## CSE 143

## Stream I/O

Appendix A

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## Input/Output Concepts

- Concepts should be review!
  - New syntax, but same fundamental concepts
- input vs. output, read vs. write
- conversion between characters in a stream and C/C++ data values (types) in a program
- File concepts
  - what is a file?
  - file name vs. file variable
  - open, close
  - end-of-file

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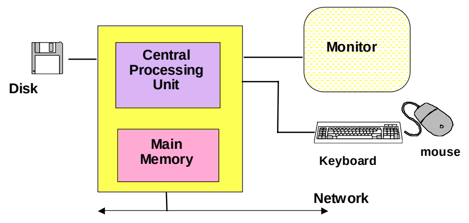
## What's a Computer?



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## Stream I/O

- The basic C++ I/O library is built around the concept of streams.
  - both for keyboard/monitor and for files
- Old C-style **`printf`**, **`scanf`**, etc. library is still available, **but**….
  - Mixing the two is bad news
  - You **must** use only stream I/O in CSE143

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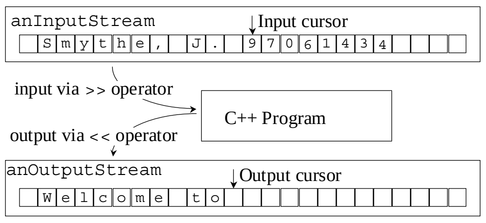
## What is a Stream?

A stream is just a sequence of *characters*, nothing else:



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## Only characters?!

- Wait a minute... if the stream is only characters, how can we read or write integers, or doubles, or strings?
- Answer: the library functions *convert* other types to and from characters.

Example: the stream contains

`45`

That is two characters, not a number!

`cin >> i;` converts the two characters into an integer and stores it in the integer variable i.

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## Well-Known Streams

- Global streams defined in **`iostream.h`** :
  - **`cin`**: standard *input* stream (usually keyboard)
  - **`cout`**: standard *output* stream (usually screen)
  - **`cerr`**: standard *error* stream (also usually directed to the screen)
- Programs can open other streams to/from files and other devices.

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## << Review

For output streams, **<<** is the “put to” or "insertion" operator

```
#include <iostream.h>
…
int count = 23;
cout << "Hello, World!" << '\n';
          // endl: same as '\n', but flushes output
cout << "The count is " << count << endl;
```

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## >> Review

For input streams, >> is the “get from” or "extraction" operator

```
#include <iostream.h>
…
int x, ID;
char Name[40];
cin >> x;
cin >> Name >> ID;
// Can read multiple items on one line
// Note: no &'s as with scanf
```

- **`<< and >> are aware of the types of the data`**

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## How Stream Input Works

Rule: With simple types: leading whitespace is skipped

```
int ID;
char Name[40];
char ch;

cin >> ID;   // interprets as integer
cin >> ch;   // reads a char
cin >> Name; // interprets as character string,
             // stopping at trailing whitespace
```

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## In more detail

```
int i; char ch; char buffer[BUF_SIZE];
cin >> ch >> buffer >> i;
```

*input:* “_hello\t\n15w”

|   |   |   |   |   |   |   |   |   |   |   |
|---|---|---|---|---|---|---|---|---|---|---|
| _ | h | e | l | l | o | \t | \n | 1 | 5 | w |

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## Built-in vs other types

- cin and cout understand the basic C++ types, including strings
- They do not understand other arrays or user-defined types (structs, classes, enums, etc)
- But... it is possible to “overload” << and >> to understand your classes!
- Eventually you will be able to write

  **cout << myFavoriteBook**
- and have it do something reasonable

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## Stream States

- All streams have a "state".
- All streams are objects (instances of stream classes)
- Several member functions are available to check or set state.

```
    cin.eof();   // true if cin eof reached
    cin.clear(); // set state to "good"
```

- The stream itself can be used in an expression to check its state

```
    if (!cin)
      cerr << "error or eof on cin" <<
endl;
```

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## End-Of-File State

- Means there is no more input in the stream
- *eof is a state; it's not a special value in the stream*
- eof is most often used with files
- eof with keyboard input?
  - User signals by typing a special key combination
  - CNTL-Z, CNTL-D, etc. depends on operating system
  - The special key is NOT sent to the program. The eof status is what is detected.

