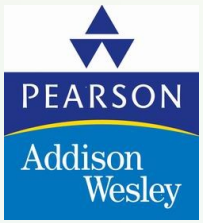
Starting Out with C++: Early Objects
5th Edition

Chapter 13
Advanced File and I/O Operations



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Steps to Using a File

1. Open the file
2. Use (read from, write to) the file
3. Close the file

File Stream Objects

- Use of files requires file stream objects
- There are three types of file stream objects
  (1) `ifstream` objects: used for input
  (2) `ofstream` objects: used for output
  (3) `fstream` objects: used for both input and output

File Names

- File name can be a full pathname to file:

```
c:\data\student.dat
```

  tells compiler exactly where to look
- File name can also be simple name:

```
student.dat
```

  this must be in the same directory as the program executable, or in the compiler's default directory

Opening a File

- A file is known to the system by its name
- To use a file, a program needs to connect a suitable stream object to the file. This is known as opening the file
- Opening a file is achieved through the `open` member function of a file stream object

Opening a File for Input

- Create an **`ifstream`** object in your program

```
ifstream inFile;
```

- Open the file by passing its name to the stream's open member function

```
inFile.open("myfile.dat");
```

Getting File Names from Users

- Define file stream object, variable to hold file name

```
ifstream inFile;
char FileName(81);
```

- Prompt user to enter filename and read the filename

```
cout << "Enter filename: ";
cin.getline(FileName, 81);
```

- Open the file

```
inFile.open(FileName);
```

Opening a File for Output

- Create an **`ofstream`** object in your program

```
ofstream outFile;
```

- Open the file by passing its name to the stream's open member function

```
outFile.open("myfile.dat");
```

The `fstream` Object

- **`fstream`** object can be used for either input or output

```
fstream file;
```

- To use **`fstream`** for input, specify **`ios::in`** as the second argument to open

```
file.open("myfile.dat",ios::in);
```

- To use **`fstream`** for output, specify **`ios::out`** as the second argument to open

```
file.open("myfile.dat",ios::out);
```

Opening a File for Input and Output

- **`fstream`** object can be used for both input and output at the same time
- Create the fstream object and specify both **`ios::in`** and **`ios::out`** as the second argument to the open member function

```
fstream file;
file.open("myfile.dat",
          ios::in|ios::out);
```

Opening Files with Constructors

- Stream constructors have overloaded versions that take the same parameters as **`open`**
- These constructors open the file, eliminating the need for a separate call to **`open`**

```
fstream inFile("myfile.dat",
               ios::in);
```

File Open Modes

- File open modes specify how a file is opened and what can be done with the file once it is open
- **`ios::in`** and **`ios::out`** are examples of file open modes, also called file mode flags
- File modes can be combined and passed as second argument of open member function

File Mode Flags

`ios::app`	create new file, or append to end of existing file
`ios::ate`	go to end of existing file; write anywhere
`ios::binary`	read/write in binary mode (not text mode)
`ios::in`	open for input
`ios::out`	open for output

File Open Modes

- Not all combinations of file open modes make sense
- **`ifstream`** and **`ofstream`** have default file open modes defined for them, hence the second parameter to their **`open`** member function is optional

Default File Open Modes

- **`ofstream`:**
  - open for output only
  - file cannot be read from
  - file created if no file exists
  - file contents erased if file exists

- **`ifstream`:**
  - open for input only
  - file cannot be written to
  - open fails if file does not exist

Detecting File Open Errors

- Two methods for detecting if a file open failed

  (1) Call **`fail()`** on the stream

```
inFile.open("myfile");
if (inFile.fail())
  { cout << "Can't open file";
    exit(1);
  }
```

Detecting File Open Errors

(2) Test the status of the stream using the ! operator

```
inFile.open("myfile");
if (!inFile)
  { cout << "Can't open file";
    exit(1);
  }
```

Using `fail()` to detect eof

- Example of reading all integers in a file

```
//attempt a read
int x;  infile >> x;
while (!infile.fail())
{  //success, so not eof
   cout << x;
   //read again
   infile >> x;
}
```

