9.1 Output and input streams

The ostream and cout streams

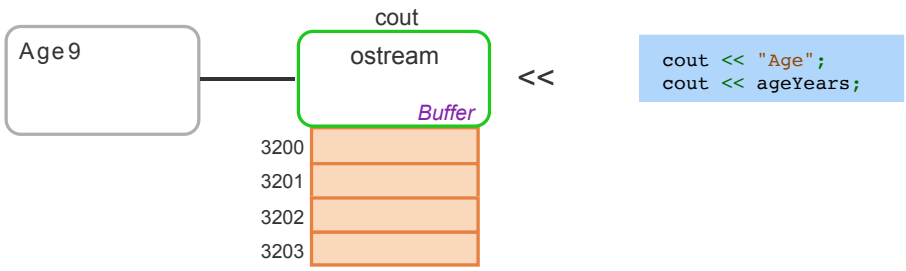
Programs need a way to output data to a screen, file, or elsewhere. An ***ostream***, short for "output stream," is a class that supports output, available via `#include <iostream>` and in namespace "std". ostream provides the ***<< operator***, known as the ***insertion operator***, for converting different types of data into a sequence of characters. That sequence is normally placed into a buffer, and the system then outputs the buffer at various times. The << operator returns a reference to the ostream that called the operator, and is evaluated from left to right like most operators, so << operators can appear in series.

The << operator is overloaded with functions to support the various standard data types, such as int, bool, float, etc., each function converting that data type to a sequence of characters. The operator may be further overloaded by the string library from `#include <string>` or by the programmer for programmer-created classes.

cout is a predefined ostream object (declared as `ostream cout;` in the iostream library) that is pre-associated with a system's standard output, usually a computer screen.

Basic use of cout and the insertion operator were covered in an earlier section.

PARTICIPATION ACTIVITY 9.1.1: ostream supports output.



Animation content:

Static figure:
Begin C++ code:
cout << "Age";
cout << ageYears;
End C++ code.

An empty output box.

A box labeled cout. Inside it is labeled as an ostream and is the output buffer.

A memory region of 4 empty memory locations addressed 3200 to 3203.

Step 1:
A memory region of 13 empty memory locations addressed 75 to 87.
The line of code, cout << "Age";, is highlighted.
The string, Age is passed to the output buffer.
One at a time, the characters of Age are sent through the output bufferinto adjacent memory

locations.
Memory address 3200 is assigned the string A.
Memory address 3201 is assigned the string g.
Memory address 3202 is assigned the string e.
The line of code, cout << ageYears;, is highlighted.
The value of ageYears, which is 9 is passed to the output buffer and assigned to memory address 3203.

Step 2:
The system then writes the buffer's content to screen.
The string, A, is passed from memory address 3200 to the output box.
The string, g, is passed from memory address 3201 to the output box.
The string, e, is passed from memory address 3202 to the output box.
The integer, 9, is passed from memory address 3203 to the output box.
The output box displays Age9.

Animation captions:

1. The insertion operator converts the string literal to characters, temporarily storing characters in an output buffer.
2. The system then writes the buffer's content to screen.

PARTICIPATION ACTIVITY 9.1.2: ostream and cout.

1) Characters written to cout are immediately written to a system's standard output.
   - True
   - False

2) To use cout, a program must include the statement `#include <iostream>`.
   - True
   - False

3) << is known as the stream operator.
   - True
   - False

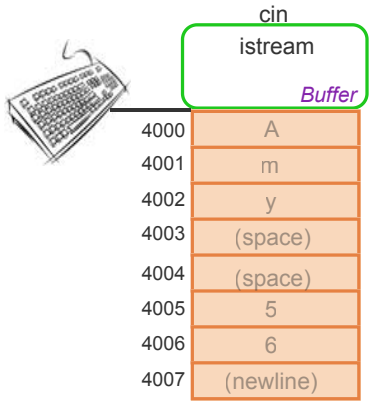
The istream and cin streams

Programs need to receive input data, whether from a keyboard, touchscreen, or elsewhere. An ***istream***, short for "input stream," is a class that supports input. Available via `#include <iostream>`, istream provides the ***>> operator***, known as the ***extraction operator***, to extract data from a data buffer and write the data into different types of variables.

cin is a predefined istream pre-associated with a system's standard input, usually a computer keyboard. The system automatically puts the standard input into a data buffer associated with cin. The >> operator skips leading whitespace and extracts as many characters as possible consistent with the target variable's type. The operator then stops at the next whitespace, converts the extracted characters to the target variable's type, and stores the result into the variable.

Basic use of cin and the extraction operator were covered in an earlier section.

PARTICIPATION ACTIVITY 9.1.3: istream and the extraction operator support input.




```
cin >> firstName;
cin >> studentId;
```


Animation captions:

1. The system puts input characters into a buffer.
2. The extraction operator reads characters up to the next whitespace, converts to the target variable's data type, and stores the results into variable firstName.
3. The extraction operator skips leading whitespaces.

PARTICIPATION ACTIVITY 9.1.4: istream and cin.

1) cin is a predefined istream associated with the system's standard input.
   - True
   - False

2) A read from cin will directly read characters from the system's keyboard.
   - True
   - False

3) >> is known as the extraction operator.
   - True
   - False

4) If the istream data buffer currently has " Hi friend!" and firstString is a string variable, then `cin >> firstString` will store " Hi " into firstString.
   - True
   - False

5) If the istream data buffer currently has "friend!" and secondString is a string variable, then `cin >> secondString` will store "friend" into secondString.

- True
- False

6) If the istream data buffer currently has "Hey" and myChar is a char type, then `cin >> myChar` will store "Hey" into myChar.

- True
- False

7) If the istream data buffer currently has "21JumpStreet" and userVal is an int type, then `cin >> userVal` will store 21 into userVal.

- True
- False

Exploring further:

- ostream Reference Page from cplusplus.com
- More on ostreams from msdn.microsoft.com
- istream Reference Page from cplusplus.com
- More on istreams from msdn.microsoft.com

Survey

The following questions are part of a zyBooks survey to help us learn about the experiences in programming classes among college students. The survey can be taken anonymously and takes just 5-10 minutes. Please take a short moment to answer by clicking the following link.

