Standard Version of Starting Out with C++, 4th Edition

Chapter 3

Expressions and Interactivity

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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
- Information retrieved from `cin` with `>>`
- Input information stored in one or more variables

The `cin` Object

- User input goes from keyboard to keyboard buffer
- cin converts information 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 > 1 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

- Can be used to read in a string
- Must first declare an array to hold characters in string:

```
char myName[20];
```

- `myName` is name of array, `20` is the number of characters that can be stored (the size of the array), including the NULL character at the end
- Can be used with `cin` to assign a value:

```
cin >> myName;
```

3.2 Mathematical Expressions

- Can create complex expressions using multiple mathematical operators
- An expression can be a constant, a variable, or a mathematical combination of constants and variables
- Can be used in assignment, `cout`, other statements:

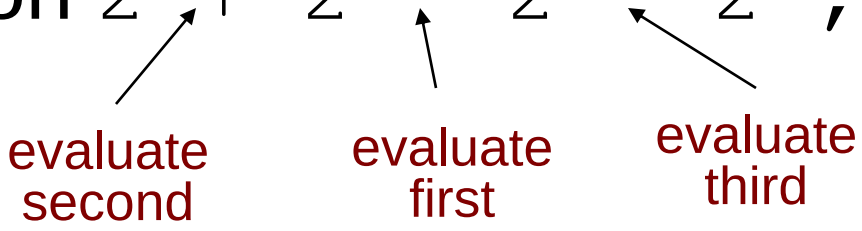
```
area = 2 * PI * radius;
cout << "border is: " << 2*(l+w);
```

Order of Operations

In an expression with > 1 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` ,



Associativity of Operators

- – (unary negation) associates right to left
- *, /, %, +, – 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);`

- 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 When You Mix Apples and Oranges: *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
- This can impact the results of calculations.

Hierarchy of Types

Highest: `long double`
`double`
`float`
`unsigned long`
`long`
`unsigned int`
Lowest: `int`

Ranked by largest number they can hold

Type Coercion

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

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

3.4 Overflow and Underflow

- Occurs when assigning a value that is too large (overflow) or too small (underflow) to be held in a variable
- Variable contains value that is ‘wrapped around’ set of possible values
- Different systems may display a warning/error message, stop the program, or continue execution using the incorrect value

3.5 Type Casting

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

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

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

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

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

3.6 Named Constants

- Named constant (constant variable): variable whose content cannot be changed during program execution
- Used for representing constant values with descriptive names:

```
const float TAXRATE = 0.0675;
const int NUMSTATES = 50;
```

- Often named in uppercase letters

`const` vs. `#define`

- `#define` – C-style of naming constants:

```
#define NUMSTATES 50
```

  - Note no ; at end
- Interpreted by pre-processor rather than compiler
- Does not occupy memory location like `const`

3.7 Multiple Assignment and Combined Assignment

- = is an operator that can be used > 1 time in an expression:

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

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

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

value is 5 value is 5 value is 5

Combined Assignment

- C++ shorthand for common mathematical operations:

```
sum = sum + newnum;
```

  - Note: not an algebraic equation!
- Operators: `+=, -=, *=, /=, %=`
- `sum += newnum;` short for expression above

3.8 Formatting Output

- Can control how output displays for numeric, 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 field is not wide enough
- Some affect values until changed again:
  - `fixed`: use decimal 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

Manipulator Examples

```
const float e = 2.718;
cout << setw(8) << e;    // 2.718 in a
                         // field 8 wide
cout << setprecision(2);
cout << e;               // 2.7
float price = 25.0, discount = 0.6;
cout << fixed << setprecision(2);
cout << price * discount; // 15.00
```

3.9 Formatted Input

- Can format field width for use with `cin`
- Useful when reading string data to be stored in a character array:

```
char fName[10];
cout << "Enter your name: ";
cin >> setw(10) >> fName;
```

- `cin` reads one less character than specified in `setw()` directive

Formatted Input

- To read an entire line of input, use `cin.getline()`:

```
char address[81];
cout << "Enter your address: ";
cin.getline(address, 81);
```

- `cin.getline` takes two arguments:
  - Name of array to store string
  - Size of the array

Formatted Input

- 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

Formatted Input

- 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
cin.ignore(10, '\n'); // skip the next
                      // 10 char. or until a '\n'
```

3.10 More About Member Functions

- Member Function: procedure that is part of an object
- `cout`, `cin` are objects
- Some member functions of the `cin` object:
  - `getline`
  - `get`
  - `ignore`

3.11 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 computer holds. Yields same sequence of numbers each time program is run.
- `srand(x)`: initializes random number generator with `unsigned int x`

3.12 Hand Tracing a Program

- Hand trace a program: act as if you are the computer, executing a program:
  - step through and ‘execute’ each statement, one-by-one
  - record the contents of variables after statement execution, using a hand trace chart (table)
- Useful to locate logic or mathematical errors

3.14 Introduction to File Input and Output

- Can use files instead of keyboard, monitor screen for program input, output
- Allows data to be retained between program runs
- Steps:
  - *Open* the file
  - *Use* the file (read from, write to, or both)
  - *Close* the file

Files: What is Needed

- Use `fstream` header file for file access
- File stream types:
  - `ifstream` for input from a file
  - `ofstream` for output to a file
  - `fstream` for input from or output to a file
- Define file stream objects:

```
ifstream infile;
ofstream outfile;
```

Opening Files

- Create a link between file name (outside the program) and file stream object (inside the program)
- 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 file will be erased first
- Input file must exist for `open` to work

Using Files

- 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;
```

Closing Files

- 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 send to file

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