Lecture 4: Streams

CS 106L, Winter ‘21

Today's Agenda

- Recap: **References**
- Streams
- File Streams
- String Streams
- Buffering
- State Bits
- Chaining

Recap: Something

Uniform initialization

```
int x{3};          // One syntax to initialize all variables

// Both of these are vectors with elements {3, 5, 7}
std::vector<int> a_vector{3, 5, 7};
std::vector<int> another_vector = {3, 5, 7};

Student s = {"Ethan", "CA", 20};
```

References

```
int b = 5;
int& a = b;
a = 2;                          // now b = 2 as well

void switch(int& c) { c = 3; }
switch(a);                      // now b = 3 as well

const int& d = a;
d = 5;                          // fails because const reference
```

You can return references

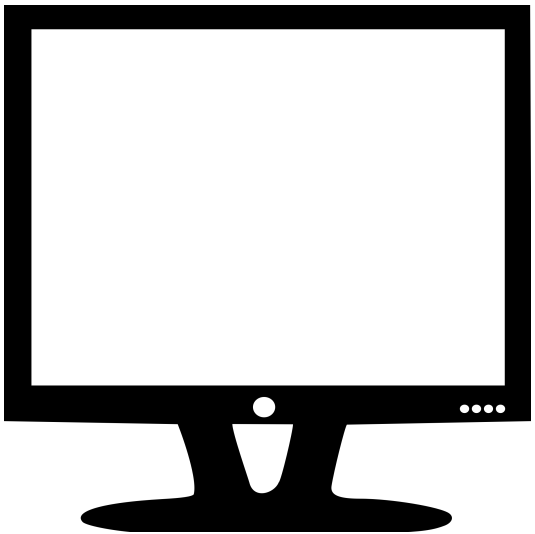
Common idiom: return an element inside our class.

```
// Note that the parameter must be a non-const reference to return
// a non-const reference to one of its elements!
int& front(std::vector<int>& vec) {
    // assuming vec.size() > 0
    return vec[0];
}

int main() {
    std::vector<int> numbers{1, 2, 3};
    front(numbers) = 4; // vec = {4, 2, 3}
    return 0;
}
```

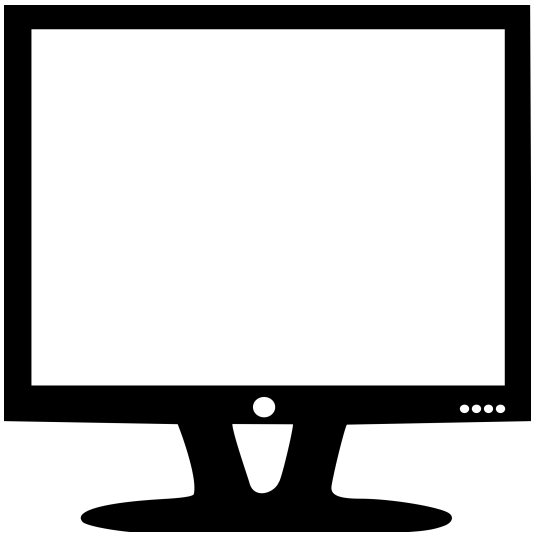
Streams

A stream is an abstraction for input/output



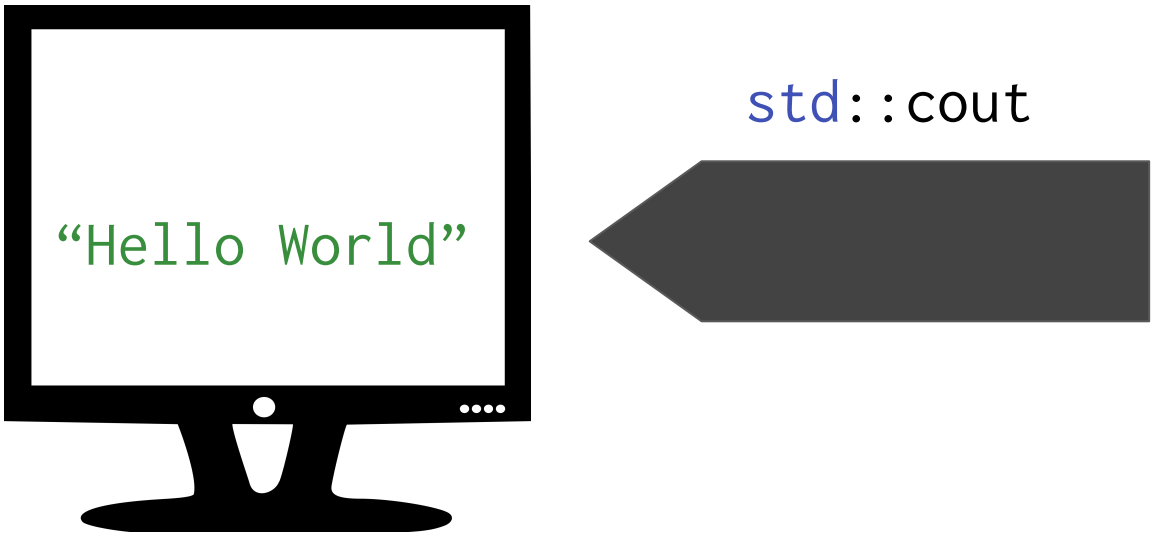
```
std::cout
```

```
<< “Hello World”
```



```
std::cout
```

```
“Hello World”
```


