Streams

How can we convert between string-represented data and the real thing?

Attendance

bit.ly/3mpdw

Announcement

Optional Extra Practice

- On class website under code for today's lecture

APRIL 13

4. Streams
📖 Slides
💻 Code

Recap

Recap:

- **Uniform Initialization**
  - A "uniform" way to initialize variables of different types!

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- **Uniform Initialization**
  - A "uniform" way to initialize variables of different types!

- **References**
  - Allow us to alias variables

- **Const**
  - Allow us to specify that a variable can't be modified

Today

- **What are streams?**
- Output streams
- Input streams
- String streams!

stream: an abstraction for input/output. Streams convert between *data* and the *string representation of data.*

A stream you've used: cout

```cpp
// use a stream to print any primitive type!
std::cout << 5 << std::endl; // prints 5
// and most from the STL work!
std::cout << "Sarah" << std::endl;
```

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// Mix types!
std::cout << "Sarah is " << 21 << std::endl;
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// structs?
Student s = {"Sarah", "CA", 21};
std::cout << s << std::endl;
```

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ERROR!

A stream you've used: cout

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// use a stream to print
std::cout << 5 << std::e
// and most from the STL
std::cout << "Sarah" <<
// Mix types!
std::cout << "Sarah is '
// structs?
Student s = {"Sarah", "CA", 21};
std::cout << s << std::endl;
```

Reminder: Our student struct
```cpp
struct Student {
    string name;
    string state;
    int age;
};
```

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// structs?
Student s = {"Sarah", "CA", 21};
std::cout << s.name << s.age << std::endl;
```

Works ✓

A stream you've used: cout

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// and most from the STL work!
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// Mix types!
std::cout << "Sarah is " << 21 << std::endl;
// Any primitive type + most from the STL work!
// For other types, you will have to write the
//              << operator yourself!
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// Mix types!
std::cout << "Sarah is " <<
// Any primitive type + most
// For other types, you will
            << operator yourself!
```

> **We'll talk about how to write the << operator for custom types during lecture 11 on Operators!**

`std::cout` is an *output stream.* It has type `std::ostream`

Two ways to classify streams

By Direction:

By Source or Destination:

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- **Output streams:** Used for writing data (ex. 'std::ostream', 'std::cout')

- **Input/Output streams:** Used for both reading and writing data (ex. 'std::iostream', 'std::stringstream')

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By Source or Destination:

- **Console streams:** Read/write to console (ex. 'std::cout', 'std::cin')

- **File streams:** Read/write to files (ex. 'std::fstream', 'std::ifstream', 'std::ofstream')

Two ways to classify streams

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- **Input streams:** Used for reading data (ex. 'std::istream', 'std::cin')

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By Source or Destination:

- **Console streams:** Read/write to console (ex. 'std::cout', 'std::cin')

- **File streams:** Read/write to files (ex. 'std::fstream', 'std::ifstream', 'std::ofstream')

- **String streams:** Read/write to strings (ex. 'std::stringstream', 'std::istringstream', 'std::ostringstream')

Today

~~What are streams?~~
- **Output streams**
- Input streams
- String streams!

Output Streams!

Output Streams

- Have type `std::ostream`
- You can only **send** data to the stream
    - Interact with the stream using the `<<` operator
    - Converts any type into string and **sends** it to the stream

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- You can only **send** data to the stream
    - Interact with the stream using the `<<` operator
    - Converts any type into string and **sends** it to the stream

- `std::cout` is the output stream that goes to the console

```
std::cout << 5 << std::endl;
// converts int value 5 to string "5"
// sends "5" to the console output stream
```

Output File Streams

- Have type `std::ofstream`
- You can only *send* data to file using the `<<` operator
  - Converts data of any type into a string and sends it to the **file stream**

Output File Streams

- Have type `std::ofstream`
- You can only **send** data to file using the `<<` operator
  - Converts data of any type into a string and sends it to the **file stream**

- Must initialize your own `ofstream` object linked to your file

```
std::ofstream out("out.txt");
// out is now an ofstream that outputs to
out.txt
out << 5 << std::endl; // out.txt contains 5
```

[Code Demo](#) with ofstream

`std::cout` is a *global constant object* that you get from `#include <iostream>`

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To use any other output stream, you must first initialize it!

