Streams
IO Streams

Streams are objects with names such as cin, cout, or cerr
Buffer

- Each stream has an associate buffer, part of the stream object, that data is pulled/pushed from
The >> (extraction) operator is an overloaded operator that takes values out of an input stream (cin) and stores them as the type indicated by the target variable.

```
int my_var; cin >> my_var;
```

The ‘1’ is read and then the ‘8’ is read. Then the two characters are converted into the integer 18 which is stored in variable my_var.
When cin goes bad

```cpp
int my_int = 10;
cin >> my_int;
```

Typed operator, can only read `int` stuff, fails at the ‘a’
fail is fail, you must fix

```cpp
int my_int = 10;
cin >> my_int; // fail
cin >> my_char; // fail
```

`abc123` is in the `cin` buffer.

`cin` stays in a failed state until you clean it up. All subsequent reads fail until that happens.
Status functions

- Useful boolean member functions
  - `cin.good()`: all is well in the istream
  - `cin.bad()`: something is wrong with the istream
  - `cin.fail()`: last op could not be completed
  - `cin.eof()`: last op encountered end-of-file

- Useful with the `assert()` function: e.g. `assert(cin.good())`
cin.clear()

```cpp
int my_int, an_int;
cin >> my_int;
if (cin.fail())
    cin.clear(); // good
    cin >> my_int; // fail
```

`clear` clears the error, back to `good`, but not the problem. Buffer is unchanged! Fails again.
Clear the buffer

- `cin.ignore(num_chars_to_skip, stop_char)`
- Clears that number of characters up to and including `stop_char`
- E.g. `cin.ignore(20, '\n')` skips 20 characters or until `\n`, whichever comes first
int my_int, an_int;
cin >> my_int;
if (cin.fail()) {
    cin.clear(); // good
    cin.ignore(1000, '\n');
}
// reprompt, try again

ignore empties the buffer. Now you can try again (reprompt for example)
More on ignore

- Takes a default count of 1
  - Any number works
    - `numeric_limits<streamsize>::max()` *(requires `#include<limits>*) means as many as necessary to hit the stop char
- Takes a default stop at the `eof` char
More complicated for a float

- The situation is more complicated for numbers. For example, try reading a float into an integer.
When cin goes bad

```cpp
int my_int;
cin >> my_int; // 18
```

Typed operator, can only read `int` type stuff, stops (*not fails*) at the '.'

Not a failure, more like a separator
When cin goes bad

```cpp
int my_int, an_int;
cin >> my_int; // 18
cin >> an_int;
```

Next read is a failure (chokes on the '.')
When cin goes bad

int my_int, an_int;
cin >> my_int; // 18
cin >> an_int;

Next read is a failure (chokes on the ‘\n’)
Better to treat as a string and cast

- We’ll see it is easier to treat this as a string and try to cast it
cin returns?

- cin >> some_var returns
  - cin if things go well
  - false if you hit eof
  - false if the stream is in a fail or bad mode

- Thus you can

while (cin >> some_var)
White space

- White space: blanks, tabs, and returns
- By default, the >> operator skips *leading* whitespace

```cpp
int x, y, z;
cin >> x >> y >> z;
```

**Input:**
```
3     4               5
```

**x is 3, y is 4, z is 5**
Controlling White Space

- Turn off skipping white space:
  - `cin >> noskipws`

- Turn skipping white space back on:
  - `cin >> skipws`

- Alternative: Use an input function which does not skip whitespace
  - `cin.get(ch)` reads **exactly one** character, no matter the character
**Single Character**

- To read a single character, not skipping:
  - `cin.get(ch)`

- To put that character back into the buffer:
  - `cin.putback(ch)`

- To peek without removing it:
  - `cin.peek()`
Output functions

- Single character function:
  - `cout.put(ch)` puts a single character into the ostream
cout and cerr are particular instances of an ostream.
// << operator

double PI = 3.1416;
cout << PI;

The double PI is converted into the six characters for output: ‘3’, ‘.’, ‘1’, ‘4’, ‘1’, ‘6’
Output formatting

- We have seen many of the format codes (see pg 757 of book)
  - `skipws`, `left`, `right`, `dec`, `oct`, `hex`, `uppercase`, `scientific`, `fixed`
- There are others
- `in_stream.setf(ios::skipws)` is an alternate way to some of these.
- Book uses the former
Buffer

- Output characters are stored into a buffer before being output
  - i.e. Gather a bunch of characters before sending them to the screen.
- This can be a problem when debugging
  - Output may be in the buffer
  - You believe the error occurred before the output statement when it actually occurred afterward
Buffering and Debugging

double f(double x) {
    cout << "entering f";
    ...
    cout << "exiting f";
    return z;
}
Flush buffer

double f(double x) {
    cout << "entering f" << endl;
    ... 
    cout << "exiting f" << flush;
    return z;
}
File Streams
Files

- Files are collections of data and are stored in nonvolatile memory
  - e.g. secondary storage such as disk
- Text files store characters such as ASCII
  - e.g. source code
- Binary files contain non-ASCII characters
  - e.g. compiled code
- Humans can read text files
Streams are objects with names such as cin, cout, or cerr
File Streams

Previous streams are objects with names such as cin, cout, or cerr. Now we add streams which are files. We can name them.
Just another stream

- Because we are working with the stream object, the pipe, we do not have to worry about particular devices (that is the software’s problem).
- Result is that many of the operations we used with `cin` and `cout` work with files.
To work with a file

- Required `#include<fstream>`. This provides two kinds
  - `ifstream` (input files)
  - `ofstream` (output files)

- Can establish a connection by
  - Declare with the name (as a string) to open automatically
  - `.open(string)` method to establish connection between a program and a file
Example

```cpp
#include<fstream>
// automatically open in_file
ifstream in_file("my_file.txt");
ofstream out_file;
string file_name;
cin >> file_name;
// out_file created and now opened
out_file.open(file_name);
```
Where is that file?

- When you open a file with a simple name, like “file.txt”, the assumption is that the file is located in the same directory / folder as the executing program.
- If not there, you may have to give a fully qualified path
Fully Qualified Path

- Sadly, this can depend on the underlying operating system
  - C:\Documents\My Folder\file.txt
  - /usr/local/joshnahum/file.txt
Standard Operations

- `>>, <<` input and output operations
- `getline(istream, str)` reads a line into a string
- `eof()` true if end-of-file mark was read
- `get()` or `put()`
- etc.
Unique operations

- `.open()` method
- `is_open()` true if file was successfully opened
- `close()` method terminates the connection between a program and a file
  - flushes the buffer
Other file modes

- **in**: open for input
- **out**: open for output
- **app**: seek to the end before every write
- **ate**: seek to the end immediately after opening
- **trunc**: Truncate the file
- **binary**: Do IO operations in binary mode

- For input files, the default is input
- For output files, the default is open and trunc.
  - By default, wipes out any info in the file being written to
- See Table 8.4 on page 319
Specify yourself

- If you declare a file as an fstream, you get to decide what aspects you want.

```cpp
fstream in_out_file("file.txt",
    fstream::in | fstream::out | fstream::ate);
```

Vertical bars are bitwise or operator
One can combine all aspects this way

- This file can read from and write to and writing occurs at the end of the file