File Input / Output Streams in C++

CS 16: Solving Problems with Computers I
Lecture #9

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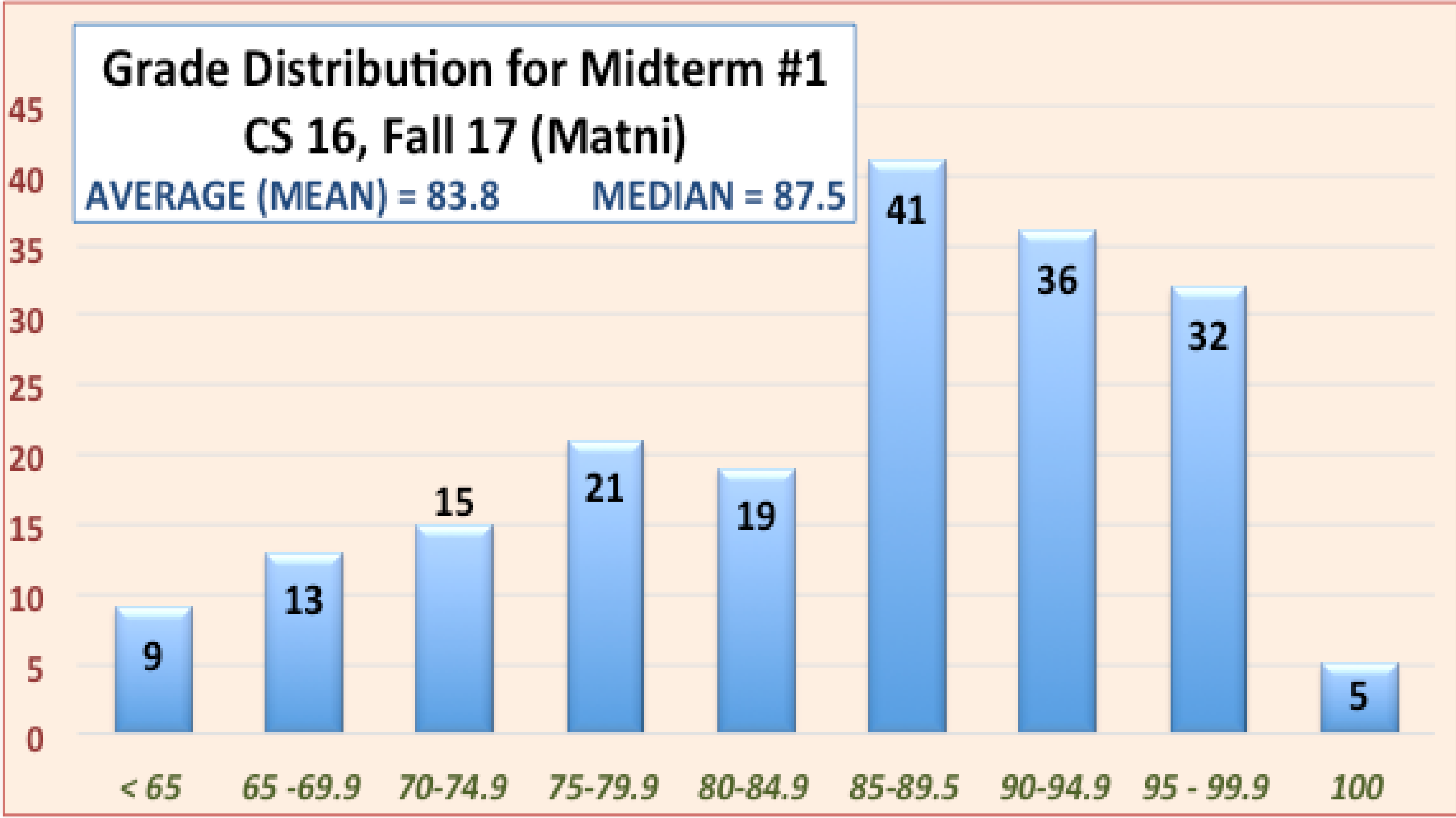
Announcements

- Midterm Exam grades out! ☺
  - If you want to see your exams, visit your lab TA during his/her office hours
  - You will only be able to view exams in their (or my) office
  - You will not be allowed to take the exams out of the office



Grade Distribution for Midterm #1
CS 16, Fall 17 (Matni)

