used only with integer operands.
- The expression `x % y` yields the remainder after `x` is divided by `y`.
- Thus, `7 % 4` yields `3` and `17 % 5` yields `2`.

Common Programming Error 2.7

An attempt to divide by zero is normally undefined on computer systems and generally results in a fatal error, i.e., an error that causes the program to terminate immediately without having successfully performed its job. Nonfatal errors allow programs to run to completion, often producing incorrect results.

2.5 Arithmetic in C (Cont.)

Arithmetic Expressions in Straight-Line Form

- Arithmetic expressions in C must be written in straight-line form to facilitate entering programs into the computer.
- Thus, expressions such as "`a` divided by `b`" must be written as `a/b` so that all operators and operands appear in a straight line.
- The algebraic notation

  $$\frac{a}{b}$$

  is generally not acceptable to compilers, although some special-purpose software packages do support more natural notation for complex mathematical expressions.

2.5 Arithmetic in C (Cont.)

Parentheses for Grouping Subexpressions

- 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 )`.

2.5 Arithmetic in C (Cont.)

Rules of Operator Precedence

- 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 in algebra:
  - Operators in expressions contained within pairs of parentheses are evaluated first. Parentheses are said to be at the "highest level of precedence." In cases of nested, or embedded, parentheses, such as
    - `( ( a + b ) + c )`

    the operators in the innermost pair of parentheses are applied first.

2.5 Arithmetic in C (Cont.)

- Multiplication, division and remainder operations are applied next. If an expression contains several multiplication, division and remainder operations, evaluation proceeds from left to right. Multiplication, division and remainder are said to be on the same level of precedence.
- Addition and subtraction operations are evaluated next. If an expression contains several addition and subtraction operations, evaluation proceeds from left to right. Addition and subtraction also have the same level of precedence, which is lower than the precedence of the multiplication, division and remainder operations.
- The assignment operator (=) is evaluated last.

2.5 Arithmetic in C (Cont.)

- The rules of operator precedence specify the order C uses to evaluate expressions. When we say evaluation proceeds from left to right, we're referring to the associativity of the operators.
- We'll see that some operators associate from right to left.
- Figure 2.10 summarizes these rules of operator precedence for the operators we've seen so far.

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 Remainder	Evaluated second. If there are several, they're evaluated left to right.
+ -	Addition Subtraction	Evaluated third. If there are several, they're evaluated left to right.
=	Assignment	Evaluated last.

Fig. 2.10 | Precedence of arithmetic operators.

2.5 Arithmetic in C (Cont.)

- Figure 2.11 illustrates the order in which the operators are applied.

```
Step 1.   y = 2 * 5 * 5 + 3 * 5 + 7;      (Leftmost multiplication)
              2 * 5 is 10

Step 2.   y = 10 * 5 + 3 * 5 + 7;         (Leftmost multiplication)
              10 * 5 is 50

Step 3.   y = 50 + 3 * 5 + 7;             (Multiplication before addition)
                   3 * 5 is 15

Step 4.   y = 50 + 15 + 7;                (Leftmost addition)
              50 + 15 is 65

Step 5.   y = 65 + 7;                     (Last addition)
              65 + 7 is 72

Step 6.   y = 72                          (Last operation—place 72 in y)
```

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

2.5 Arithmetic in C (Cont.)

- As in algebra, it’s acceptable to place unnecessary parentheses in an expression to make the expression clearer.
- These are called redundant parentheses.

2.6 Decision Making: Equality and Relational Operators

- Executable C statements either perform actions (such as calculations or input or output of data) or make decisions (we'll soon see several examples of these).
- We might make a decision in a program, for example, to determine whether a person's grade on an exam is greater than or equal to 60 and whether the program should print the message "Congratulations! You passed."
- This section introduces a simple version of C's `if` statement that allows a program to make a decision based on the truth or falsity of a statement of fact called a condition.

2.6 Arithmetic in C (Cont.)

- If the condition is true (i.e., the condition is met) the statement in the body of the `if` statement is executed.
- If the condition is false (i.e., the condition isn't met) the body statement is not executed.
- Whether the body statement is executed or not, after the `if` statement completes, execution proceeds with the next statement after the `if` statement.
- Conditions in `if` statements are formed by using the equality operators and relational operators summarized in Fig. 2.12.

2.6 Arithmetic in C (Cont.)

- The relational operators all have the same level of precedence and they associate left to right.
- The equality operators have a lower level of precedence than the relational operators and they also associate left to right.
- In C, a condition may actually be *any expression that generates a zero (false) or nonzero (true) value*.

