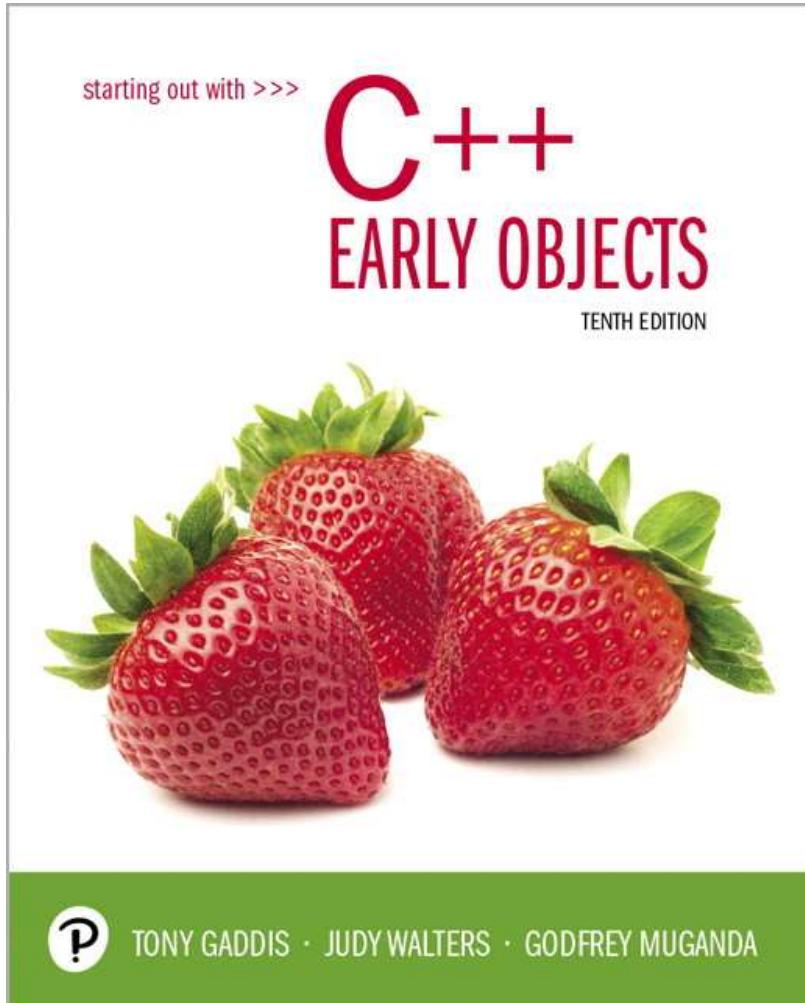


Starting Out with C++ Early Objects

Tenth Edition



Chapter 3

Expressions and
Interactivity

Topics 1 of 2

3.1 The `cin` Object

3.2 Mathematical Expressions

3.3 Data Type Conversion and Type Casting

3.4 Overflow and Underflow

3.5 Named Constants

Topics 2 of 2

3.6 Multiple and Combined Assignment

3.7 Formatting Output

3.8 Working with Characters and Strings

3.9 More Mathematical Library Functions

3.10 Random Numbers

3.1 The `cin` Object 1 of 3

- `cin` is the standard input object
- Like `cout`, requires `iostream` file
- Used to read input from keyboard
- Often used with `cout` to display a user prompt first
- Data is retrieved from `cin` with `>>`, the stream extraction operator
- Input data is stored in one or more variables

The `cin` Object 2 of 3

- User input goes from keyboard to the input buffer, where it is stored as characters
- `cin` converts the data to the type that matches the variable

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

The `cin` Object 3 of 3

- Can be used to input multiple values
`cin >> height >> width;`
- Multiple values from keyboard must be separated by spaces or [Enter]
- Must press [Enter] after typing last value
- Multiple values need not all be of the same type
- Order is important; first value entered is stored in first variable, etc.