Questions?

Today

~~What are streams?~~

~~Output streams~~

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Input Streams!

What does this code do?

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

What does this code do?

```cpp
int x;
std::cin >> x;
// what happens if input is 5 ?
// how about 51375 ?
// how about 5 1 3 7 5?
```

Let's try it out!

A note about nomenclature

- "**>>**" is the **stream extraction operator** or simply extraction operator
  - Used to **extract data from a stream** and place it into a variable

A note about nomenclature

- "**>>**" is the **stream extraction operator** or simply extraction operator
  - Used to **extract data from a stream** and place it into a variable

- "**<<**" is the **stream insertion operator** or insertion operator
  - Used to **insert data into a stream** usually to output the data to a file, console, or string

`std::cin` is an *input stream.* It has type `std::istream`

Input Streams

- Have type `std::istream`
- You can only ***receive*** strings using the >> operator
  - ***Receives*** a string from the stream and converts it to data

Input Streams

- Have type `std::istream`
- You can only **receive** strings using the `>>` operator
  - **Receives** a string from the stream and converts it to data

- `std::cin` is the input stream that gets input from the console

```cpp
int x;
string str;
std::cin >> x >> str;
//reads exactly one int then one string from console
```

Nitty Gritty Details: `std::cin`

- First call to `std::cin >>` creates a command line prompt that allows the user to type until they hit enter

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- Everything after the first whitespace gets saved and used the next time `std::cin >>` is called
 - The place its saved is called a **buffer**!

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Nitty Gritty Details: `std::cin`

- First call to `std::cin >>` creates a command line prompt that allows the user to type until they hit enter
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- Everything after the first whitespace gets saved and used the next time `std::cin >>` is called
  - The place its saved is called a **buffer**!
- If there is nothing waiting in the buffer, `std::cin >>` creates a new command line prompt
- Whitespace is eaten; it won't show up in output

That was a lot of text. Let's see what that looks like in practice
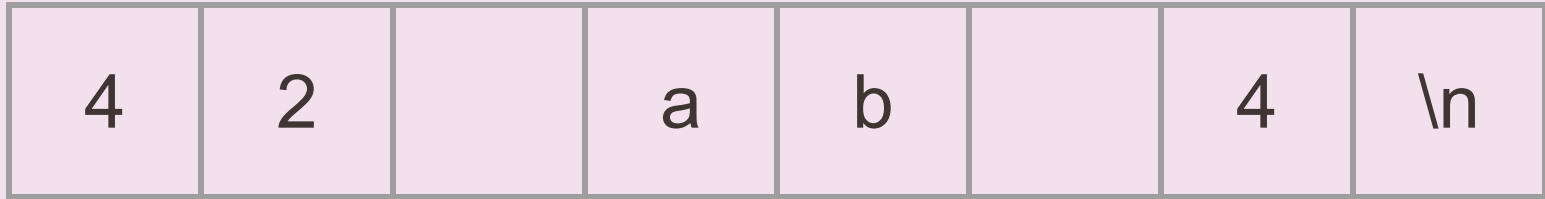
[Code Demo](#)

