

# **Software Engineering 2**

## **(C++)**

**CSY2006**  
**(Week 22)**

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# Using Files for Data Storage

- 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

1. Requires `fstream` header file
  - use `ifstream` data type for input files
  - use `ofstream` data type for output files
  - use `fstream` data type for both input, output files
2. Can use `>>`, `<<` to read from, write to a file
3. Can use `eof` member function to test for end of input file

# 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

# Testing for File Open Errors

- Can test a file stream object to detect if an open operation failed:

```
infile.open("test.txt");  
if (!infile)  
{  
    cout << "File open failure!";  
}
```

- Can also use the `fail` member function

# 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;
```

# Using Loops to Process Files

- The stream extraction operator `>>` returns `true` when a value was successfully read, `false` otherwise
- Can be tested in a `while` loop to continue execution as long as values are read from the file:

```
while (inputFile >> number) ...
```

# 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



# Letting the User Specify a Filename

- The `open` member function requires that you pass the name of the file as a null-terminated string, which is also known as a C-string.
- *String literals are stored* in memory as null-terminated C-strings, but string objects are **not**.

# Letting the User Specify a Filename

- `string` objects have a member function named `c_str`
  - It returns the contents of the object formatted as a null-terminated C-string.
  - Here is the general format of how you call the `c_str` function:

```
stringObject.c_str()
```

# Letting the User Specify a Filename in Program 5-24

## Program 5-24

```
1 // This program lets the user enter a filename.
2 #include <iostream>
3 #include <string>
4 #include <fstream>
5 using namespace std;
6
7 int main()
8 {
9     ifstream inputFile;
10    string filename;
11    int number;
12
13    // Get the filename from the user.
14    cout << "Enter the filename: ";
15    cin >> filename;
16
17    // Open the file.
18    inputFile.open(filename.c_str());
19
20    // If the file successfully opened, process it.
21    if (inputFile)
```

Continued...

# Letting the User Specify a Filename in Program 5-24

```
22     {
23         // Read the numbers from the file and
24         // display them.
25         while (inputFile >> number)
26         {
27             cout << number << endl;
28         }
29
30         // Close the file.
31         inputFile.close();
32     }
33     else
34     {
35         // Display an error message.
36         cout << "Error opening the file.\n";
37     }
38     return 0;
39 }
```

## Program Output with Example Input Shown in Bold

```
Enter the filename: ListOfNumbers.txt [Enter]
100
200
300
400
500
600
700
```

# File Access Flags

**Table 12-2**

File Access Flag	Meaning
<code>ios::app</code>	Append mode. If the file already exists, its contents are preserved and all output is written to the end of the file. By default, this flag causes the file to be created if it does not exist.
<code>ios::ate</code>	If the file already exists, the program goes directly to the end of it. Output may be written anywhere in the file.
<code>ios::binary</code>	Binary mode. When a file is opened in binary mode, data is written to or read from it in pure binary format. (The default mode is text.)
<code>ios::in</code>	Input mode. Data will be read from the file. If the file does not exist, it will not be created and the open function will fail.
<code>ios::out</code>	Output mode. Data will be written to the file. By default, the file's contents will be deleted if it already exists.
<code>ios::trunc</code>	If the file already exists, its contents will be deleted (truncated). This is the default mode used by <code>ios::out</code> .

# `fstream` Object

- `fstream` object can be used for either input or output
- Must specify mode on the `open` statement
- Sample modes:
  - `ios::in` – input
  - `ios::out` – output
- Can be combined on `open` call:
- ```
fstream dFile;  
dFile.open("class.txt", ios::in | ios::out);
```

# Using Files - Example

```
// copy 10 numbers between files
// open the files
//can open file using constructor below
fstream infile("input.txt", ios::in);
fstream outfile("output.txt", ios::out);
int num;
for (int i = 1; i <= 10; i++)
{
    infile >> num;        // use the files
    outfile << num;
}
infile.close();           // close the files
outfile.close();
```

# More File Open Details

- Can use filename, flags in definition:

```
ifstream gradeList("grades.txt");
```

- File stream object set to 0 (`false`) if open failed:

```
if (!gradeList) ...
```

- Can also check `fail` member function to detect file open error:

```
if (gradeList.fail()) ...
```



# File Output Formatting

- Use the same techniques with file stream objects as with `cout`: `showpoint`, `setw(x)`, `showprecision(x)`, etc.
- Requires `iomanip` to use manipulators

### Program 12-3

```
1  // This program uses the setprecision and fixed
2  // manipulators to format file output.
3  #include <iostream>
4  #include <iomanip>
5  #include <fstream>
6  using namespace std;
7
8  int main()
9  {
10     fstream dataFile;
11     double num = 17.816392;
12
13     dataFile.open("numfile.txt", ios::out);    // Open in output mode
14
15     dataFile << fixed;                        // Format for fixed-point notation
16     dataFile << num << endl;                  // Write the number
17
18     dataFile << setprecision(4);              // Format for 4 decimal places
19     dataFile << num << endl;                  // Write the number
20
21     dataFile << setprecision(3);              // Format for 3 decimal places
22     dataFile << num << endl;                  // Write the number
23 }
```

## Program 12-3 (Continued)