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## Input Errors

- Stream input "fails" if the next thing in the input has the wrong format or if there is no more data (end of file).
- If an input operation fails, the variable involved is not changed.

```
    if (cin >> k)
      cout << "new value for k read ok";
    else
      cout << "input failed; "
              << "k not changed";
```

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## Input Errors (cont)

- Once a stream input operation has failed, any further operations will also fail until the stream state is cleared.

```
    // suppose next input is "xyz"
    cin >> k;  // fails (why?); k unchanged
    cin >> j;  // cin state not good, so
               // nothing happens
    cin.clear();  // cin can be used for
                  // input again
```

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## Example: Copy Integers

- This program copies integers from cin to cout until an input operation fails. Each integer is written on a separate output line.

```
  #include <iostream.h>
  int main() {
    int j;
    while (cin >> j)
       cout << j << '\n';

    return 0;
  }
```

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## Reading a Whole Line

- Reading

    **Seattle  Rain**

- vs

    **Seattle-Rain**

- cin >> stringvar  won't do the former -- why?
- Need an additional function: getline

    ***cin.getline (stringvar, len);***

- Dot notation! What's happening here??
  - Answer: Remember, cin and cout are really objects

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## Unformatted Stream I/O

- >> and << provide formatted I/O.
  - There are member functions which provide unformatted (character-level) I/O.
- Examples:

```
char ch; char s[100];
cin.get(ch);  // read 1 character into ch
cin.getline(s,n); // read next line into s
cout.put(ch); // write 1 character ch
```

- Variations available to limit how many characters are read, specify end-of-line characters, etc.

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## Next Step: Files

- Review: File is a named collection of data on disk
- Basic idea of using files in C++: Attach a file to a stream!
  - Then the characters of that file become the characters of the stream.
- Use class *ifstream* for input text files, *ofstream* for output text files.
- You can attach (open) the file by giving its name to the constructor:
  - ifstream myfile (“c:\\testdata.txt”);    // why “\\” here?

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## What is a file?

- A collection of data stored on a disk
- Text file
  - A sequence of characters
- Binary file
  - stores data in an efficient, non-human-readable, form
- “File name”: a way of naming a file
  - OS rules such as DOS: 8 chars . 3 chars

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| a | _ | f | i | l | e | \n | e | n | d | **EOF** |

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## File Operations (Abstract)

- “open”
  - Creating a variable to represent the file
  - Allows you to access the file’s contents
- “read”
  - getting data from the file, similar to `cin >> var;`
- “write”
  - storing data to a file, similar to `cout << var;`
- “close”
  - Tells the OS you’re finished with a file
  - Can’t do any more reading/writing
  - Might lose data if you forget to close!

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## Stream Classes

- cin and cout are defined in <iostream.h>.
- Library <fstream.h> contains similar classes for file I/O
- Input stream classes:
  - istream: console input (cin)
  - ifstream: file input
- Output stream classes
  - ostream: console output (cout, cerr)
  - ofstream: file output

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## Streams as C++ Classes

- Streams are C++ classes
- Streams have lots of built-in methods
- We use the “.” syntax to access member functions, as usual.

```
inFile.get(ch);        // get a character
outFile.put(ch);       // put a character
outFile.getline(str, len); //get a whole line
outFile.close();       // close the stream
inFile.eof();          // end of File??
```

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## Testing the Stream

- The stream can be tested as if it were a boolean
  - **if (mystream)...**
- Two typical occasions for testing:

1. Right after opening, to see if the open worked
   - **ifstream dfile (“c:data”);**
   - **if (dfile) cout << “OK”; else cout << “bad”;**
2. While processing, to see if end of file
   - **while (dfile ) //is the stream still good?**
     - **{ keep reading data}**

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## File Stream Example

```
#include <iostream.h>
#include <fstream.h>

void main() {
     // open file--ios:: flags needed in MSVC++
  ifstream inFile("input.txt",
                  ios::nocreate | ios::in);
  ofstream outFile("output.txt");  // open output
  char ch;

  // should test for successful opening here..

  while (inFile.get(ch)) { // while more input
     outFile.put(ch);      // write it to output
  }

  inFile.close();          // close the files...
  outFile.close();
}
```

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## Another File Example

```
#include <fstream.h>

  // multiply every int in a file by a factor
void multiplyFile(char in[], char out[],
                    int factor) {
     // open file--ios:: flags needed in MSVC++
  ifstream inFile(in, ios::nocreate | ios::in);
  ofstream outFile(out);  // open output
  int i;

  // should test for successful opening here..

  while (inFile >> i)) {    // while more input
      outFile << i * factor << ‘ ’;
  }

  inFile.close();          // close the files...
  outFile.close();
}
```

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## Stream Class Relationships

- Every ifstream (file) is also a istream.
  - An ifstream is an “enhanced” istream that has extra capabilities to work with disk files
    - An ifstream object can be used wherever an istream object is needed (function parameter, for example)
  - But the reverse is not true. An istream is not also an ifstream.
    - So if an ifstream is explicitly called for, cin can’t be used
- A similar relationship holds between ofstreams and ostreams.
- This is an example of "inheritance"
  - An important object-oriented concept we will study later

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## Notes and Advice

- File and stream processing can get VERY baroque
  - Many details, gotchas, exceptions, etc. in the C++
  - File formats are often complex
- Learn the basics
- Try to keep it simple (not always possible)
- You can't memorize it all
- Buy a good C++ book and keep it handy when programming!
  - Bookstore has lots to choose from. Browse and buy one you like

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