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

4	2		a	b		4	\n
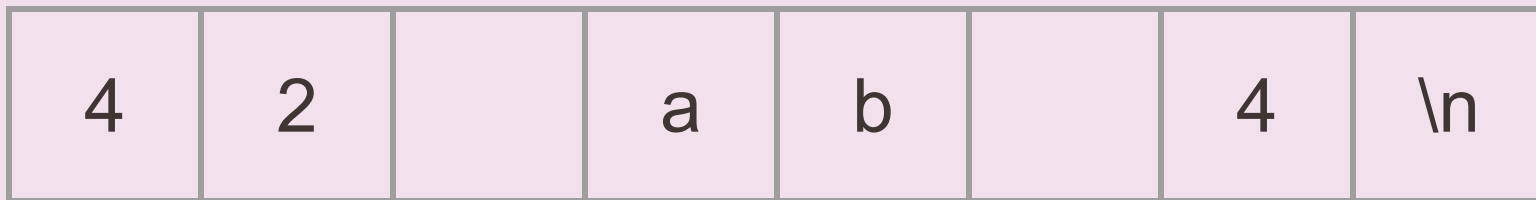
position

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

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

4	2		a	b		4	\n

position

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

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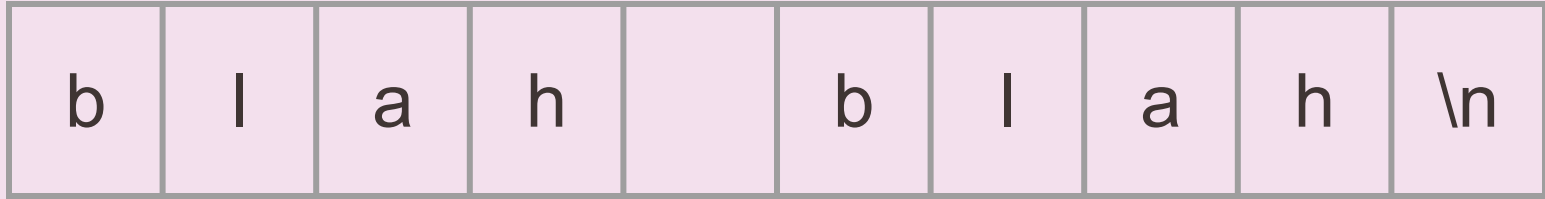| 4	2		a	b		4	\n
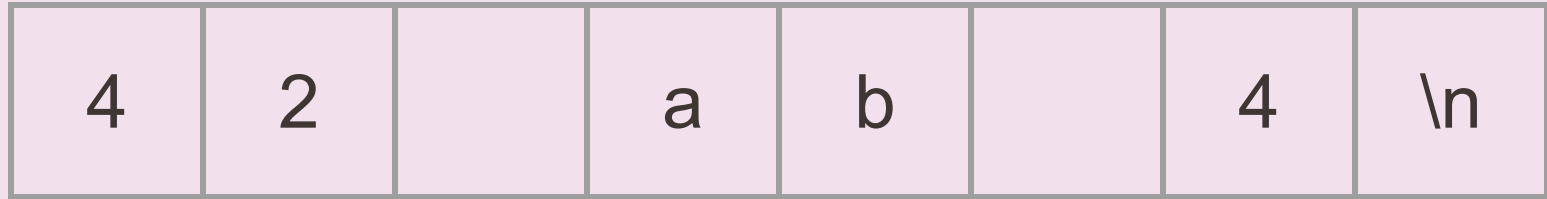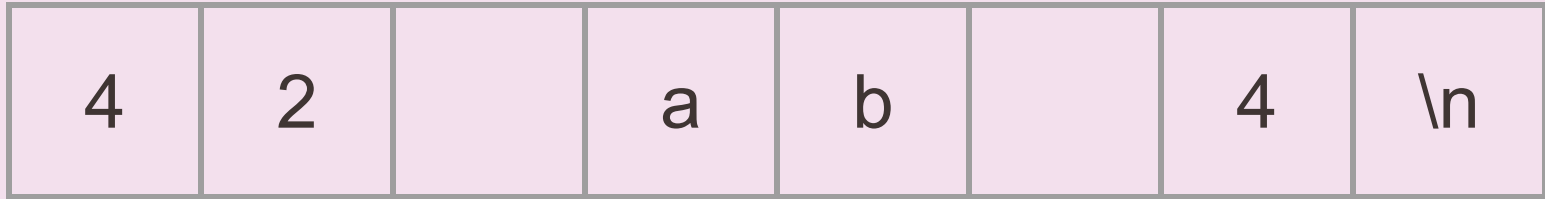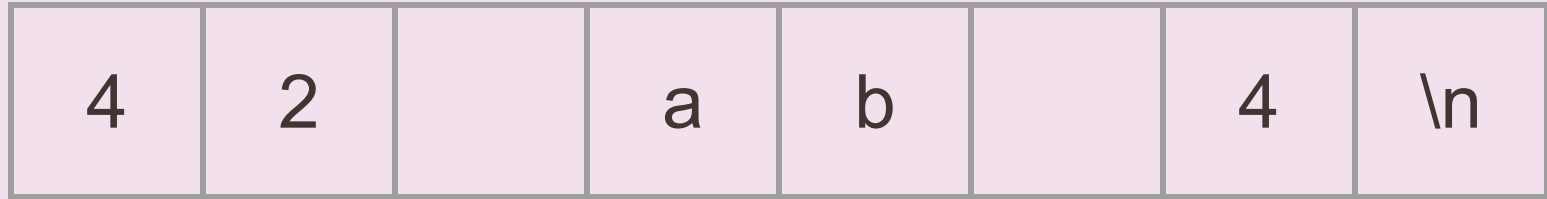
position