```
24     dataFile << setprecision(2); // Format for 2 decimal places
25     dataFile << num << endl;    // Write the number
26
27     dataFile << setprecision(1); // Format for 1 decimal place
28     dataFile << num << endl;    // Write the number
29
30     cout << "Done.\n";
31     dataFile.close();           // Close the file
32     return 0;
33 }
```

### **Contents of File numfile.txt**

```
17.816392
17.8164
17.816
17.82
17.8
```

# Passing File Stream Objects to Functions

- It is very useful to pass file stream objects to functions
- Be sure to always pass file stream objects by reference

### Program 12-5

```
1 // This program demonstrates how file stream objects may
2 // be passed by reference to functions.
3 #include <iostream>
4 #include <fstream>
5 #include <string>
6 using namespace std;
7
8 // Function prototypes
9 bool openFileIn(fstream &, string);
10 void showContents(fstream &);
11
12 int main()
13 {
14     fstream dataFile;
15
16     if (openFileIn(dataFile, "demofile.txt"))
17     {
18         cout << "File opened successfully.\n";
19         cout << "Now reading data from the file.\n\n";
20         showContents(dataFile);
21         dataFile.close();
22         cout << "\nDone.\n";
23     }
```

```

24     else
25         cout << "File open error!" << endl;
26
27     return 0;
28 }
29
30 /*******
31 // Definition of function openFileIn. Accepts a reference *
32 // to an fstream object as an argument. The file is opened *
33 // for input. The function returns true upon success, false *
34 // upon failure. *
35 /*******
36
37 bool openFileIn(fstream &file, string name)
38 {
39     file.open(name.c_str(), ios::in);
40     if (file.fail())
41         return false;
42     else
43         return true;
44 }
45
46 /*******
47 // Definition of function showContents. Accepts an fstream *
48 // reference as its argument. Uses a loop to read each name *
49 // from the file and displays it on the screen. *
50 /*******

```

```
51
52 void showContents(fstream &file)
53 {
54     string line;
55
56     while (file >> line)
57     {
58         cout << line << endl;
59     }
60 }
```

### **Program Output**

File opened successfully.  
Now reading data from the file.

Jones  
Smith  
Willis  
Davis

Done.

# More Detailed Error Testing

- Can examine error state bits to determine stream status
- Bits tested/cleared by stream member functions

|                            |                                         |
|----------------------------|-----------------------------------------|
| <code>ios::eofbit</code>   | set when end of file detected           |
| <code>ios::failbit</code>  | set when operation failed               |
| <code>ios::hardfail</code> | set when error occurred and no recovery |
| <code>ios::badbit</code>   | set when invalid operation attempted    |
| <code>ios::goodbit</code>  | set when no other bits are set          |



# Member Functions / Flags

|                      |                                                                            |
|----------------------|----------------------------------------------------------------------------|
| <code>eof()</code>   | true if <code>eofbit</code> set, false otherwise                           |
| <code>fail()</code>  | true if <code>failbit</code> or <code>hardfail</code> set, false otherwise |
| <code>bad()</code>   | true if <code>badbit</code> set, false otherwise                           |
| <code>good()</code>  | true if <code>goodbit</code> set, false otherwise                          |
| <code>clear()</code> | clear all flags (no arguments), or clear a specific flag                   |

# From Program 12-6

```
68 void showState(fstream &file)
69 {
70     cout << "File Status:\n";
71     cout << "    eof bit: " << file.eof() << endl;
72     cout << "    fail bit: " << file.fail() << endl;
73     cout << "    bad bit: " << file.bad() << endl;
74     cout << "    good bit: " << file.good() << endl;
75     file.clear();    // Clear any bad bits
76 }
```

# Member Functions for Reading and Writing Files

- Functions that may be used for input with whitespace, to perform single character I/O, or to return to the beginning of an input file
- Member functions:
  - `getline`: reads input including whitespace
  - `get`: reads a single character
  - `put`: writes a single character

# The `getline` Function

- Three arguments:
  - Name of a file stream object
  - Name of a `string` object
  - Delimiter character of your choice
  - Examples, using the file stream object `myFile`, and the `string` objects `name` and `address`:  

```
getline(myFile, name);  
getline(myFile, address, '\t');
```
  - If left out, `'\n'` is default for third argument

## Program 12-8

```
1 // This program uses the getline function to read a line of
2 // data from the file.
3 #include <iostream>
4 #include <fstream>
5 #include <string>
6 using namespace std;
7
8 int main()
9 {
10     string input;      // To hold file input
11     fstream nameFile; // File stream object
12
13     // Open the file in input mode.
14     nameFile.open("murphy.txt", ios::in);
15
16     // If the file was successfully opened, continue.
17     if (nameFile)
18     {
19         // Read an item from the file.
20         getline(nameFile, input);
21     }
```