AVERAGE (MEAN) = 83.8 MEDIAN = 87.5

Lecture Outline

- **I/O Data Streams and File I/O**
- An introduction to Objects and Member Functions
- Handling File I/O Errors

File I/O

- **Read (input) from a file**
  - Usually done *from beginning to the end* of file (not always)
    - No backing up to read something again (but you can start over)
    - Similar to how it's done from the keyboard

- **Write (output) to a file**
  - Usually done *from beginning to end* of file (not always)
    - No backing up to write something again (but you can start over)
    - Similar to how it's done to the screen

Stream Variables for File I/O

You have to use "stream variables" for file I/O and they…

- Must be **declared** before it can be used
- Must be **initialized** before it can contain valid data
  - Initializing a stream means ***connecting it to a file***
  - The value of the stream variable is really the filename it is connected to
- Can have their **values changed**
  - Changing a stream value means
    disconnecting from one file and then connecting to another

Streams and Assignment

- Streams use special built-in (member) functions instead of the assignment operator to change values

- ***Example***:

```
streamObjectX.open(“addressBook.txt”); // connects to file
streamObjectX.close();                 // closes connection to file
```

Declaring An **Input-File** Stream Variable

- Input-file streams are of type **ifstream**

- Type **ifstream** is defined in the **fstream** library
- You must use *include* statement and *using* directives

```
#include <fstream>
using namespace std;
```

- Declare an input-file stream variable with:

```
ifstream in_stream;
```

Variable type

Variable name

Declaring An **Output-File** Stream Variable

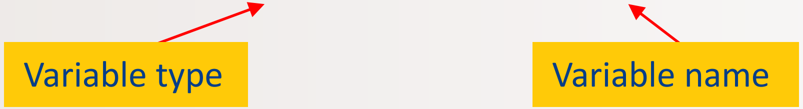
- Ouput-file streams of are type **ofstream**

- Type **ofstream** is defined in the **fstream** library
- Again, you must use the *include* and *using* directives

```
#include <fstream>
using namespace std;
```

- Declare an output-file stream variable using

```
ofstream out_stream;
```



Variable type

Variable name

Connecting To A File

Input Data File
Your C++ Program
Output Data File

- Once a stream variable is declared, you can connect it to a file
  - Connecting a stream to a file means "opening" the file
  - Use the *open* member function of the stream object

```
in_stream.open("infile.dat");
```

Double quotes

Period

Member function syntax

File name on the disk

Must include a true path (relative or absolute)

Using The Input Stream

- Once connected to a file, get input from the file using the extraction operator (**>>**)
  - Just like with **cin**

Example:

```
ifstream in_stream;
in_stream.open(“infile.dat”);
int one_number, another_number;

in_stream >> one_number >> another_number;

in_stream.close();
```

The inputs are read from the ***infile.dat*** *file separated by either spaces or newline characters*

DEMO!

Using The Output Stream

- An output-stream works similarly using the insertion operator (**<<**)
  - Just like with **cout**

Example:

```
ofstream out_stream;
out_stream.open(“outfile.dat”);

out_stream << “one number = ” << num1
        << “, another number = ” << num2;

out_stream.close();
```

*The output gets written in the **outfile.dat** file*

DEMO!

The **External File Name**

- Must be the name of a file that the operating system can use/open/read/write
- Be compliant with naming conventions on your system
  - Example: Don’t call an input **text** file ***XYZ.jpg***
- Make sure the path is true
  - If the file is local to your program, then no path is needed
  - Otherwise use either relative or absolute path names

Example: `infile.open(“../MyDirectory/inputFile_42.txt”);`

Closing a File

- After using a file, it should be closed using the .close() function
  - This *disconnects* the stream from the file
  - Close files to reduce the chance of a file being corrupted if the program terminates abnormally

- ***Example:*** `in_stream.close();`

- **It is important to close an output file if your program later needs to read input from the output file**

- The system will automatically close files if you forget
  as long as your program ends normally!