“Hello World”
std::cout

Streams can take different types of input!

```
cout << “Strings work!” << endl;
cout << 1729 << endl;
cout << 3.14 << endl;
cout << “Mixed types: ” << 1123 << endl;
```

Any primitive type can be inserted;
for other types, you need to explicitly tell C++ how to do this

Streams convert between the string representation of data and the data itself.

Idea: both input and output are strings;
need to do computation on object representation

Types of Streams

Output Streams

- Of type **std::ostream**
- Can only **receive** data with the << operator
  - Converts data to string and **sends** it to stream

```
std::cout << 5 << std::endl;     // prints 5 to the console

std::ofstream out("out.txt", std::ofstream::out);
out << 5 << std::endl;           // out.txt contains 5
```

Live Code Demo:
Ostreams.cpp

Input Streams

What does this do?

```
int x;
std::cin >> x;

// what happens if input is 5 ?
// how about 51375 ?
```

Input Streams

- Of type **std::istream**
- Can only **give you** data with the >> operator
  - Receives string from stream and converts it to data

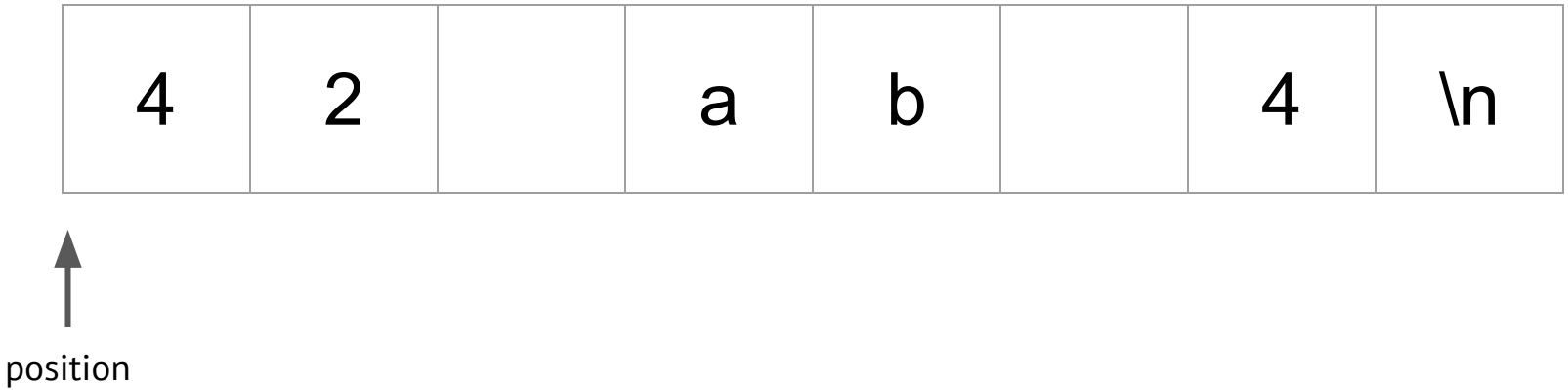
```
// input: 5 abc 7
int x, z; string y;
std::cin >> x > y > z;                          // x=5, y="xyz", z=7

// std::ifstream does the same for files
std::ifstream in("out.txt", std::ifstream::in);
in >> x >> y >> z;                             // out.txt contains 5
```


Questions?