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

Input Streams: When things go wrong

```cpp
string str;
int x;
std::cin >> str >> x;
//what happens if input is blah blah?
std::cout << str << x;
```
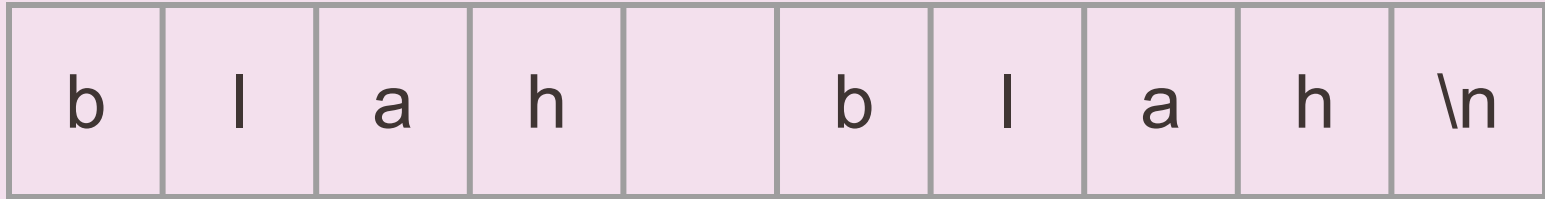
Think of a `std::istream` as a **sequence** of characters