Member Functions

Member function: function associated with an object

- ***.open()*** is a member function of **in_stream** in the previous examples
  - **in_stream** is an **object** of **class** **ifstream**

- Likewise, a ***different .open()*** is a member function of **out_stream** in the previous examples
  - Despite having the same name!
  - **out_stream** is an object of class **ofstream**

For a list of member functions for I/O stream classes, also see:
http://www.cplusplus.com/reference/fstream/ifstream/
http://www.cplusplus.com/reference/fstream/ofstream/

Classes vs. Objects

- A class is a **complex data type** that can contain variables & functions
  - Example: **ifstream**, **ofstream**, **string** are examples of C++ classes
  - We'll discuss classes and objects in C++ later in the quarter

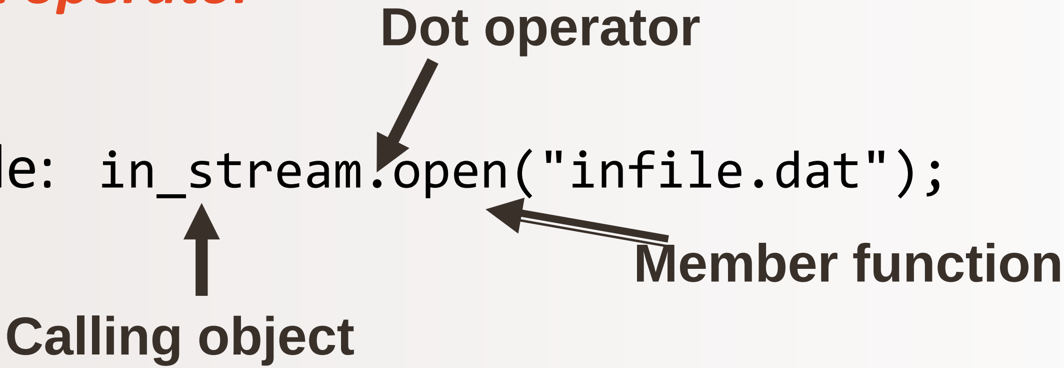
- When you call up a class to use it in a program,

  you ***instantiate*** it as an object
  - Example:

```
ifstream MyInputStream; // MyInputStream is an object of class ifstream
```

Calling a Member Function

- Calling a member function requires specifying the object containing the function
- The calling object is separated from the member function by the *dot operator*
- Example: `in_stream.open("infile.dat");`



Dot operator

Member function

Calling object

Errors On Opening Files

- Opening a file can fail for several reasons
  - The file might not exist
  - The name might be typed incorrectly
  - Other reasons

- **Caution**:
  You may not see an *error message* if the call to open fails!!
  - Program execution usually continues!

Catching Stream Errors

- Member function **fail()**, can be used to test the success of a stream operation

- `fail()` returns a Boolean type (True or False)

- `fail()` returns True (1) if the stream operation failed

Halting Execution

- When a stream open function fails, it is generally best to stop the program then and there!

- The function **exit()**, halts a program
  - `exit(n)` returns its argument (n) to the operating system
  - `exit(n)` causes program execution to stop
  - `exit(n)` is NOT a member function! It’s a function defined in **cstdlib**

- Exit requires the include and using directives

```
#include <cstdlib>
using namespace std;
```

Using **fail** and **exit**

- **Immediately following the call to open,**
  check that the operation was successful:

```
in_stream.open("stuff.dat");
if( in_stream.fail( ) )
  {
          cout << "Input file opening failed.\n";
                     // You can also use cerr instead of cout
          exit(1);   // Program quits right here!
   }
```

A Note on **cerr** vs **cout**

- Use **cout** for the standard output.
- Use **cerr** to show errors.

- There is a difference in how the outputs are “buffered” or not.
  - Has to do with how the memory is used: **Not a scope of CS16…**