Link: Student survey

9.2 Output formatting

Floating-point manipulators

A programmer can adjust the way that a program's output appears, a task known as output formatting. The main formatting approach uses manipulators. A ***manipulator*** is a function that overloads the insertion operator << or extraction operator >> to adjust the way output appears. Manipulators are defined in the iomanip and ios libraries in namespace std.

PARTICIPATION ACTIVITY 9.2.1: Floating-point manipulators.


```
#include <iostream>
#include <iomanip>
using namespace std;

int main() {
   double miles = 765.4261;

   cout << "setprecision(p) sets # digits" << endl;
   cout << miles << " (default p is 6)" << endl;
   cout << setprecision(8) << miles << " (p = 8)" << endl;
   cout << setprecision(5) << miles << " (p = 5)" << endl;
   cout << setprecision(2) << miles << " (p = 2)" << endl;
   cout << miles << endl << endl;

   // fixed uses fixed point notation
   cout << fixed;
   cout << "fixed: " << miles << endl;

   // scientific uses scientific notation
   cout << scientific;
   cout << "scientific: " << miles << endl;

   return 0;
}
```

```
setprecision(p) sets # digits
765.426 (default p is 6)
765.4261 (p = 8)
765.43 (p = 5)
7.7e+02 (p = 2)
7.7e+02

fixed: 765.43
scientific: 7.65e+02
```

Animation content:

Static figure:
Begin C++ code:
#include <iostream>
#include <iomanip>
using namespace std;

int main() {
  double miles = 765.4261;

  cout << "setprecision(p) sets # digits" << endl;
  cout << miles << " (default p is 6)" << endl;
  cout << setprecision(8) << miles << " (p = 8)" << endl;
  cout << setprecision(5) << miles << " (p = 5)" << endl;
  cout << setprecision(2) << miles << " (p = 2)" << endl;
  cout << miles << endl << endl;

  // fixed uses fixed point notation
  cout << fixed;
  cout << "fixed: " << miles << endl;

  // scientific uses scientific notation
  cout << scientific;
  cout << "scientific: " << miles << endl;

```
   return 0;
}
```
End C++ code.

An empty output box.

Step 1:
The iostream and iomanip libraries define several floating-point manipulators.
The lines of code, #include <iostream>, and , #include <iomanip>, are highlighted.

Step 2:
When a floating-point number is output, the default number of digits to display is 6.
The lines of code, cout << "setprecision(p) sets # digits" << endl;, and
cout << miles << " (default p is 6)" << endl;, are highlighted.
The string, setprecision(p) sets # digits, is outputted.
The string, 765.426 (default p is 6), is outputted.

Step 3:
The setprecision() manipulator changes the total number of digits to display. Scientific notation (e with a power of 10) may result for smaller precision values.
The lines of code, cout << setprecision(8) << miles << " (p = 8)" << endl;,
cout << setprecision(5) << miles << " (p = 5)" << endl;, and
cout << setprecision(2) << miles << " (p = 2)" << endl;, are highlighted.
The string, 765.4261 (p = 8), is outputted.
The string, 765.43 (p = 5), is outputted.
The string, 7.7e+02 (p = 2), is outputted.

Step 4:
setprecision() affects all subsequent floating-point number output, not just the next output.
The line of code, cout << miles << endl << endl;, is highlighted.
The string, 7.7e+02, is outputted.

Step 5:
The fixed manipulator uses fixed-point notation, and the precision (2) now applies to the number of decimal places.
The lines of code, cout << fixed;, and ,cout << "fixed: " << miles << endl;, are highlighted.
The string, fixed: 765.43, is outputted.

Step 6:
The scientific manipulator turns scientific notation on.
The lines of code, cout << scientific;, and ,cout << "scientific: " << miles << endl;, are highlighted.
The string, scientific: 7.65e+02, is outputted.

Animation captions:

1. The iostream and iomanip libraries define several floating-point manipulators.
2. When a floating-point number is output, the default number of digits to display is 6.
3. The setprecision() manipulator changes the total number of digits to display. Scientific notation (e with a power of 10) may result for smaller precision values.
4. setprecision() affects all subsequent floating-point number output, not just the next output.
5. The fixed manipulator uses fixed-point notation, and the precision (2) now applies to the number of decimal places.
6. The scientific manipulator turns scientific notation on.

Table 9.2.1: Floating-point manipulators.

Manipulator	Description	Example
fixed	Use fixed-point notation. From <iostream>	`// 12.340000` `cout << fixed << 12.34;`
scientific	Use scientific notation. From <iostream>	`// 1.234000e+01` `cout << scientific << 12.34;`

setprecision(p)	If stream has not been manipulated to fixed or scientific:
	Sets max number of digits in number
		`// 12.3`
		`cout << setprecision(3) << 12.34;`
		
		`// 12.34`
		`cout << setprecision(5) << 12.34;`

	If stream has been manipulated to fixed or scientific:
	Sets max number of digits in fraction only (after the decimal point).
	From <iomanip>
		`// 12.3`
		`cout << fixed << setprecision(1) << 12.34;`
		
		`// 1.2e+01`
		`cout << scientific << setprecision(1) << 12.34;`

showpoint	Even if fraction is 0, show decimal point and trailing 0s.
	Opposite is noshowpoint.
	From <iostream>
		`// 99`
		`cout << setprecision(3) << 99.0;`
		
		`// 99.0`
		`cout << setprecision(3) << showpoint << 99.0;`

Manipulators are always meant to be used with the << and >> operators. *A common error is to have a statement like* ***`setprecision(2);`*** *rather than* ***`cout << setprecision(2);`****, which compiles fine but does not impact cout.* Details on operator overloading are presented elsewhere in this material.

PARTICIPATION ACTIVITY 9.2.2: Output formatting for floating-point manipulators.

Use the code below to answer each question, and assume no manipulators have previously been applied.


```
double temp;
temp = 98.63;
// a floating-point manipulator
cout << temp;
```

1) Which causes the output to appear as "98.6"?

- `cout << fixed;`
- `cout << setprecision(3);`
- `cout << setprecision(2);`
- `cout << scientific << setprecision(2);`

2) Which causes the output to appear as "9.86e+01"?