```
22         // While the last read operation
23         // was successful, continue.
24         while (nameFile)
25         {
26             // Display the last item read.
27             cout << input << endl;
28
29             // Read the next item.
30             getline(nameFile, input);
31         }
32
33         // Close the file.
34         nameFile.close();
35     }
36     else
37     {
38         cout << "ERROR: Cannot open file.\n";
39     }
40     return 0;
41 }
```

### **Program Output**

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# Single Character I/O

- **get: read a single character from a file**

```
char letterGrade;
```

```
gradeFile.get(letterGrade);
```

**Will read any character, including whitespace**

- **put: write a single character to a file**

```
reportFile.put(letterGrade);
```

# Working with Multiple Files

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



## Program 12-12

```
1 // This program demonstrates reading from one file and writing
2 // to a second file.
3 #include <iostream>
4 #include <fstream>
5 #include <string>
6 #include <cctype> // Needed for the toupper function.
7 using namespace std;
8
9 int main()
10 {
11     string fileName;    // To hold the file name
12     char ch;            // To hold a character
13     ifstream inFile;    // Input file
14
15     // Open a file for output.
16     ofstream outFile("out.txt");
17
18     // Get the input file name.
19     cout << "Enter a file name: ";
20     cin >> fileName;
21
22     // Open the file for input.
23     inFile.open(fileName.c_str());
24
25     // If the input file opened successfully, continue.
```

```
26     if (inFile)
27     {
28         // Read a char from file 1.
29         inFile.get(ch);
30
31         // While the last read operation was
32         // successful, continue.
33         while (inFile)
34         {
35             // Write uppercase char to file 2.
36             outFile.put(toupper(ch));
37
38             // Read another char from file 1.
39             inFile.get(ch);
40         }
41
42         // Close the two files.
43         inFile.close();
44         outFile.close();
45         cout << "File conversion done.\n";
46     }
47     else
48         cout << "Cannot open " << fileName << endl;
49     return 0;
50 }
```

### **Program Screen Output with Example Input Shown in Bold**

Enter a file name: **hownow.txt** [Enter]

File conversion done.

#### **Contents of** `hownow.txt`

`how now brown cow.`

`How Now?`

#### **Resulting Contents of** `out.txt`

`HOW NOW BROWN COW.`

`HOW NOW?`

# Binary Files

- Binary file contains unformatted, non-ASCII data
- Indicate by using `binary` flag on open:

```
inFile.open("nums.dat", ios::in |  
ios::binary);
```

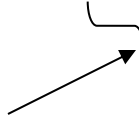
# Binary Files

- Use `read` and `write` instead of `<<`, `>>`

```
char ch;
```

```
// read in a letter from file
```

```
inFile.read(&ch, sizeof(ch));
```



address of where to put  
the data being read in.  
The `read` function expects  
to read `chars`



how many bytes to  
read from the file

```
// send a character to a file
```

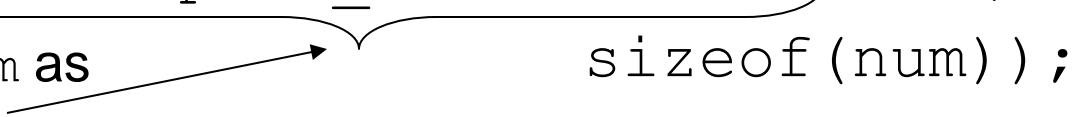
```
outFile.write(&ch, sizeof(ch));
```

# Binary Files

- To read, write non-character data, must use a typecast operator to treat the address of the data as a character address

```
int num;  
// read in a binary number from a file  
inFile.read(reinterpret_cast<char *>&num,  
            sizeof(num));  
// send a binary value to a file  
outf.write(reinterpret_cast<char *>&num,  
            sizeof(num));
```

treat the address of num as  
the address of a char



# Creating Records with Structures

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

# Creating Records with Structures

```
struct TestScore
{
    int studentId;
    double score;
    char grade;
};
TestScore oneTest;
...
// write out oneTest to a file
gradeFile.write(reinterpret_cast<char *>
    (&oneTest), sizeof(oneTest));
```

**See: Pr 12-15**



# Caution

- Structures containing pointers cannot be stored using the method explained. Because string class objects contain implicit pointers, they cannot be part of a structure that has to be stored.

# Random-Access Files

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

# Random Access Member Functions

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

# Random Access Member Functions

- `seekg, seekp` arguments:
  - offset: number of bytes, as a `long`
  - mode flag: starting point to compute offset
- Examples:

```
inData.seekg(25L, ios::beg);  
// set read position at 26th byte  
// from beginning of file  
outData.seekp(-10L, ios::cur);  
// set write position 10 bytes  
// before current position
```

# Important Note on Random Access

- If `eof` is true, it must be cleared before `seekg` **or** `seekp`:

```
gradeFile.clear();  
gradeFile.seekg(0L, ios::beg);  
// go to the beginning of the file
```

# Random Access Information

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

```
long int whereAmI;
```

```
whereAmI = inData.tellg();
```

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

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

# 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);
```
- Can also use `ios::binary` flag for binary data