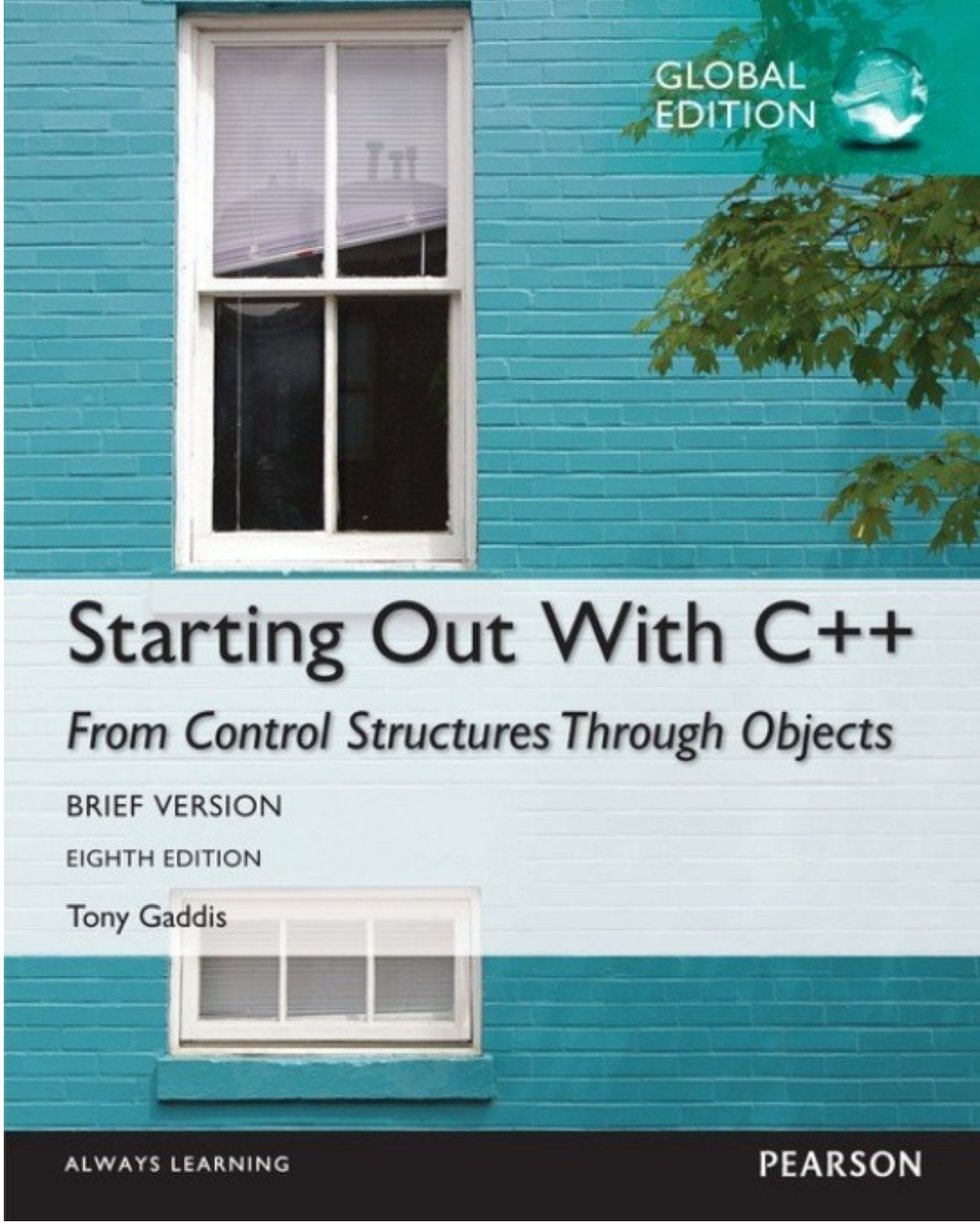
Chapter 3:

Expressions and Interactivity



The `cin` Object

- Standard input object
- Like `cout`, requires `iostream` file
- Used to read input from keyboard
- Information retrieved from `cin` with `>>`
- Input is stored in one or more variables

The `cin` Object in Program 3-1

Program 3-1

```
1  // This program asks the user to enter the length and width of
2  // a rectangle. It calculates the rectangle's area and displays
3  // the value on the screen.
4  #include <iostream>
5  using namespace std;
6
7  int main()
8  {
9     int length, width, area;
10
11    cout << "This program calculates the area of a ";
12    cout << "rectangle.\n";
13    cout << "What is the length of the rectangle? ";
14    cin >> length;
15    cout << "What is the width of the rectangle? ";
16    cin >> width;
17    area = length * width;
18    cout << "The area of the rectangle is " << area << ".\n";
19    return 0;
20 }
```

Program Output with Example Input Shown in Bold

```
This program calculates the area of a rectangle.
What is the length of the rectangle? 10 [Enter]
What is the width of the rectangle? 20 [Enter]
The area of the rectangle is 200.
```

Displaying a Prompt

- A prompt is a message that instructs the user to enter data.
- You should always use **`cout`** to display a prompt before each **`cin`** statement.

```
cout << "How tall is the room? ";
cin >> height;
```

The `cin` Object

- Can be used to input more than one value:

```
cin >> height >> width;
```

- Multiple values from keyboard must be separated by spaces

- Order is important: first value entered goes to first variable, etc.

The `cin` Object Gathers Multiple Values in Program 3-2

Program 3-2

```
1  // This program asks the user to enter the length and width of
2  // a rectangle. It calculates the rectangle's area and displays
3  // the value on the screen.
4  #include <iostream>
5  using namespace std;
6
7  int main()
8  {
9     int length, width, area;
10
11    cout << "This program calculates the area of a ";
12    cout << "rectangle.\n";
13    cout << "Enter the length and width of the rectangle ";
14    cout << "separated by a space.\n";
15    cin >> length >> width;
16    area = length * width;
17    cout << "The area of the rectangle is " << area << endl;
18    return 0;
19 }
```

Program Output with Example Input Shown in Bold

```
This program calculates the area of a rectangle.
Enter the length and width of the rectangle separated by a space.
10 20 [Enter]
The area of the rectangle is 200
```

The `cin` Object Reads Different Data Types in Program 3-3

Program 3-3

```
1  // This program demonstrates how cin can read multiple values
2  // of different data types.
3  #include <iostream>
4  using namespace std;
5
6  int main()
7  {
8     int whole;
9     double fractional;
10    char letter;
11
12    cout << "Enter an integer, a double, and a character: ";
13    cin >> whole >> fractional >> letter;
14    cout << "Whole: " << whole << endl;
15    cout << "Fractional: " << fractional << endl;
16    cout << "Letter: " << letter << endl;
17    return 0;
18 }
```

Program Output with Example Input Shown in Bold

```
Enter an integer, a double, and a character: 4 5.7 b [Enter]
Whole: 4
Fractional: 5.7
Letter: b
```

Order of Operations

In an expression with more than one operator, evaluate in this order:

- – (unary negation), in order, left to right
- * / %, in order, left to right
- + –, in order, left to right

In the expression `2 + 2 * 2 – 2`

Order of Operations

Table 3-2 Some Simple Expressions and Their Values

Expression	Value
`5 + 2 * 4`	13
`10 / 2 - 3`	2
`8 + 12 * 2 - 4`	28
`4 + 17 % 2 - 1`	4
`6 - 3 * 2 + 7 - 1`	6

Associativity of Operators

- parentheses ( ) can be used to override the order of operations:

```
 2 + 2   *   2 – 2   = 4
(2 + 2)  *   2 – 2   = 6
 2 + 2   *  (2 – 2)  = 2
(2 + 2)  *  (2 – 2)  = 0
```