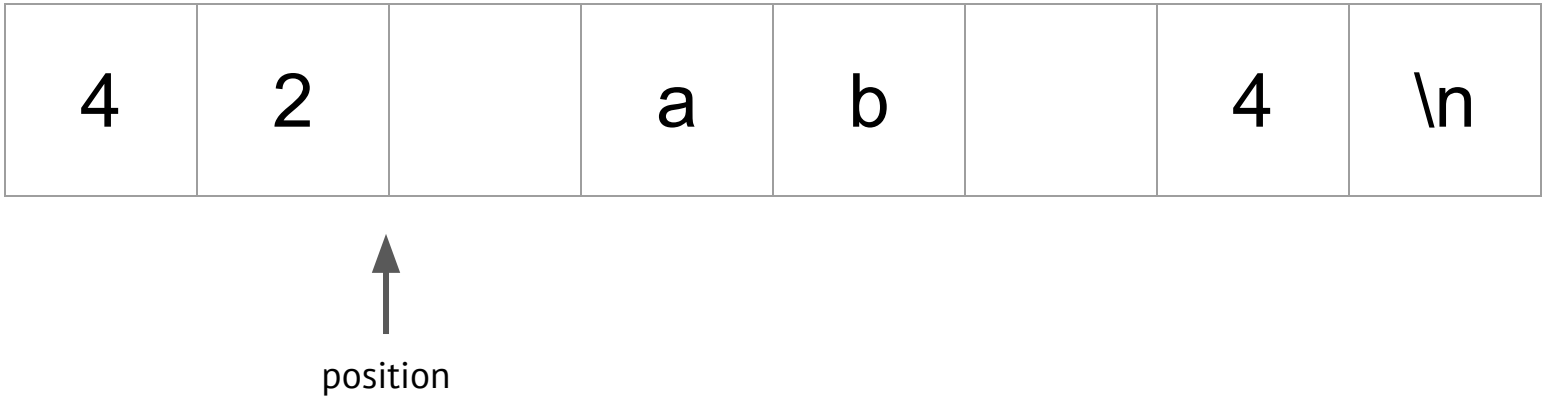
Why does this work?

Think of a `std::istream` as a sequence of characters



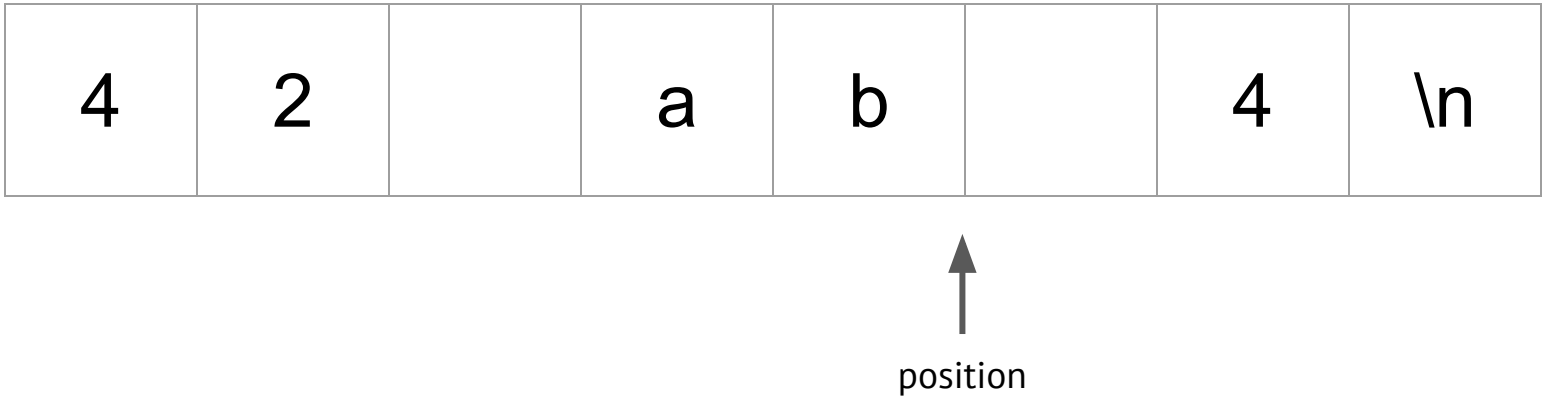

```
int x; string y; int z;
input >> x;
input >> y;
input >> z;
```