Common Programming Error 2.8

A syntax error occurs if the two symbols in any of the operators ==, != , >= and <= are separated by spaces.

Common Programming Error 2.9

Confusing the equality operator == with the assignment operator. To avoid this confusion, the equality operator should be read “double equals” and the assignment operator should be read “gets” or “is assigned the value of.” As you’ll see, confusing these operators may not cause an easy-to-recognize compilation error, but may cause extremely subtle logic errors.

Algebraic equality or relational operator	C equality or relational operator	Example of C conditio n	Meaning of C condition
Equality operators			
$=$	`==`	`x == y`	x is equal to y
$\neq$	`!=`	`x != y`	x is not equal to y
Relational operators			
$>$	`>`	`x > y`	x is greater than y
$<$	`<`	`x < y`	x is less than y
$\geq$	`>=`	`x >= y`	x is greater than or equal to y
$\leq$	`<=`	`x <= y`	x is less than or equal to y

Fig. 2.12 | Equality and relational operators.

2.6 Arithmetic in C (Cont.)

- Figure 2.13 uses six `if` statements to compare two numbers entered by the user.
- If the condition in any of these `if` statements is true, the `printf` statement associated with that `if` executes.

```c
// Fig. 2.13: fig02_13.c
// Using if statements, relational
// operators, and equality operators.
#include <stdio.h>

// function main begins program execution
int main( void )
{
   int num1; // first number to be read from user
   int num2; // second number to be read from user

   printf( "Enter two integers, and I will tell you\n" );
   printf( "the relationships they satisfy: " );

   scanf( "%d%d", &num1, &num2 ); // read two integers

   if ( num1 == num2 ) {
      printf( "%d is equal to %d\n", num1, num2 );
   } // end if

   if ( num1 != num2 ) {
      printf( "%d is not equal to %d\n", num1, num2 );
   } // end if
```

Fig. 2.13 | Using if statements, relational operators, and equality operators. (Part 1 of 3.)

```
    if ( num1 < num2 ) {
       printf( "%d is less than %d\n", num1, num2 );
    } // end if

    if ( num1 > num2 ) {
       printf( "%d is greater than %d\n", num1, num2 );
    } // end if

    if ( num1 <= num2 ) {
       printf( "%d is less than or equal to %d\n", num1, num2 );
    } // end if

    if ( num1 >= num2 ) {
       printf( "%d is greater than or equal to %d\n", num1, num2 );
    } // end if
} // end function main
```

Fig. 2.13 | Using `if` statements, relational operators, and equality operators. (Part 2 of 3.)

```
Enter two integers, and I will tell you
the relationships they satisfy: 3 7
3 is not equal to 7
3 is less than 7
3 is less than or equal to 7
```

```
Enter two integers, and I will tell you
the relationships they satisfy: 22 12
22 is not equal to 12
22 is greater than 12
22 is greater than or equal to 12
```

```
Enter two integers, and I will tell you
the relationships they satisfy: 7 7
7 is equal to 7
7 is less than or equal to 7
7 is greater than or equal to 7
```

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

2.6 Arithmetic in C (Cont.)

- The program uses `scanf` (line 15) to input two numbers.
- Each conversion specifier has a corresponding argument in which a value will be stored.
- The first `%d` converts a value to be stored in the variable `num1`, and the second `%d` converts a value to be stored in variable `num2`.

Good Programming Practice 2.10

Although it's allowed, there should be no more than one statement per line in a program.

Common Programming Error 2.10

Placing commas (when none are needed) between conversion specifiers in the format control string of a `scanf` statement.

2.6 Arithmetic in C (Cont.)

Comparing Numbers

- The if statement in lines 17–19

  ```
  if ( num1 == num2 ) {
     printf( "%d is equal to %d\n", num1, num2 );
  }
  ```