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- Listing 3-1

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- Listing 3-2

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- Listing 3-3

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- Listing 3-4

3.2 Mathematical Expressions

- An expression is something that can be evaluated to produce a value.
- It can be a constant, a variable, or a combination of constants and variables combined with operators and grouping symbols
- We can create complex expressions using multiple mathematical operators
- Examples of mathematical expressions:

2

height

a + b / c

Using Mathematical Expressions

- Can be used in assignment statements, with `cout`, and in other types of statements
- Examples:

```
area = 2 * PI * radius;  
cout << "border is: " << (2*(l+w)) ;
```

This is an expression

These are expressions

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- Listing 3-5

Order of Operations 1 of 2

In an expression with > 1 operator, evaluate it in this order:

First: () expressions in parentheses

Then: - (unary negation) in order, left to right

Then: * / % in order, left to right

Finally: + - in order, left to right

Order of Operations 2 of 2

Ex: In the expression $2 + 2 * 2 - 2$,

- Perform the multiplication first
- Perform the addition next
- Finally, perform the subtraction

Associativity of Operators

- $-$ (unary negation) associates right to left
- $*$ $/$ $\%$ $+$ $-$ all associate left to right
- parentheses $()$ can be used to override the order of operations

Expression	Value
$2 + 2 * 2 - 2$	4
$(2 + 2) * 2 - 2$	6
$2 + 2 * (2 - 2)$	2
$(2 + 2) * (2 - 2)$	0

Algebraic Expressions

- Multiplication requires an operator

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

- There is no exponentiation operator

Area = s² is written as `Area = pow(s, 2);`

(note: `pow` requires the `cmath` header file)

- 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);`

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- Listing 3-6

3.3 Data Type Conversion and Type Casting

- Operations are performed between operands of the same type
- If operands do not have the same type, C++ will automatically convert one to be the type of the other
- This can impact the results of calculations

Hierarchy of Data Types

- Highest
 - `long double`
 - `double`
 - `float`
 - `unsigned long long int`
 - `long long int`
 - `unsigned long int`
 - `long int`
 - `unsigned int`
 - `int`
- Lowest
- Ranked by largest number they can hold

Type Coercion

- **Coercion**: automatic conversion of an operand to another data type
- **Promotion**: conversion to a higher type
- **Demotion**: conversion to a lower type

Coercion Rules 1 of 2

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

Coercion Rules 2 of 2

Important Notes:

- 1) If demotion is required by the = operator,
 - the stored result may be incorrect if there is not enough space available in the receiving variable
 - floating-point values are truncated when assigned to integer variables
- 2) Coercion affects the value used in a calculation. It does not change the type associated with a variable.

Type Casting

- Is used for manual data type conversion
- Format:

```
static_cast<Data Type>(Value)
```

- Example:

```
cout << static_cast<int>(4.2);  
                                // Displays 4
```

More Type Casting Examples

```
char ch = 'C';
```

```
cout << ch << " is stored as "  
<< static_cast<int>(ch);
```

```
gallons = static_cast<int>(area/500);
```

```
average = static_cast<double>(sum)/count;
```

Older Type Cast Styles

```
double volume = 21.58;  
  
int intVol1, intVol2;  
  
intVol1 = (int) volume; // C-style cast  
intVol2 = int (volume); // Prestandard C++  
                      // style cast
```

C-style cast uses **prefix notation**

Prestandard C++ cast uses **functional notation**

static_cast is the current standard

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- Listing 3-7

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- Listing 3-8

3.4 Overflow and Underflow

- Occurs when assigning a value that is too large (overflow) or too close to zero (underflow) to be held in a variable
- This occurs with both int and floating-point data types

Overflow Example

```
// Create a short int initialized to  
// the largest value it can hold  
short int num = 32767;  
  
cout << num;          // Displays 32767  
num = num + 1;  
cout << num;          // Displays -32768
```

Handling Overflow and Underflow

Different systems handle the problem differently.
They may

- display a warning / error message
- stop the program
- continue execution with the incorrect value

Using variables with appropriately-sized data types can minimize this problem

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- Listing 3-9

3.5 Named Constants

- Also called **constant variables**
- Variables whose content cannot be changed during program execution
- Used for representing constant values with descriptive names

```
const double TAX_RATE = 0.0775;  
const int NUM_STATES = 50;
```

- Often named using uppercase letters

Defining and Initializing Named Constants

- The value of a named constant must be assigned when the variable is defined:

```
const int CLASS_SIZE = 24;
```

- An error occurs if you try to change the value stored in a named constant after it is defined:

```
// This won't work
```

```
CLASS_SIZE = CLASS_SIZE + 1;
```

Benefits of Named Constants

- They make program code more readable by documenting the purpose of the constant in the name:

```
const double TAX_RATE = 0.0775;
```

```
...
```

```
salesTax = purchasePrice * TAX_RATE;
```

