Chapter 3: Expressions and Interactivity

Starting Out with C++
Early Objects
Seventh Edition

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Topics

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3.1 The `cin` Object

- 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 **`>>`**
- Input data is stored in one or more variables

The `cin` Object

- 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

- Can be used to input multiple values

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

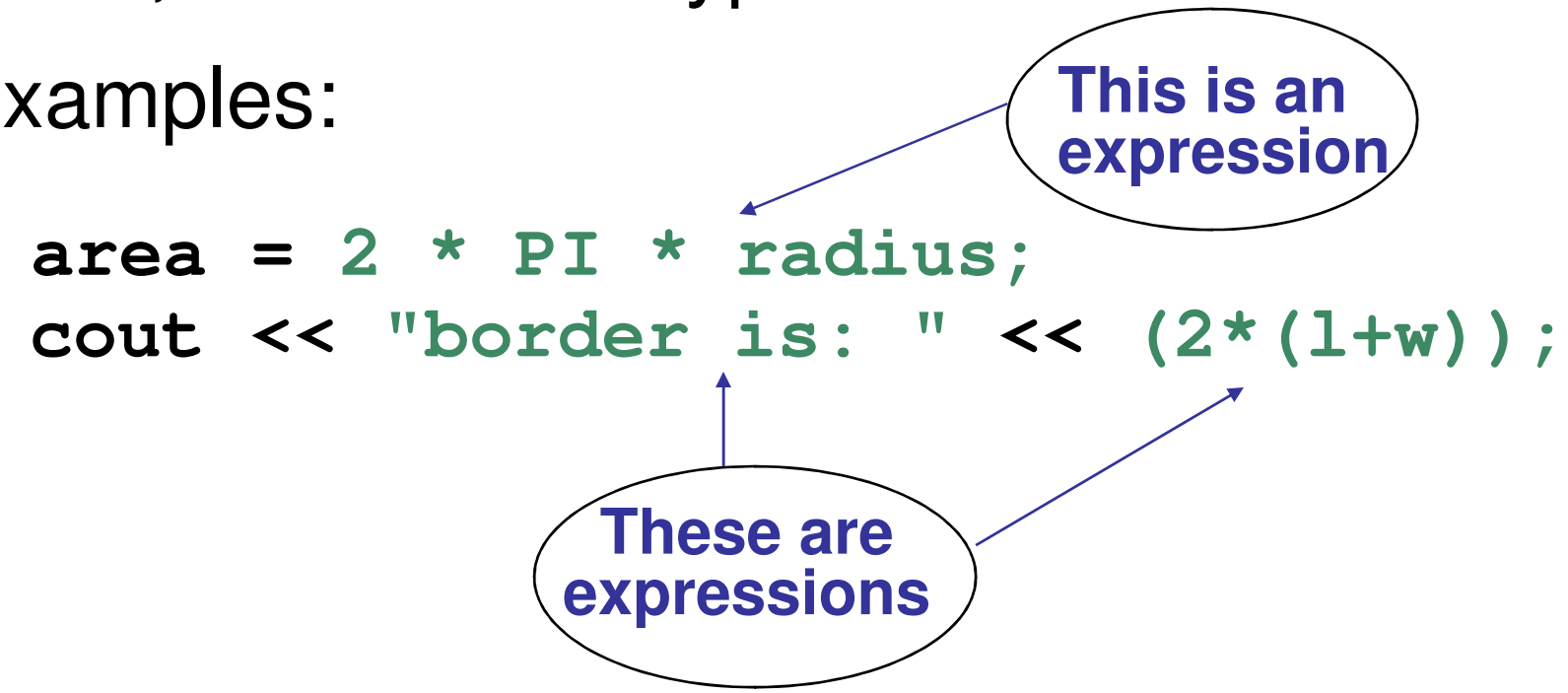
- Multiple values from keyboard must be separated by spaces or [Enter]
- Must press [Enter] after typing last value
- Multiple values need not all be of the same type
- Order is important; first value entered is stored in first variable, etc.

3.2 Mathematical Expressions

- An expression can be a constant, a variable, or a combination of constants and variables combined with operators
- 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:



Order of Operations

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

Do first: `-` (unary negation) in order, left to right

Do next: `*` `/` `%` in order, left to right

Do last: `+` `-` in order, left to right

- In the expression `2 + 2 * 2 - 2 ,`

Evaluate 2nd **Evaluate 1st** **Evaluate 3rd**

Associativity of Operators

- – (unary negation) associates right to left
- * / % + – all associate left to right
- 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
```


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);`

  (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);
```

3.3 Implicit Type Conversion

- Operations are performed between operands of the same type
- If not of 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
- Lowest

```
long double
double
float
unsigned long
long
unsigned int
int
unsigned short
short
char
```

- Ranked by largest number they can hold

Type Coercion

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

Coercion Rules

1) **`char`**, **`short`**, **`unsigned short`** are 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 the type of variable on left