Grouping with Parentheses

Table 3-4 More Simple Expressions and Their Values

Expression	Value
`(5 + 2) * 4`	28
`10 / (5 - 3)`	5
`8 + 12 * (6 - 2)`	56
`(4 + 17) % 2 - 1`	0
`(6 - 3) * (2 + 7) / 3`	9

Algebraic Expressions

- Multiplication requires an operator:

  $Area = lw$ is written as `Area = l * w;`

- There is no exponentiation operator:

  $Area = s^2$ is written as `Area = pow(s, 2);`

- Parentheses may be needed to maintain order of operations:

$$m = \frac{y_2 - y_1}{x_2 - x_1}$$

is written as

```
m = (y2-y1) /(x2-x1);
```

Algebraic Expressions

Table 3-5 Algebraic and C++ Multiplication Expressions

Algebraic Expression	Operation	C++ Equivalent
$6B$	`6 times B`	`6 * B`
$(3)(12)$	`3 times 12`	`3 * 12`
$4xy$	`4 times x times y`	`4 * x * y`

C++ Type Conversion

- Operations are performed between operands of the same type.
- If not of the same type, C++ will convert one to be the type of the other
- Coercion: automatic conversion of an operand to another data type
- Promotion: convert to a higher type
- Demotion: convert to a lower type

Hierarchy of Types

Highest:

```
long double
double
float
unsigned long
long
unsigned int
int
```

Lowest:

Ranked by largest number they can hold

Coercion Rules

1) `char`, `short`, `unsigned short` automatically promoted to `int`
2) When operating on values of different data types, the lower one is promoted to the type of the higher one.
3) When using the = operator, the type of expression on right will be converted to type of variable on left

Type Casting

- Used for manual data type conversion
- Useful for floating point division using ints:

```
double m;
m = static_cast<double>(y2-y1)
                        /(x2-x1);
```

- Useful to see `int` value of a `char` variable:

```
char ch = 'C';
cout << ch << " is "
     << static_cast<int>(ch);
```

Type Casting in Program 3-9

Program 3-9

```
1  // This program uses a type cast to avoid integer division.
2  #include <iostream>
3  using namespace std;
4
5  int main()
6  {
7     int books;         // Number of books to read
8     int months;        // Number of months spent reading
9     double perMonth;   // Average number of books per month
10
11    cout << "How many books do you plan to read? ";
12    cin >> books;
13    cout << "How many months will it take you to read them? ";
14    cin >> months;
15    perMonth = static_cast<double>(books) / months;
16    cout << "That is " << perMonth << " books per month.\n";
17    return 0;
18 }
```

Program Output with Example Input Shown in Bold

```
How many books do you plan to read? 30 [Enter]
How many months will it take you to read them? 7 [Enter]
That is 4.28571 books per month.
```

C-Style and Prestandard Type Cast Expressions

- C-Style cast: data type name in `()`

```
cout << ch << " is " << (int)ch;
```

- Prestandard C++ cast: value in `()`

```
cout << ch << " is " << int(ch);
```

- Both are still supported in C++, although `static_cast` is preferred

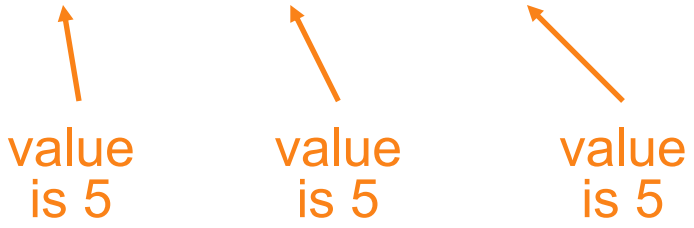
Multiple Assignment and Combined Assignment

- The = can be used to assign a value to multiple variables:

```
x = y = z = 5;
```

- Value of = is the value that is assigned
- Associates right to left:

```
x = (y = (z = 5));
```



Combined Assignment

- Look at the following statement:

```
sum = sum + 1;
```

This adds 1 to the variable **sum**.