- `cout << fixed;`
- `cout << setprecision(3);`
- `cout << setprecision(2);`
- `cout << scientific << setprecision(2);`

3) Which causes the output to appear as "99"?

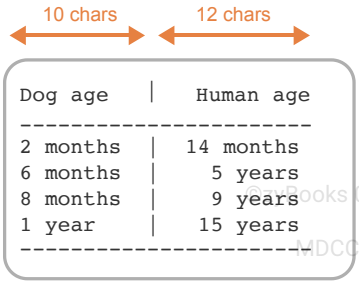
- `cout << fixed;`
- `cout << setprecision(3);`
- `cout << setprecision(2);`
- `cout << scientific << setprecision(2);`

Text-alignment manipulators

Some manipulators help align output.

PARTICIPATION ACTIVITY 9.2.3: Text-alignment manipulators.

```
#include <iostream>
#include <iomanip>
using namespace std;

int main() {
   // Dog age in human years (dogyears.com)
   cout << setw(10) << left  << "Dog age" << "|";
   cout << setw(12) << right << "Human age" << endl;

   // Produce long line
   cout << setfill('-') << setw(23) << "" << endl;

   // Reset fill character back to space
   cout << setfill(' ');

   cout << setw(10) << left  << "2 months" << "|";
   cout << setw(12) << right << "14 months" << endl;
   cout << setw(10) << left  << "6 months" << "|";
   cout << setw(12) << right << "5 years" << endl;
   cout << setw(10) << left  << "8 months" << "|";
   cout << setw(12) << right << "9 years" << endl;
   cout << setw(10) << left  << "1 year" << "|";
   cout << setw(12) << right << "15 years" << endl;

   // Produce long line
   cout << setfill('-') << setw(23) << "" << endl;
```



```
   return 0;
}
```

Animation captions:

1. The setw() manipulator sets the number of characters for displaying the following item to 10. The left manipulator outputs the following item "Dog age" left-aligned within 10 characters.
2. The vertical bar | is output at the end of the 10 characters. setw() only affects the "Dog age" output.
3. The setw() and right manipulators output "Human age" right-aligned within 12 characters.
4. The setfill() manipulator sets the dash character to fill the empty space created when outputting an empty string in the next 23 characters.
5. setfill(' ') sets the empty space character back to the default space character.
6. The dog age values are output left-aligned within 10 spaces, and the human age values are output right-aligned within 12 spaces.
7. One final line of 23 dashes is output.

Table 9.2.2: Text-alignment manipulators.

Manipulator	Description	Example

setw(n)	Sets the number of characters for the next output item only (does not persist, in contrast to other manipulators). By default, the item will be right-aligned, and filled with spaces. From <iomanip>	`// "    Amy"`
		`// " George"`
		`cout << setw(7) << "Amy" << endl;`
		`cout << setw(7) << "George" << endl;`

setfill(c)	Sets the fill to character c. From <iomanip>	`// "****Amy"` `cout << setfill('*') << setw(7) << "Amy";`
left	Changes to left alignment. From <iostream>	`// "Amy    "` `cout << left << setw(7) << "Amy";`
right	Changes back to right alignment. From <iostream>	`// "    Amy"` `cout << right << setw(7) << "Amy";`

PARTICIPATION ACTIVITY 9.2.4: Output formatting for text manipulators.

Use the code below to answer each question, and assume no manipulators have previously been applied.

```
string str = "Amy";
```

1) Which statement prints `"...Amy"`?

- `cout << setfill('.') << str;`
- `cout << setw(6) << setfill('.') << str;`
- `cout << setw(6) << "." << str;`
- `cout << right << setw(6) << str;`

2) Which statement prints `"Amy"`?

- `cout << setfill('.') << str;`
- `cout << setw(6) << setfill('.') << str;`
- `cout << setw(6) << "." << str;`
- `cout << right << setw(6) << str;`

3) Which statement prints`"  Amy"`?

- `cout << setfill('.') << str;`
- `cout << setw(6) << setfill('.') << str;`
- `cout << setw(6) << "." << str;`
- `cout << right << setw(6) << str;`

Buffer manipulators

Printing characters from the buffer to the output device (e.g., screen) requires a time-consuming reservation of processor resources. Once the resources are reserved, moving characters is fast, whether there is 1 character or 50 characters to print.

To preserve resources, the system may wait until the output buffer is full, or at least has a certain number of characters, before moving the characters to the output device. Or, with fewer characters in the buffer, the system may wait until the resources are not busy. Sometimes a programmer does not want the system to wait. Ex: In a very processor-intensive program, waiting could cause delayed and/or jittery output.

Two manipulators exist to send all buffer contents to the output device without waiting: endl and flush.

Table 9.2.3: Buffer manipulators.

Manipulator	Description	Example
endl	Inserts a newline character '\n' into the output buffer	`// Insert newline and flush` `cout << endl;`

	and informs the system to flush the buffer. From <iostream>	
flush	Informs the system to flush the buffer. From <iostream>	`// Flush buffer` `cout << flush;`

A common error is to assume that a cout statement is never reached because the output had not been flushed when the program crashed. Ex: If the program crashes on the statement `cout << "value is " << someFunction();`, the words "value is" will not output because the buffer was not flushed.

Exploring further:

- More manipulators exist. See cplusplus.com

PARTICIPATION ACTIVITY 9.2.5: Buffer manipulators.

1) The text "test" is likely to immediately display on the screen.

```
cout << "test";
```

- True
- False

2) The text "test" and "this" are likely to immediately display on the screen.

```
cout << "test" << endl <<
"this\n";
```

- True
- False

3) The text "test" is likely to immediately display on the screen.

```
cout << "test" << flush;
```

- True
- False

CHALLENGE ACTIVITY 9.2.1: Output formatting.

539740.3879454.qx3zqy7

Start

Type the program's output

```
#include <iostream>
#include <iomanip>

using namespace std;

int main() {
   float myFloat;

   myFloat = 31.4124;

   cout << setprecision(3) << myFloat << endl;
   cout << setprecision(4) << myFloat << endl;

   return 0;
}
```

```
31.4
31.41
```


1 2 3 4 5 6

Check Next

CHALLENGE ACTIVITY 9.2.2: Output formatting.