3.4 Explicit Type Conversion

- Also called type casting
- Used for manual data type conversion
- Format

```
static_cast<type>(expression)
```

- Example:

```
cout << static_cast<char>(65);
                        // Displays 'A'
```

More Type Casting Examples

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

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

avg = 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

3.5 Overflow and Underflow

- Occurs when assigning a value that is too large (overflow) or too small (underflow) to be held in a variable
- The variable contains a value that is ‘wrapped around’ the set of possible values

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
- display a dialog box and ask what to do
- stop the program
- continue execution with the incorrect value

3.6 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 = 0.0675;
const int NUM_STATES = 50;
```

- Often named in uppercase letters

`const` vs. `#define`

`#define`

- C-style of naming constants

```
#define NUM_STATES 50
```

- Interpreted by pre-processor rather than compiler
- Does not occupy a memory location like a constant variable defined with **`const`**
- Instead, causes a text substitution to occur. In above example, every occurrence in program of `NUM_STATES` will be replaced by `50`

3.7 Multiple and Combined Assignment

- The assignment operator (=) can be used more than 1 time in an expression

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

- 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: `+=` `-=` `*=` `/=` `%=`
- Example:
- `sum += amt;` is short for `sum = sum + amt;`

More Examples

```
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);
```

3.8 Formatting Output

- Can control how output displays for numeric and string data
  - size
  - position
  - number of digits
- Requires **`iomanip`** header file

Stream Manipulators

- Used to control features of an output field
- Some affect just the next value displayed
  - **`setw(x)`** : Print in a field at least **`x`** spaces wide. Use more spaces if specified field width is not big enough.

Stream Manipulators

- 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.
  - **`showpoint`**: Always print decimal for floating-point values.
  - **`left, right`**: left-, right justification of value

Manipulator Examples

```
const float e = 2.718;
float price = 18.0;
cout << setw(8) << e << endl;
cout << left << setw(8) << e
     << endl;
cout << setprecision(2);
cout << e << endl;
cout << fixed << e << endl;
cout << setw(6) << price;
```

Displays

```
^^^2.718

2.718^^^

2.7
2.72
^18.00
```

3.9 Working with Characters and String Objects

- **`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
                             // with no blanks

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

Character Input

Reading in a character

```
char ch;

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

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

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


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"
```


3.10 Using C-Strings

- C-string is stored as an array of characters
- Programmer must indicate 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

H	o	t	\0	

- Programmer must make sure array is big enough for desired use; `temp` can hold up to 4 characters plus the `\0`.

C-String Input

- Reading in a C-string

```
const int SIZE = 10;
char Cstr[SIZE];
cin >> Cstr;      // Reads in a C-string with no
                  // blanks. Will write past the
                  // end of the array if input string
                  // is too long.
cin.getline(Cstr, 10);
                  // Reads in a C-string that may
                  // contain blanks. Ensures that <= 9
                  // chars are read in.
```

- Can also use **`setw()`** and **`width()`** to control input field widths

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
```

3.11 More Mathematical Library Functions

- These require **`cmath`** header file
- Take **`double`** arguments and return a **`double`**
- Commonly used functions

`abs`	Absolute value
`sin`	Sine
`cos`	Cosine
`tan`	Tangent
`sqrt`	Square root
`log`	Natural (e) log

More Mathematical Library Functions

- These require **`cstdlib`** header file
- **`rand`**
  - Returns a random number between **`0`** and the largest **`int`** the computer holds
  - Will yield same sequence of numbers each time the program is run
- **`srand(x)`**
  - Initializes random number generator with **`unsigned int x`**
  - Should be called at most once in a program

3.12 Introduction to Files

- Can use a file instead of keyboard for program input
- Can use a file instead of monitor screen for program output
- Files are stored on secondary storage media, such as disk
- Files allow data to be retained between program executions

What is Needed to Use Files

1. Include the **`fstream`** header file
2. Define a file stream object
   - **`ifstream`** for input from a file

     ```
     ifstream inFile;
     ```

   - **`ofstream`** for output to a file

     ```
     ofstream outFile;
     ```


Open the File

3. Open the file

- Use the **`open`** member function

```
inFile.open("inventory.dat");
outFile.open("report.txt");
```

- Filename may include drive, path info.
- Output file will be created if necessary; existing output file will be erased first
- Input file must exist for **`open`** to work

Use the File

4. Use the file

- Can use output file object and << to send data to a file

```
outFile << "Inventory report";
```

- Can use input file object and >> to copy data from file to variables

```
inFile >> partNum;
inFile >> qtyInStock >> qtyOnOrder;
```


Close the File

5. Close the file

- Use the **`close`** member function

```
inFile.close();
outFile.close();
```

- Don't wait for operating system to close files at program end
  - May be limit on number of open files
  - May be buffered output data waiting to be sent to a file that could be lost

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