Table 3-8 (Assume x = 6)

Statement	What It Does	Value of x After the Statement
`x = x + 4;`	Adds 4 to x	10
`x = x - 3;`	Subtracts 3 from x	3
`x = x * 10;`	Multiplies x by 10	60
`x = x / 2;`	Divides x by 2	3
`x = x % 4`	Makes x the remainder of x / 4	2

Combined Assignment

- The combined assignment operators provide a shorthand for these types of statements.
- The statement

```
sum = sum + 1;
```

is equivalent to

```
sum += 1;
```

Combined Assignment Operators

Table 3-9

Operator	Example Usage	Equivalent to
`+=`	`x += 5;`	`x = x + 5;`
`-=`	`y -= 2;`	`y = y - 2;`
`*=`	`z *= 10;`	`z = z * 10;`
`/=`	`a /= b;`	`a = a / b;`
`%=`	`c %= 3;`	`c = c % 3;`

Working with Characters and `string` Objects

- Using `cin` with the >> operator to input strings can cause problems:
- It passes over and ignores any leading *whitespace characters (spaces, tabs, or line breaks)*
- To work around this problem, you can use a C++ function named `getline`.
- `getline(cin,stringVariable);`

Using `getline` in Program 3-19

Program 3-19

```
1  // This program demonstrates using the getline function
2  // to read character data into a string object.
3  #include <iostream>
4  #include <string>
5  using namespace std;
6
7  int main()
8  {
9     string name;
10    string city;
11
12    cout << "Please enter your name: ";
13    getline(cin, name);
14    cout << "Enter the city you live in: ";
15    getline(cin, city);
16
17    cout << "Hello, " << name << endl;
18    cout << "You live in " << city << endl;
19    return 0;
20 }
```

Program Output with Example Input Shown in Bold

```
Please enter your name: Kate Smith [Enter]
Enter the city you live in: Raleigh [Enter]
Hello, Kate Smith
You live in Raleigh
```

Working with Characters and `string` Objects

- To read a single character:
  - Use `cin`:

```
char ch;
cout << "Strike any key to continue";
cin >> ch;
```

Problem: will skip over blanks, tabs, <CR>

  - Use `cin.get()`:

```
cin.get(ch);
```

Will read the next character entered, even whitespace

Using `cin.get()` in Program 3-21

Program 3-21

```
1  // This program demonstrates three ways
2  // to use cin.get() to pause a program.
3  #include <iostream>
4  using namespace std;
5
6  int main()
7  {
8     char ch;
9
10    cout << "This program has paused. Press Enter to continue.";
11    cin.get(ch);
12    cout << "It has paused a second time. Please press Enter again.";
13    ch = cin.get();
14    cout << "It has paused a third time. Please press Enter again.";
15    cin.get();
16    cout << "Thank you!";
17    return 0;
18 }
```

Program Output with Example Input Shown in Bold

```
This program has paused. Press Enter to continue. [Enter]
It has paused a second time. Please press Enter again. [Enter]
It has paused a third time. Please press Enter again. [Enter]
Thank you!
```

Working with Characters and `string` Objects

- Mixing `cin >>` and `cin.get()` in the same program can cause input errors that are hard to detect
- To skip over unneeded characters that are still in the keyboard buffer, use `cin.ignore()`:

```
cin.ignore(); // skip next char
```

`string` Functions and Operators

- To find the length of a string:

```
string state = "Texas";
int size = state.length();
cout<< "string size= "<<size;   // string size= 5
```

- To concatenate (join) multiple strings:

```
string greeting1 = "Good ", greeting2;
string name1 = "morning", name2 = "evening";

greeting2 = greeting1 + name1; // Good morning

greeting1 = greeting1 + name2; // Good evening
```

Or using the += combined assignment operator:

```
greeting1 += name2; // Good evening
```

More Mathematical Library Functions

- Require `cmath` header file
- Take `double` as input, return a `double`
- Commonly used functions:

`sin`	Sine
`cos`	Cosine
`tan`	Tangent
`sqrt`	Square root
`log`	Natural (e) log
`abs`	Absolute value (takes and returns an int)