539740.3879454.qx3zqy7

Start

Double areaApplied is read from input. Output areaApplied in scientific notation with a maximum of four digits in the fraction with a newline.

Ex: If the input is `2810981.75`, then the output is:

```
2.8110e+06
```

```
1 #include <iostream>
2 #include <iomanip>
3 using namespace std;
4
5 int main() {
6    double areaApplied;
7
8    cin >> areaApplied;
9
10   /* Your code goes here */
11
12   return 0;
13 }
```

1 2 3

Check Next level

9.3 Input string stream

Input string stream

Sometimes a programmer wishes to read input data from a string rather than from the keyboard. A new ***input string stream*** variable of type ***istringstream*** can be created that reads input from an associated string instead of the keyboard (standard input). istringstream is derived from istream. An istringstream can be used just like the cin stream as illustrated in the program below.

PARTICIPATION ACTIVITY 9.3.1: Reading a string as an input stream.


```
#include <iostream>
#include <sstream>
#include <string>
using namespace std;


int main() {
   string  userInfo = "Amy Smith 19"; // Input string
   istringstream inSS(userInfo);      // Input string stream
   string firstName;                  // First name
   string lastName;                   // Last name
   int userAge;                       // Age

   // Parse name and age values from input string
   inSS >> firstName;
   inSS >> lastName;
   inSS >> userAge;


   // Output parsed values
   cout << "First name: " << firstName << endl;
   cout << "Last  name: " << lastName << endl;
   cout << "Age: "        << userAge << endl;

   return 0;
}
```

```
First name: Amy
Last name : Smith
Age: 19
```

Animation captions:

1. The program uses #include <sstream> for access to the string stream class, which is in namespace std.
2. istringstream inSS(userInfo); declares a new string stream variable and initializes the string stream's buffer to a copy of string userInfo.
3. Then the program extracts data from stream inSS using >>, similar to extracting from cin.
4. The extracted data is output to the screen.

PARTICIPATION ACTIVITY 9.3.2: Input string streams.

1) Declare an istringstream variable named inSS that creates an input string stream using the string variable myStrLine.

Check Show answer

Using getline() with string streams

A common use of string streams is to process user input line-by-line. The program below reads in a line as a string and then extracts individual data items from the string. The getline() function reads an input line into a string, and `inSS.str(lineString);` uses the str() function to initialize the stream's buffer to string lineString. Afterwards, the program extracts input from inSS using >>. The statement `inSS.clear();` is necessary to reset the state of the stream so that subsequent extractions start from the beginning of the input strings.

Figure 9.3.1: Using a string stream to process a line of input text.

```
#include <iostream>
#include <string>
#include <sstream>
using namespace std;

int main() {
   istringstream inSS;       // Input string
stream
   string lineString;        // Holds line of
text
   string firstName;         // First name
   string lastName;          // Last name
   int    userAge;           // Age
   bool   inputDone;         // Flag to indicate
next iteration

   inputDone = false;

   // Prompt user for input
   cout << "Enter \"firstname lastname age\" on
each line" << endl;
   cout << "(\"Exit\" as firstname exits)." <<
endl << endl;

   // Grab data as long as "Exit" is not entered
   while (!inputDone) {

      // Entire line into lineString
      getline(cin, lineString);

      // Copies to inSS's string buffer
      inSS.clear();
      inSS.str(lineString);

      // Now process the line
      inSS >> firstName;

      // Output parsed values
      if (firstName == "Exit") {
         cout << "   Exiting." << endl;

         inputDone = true;
      }
      else {
         inSS >> lastName;
         inSS >> userAge;

         cout << "   First name: " << firstName
<< endl;
         cout << "   Last  name: " << lastName <<
endl;
         cout << "   Age:        " << userAge
<< endl;
         cout << endl;
      }
   }

   return 0;
}
```

```
Enter "firstname lastname age"
on each line
("Exit" as firstname exits).

Mary Jones 22
   First name: Mary
   Last  name: Jones
   Age:        22

Sally Smith 14
   First name: Sally
   Last  name: Smith
   Age:        14

Exit
   Exiting.
```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Rob Daglio
MDCCOP2335Spring2024

PARTICIPATION ACTIVITY 9.3.3: Using getline() with string streams.

1) Which function is used to read an entire string from user input?
   - getline()
   - str()
   - clear()

2) Which function resets the string stream's state?
   - getline()
   - str()
   - clear()

3) Which function copies the input string into the string stream?
   - getline()
   - str()
   - clear()

Reaching the end of a string stream

A programmer will not always know how much data exists in a user input string, so using multiple individual extractions (Ex: `inSS >> data1; inSS >> data2;`) is not useful for reading all of the input data. Input streams have a Boolean function called ***eof()*** or ***end of file*** that returns true or false depending on whether or not the end of the stream has been reached. An if statement or while loop can check if the end of input string stream has been reached by using the extraction operator. Ex: In the code

```
while (inSS >> data) {
   ...
}
```

the while statement implicitly calls inSS's eof() function, which returns false if more data exists in the string stream to be read and true if the end of string stream has been reached. When eof() returns false, `inSS >> data` resolves to true, causing the loop to continue. Conversely, when eof() returns true, `inSS >> data` resolves to false, meaning the end of the string stream has been reached, and the loop exits.

PARTICIPATION ACTIVITY 9.3.4: Reaching the end of a string stream.

```
#include <iostream>
#include <sstream>
#include <string>
using namespace std;

int main() {
   istringstream inSS;       // Input string stream
   string lineString;        // Holds input string
   string data;

   cout << "Enter a list of names separated by spaces: ";

   // Entire line into lineString
   getline(cin, lineString);
   inSS.str(lineString);

   while (inSS >> data) {
      cout << data << endl;
   }
```

```
    return 0;
}
```

```
Enter a list of names separated by spaces:  Iker Lottie Carlos Haya
Iker
Lottie
Carlos
Haya
```


Animation content:

Static figure:
Begin C++ code:

```
#include <iostream>
#include <sstream>
#include <string>
using namespace std;

int main() {
  istringstream inSS;     // Input string stream
  string lineString;      // Holds input string
  string data;

  cout << "Enter a list of names separated by spaces: ";

  // Entire line into lineString
  getline(cin, lineString);
  inSS.str(lineString);

  while (inSS >> data) {
    cout << data << endl;
  }

  return 0;
}
```

End C++ code.