- They improve accuracy and simplify program maintenance

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- Listing 3-10

3.6 Multiple and Combined Assignment

- The assignment operator (=) can be used multiple times in an expression

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

- Assignment associates right to left

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

Done 3rd Done 2nd Done 1st

Combined Assignment

- Applies an arithmetic operation to a variable and assigns the result as the new value of that variable
- Operators: `+=` `-=` `*=` `/=` `%=`
- These are also called compound operators or arithmetic assignment operators
- Example:

`sum += amt;` is short for `sum = sum + amt;`

More Examples of Combined Assignment

`x += 5;` means `x = x + 5;`

`x -= 5;` means `x = x - 5;`

`x *= 5;` means `x = x * 5;`

`x /= 5;` means `x = x / 5;`

`x %= 5;` means `x = x % 5;`

The right hand side is evaluated before the combined assignment operation is done.

`x *= a + b;` means `x = x * (a + b);`

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- Listing 3-11

3.7 Formatting Output

- We can control how output displays for numeric and string data
 - size
 - position
 - number of digits
- This requires the `iomanip` header file

Stream Manipulators 1 of 2

- Are used to control features of an output field
- Some affect just the next value displayed

`setw(x)` : Print a value in a field at least `x` spaces wide.

- It will use more spaces if the specified field width is not big enough.
- It right-justifies the value if it does not require `x` spaces.
- Decimal points in floating-point values use a space.
- All characters in strings, including space characters, use space

Stream Manipulators 2 of 2

- Some affect values until changed again
 - fixed**: Use decimal notation (not E-notation) for floating-point values.
 - setprecision (x)**:
 - When used with **fixed**, print floating-point value using **x** digits after the decimal.
 - Without **fixed**, print floating-point value using **x** significant digits.
 - Rounding is used if **x** is smaller than the number of significant digits

Stream Manipulators

- Some additional manipulators:
 - showpoint**: Always print a decimal point for floating-point values. This is useful with **fixed** and **setprecision** when printing monetary values.
 - left**, **right**: left- or right justification of a value in a field.

Manipulator Examples

Code	Displays
<code>const double e = 2.718;</code>	
<code>double price = 18.0;</code>	
<code>cout << setw(8) << e << endl;</code>	^^^^2.718
<code>cout << left << setw(8) << e << endl;</code>	2.718^^^
<code>cout << setprecision(2) ;</code>	
<code>cout << e << endl;</code>	2.7
<code>cout << fixed << e << endl;</code>	2.72
<code>cout << setw(6) << price;</code>	18.00^

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- Listing 3-12

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- Listing 3-13

Hands-On Pg. 110

- Listing 3-14

Hands-On Pg. 111

- Listing 3-15

Hands-On Pg. 113

- Listing 3-16

Hands-On Pg. 115

- Listing 3-17

Hands-On Pg. 117

- Listing 3-18

3.8 Working with Characters and Strings

- **char**: holds a single character
- **string**: holds a sequence of characters
- Both can be used in assignment statements
- Both can be displayed with **cout** and **<<**

String Input

Reading in a string object

```
string str;
```

```
cin >> str;           // Reads in a string  
                      // containing no blanks
```

```
getline(cin, str); // Reads in a string  
                      // that may contain  
                      // blanks
```

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- Listing 3-19

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- Listing 3-20

Character Input

Reading in a character:

```
char ch;
```

```
cin >> ch; // Reads in any non-blank char
```

```
cin.get(ch); // Reads in any char
```

```
ch=cin.get(); // Reads in any char
```

```
cin.ignore(); // Skips over next char in  
// the input buffer
```

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- Listing 3-21

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- Listing 3-22

`cin.ignore()`

General form: `cin.ignore(n, c)` ;

- `n` – number of characters to skip
- `c` – stop when character `c` is encountered

How it works:

- It stops if `c` is encountered before `n` characters have been skipped. Otherwise, `n` characters are skipped.
- Use `cin.ignore() ;` to skip a single character

string Member Functions 1 of 2

- **length()** – the number of characters in a string

```
string town="Coal City";  
int size=town.length(); // size is 9
```

- **length()** includes blank characters
- **length()** does not include the '\0' null character that terminates the string

string Member Functions 2 of 2

- `assign()` – put repeated characters in a string.
- It can be used for formatting output.

```
string equals;
equals.assign(80, '=');

. . .

cout << equals << endl;
cout << "Total: " << total << endl;
```