Extracting an `int` reads as many characters as possible until whitespace



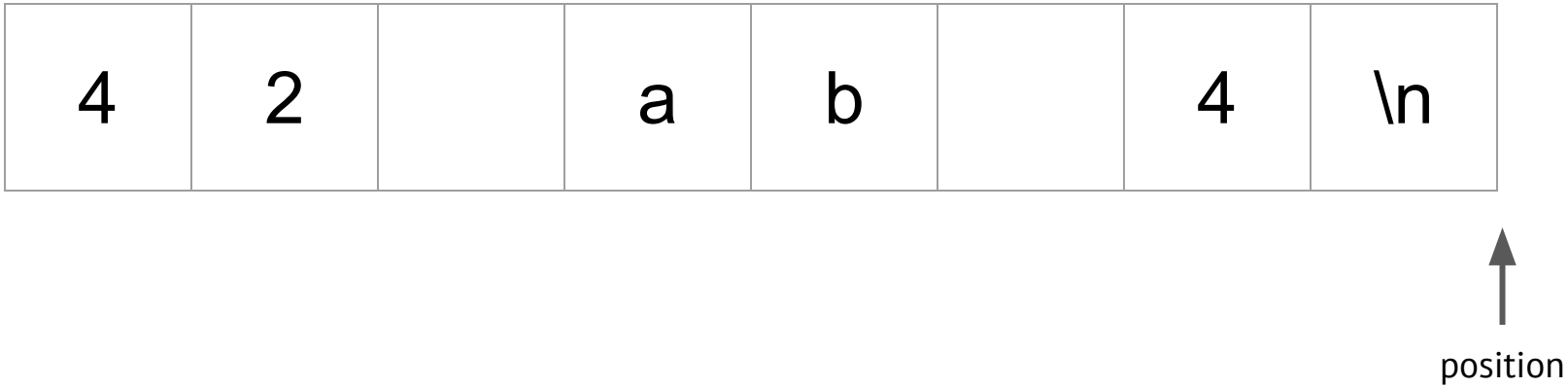

```
int x; string y; int z;
input >> x; // 42 put into x
input >> y;
input >> z;
```

Next time, first skip over any whitespace




```
int x; string y; int z;
input >> x;
input >> y; // ab put into y
input >> z;
```

When no more data is left, fail bit set to true




```
int x; string y; int z;
input >> x;
input >> y;
input >> z; // 4 put into z
```

Input Streams

Given what we just learned, what does this do? Answer in the chat.

```
int x;
std::cin >> x;
std::cout << x * 5 << std::endl;

// what happens if input is blah ?
```

Reading using >> extracts a single "word"

including for strings

To read a whole line, use

```
getline(istream& stream, string& line);
```

Don’t mix >> with getline!

- **>>** reads up to the next whitespace character and *does not* go past that whitespace character.
- **getline** reads up to the next delimiter (by default, ‘\n’), and *does* go past that delimiter.
- Don’t mix the two or bad things will happen!

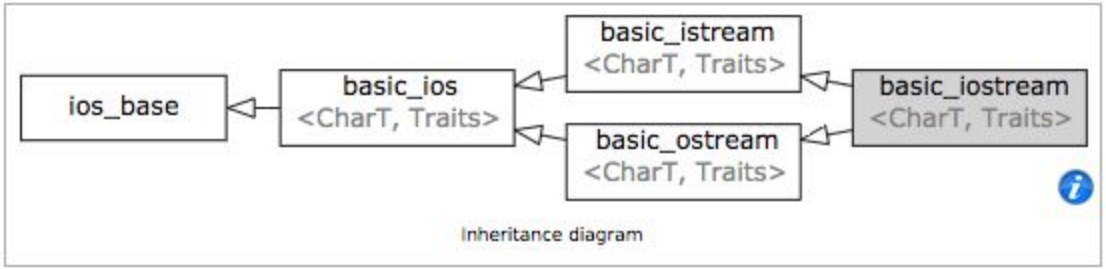
📝 **Note for 106B/X:** Don’t use >> with Stanford libraries, which use getline.

Additional Stream Methods

```
input.get(ch);                  // reads a single char
input.clear();                  // resets the fail bit
input.open("filename");         // opens stream on a file
input.seekg(0);                 // rewinds stream to start

input.close();                  // closes stream
                                // done automatically for you,
                                // so not necessary
```

std::iostream is both a istream & ostream




Questions?

Stringstreams

Work with a string as if it were a stream

```
std::string input = “5 seventy 2”;

std::istringstream i(input);
int x; std::string y; int z;
i >> x >> y >> z;

std::cout << z << std::endl;
```

Live Code Demo:
String Streams

Stream Internals

Stream Internals

- Buffering
- State Bits
- Chaining (a.k.a. why << << << works)

Buffering

Writing to console/file is slow.