More Mathematical Library Functions

- These require `cstdlib` header file
- `rand()`: returns a random number (`int`) between `0` and the largest int the compute holds. Yields same sequence of numbers each time program is run.
- `srand(x)`: initializes random number generator with `unsigned int x`

A Case Study

- General Crates, Inc. builds custom-designed wooden crates.
- You have been asked to write a program that calculates the:
  - Volume (in cubic feet)
  - Cost
  - Customer price
  - Profit of any crate GCI builds

Program Design

The program must perform the following general steps:

Step 1:
    Ask the user to enter the dimensions of the crate
Step 2:
    Calculate:
        the crate's volume
        the cost of building the crate
        the customer's charge
        the profit made
Step 3:
    Display the data calculated in Step 2.

Psuedocode

Ask the user to input the crate's length.
Ask the user to input the crate's width.
Ask the user to input the crate's height.
Calculate the crate's volume.
Calculate the cost of building the crate.
Calculate the customer's charge for the crate.
Calculate the profit made from the crate.
Display the crate's volume.
Display the cost of building the crate.
Display the customer's charge for the crate.
Display the profit made from the crate.

Calculations

The following formulas will be used to calculate the crate's volume, cost, charge, and profit:

$$\text{volume} = \text{length} \times \text{width} \times \text{height}$$

$$\text{cost} = \text{volume} \times 0.23$$

$$\text{charge} = \text{volume} \times 0.5$$

$$\text{profit} = \text{charge} - \text{cost}$$

The Program

Program 3-28

```
1  // This program is used by General Crates, Inc. to calculate
2  // the volume, cost, customer charge, and profit of a crate
3  // of any size. It calculates this data from user input, which
4  // consists of the dimensions of the crate.
5  #include <iostream>
6  #include <iomanip>
7  using namespace std;
8
9  int main()
10 {
11    // Constants for cost and amount charged
12    const double COST_PER_CUBIC_FOOT = 0.23;
13    const double CHARGE_PER_CUBIC_FOOT = 0.5;
14
15    // Variables
16    double length,   // The crate's length
17           width,    // The crate's width
18           height,   // The crate's height
19           volume,   // The volume of the crate
20           cost,     // The cost to build the crate
21           charge,   // The customer charge for the crate
22           profit;   // The profit made on the crate
23
24    // Set the desired output formatting for numbers.
25    cout << setprecision(2) << fixed << showpoint;
26
```

Continued…

The Program

```
27      // Prompt the user for the crate's length, width, and height
28      cout << "Enter the dimensions of the crate (in feet):\n";
29      cout << "Length: ";
30      cin >> length;
31      cout << "Width: ";
32      cin >> width;
33      cout << "Height: ";
34      cin >> height;
35
36      // Calculate the crate's volume, the cost to produce it,
37      // the charge to the customer, and the profit.
38      volume = length * width * height;
39      cost = volume * COST_PER_CUBIC_FOOT;
40      charge = volume * CHARGE_PER_CUBIC_FOOT;
41      profit = charge - cost;
42
43      // Display the calculated data.
44      cout << "The volume of the crate is ";
45      cout << volume << " cubic feet.\n";
46      cout << "Cost to build: $" << cost << endl;
47      cout << "Charge to customer: $" << charge << endl;
48      cout << "Profit: $" << profit << endl;
49      return 0;
50  }
```

Continued…

The Program

Program Output with Example Input Shown in Bold

```
Enter the dimensions of the crate (in feet):
Length: 10 [Enter]
Width: 8 [Enter]
Height: 4 [Enter]
The volume of the crate is 320.00 cubic feet.
Cost to build: $73.60
Charge to customer: $160.00
Profit: $86.40
```

Program Output with Different Example Input Shown in Bold

```
Enter the dimensions of the crate (in feet):
Length: 12.5 [Enter]
Width: 10.5 [Enter]
Height: 8 [Enter]
The volume of the crate is 1050.00 cubic feet.
Cost to build: $241.50
Charge to customer: $525.00
Profit: $283.50
```