String Operators

= Assigns a value to a string

```
string words;  
words = "Tasty ";
```

+ Joins two strings together

```
string s1 = "hot", s2 = "dog";  
string food = s1 + s2; // food = "hotdog"
```

+= Concatenates a string onto the end of another one

```
words += food; // words now = "Tasty hotdog"
```

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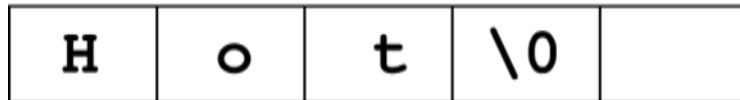
- Listing 3-23

Using C-Strings

- A C-string is stored as an array of characters
- The programmer must indicate the maximum number of characters at definition

```
const int SIZE = 5;  
char temp[SIZE] = "Hot";
```

- NULL character (\0) is placed after final character to mark the end of the string



- The programmer must make sure that the array is big enough for desired use. **temp** can hold up to 4 characters plus the \0.

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- Listing 3-24

Hands-On Pg. 128

- Listing 3-25

C-String and Keyboard Input

- Reading in a C-string

```
const int SIZE = 10;
```

```
char Cstr[SIZE];
```

```
cin >> Cstr; // Reads in a C-string with no blanks.  
// It will write data past the end of the  
// array if the input string is too long.
```

```
cin.getline(Cstr, SIZE);
```

```
// Reads in a C-string that may  
// contain blanks. Ensures that <= 9  
// chars are read in.
```

- You can also use **setw()** and **width()** manipulators.

C-String and Input Field Width

- The `setw()` stream manipulator can be used with `cin` as well as with `cout`.
- When used with `cin` and a target C-string array, `setw()` limits the number of characters that are stored in the array

```
const int SIZE = 10;  
char Cstr[SIZE];  
cin >> setw(SIZE) >> Cstr;
```

- `cin.width()` can also provide this limit

```
cin.width(SIZE);  
  
cin >> Cstr;
```

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- Listing 3-27

C-String Initialization vs. Assignment

- A C-string can be initialized at the time of its creation, just like a string object

```
const int SIZE = 10;
```

```
char month[SIZE] = "April";
```

- However, a C-string cannot later be assigned a value using the = operator; you must use the **strcpy()** function

```
char month[SIZE];
```

```
month = "August"           // wrong!
```

```
strcpy(month, "August"); //correct
```

More on C-Strings and Keyboard Input

- `cin` can be used to put a single word from the keyboard into a C-string
- The programmer must use `cin.getline()` to read an input string that contains spaces
- Note that `cin.getline() ≠ getline()`
- The programmer must indicate the target C-string and maximum number of characters to read:

```
const int SIZE = 25;  
char name[SIZE];  
cout << "What's your name? ";  
cin.getline(name, SIZE);
```

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- Listing 3-28

3.9 More Mathematical Library Functions

- These require `cmath` header file
- They take `double` arguments and return a `double`
- Some commonly used functions

Function	Meaning
<code>abs</code>	Absolute value
<code>sin</code>	Sine
<code>cos</code>	Cosine
<code>tan</code>	Tangent
<code>sqrt</code>	Square root
<code>log</code>	Natural (e) log
<code>pow</code>	Raise to a power

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- Listing 3-29

3.10 Random Numbers

- Random number - a value that is chosen from a set of possible values. Each value in the set has an equal likelihood of being chosen.
- Random numbers are used in games and in simulations.
- You have to use the `cstdlib` header file

Getting Random Numbers

- **rand()**

- Returns a random number between 0 and the largest **int** the computer holds
- Will yield the same sequence of numbers each time the program is run

- **srand(x)**

- Initializes the random number generator with **unsigned int x**. **x** is the “seed value”.
- This should be called at most once in a program

More on Random Numbers

- Use `time()` to generate different seed values each time that a program runs:

```
#include <ctime> //needed for time()  
...  
unsigned seed = time(0);  
  
srand(seed);
```

- Random numbers can be scaled to a range:

```
int max=6;  
  
int num;  
  
num = rand() % max + 1;
```

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- Listing 3-30

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- Listing 3-31

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- Listing 3-32

Greenfield Case Study Part 1

- Pg. 140

Word Game

- Listing 3-35, Pg. 143

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