If we had to write each character separately, slow runtime.

Accumulate characters in a temporary buffer.

```
input << “hel”;
input << “lo ”;
input << “world”;
```

When full, write entire buffer to output

```
Output: hello world
```

Empty the buffer early by flushing:

```
stream << std::flush;          // flush what we have so far
stream << std::endl;           // flush with newline
// this is equivalent to: stream << “\n” << std::flush;
```

Buffer Takeaways

- The internal sequence of data stored in a stream is called a **buffer.**
- Istreams use buffers to store data we haven't used yet.
- Ostreams use buffers to store data that hasn't been outputted yet.

🤔 There's actually a third standard stream, `std::cerr`, which is not buffered. Why?

State Bits

Streams have four state bits

Good bit: whether ready for read/write

Fail bit: previous operation failed, future operations frozen

EOF bit: previous operation reached end of file

Bad bit: external integrity error

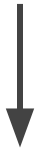
Using State Bits

```
// here's a very common read loop:

while (true) {
    stream >> temp;                 // read data
    if (stream.fail()) break;       // checks for fail bit OR bad bit
    doSomething(temp);
}
```

Streams can be converted to bool

```
stream >> temp;
if (stream.fail()) break;      // checks for fail bit OR bad bit
doSomething(temp);
```



```
stream >> temp;
if (!stream) break;            // same thing
doSomething(temp);
```

Aside: Chaining

Chaining >> and <<

>> and << are actually functions!

```
std::ostream& operator<<(std::ostream& out, const std::string& s);
std::ostream& operator<<(std::ostream& out, const std::string& s);
```

```
std::cout << "hello";
```

```
operator<<(std::cout, "hello");
```

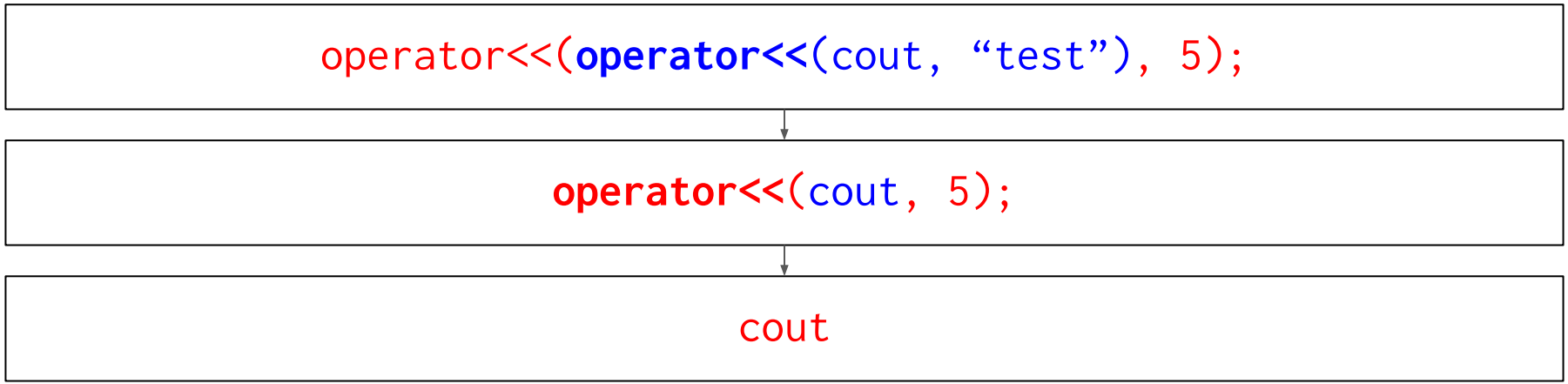
```
std::cin << temp;
```

```
operator>>(std::cout, temp);
```

This is how the magic std::cout mixing types works!

```
std::ostream& operator<<(std::ostream& out, const std::string& s);
std::ostream& operator<<(std::ostream& out, const int& i);
```

```
cout << "test" << 5;        // (cout << "test") << 5;
```



Using State Bits – Part 2

```
// here's a very common read loop:

while (true) {
    stream >> temp;                 // read data
    if (!stream) break;             // checks for fail bit OR bad bit
    doSomething(temp);
}
```

This returns the stream itself!

Using State Bits – Part 2

```
// here's a very common read loop:

while (stream >> temp) {
    doSomething(temp);
}
```