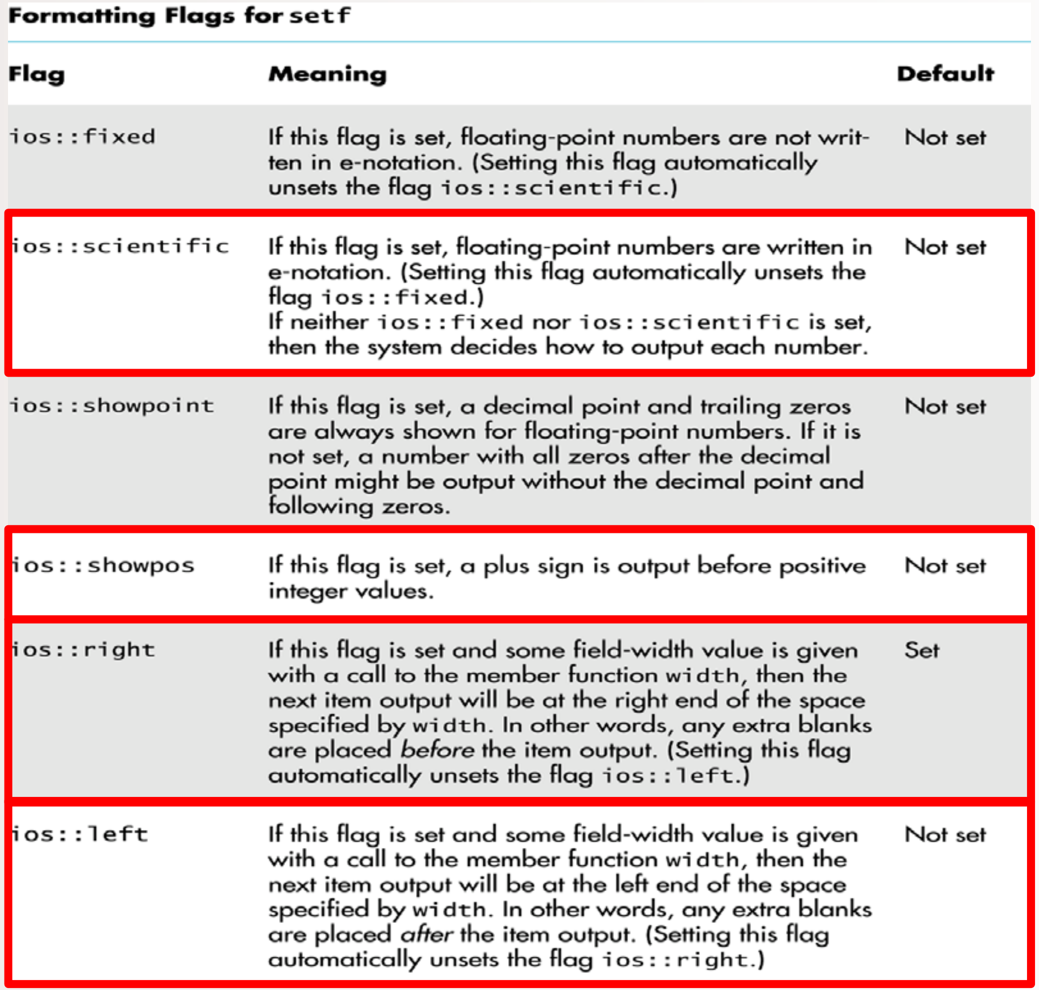
Formatting Output to Files

- Recall: Format output to the screen with:

```
cout.setf(ios::fixed);
cout.setf(ios::showpoint);
cout.precision(2);
```

- Similarly, format output to a file using out_stream with:

```
out_stream.setf(ios::fixed);
out_stream.setf(ios::showpoint);
out_stream.precision(2);
```



Formatting Flags for `setf`

Flag	Meaning	Default
`ios::fixed`	If this flag is set, floating-point numbers are not written in e-notation. (Setting this flag automatically unsets the flag `ios::scientific`.)	Not set
`ios::scientific`	If this flag is set, floating-point numbers are written in e-notation. (Setting this flag automatically unsets the flag `ios::fixed`.) If neither `ios::fixed` nor `ios::scientific` is set, then the system decides how to output each number.	Not set
`ios::showpoint`	If this flag is set, a decimal point and trailing zeros are always shown for floating-point numbers. If it is not set, a number with all zeros after the decimal point might be output without the decimal point and following zeros.	Not set
`ios::showpos`	If this flag is set, a plus sign is output before positive integer values.	Not set
`ios::right`	If this flag is set and some field-width value is given with a call to the member function `width`, then the next item output will be at the right end of the space specified by `width`. In other words, any extra blanks are placed *before* the item output. (Setting this flag automatically unsets the flag `ios::left`.)	Set
`ios::left`	If this flag is set and some field-width value is given with a call to the member function `width`, then the next item output will be at the left end of the space specified by `width`. In other words, any extra blanks are placed *after* the item output. (Setting this flag automatically unsets the flag `ios::right`.)	Not set

Creating Space in Output

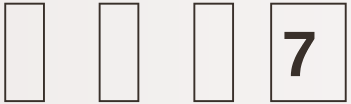
- The **width member** function specifies the number of spaces for the next item
  - Applies *only to the **next** item of output*

Example:

- To print the digit **7** in four spaces and use

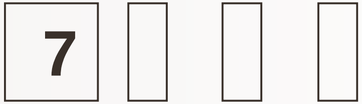
```
out_stream.width(4);
out_stream << 7 << endl;
```

Three of the spaces will be blank:



.setf(ios::right)

default



.setf(ios::left)

Not Enough Width?