Step 1:
The user enters a single string, which contains any number of names.
The line of code, cout << "Enter a list of names separated by spaces: ";, is highlighted.
The string, Enter a list of names separated by spaces: , is outputted.
The line of code, getline(cin, lineString);, is highlighted.
The string of names, Iker Lottie Carlos Haya, is appended to the output.
The output now displays, Enter a list of names separated by spaces: Iker Lottie Carlos Haya
The line of code, inSS.str(lineString);, is highlighted.

Step 2:
The extraction in the while loop condition implicitly calls inSS's eof() function, which indicates if data exists in the string to be read or if the end of the string has been reached.
The line of code, while (inSS >> data) {, is highlighted.
data equals Iker, while loop condition is true.
The line of code, cout << data << endl;, is highlighted.
The string, Iker, is outputted.

Step 3:
The program continues to loop and output each name.
The line of code, while (inSS >> data) {, is highlighted.
data equals Lottie, while loop condition is true.
The line of code, cout << data << endl;, is highlighted.
The string, Lottie, is outputted.
The line of code, while (inSS >> data) {, is highlighted.
data equals Carlos, while loop condition is true.
The line of code, cout << data << endl;, is highlighted.
The string, Carlos, is outputted.
The line of code, while (inSS >> data) {, is highlighted.
data equals Haya, while loop condition is true.
The line of code, cout << data << endl;, is highlighted.
The string, Haya, is outputted.

Step 4:
When the end of the string is reached, the loop condition resolves to false and the loop exits.
The line of code, while (inSS >> data) {, is highlighted.
data equals "", the empty string. while loop condition is false.

Animation captions:

1. The user enters a single string, which contains any number of names.
2. The extraction in the while loop condition implicitly calls inSS's eof() function, which indicates if data exists in the string to be read or if the end of the string has been reached.
3. The program continues to loop and output each name.
4. When the end of the string is reached, the loop condition resolves to false and the loop exits.

PARTICIPATION ACTIVITY 9.3.5: Reaching the end of a string stream.

1) In the animation above, how many times does the while loop iterate?
   - 3
   - 4
   - 5

2) What indicates to a program that the end of an input string stream has been reached?
   - The string stream's eof() function
   - The extraction operator (>>)
   - getline()

3) If in the loop condition inSS >> data, inSS's eof() function returns true, what does the condition inSS >> data resolve to?
   - true
   - false

Example: Phone number formats

The example below reads in phone numbers in two different formats and then presents the phone numbers in a standard 10-digit format. American phone numbers include an area code (3 digits), central office code (3 digits), and station number (4 digits). The program uses an input string stream to read each portion of the phone number, the ios good() function to determine if the area code entered consists solely of integers, and two dummy characters to read and determine if valid phone number delimiters were used. If the area code does not contain solely integers or the delimiters are not valid, the string stream is placed into an error state, and an error message is output. The program outputs all valid phone numbers in a standardized format.

Figure 9.3.2: Input stream example: Phone number formats.

```
Enter a 10-digit phone number
(or -1 to exit):
342-555-9084
   Standardized format: (342)
555-9084

*1778.555.2925
   Invalid phone number.

778.555.2925
   Invalid phone number.

(302)555-8927
   Standardized format: (302)
555-8927

-1
```

```
#include <iostream>
#include <sstream>
#include <string>
using namespace std;

int main() {
   istringstream inSS;      // Input string
stream
   string lineString;       // Holds line of text
   int    areaCode;         // Area code (3
digits)
   int    officeCode;       // Central office
code (3 digits)
   int    stationNum;       // Station number (4
digits)
   char   dummyChar1;
   char   dummyChar2;
   bool   isValidNumber;

   cout << "Enter a 10-digit phone number (or -1
to exit):" << endl;
   getline(cin, lineString);

   while (lineString != "-1") {
      isValidNumber = false; // Set to false
before extracting phone number
      dummyChar1 = ' '; // Reset dummy chars to
character other than - and (
      dummyChar2 = ' ';

      // Copy input to inSS's string buffer
      inSS.clear();
      inSS.str(lineString);

      // Try extracting area code.
      inSS >> areaCode;
      if (inSS.good()) {
         // Number format should be ###-###-####
         inSS >> dummyChar1 >> officeCode >>
dummyChar2 >> stationNum;

         if (inSS.eof() && dummyChar1 == '-' &&
dummyChar2 == '-') {
            isValidNumber = true;
         }
      }
      else {
         // Number format should be (###) ###-
####

         // Clear inSS state, and try extracting
with area code in ()
         inSS.clear();
         inSS >> dummyChar1 >> areaCode >>
dummyChar2;
         if (inSS.good()  && dummyChar1 == '(' &&
dummyChar2 == ')') {
            // Extract office code, then -, and
then station number
            inSS >> officeCode >> dummyChar1 >>
stationNum;
            if (inSS.eof() && dummyChar1 == '-')
{
               isValidNumber = true;
            }
         }
      }

      if (isValidNumber) {
         cout << "   Standardized format: (" <<
areaCode << ") "
              << officeCode << "-" << stationNum
<< endl << endl;
```

```
<< endl << endl;
      }
      else {
         cout << "   Invalid phone number." <<
endl << endl;
      }

      // Get next user input
      getline(cin, lineString);
   }

   return 0;
}
```


PARTICIPATION ACTIVITY 9.3.6: String stream error state.

1) Which phone number would result in "Invalid phone number." being printed to the screen?
   - 399+555@8493
   - (430) 555-2029
   - 224-555-7326

2) What function checks if the string stream is in an error state?
   - good()
   - eof()

Exploring further:

- stringstream Reference Page from cplusplus.com

CHALLENGE ACTIVITY 9.3.1: Input string streams.