b	l	a	h		b	l	a	h	\n

↑
position

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

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

b	l	a	h		b	l	a	h	\n

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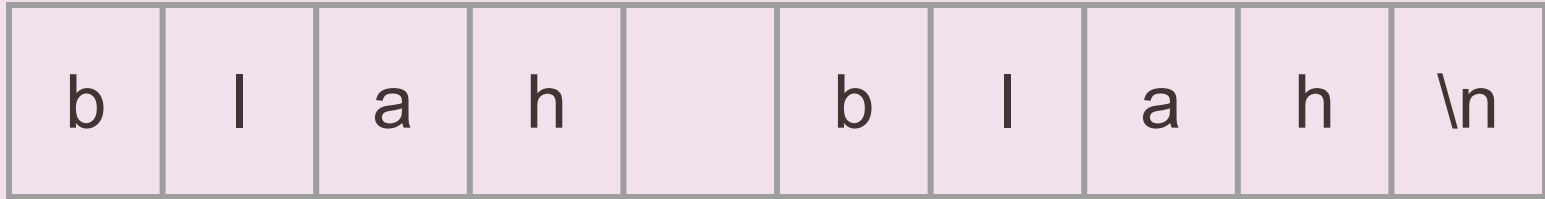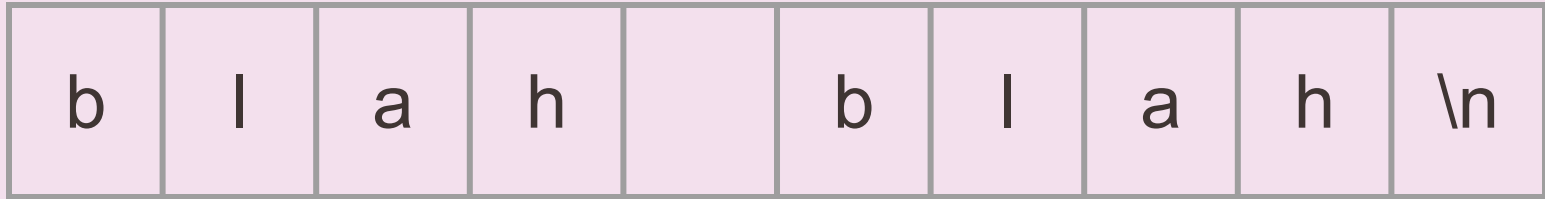
position
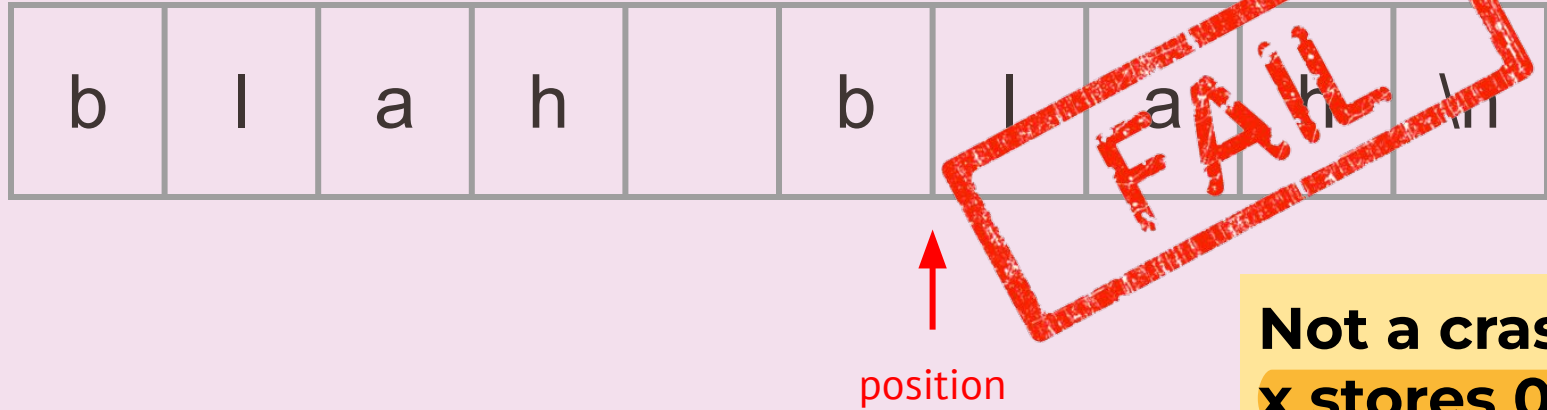
FAIL

Not a crash. x stores 0 to indicate a fail.

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

Input Streams: When things go wrong

```cpp
string str;
int x;
string otherStr;
std::cin >> str >> x >> otherStr;
//what happens if input is blah blah blah?
std::cout << str << x << otherStr;
```

Let's try it out!

Input Streams: When things go wrong

```
string str;
int x;
string otherStr;
std::cin >> str >> x >> otherStr;
//what happens if input is blah blah blah?
std::cout << str << x << otherStr;
//once an error is detected, the input stream's
//fail bit is set, and it will no longer accept
//input
```
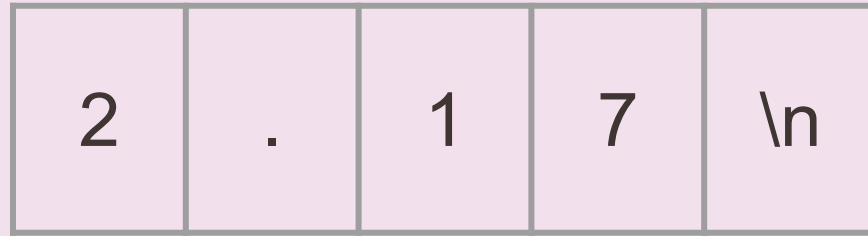
str → "blah"
x → 0
otherStr → NOTHING