Using >> to detect eof

- To detect end of file, `fail()` must be called immediately after the call to `>>`
- The extraction operator returns the same value that will be returned by the next call to fail:
  - (`infile >> x`) is nonzero if `>>` succeeds
  - (`infile >> x`) is zero if `>>` fails

Detecting End of File

- Reading all integers in a file

```
int x;
while (infile >> x)
{
   // read was successful
   cout >> x;
   // go to top of loop and
   // attempt another read
}
```

13.2 Output Formatting

- Can format with I/O manipulators: they work with file objects just like they work with **`cout`**
- Can format with formatting member functions
- The **`ostringstream`** class allows in-memory formatting into a string object before writing to a file

I/O Manipulators

`left, right`	left or right justify output
`oct, dec, hex`	display output in octal, decimal, or hexadecimal
`endl, flush`	write newline (**`endl`** only) and flush output
`showpos, noshowpos`	do, do not show leading **+** with non-negative numbers
`showpoint, noshowpoint`	do, do not show decimal point and trailing zeroes

More I/O Manipulators

`fixed`, `scientific`	use fixed or scientific notation for floating-point numbers
`setw(n)`	sets minimum field output width to **`n`**
`setprecision(n)`	sets floating-point precision to **`n`**
`setfill(ch)`	uses **`ch`** as fill character

Formatting with Member Functions

- Can also use stream object member functions to format output:

```
gradeFile.width(3); // like
                    // setw(3)
```

- Names of member functions may differ from manipulators.

Formatting with Member Functions

Member Function	Manipulator or Meaning
`width(n)`	`setw(n)`
`precision(n)`	`setprecision(n)`
`setf()`	set format flags
`unsetf()`	disable format flags

`sstream` Formatting

1) To format output into an in-memory string object, include the **`sstream`** header file and create an **`ostringstream`** object

```
#include <sstream>
ostringstream outStr;
```

`sstream` Formatting

2) Write to the **`ostringstream`** object using I/O manipulators, all other stream member functions:

```
outStr << showpoint << fixed
       << setprecision(2)
       << 'S'<< amount;
```

`sstream` Formatting

3) Access the C-string inside the **`ostringstream`** object by calling its `str` member function

```
cout << outStr.str();
```

13.3 Passing File Stream Objects to Functions

- File stream objects keep track of current read or write position in the file

- Always use pass a file object as parameter to a function using pass by reference

Passing File Stream Objects to Functions

```
//print all integers in a file to screen
  void printFile(ifstream &in)
  { int x;
    while(in >> x)
    { out << x << " "; }
  }
```

13.4 More Detailed Error Testing

- Streams have error bits (flags) that are set by every operation to indicate success or failure of the operation, and the status of the stream
- Stream member functions report on the settings of the flags

Error State Bits

- Can examine error state bits to determine file stream status

`ios::eofbit`	set when end of file detected
`ios::failbit`	set when operation failed
`ios::hardfail`	set when an irrecoverable error occurred
`ios::badbit`	set when invalid operation attempted
`ios::goodbit`	set when no other bits are set

Error Bit Reporting Functions

`eof()`	true if **`eofbit`** set, false otherwise
`fail()`	true if **`failbit`** or **`hardfail`** set, false otherwise
`bad()`	true if **`badbit`** set, false otherwise
`good()`	true if **`goodbit`** set, false otherwise
`clear()`	clear all flags (no arguments), or clear a specific flag

13.5 Member Functions for Reading and Writing Files

- Unlike the extraction operator `>>`, these reading functions do not skip whitespace:
  - `getline`: read a line of input
  - `get`: reads a single character
  - `seekg`: goes to beginning of input file

`getline` Member Function

- `getline(char s[ ], int max, char stop ='\n')`
  - `char s[ ]:` Character array to hold input
  - `int max` : Maximum number of characters to read
  - `char stop`: Terminator to stop at if encountered before `max` number of characters is read . Default is `'\n'`

Single Character Input

- `get(char &ch)`

  Read a single character from the input stream. Does not skip whitespace.

```
ifstream inFile;  char ch;
inFile.open("myFile");
inFile.get(ch);
cout << "Got " << ch;
```