539740.3879454.qx3zqy7

Start

Type the program's output

```
#include <iostream>
#include <sstream>
#include <string>
using namespace std;

int main() {
   string objectInfo = "Mug 14 13";
   istringstream objectISS(objectInfo);
   string object;
   int quantity;
   int price;

   objectISS >> object >> price >> quantity;

   cout << object << " x" << quantity << endl;
   cout << "Price: " << price;

   return 0;
}
```

```
Mug x13
Price: 14
```


1 2

Check Next

CHALLENGE ACTIVITY 9.3.2: Reading from a string.

Write code that uses the input string stream inSS to read input data from string userInput, and updates variables userMonth, userDate, and userYear. Sample output if the input is "Jan 12 1992":

```
Month: Jan
Date: 12
Year: 1992
```

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539740.3879454.qx3zqy7

```
1  #include <iostream>
2  #include <sstream>
3  #include <string>
4  using namespace std;
5
6  int main() {
7     istringstream inSS;
8     string userInput;
9     string userMonth;
10    int userDate;
11    int userYear;
12
13    getline(cin, userInput);
14    inSS.str(userInput);
15
```


Run

9.4 Output string stream

Output string stream

An ***output string stream*** variable of type ***ostringstream*** can insert characters into a string buffer instead of the screen (standard output). ostringstream is derived from ostream. A program can insert characters into an ostringstream buffer using <<, just like the cout stream. The ostringstream member function ***str()*** returns the contents of an ostringstream buffer as a string.

PARTICIPATION ACTIVITY 9.4.1: Using an output string stream.

```
#include <iostream>
#include <string>
#include <sstream>
using namespace std;

int main() {
   ostringstream infoOSS;     // Output string stream
   string infoStr;            // Information string
   string firstName;          // First name
   string lastName;           // Last name
   int userAge;               // Age

   // Prompt user for input
   cout << "Enter \"firstname lastname age\": " << endl;
   cin >> firstName;
   cin >> lastName;
   cin >> userAge;

   // Write user input to string stream
   infoOSS << lastName << ", " << firstName;
   infoOSS << " " << userAge;

   // Appends (minor) to string stream if less than 21
   if (userAge < 21) {
      infoOSS << " (minor)";
   }

   // Extract string stream buffer as a single string
   infoStr = infoOSS.str();

   cout << "Information: " << infoStr << endl;

   return 0;
}
```

```
Enter "firstname lastname age":
Mary Jones 19
Information: Jones, Mary 19 (minor)
```

infoOSS buffer

Jones, Mary 19 (minor)

Animation captions:

1. The sstream library defines the ostringstream class, which is in namespace std.
2. ostringstream infoOSS; declares a new output string stream variable. The stream's buffer is initially empty.
3. After reading input from the keyboard, the program inserts data into infoOSS's buffer using <<, similar to inserting data into the cout stream.
4. The string " (minor)" is also inserted into the string stream buffer because the user entered an age < 21.
5. The str() function returns the stream's buffer data as a single string, which is then output to the screen.

PARTICIPATION ACTIVITY 9.4.2: Output string streams.

1) Given an ostringstream variable called outSS, write a statement that appends the value of the int variable carSpeed to the stream's buffer.

Check Show answer

2) Write a statement that copies the contents of an output string stream called outSS to an existing string variable called myStr.

Check Show answer

Example: Savings table

The example below uses an output string stream to create a savings table. The ProduceSavingsTable() function has 3 parameters: the starting amount, the annual percentage rate, and number of years. ProduceSavingsTable() uses several manipulators like fixed, setprecision, and setw to create a table with an ostringstream and returns the table as a single string.

Figure 9.4.1: Output string stream example.

```
#include <iostream>
#include <iomanip>
#include <string>
#include <sstream>
using namespace std;

string ProduceSavingsTable(double startAmount, double apr, int numYears) {
   // Column widths
   const int YEAR_COL_WIDTH = 5;
   const int BALANCE_COL_WIDTH = 10;

   ostringstream outSS;
   double interest;
   double balance = startAmount;
   int month;
   int totalMonths = numYears * 12;

   // Convert APR to monthly percentage rate and decimal number
   double mpr = apr / 12 * 0.01;

   // Display 2 decimal places
   outSS << fixed << setprecision(2);

   // Table heading
   outSS << setw(YEAR_COL_WIDTH) << "Year"
      << setw(BALANCE_COL_WIDTH) << "Balance" << endl;

   // Calculate interest and ending balance for each month
   for (month = 1; month <= totalMonths; ++month) {
      interest = balance * mpr;
      balance += interest;

      // Only output year number and balance at the end of the year
      if (month % 12 == 0) {
         outSS << setw(YEAR_COL_WIDTH) << month / 12
             << setw(BALANCE_COL_WIDTH) << balance << endl;
      }
   }

   // Return the table as a string
   return outSS.str();
}

int main() {
   string table;
   double startAmount;
   double apr;
   int years;

   // Get input values
   cout << "Starting amount?" << endl;
   cin >> startAmount;
   cout << "Annual Percentage Rate?" << endl;
   cin >> apr;
   cout << "Number of years?" << endl;
   cin >> years;

   cout << endl << "Savings over time:" << endl;
   table = ProduceSavingsTable(startAmount, apr, years);
   cout << table << endl;

   return 0;
}
```

```
Starting amount?
100
Annual Percentage Rate?
5
Number of years?
6

Savings over time:
 Year   Balance
    1    105.12
    2    110.49
    3    116.15
    4    122.09
    5    128.34
    6    134.90
```


PARTICIPATION ACTIVITY 9.4.3: Output string stream example.

1) Which manipulator sets the width of the Year and Balance columns?
   - setw
   - setprecision
   - fixed

2) Which modification would cause the balance amounts to round to the nearest dollar?
   - `outSS << scientific << setprecision(2);`
   - `outSS << fixed;`
   - `outSS << fixed << setprecision(0);`

3) Which statement can be added to ProduceSavingsTable() to produce a line of dashes across the table?
   - `cout << setfill('-') << setw(15) << "";`
   - `outSS << setw(15) << "-";`
   - `outSS << setfill('-') << setw(15) << "";`

CHALLENGE ACTIVITY 9.4.1: Output string streams.