- What if the argument for width is too small?
  - Such as specifying `cout.width(3);` when the value to print is **3456.45**

- The entire item is always put in output
  - If too few spaces are specified, then spaces are added as needed
  - In the example above, the entire value (3456.45) is still printed out as if the `cout.width(3);` was not there.

Unsetting Flags

- Any flag that is set, may be unset
- Use the **unsetf** function
  - Example:

```
cout.unsetf(ios::showpos);
```

causes the program to stop printing plus signs on positive numbers

Manipulators

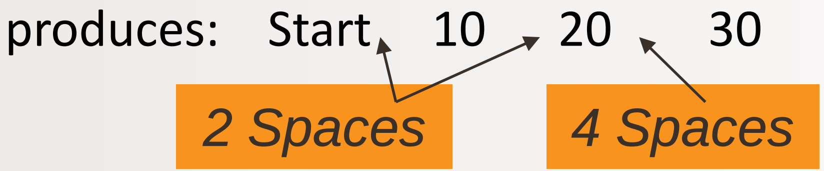
- A type of function called in a nontraditional way
- Manipulators, in turn, *call member functions*
  - May or may not have arguments to them
- Used after the insertion operator (**<<**) as if the manipulator function call is an output item

The **setw** Manipulator

- **setw** does the same task as member function **width**
  - setw calls the width function to set spaces for output: only effective for one use
  - Found in the library **<iomanip>**

- Example:

```
cout << "Start" << setw(4) << 10
     << setw(4) << 20 << setw(6) << 30;
```



produces:

```
Start  10  20    30
```

2 Spaces

4 Spaces

- *The 1st setw(4) ensures 4 spaces between “Start" and 10, INCLUSIVE of the spaces taken up by 10.*
- *The 2nd setw(4) ensures 4 spaces between 10 and 20, INCLUSIVE of the spaces taken up by 20.*
- *The 3rd setw(6) ensures 6 spaces between 20 and 30, INCLUSIVE of the space taken up by 30.*

The **setprecision** Manipulator

- **setprecision** does the same task as member function **precision**
  - Found in the library **<iomanip>**

- Example:

```
cout.setf(ios::fixed);
cout.setf(ios::showpoint);
cout << "$" << setprecision(2)
     << 10.3  << endl << "$" << 20.5 << endl;
```

produces:

```
$10.30
$20.50
```

- setprecision setting stays in effect until changed

Appending Data to Output Files

- Output examples we've given so far *create new files*
  - If the output file already contained data, that data is **now lost!**

- To ***append*** new output to the end an existing file use the constant **ios::app** defined in the **iostream** library:

  ```
  outStream.open("important.txt", ios::app);
  ```

  - If the file does not exist, a new file will be created

- There are other member functions that return the location in the I/O file where the next data will be
  - Helps with customizing read and writing files
  - To be used carefully! We won't go over them here…

Entering File Names for I/O Files

- Users can also enter the name of a file to be read/written
  - As an input read by **cin**

- You can use regular C++ strings for the filenames, but **ONLY** if you ensure that you are compiling with C++ version 11 (or later).

- OTHERWISE, you'll have to use C-strings
  - **WARNING!!!! PAY ATTENTION TO THIS!!!**

- Textbook has details on how to use C-strings for filenames

More Options for Compilations Using **g++**

So far, you've been using g++ as follows:

```
g++ myLittleProg.cpp –o myLittleProg
```

You can tell g++ to also make sure that it uses ver. 11:

```
g++ myLittleProg.cpp –o myLittleProg –std=c++11
```

Additionally, g++ can also print out "warnings" for you, not just compile errors (this can help you in catching problems early!)

```
g++ myLittleProg.cpp –o myLittleProg –std=c++11 -Wall
```

YOUR TO-DOs

- ❑ HW 5 due Thu. 11/2
- ❑ Lab 5 due Fri. 10/27

- ❑ Visit Prof’s and TAs‘ office hours if you need help!
- ❑ Call Mom

</LECTURE>