Input Streams: When things go wrong

```cpp
int age; double hourlyWage;
cout << "Please enter your age: ";
cin >> age;
cout << "Please enter your hourly wage: ";
cin >> hourlyWage;
//what happens if first input is 2.17?
```
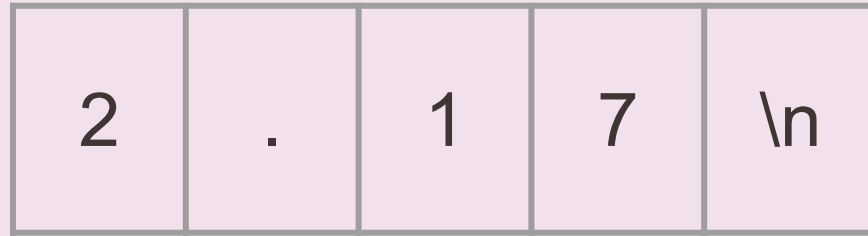
Think of a `std::istream` as a **sequence** of characters

2	.	1	7	\n

position

```cpp
cin >> age;
cout << "Wage: ";
cin >> hourlyWage;
```

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

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↑
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cin >> age;
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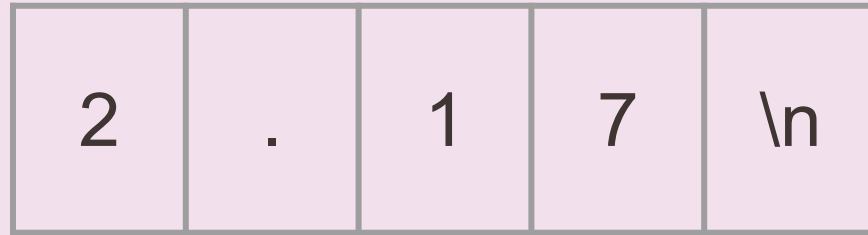
↑
position
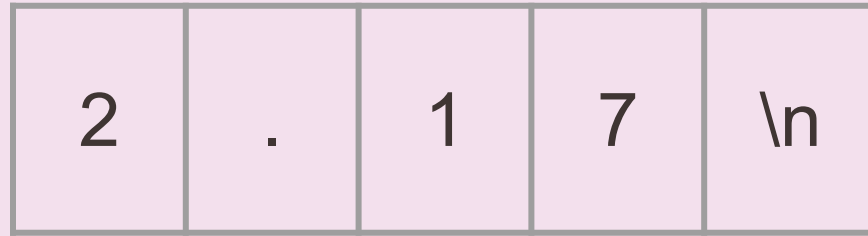
Reads until it finds
something that isn't an int!

```
cin >> age; // age = 2
cout << "Wage: ";
cin >> hourlyWage;
```

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

2	.	1	7	\n

position

```
cin >> age;
cout << "Wage: ";
cin >> hourlyWage;// =.17
```

Questions?

std::getline()

```cpp
// Used to read a line from an input stream
// Function Signature
istream& getline(istream& is, string& str, char delim);
```

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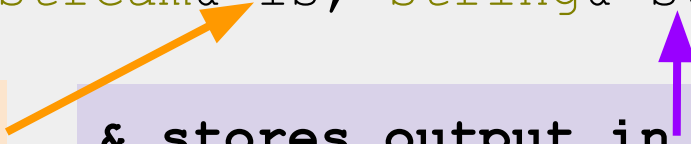
getline reads from

& stores output in

std::getline()

```cpp
// Used to read a line from an input stream
// Function Signature
istream& getline(istream& is, string& str, char delim);




// Designed to work with character sequences
```

getline reads from

& stores output in

Stops when read.
'\n' = default

std::getline(istream& is, string& str, char delim)

- **How it works:**

  - Clears contents in str

std::getline(istream& is, string& str, char delim)

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    - Clears contents in str

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    - End of file reached, sets EOF bit (checked using is.eof())

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  - Extracts chars from is and stores them in str until:

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    - Next char in is is delim, extracts but does not store delim

std::getline(istream& is, string& str, char delim)

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    - Clears contents in str

    - Extracts chars from is and stores them in str until:

        - End of file reached, sets EOF bit (checked using is.eof())