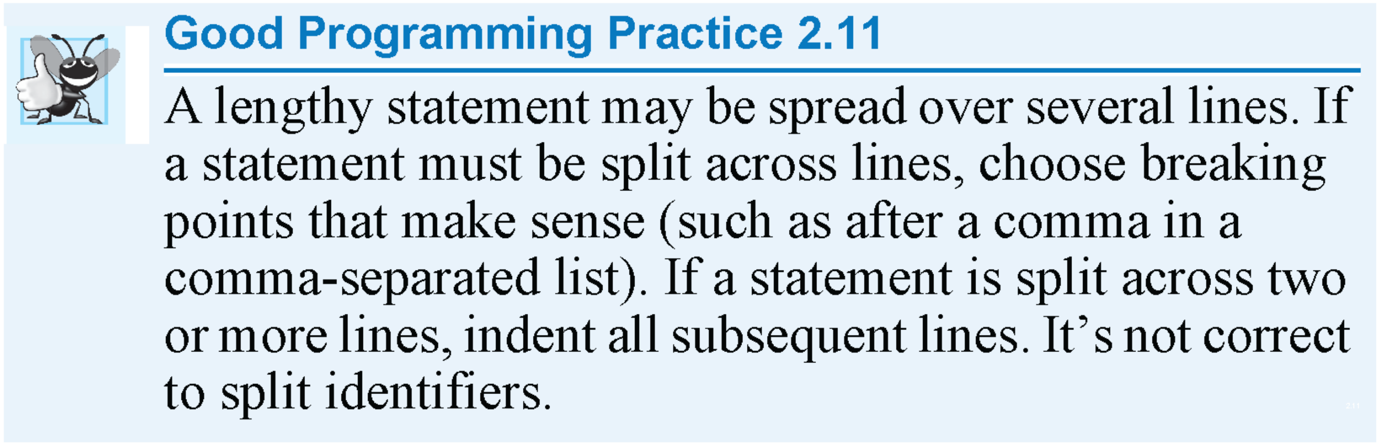
  compares the values of variables `num1` and `num2` to test for equality.
- If the values are equal, the statement in line 18 displays a line of text indicating that the numbers are equal.
- If the conditions are `true` in one or more of the `if` statements starting in lines 21, 25, 29, 33 and 37, the corresponding body statement displays an appropriate line of text.
- Indenting the body of each `if` statement and placing blank lines above and below each `if` statement enhances program readability.

Common Programming Error 2.11

Placing a semicolon immediately to the right of the right parenthesis after the condition in an `if` statement.

2.6 Arithmetic in C (Cont.)

- A left brace, `{`, begins the body of each `if` statement (e.g., line 17).
- A corresponding right brace, `}`, ends each `if` statement’s body (e.g., line 19).
- Any number of statements can be placed in the body of an `if` statement.



Good Programming Practice 2.11

A lengthy statement may be spread over several lines. If a statement must be split across lines, choose breaking points that make sense (such as after a comma in a comma-separated list). If a statement is split across two or more lines, indent all subsequent lines. It's not correct to split identifiers.

2.6 Arithmetic in C (Cont.)

- Figure 2.14 lists from highest to lowest the precedence of the operators introduced in this chapter.
- Operators are shown top to bottom in decreasing order of precedence.
- The equals sign is also an operator.
- All these operators, with the exception of the assignment operator =, associate from left to right.
- The assignment operator (=) associates from right to left.

Good Programming Practice 2.12

Refer to the operator precedence chart when writing expressions containing many operators. Confirm that the operators in the expression are applied in the proper order. If you're uncertain about the order of evaluation in a complex expression, use parentheses to group expressions or break the statement into several simpler statements. Be sure to observe that some of C's operators such as the assignment operator (`=`) associate from right to left rather than from left to right.

Operators	Associativity
`()`	left to right
`*` `/` `%`	left to right
`+` `-`	left to right
`<` `<=` `>` `>=`	left to right
`==` `!=`	left to right
`=`	right to left

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

2.6 Arithmetic in C (Cont.)

- Some of the words we've used in the C programs in this chapter—in particular `int` and `if`—are keywords or reserved words of the language.
- Figure 2.15 contains the C keywords.
- These words have special meaning to the C compiler, so you must be careful not to use these as identifiers such as variable names.

Keywords			
`auto`	`double`	`int`	`struct`
`break`	`else`	`long`	`switch`
`case`	`enum`	`register`	`typedef`
`char`	`extern`	`return`	`union`
`const`	`float`	`short`	`unsigned`
`continue`	`for`	`signed`	`void`
`default`	`goto`	`sizeof`	`volatile`
`do`	`if`	`static`	`while`
Keywords added in C99 standard			
`_Bool _Complex _Imaginary inline restrict`			
Keywords added in C11 draft standard			
`_Alignas _Alignof _Atomic _Generic _Noreturn _Static_assert _Thread_local`			

Fig. 2.15 | C's keywords.