539740.3879454.qx3zqy7

Start

Type the program's output

```
#include <iostream>
#include <sstream>
#include <string>
using namespace std;

int main() {
   ostringstream objectOSS;
   string object;
   int quantity;
   int discount;

   object = "Mug";
   quantity = 14;
   discount = 25;

   objectOSS << object << " x" << quantity << endl;
   objectOSS << discount << "% off";

   cout << objectOSS.str();

   return 0;
}
```

1 2

Check Next

CHALLENGE ACTIVITY 9.4.2: Output using string stream.

Write code that inserts userItem into the output string stream itemsOSS until the user enters "Exit". Each item should be followed by a space. Sample output if user input is "red purple yellow Exit":

```
red purple yellow
```

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539740.3879454.qx3zqy7

```
1  #include <iostream>
2  #include <sstream>
3  #include <string>
4  using namespace std;
5
6  int main() {
7     string userItem;
8     ostringstream itemsOSS;
9
10    cout << "Enter items (type Exit to quit):" << endl;
11    cin >> userItem;
12
13    while (userItem != "Exit") {
14
15       /* Your solution goes here  */
```


Run

9.5 File input

Opening and reading from a file

Sometimes a program should get input from a file rather than from a user typing on a keyboard. To read file input, a programmer can create a new input stream that comes from a file, rather than the predefined input stream cin that comes from the standard input (keyboard). An input stream can then be used just like cin.

The `inFS.open(str)` function has a string parameter str that specifies the name of the file to open. The filename parameter can be a C++ string or a null-terminated C string. A program can also use a user-entered string as the filename, such as using `cin >> filename;`.

PARTICIPATION ACTIVITY 9.5.1: Input from a file.

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

int main() {
   ifstream inFS;      // Input file stream
   int fileNum1;       // Data value from file
   int fileNum2;       // Data value from file

   // Try to open file
   cout << "Opening file numFile.txt." << endl;

   inFS.open("numFile.txt");
   if (!inFS.is_open()) {
      cout << "Could not open file numFile.txt." << endl;
      return 1; // 1 indicates error
   }

   // Can now use inFS stream like cin stream
   // numFile.txt should contain two integers, else problems
   cout << "Reading two integers." << endl;
   inFS >> fileNum1;
   inFS >> fileNum2;
   cout << "Closing file numFile.txt." << endl;
   inFS.close(); // Done with file, so close it

   // Output values read from file
   cout << "num1: " << fileNum1 << endl;
   cout << "num2: " << fileNum2 << endl;
   cout << "num1 + num2: " << (fileNum1 + fileNum2) << endl;

   return 0;
}
```

numFile.txt with two integers:

```
5
10
```

Failure to open file

```
Opening file numFile.txt.
Could not open file numFile.txt.
```

Successfully open file

```
Opening file numFile.txt.
Reading two integers.
Closing file numFile.txt.
num1: 5
num2: 10
num1 + num2: 15
```

Animation content:

Static figure:
Begin C++ Code:
#include <iostream>
#include <fstream>
using namespace std;

int main() {
  ifstream inFS; // Input file stream
  int fileNum1; // Data value from file
  int fileNum2; // Data value from file

```
  // Try to open file
  cout << "Opening file numFile.txt." << endl;

  inFS.open("numFile.txt");
  if (!inFS.is_open()) {
    cout << "Could not open file numFile.txt." << endl;
    return 1; // 1 indicates error
  }

  // Can now use inFS stream like cin stream
  // numFile.txt should contain two integers, else problems
  cout << "Reading two integers." << endl;
  inFS >> fileNum1;
  inFS >> fileNum2;
  cout << "Closing file numFile.txt." << endl;
  inFS.close(); // Done with file, so close it

  // Output values read from file
  cout << "num1: " << fileNum1 << endl;
  cout << "num2: " << fileNum2 << endl;
  cout << "num1 + num2: " << (fileNum1 + fileNum2) << endl;

  return 0;
}
```

End C++ Code:

A box representing numFile.txt.
numFile.txt contains two integers 5 and 10, on two separate lines.

Two empty output boxes.
Step 1:
#include <fstream> (short for "file stream") enables use of the ifstream class.
The line of code, #include <fstream>, is highlighted.

Step 2:
A new stream variable, ifstream inFS, is declared. ifstream is short for input file stream, and is derived from istream.
The line of code, ifstream inFS; // Input file stream, is highlighted.

Step 3:
inFS.open("numFile.txt"); opens the file for reading and associates the file with the inFS stream.
The string, Opening file numFile.txt, is outputted to output box 1.
The line of code, inFS.open("numFile.txt");, is highlighted.

Step 4:
If the open fails, either because the file does not exist or is in use by another program, the program outputs an error message, and exits.
The following block of code is highlighted:

```
  if (!inFS.is_open()) {
    cout << "Could not open file numFile.txt." << endl;
    return 1; // 1 indicates error
  }
```

The string, Could not open file numFile.txt., is outputted to output box 1.
Output box 1 is labeled as, Failure to open file.

Step 5:
A successfully opened input stream can be used like the cin stream. inFS >> fileNum1; reads an integer into fileNum1.
Output box 2 is labeled as, Successfully open a file.
The string, Opening file numFile.txt, is outputted to output box 2.
The string, Reading two integers., is outputted to output box 2.
The lines of code, inFS >> fileNum1; and inFS >> fileNum2; are highlighted.

Step 6:
When done using the stream, the program closes the file using inFS.close().
The line of code, inFS.close(); // Done with file, so close it, is highlighted.
The string, Closing file numFile.txt, is outputted to output box 2.
The lines of code, cout << "num1: " << fileNum1 << endl;,
cout << "num2: " << fileNum2 << endl;, and
cout << "num1 + num2: " << (fileNum1 + fileNum2) << endl;, are highlighted.
The strings,
num1: 5
num2: 10
num1 + num2: 15
are outputted to output box 2.

Animation captions:

1. #include <fstream> (short for "file stream") enables use of the ifstream class.
2. A new stream variable, ifstream inFS, is declared. ifstream is short for input file stream, and is derived from istream.
3. inFS.open("numFile.txt"); opens the file for reading and associates the file with the inFS stream.
4. If the open fails, either because the file does not exist or is in use by another program, the program outputs an error message, and exits.
5. A successfully opened input stream can be used like the cin stream. inFS >> fileNum1; reads an integer into fileNum1.
6. When done using the stream, the program closes the file using inFS.close().

A common error is to type ***`cin >> num1;`*** *when actually intending to get data from a file as in* ***`inFS >> num1`****. Another common error is a mismatch between the variable data type and the file data. If the data type is int but the file data is "Hello".*

PARTICIPATION ACTIVITY 9.5.2: File input.

1) What is the error in the following code?