Single Character Output

- `put(char ch)`

  Output a character to a file

- Example

```
ofstream outFile;
outFile.open("myfile");
outFile.put('G');
```

Single Character I/O

- To copy an input file to an output file

```
char ch; infile.get(ch);
while (!infile.fail())
{ outfile.put(ch);
  infile.get(ch);
}
infile.close();
outfile.close();
```

Moving About in Input Files

- **`seekg(offset, place)`**
  Move to a given **`offset`** relative to a given **`place`** in the file
  - **`offset`**: number of bytes from **`place`**, specified as a **`long`**
  - **`place`**: location in file from which to compute offset
    - **`ios::beg`**: beginning of file
    - **`ios::end`**: end of the file
    - **`ios::cur`**: current position in file

Rewinding a File

- To move to beginning of file, seek to an offset of zero from beginning of file

```
inFile.seekg(0L, ios::beg);
```

- Error or eof bits will block seeking to the beginning of file. Clear bits first:

```
inFile.clear();
inFile.seekg(0L, ios::beg);
```

13.6 Working with Multiple Files

- Can have more than one file open at a time in a program
- Files may be open for input or output
- Need to define stream object for each file

13.7 Binary Files

- Binary files store data in the same format that a computer has in main memory
- Text files store data in which numeric values have been converted into strings of ASCII characters
- Files are opened in text mode (as text files) by default

Using Binary Files

- Pass the **`ios::binary`** flag to the **`open`** member function to open a file in binary mode

```
infile.open("myfile.dat",ios::binary);
```

- Reading and writing of binary files requires special **`read`** and **`write`** member functions

```
read(char *buffer, int numberBytes)
write(char *buffer, int numberBytes)
```

Using `read` and `write`

```
read(char *buffer, int numberBytes)
write(char *buffer, int numberBytes)
```

- `buffer:` holds an array of bytes to transfer between memory and the file
- `numberBytes`: the number of bytes to transfer

Address of the buffer needs to be cast to `char *` using `reinterpret_cast`

Using `write`

- To write an array of 2 doubles to a binary file

```
ofstream
outFile("myfile", ios:binary);
double d[2] = {12.3, 34.5};
outFile.write(
   reinterpret_cast<char *>(d),
   sizeof(d)
   );
```

Using `read`

- To read two 2 doubles from a binary file into an array

```
ifstream inFile("myfile", ios:binary);
 const int DSIZE = 10;
 double data[DSIZE];
 inFile.read(
    reinterpret_cast<char *>(data),
    2*sizeof(double)
    );
 // only data[0] and data[1] contain
 // values
```

13.8 Creating Records with Structures

- Can write structures to, read structures from files
- To work with structures and files,
  - use **`binary`** file flag upon open
  - use **`read`**, **`write`** member functions

Creating Records with Structures

```
struct TestScore
{ int studentId;
  float score;
  char grade;
};
TestScore test1[20];
...
// write out test1 array to a file
gradeFile.write(
  reinterpret_cast<char*>(test1),
  sizeof(test1));
```

13.9 Random-Access Files

- Sequential access: start at beginning of file and go through data in file, in order, to end
  - to access 100th entry in file, go through 99 preceding entries first
- Random access: access data in a file in any order
  - can access 100th entry directly

Random Access Member Functions

- `seekg` (seek get): used with input files
- `seekp` (seek put): used with output files
- Both are used to go to a specific position in a file

Random Access Member Functions

- `seekg(offset,place)`
- `seekp(offset,place)`

  `offset`: long integer specifying number of bytes to move

  `place`: starting point for the move, specified by `ios:beg`, `ios::cur` or `ios:end`

Random-Access Member Functions

- Examples:

```
// Set read position 25 bytes
// after beginning of file
inData.seekg(25L, ios::beg);

// Set write position 10 bytes
// before current position
outData.seekp(-10L, ios::cur);
```

Random Access Information

- **`tellg`** member function: return current byte position in input file

```
int whereAmI;
whereAmI = inFile.tellg();
```

- **`tellp`** member function: return current byte position in output file

```
whereAmI = outFile.tellp();
```

13.10 Opening a File for Both Input and Output

- File can be open for input and output simultaneously
- Supports updating a file:
  - read data from file into memory
  - update data
  - write data back to file
- Use **`fstream`** for file object definition:

```
fstream gradeList("grades.dat",
                  ios::in | ios::out);
```