        - Next char in is is delim, extracts but does not store delim

        - str out of space, sets FAIL bit (checked using is.fail())

std::getline(istream& is, string& str, char delim)

- **How it works:**

  - Clears contents in str

  - Extracts chars from is and stores them in str until:

    - End of file reached, sets EOF bit (checked using is.eof())

    - Next char in is is delim, extracts but does not store delim

    - str out of space, sets FAIL bit (checked using is.fail())

  - If no chars extracted for any reason, FAIL bit set

std::getline(istream& **is**, string& **str**, char **delim**)

- **How it works:**

  - Clears contents in str

  - Extracts chars from is a

    - End of file reached,

    - Next char in is is delim, extracts but does not store delim

    - str out of space, sets FAIL bit (checked using is.fail())

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In contrast:
- **">>"** only **reads until it hits whitespace** (so can't read a sentence in one go)

std::getline(istream& **is**, string& **str**, char **delim**)

- **How it works:**

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  - Extracts chars from is a

    - End of file reached,

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In contrast:
- **"">>"** only **reads until it hits whitespace** (so can't read a sentence in one go)
- BUT **">>"** can **convert data to built-in types** (like ints) while getline can only produce strings.

std::getline(istream& is, string& str, char delim)

- **How it works:**

  - Clears contents in str

  - Extracts chars from is a

    - End of file reached,

    - Next char in is is del

    - str out of space, sets

  - If no chars extracted for

In contrast:
- **"">>""** only **reads until it hits whitespace** (so can't read a sentence in one go)
- BUT **"">>""** can **convert data to built-in types** (like ints) while getline can only produce strings.
- AND **"">>""** only **stops reading at predefined whitespace** while getline can stop reading at any delimiter you define

Reading using >> extracts a single "word" or built-in type
including for strings

To read a whole line, use
```
std::getline(istream& stream, string& line);
```

How to use getline

- Notice `getline(istream& stream, string& line)` takes in both parameters by reference!

```
std::string line;
std::getline(cin, line); //line changed now!
//say the user entered "Hello World 42!"
std::cout << line << std::endl;
//should print out "Hello World 42!"
```

DEMO

Let's see what happens when we mix >> and getline 👀

[Playground](#)

IMPORTANT: **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.

- TL;DR they don't play nicely

📝 **Note for 106B:** Don't use >> with Stanford libraries, they use getline.

Input File Streams

- Have type `std::ifstream`
- You can only receive strings using the `>>` operator
  - Receives strings from a file and converts it to data of any built-in type

Input File Streams

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- You can only receive strings using the `>>` operator
  - Receives strings from a file and converts it to data of any built-in type
- Must initialize your own `ifstream` object linked to your file

```cpp
std::ifstream in("out.txt");
// in is now an ifstream that reads from out.txt
string str;
in >> str; // first word in out.txt goes into str
```

`std::cin` is a *global constant object* that you get from `#include <iostream>`

To use any other input stream, you must first initialize it!

Questions?

Today

~~What are streams?~~
~~Output streams~~
~~Input streams~~
- String streams!

Stringstreams

Stringstreams

- **What:** A stream that can read from or write to a string object

- **Purpose:** Allows you to perform input/output operations on a string as if it were a stream

```cpp
std::string input = "123";

std::stringstream stream(input);

int number;

stream >> number;

std::cout << number << std::endl;  // Outputs "123"
```

If you only want to read OR write data:

- **Read only:** std::istringstream
  - Give any data type to the istringstream, it'll store it as a string!

- **Write only**: std::ostringstream
  - Make an ostringstream out of a string, read from it word/type by word/type!

- Follows same patterns as the other i/ostreams!

Let's practice using these new streams!

[CODE DEMO](#)

Recap

- Streams convert between data of any type and the string representation of that data

Recap

- Streams convert between data of any type and the string representation of that data

- Streams have an endpoint: console for cin/cout, files for i/o fstreams, string variables for i/o stringstreams where they read in a string from or output a string to.

Recap

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- To extract data from a stream, use `stream_name >> data`, and the stream will try to convert a string to whatever type `data` is

Thanks for coming!

Next time: Containers!