```
ifstream inFS;
int numBooks;
int numStudents = 40;
inFS >> numBooks;
cout << "Books per student: ";
cout << numBooks / numStudents;
```

- The file stream is not large enough.
- The file stream has not been properly opened.
- The >> operator cannot be used here.
- No error.

2) Which function checks that a file has been opened?

- open()
- close()
- is_open()

3) Which statement reads and stores data into integer variable inputNum from the file opened by the stream inFS?

- inFS >> inputNum;
- cin >> inputNum;
- inFS.open(inputNum);

File open() with C strings in older C++ versions

Before C++11, earlier versions of the C++ standard required the inFS.open(str) function's str parameter to be a null-terminated C string, not a C++ string. To use a C++ string as the filename, the c_str() function that comes with C++ strings can be used. Ex: If filename is a C++ string, then filename.c_str() returns a null-terminated C string.

Reading until the end of the file

A program can read varying amounts of data in a file by using a loop that reads until the end of the file has been reached. The ***eof()*** function returns true if the previous stream operation reached the end of the file.

Errors may be encountered while attempting to read from a file, like the inability to read the file, reading corrupt data, etc. So, a program should check that each read was successful before using the variable to which the read data was assigned. The ***fail()*** function returns true if the previous stream operation had an error.

Figure 9.5.1: Reading a varying amount of data from a file.

Program	Example input file and output
	myfile.txt with variable number of integers: 111 222 333 444 555 Opening file myfile.txt. Reading and printing numbers. num: 111 num: 222 num: 333 num: 444 num: 555 Closing file myfile.txt.

PARTICIPATION ACTIVITY 9.5.3: File input.

1) Which statement determines if the following file read operation successfully read an integer?

```
inputFile >> vehicleCount;
```

- `if (inputFile.eof()) {`
- `if (!vehicleCount.eof()) {`
- `if (!inputFile.fail()) {`

Example: Counting instances of a specific word

The following program uses both the extraction operator, eof(), and fail() to determine how many times a user entered word appears in a file. The number of words in the file is unknown, so the program extracts words until the end of the file is

reached. The program exits if the stream extraction causes an error or after the word's frequency in the file is output.

Figure 9.5.2: How many times a word appears in a file.

Program

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

int main() {
   ifstream inFS;     // Input file stream
   string userWord;
   int wordFreq = 0;
   string currWord;

   // Open file
   cout << "Opening file wordFile.txt." <<
endl;
   inFS.open("wordFile.txt");

   if (!inFS.is_open()) {
      cout << "Could not open file
wordFile.txt." << endl;
      return 1;
   }

   // Word to be found
   cout << "Enter a word: ";
   cin >> userWord;

   // Identify when a word matches the userWord
   // and increase wordFreq
   while (!inFS.eof()) {
      inFS >> currWord;
      if (!inFS.fail()) {
         if (currWord == userWord) {
            ++wordFreq;
         }
      }
   }

   cout << userWord << " appears in the file "
        << wordFreq << " times." << endl;

   // Done with file, so close it
   inFS.close();

   return 0;
}
```

Example input file and output

wordFile.txt with a list of words:

```
twenty
associable
twenty
unredacted
associable
folksay
twenty
```

```
Opening file wordFile.txt.
Enter a word: twenty
twenty appears in the file
3 times.
```


PARTICIPATION ACTIVITY 9.5.4: Counting instances of specific word example.

1) In the example above, how many times does the while loop iterate?

- 3
- 4
- 7

2) What indicates that the end of the input file stream has been reached?

- The eof() function
- The extraction operator (>>)
- The fail() function

3) If the user entered "associable" as the userWord, how many times would the while loop execute?

- 2
- 7

Example: Business reviews

The following example reads a file with business reviews as the program starts and outputs data from the file at the end of the program. The number of reviews is unknown to the program, so the program continues to read until the end of the file. Each entry contains the username of the person who left the review and a 1 - 5 rating (1 being a low rating and 5 being a high rating). Upon completion, the program outputs the data from the file along with the average business rating.

Figure 9.5.3: Program that reads business reviews from a file and computes the average rating.

Program	Example input file and output

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


int main() {
   ifstream inFS;     // Input file stream
   string restaurantName;
   string userName;
   int userRating;
   int userRatingSum = 0;
   int userRatingCount = 0;

   // Open file
   inFS.open("Trattoria_Reviews.txt");

   if (!inFS.is_open()) {
      cout << "Could not open file
Trattoria_Reviews.txt."<< endl;
      return 1;
   }

   // Read and display the restaurant's name
   getline(inFS, restaurantName);
   cout << endl << restaurantName << endl;
   cout << "--------------------" << endl;

   // Loop to read all user reviews
   while (!inFS.eof()) {
      inFS >> userName;
      inFS >> userRating;

      if (!inFS.fail()) {
         // Display user's name and rating
         cout << "User name: " << userName << endl;
         cout << "   Rating: " << userRating <<
endl;
         cout << endl;

         // Add to the sum of all ratings so far
         userRatingSum += userRating;

         // Increment the number of ratings read
         userRatingCount++;
      }
   }

   // Display the restaurant's average rating
   cout << "--------------------" << endl;
   cout << "Average rating: ";
   cout << ((double)userRatingSum /
userRatingCount) << endl;


   // Close file when done reading
   inFS.close();

   return 0;
}
```

Trattoria_Reviews.txt with a list of usernames and ratings:

```
Trattoria Italian
Bistro

sunny8trophy
4

Angelcopter
2

Mogoodid24
5

Elixirnoel8626
5

gobbledygook
1

Friderday912
3
```



```
Trattoria Italian
Bistro
--------------------
User name: sunny8trophy
   Rating: 4

User name: Angelcopter
   Rating: 2

User name: Mogoodid24
   Rating: 5

User name:
Elixirnoel8626
   Rating: 5

User name: gobbledygook
   Rating: 1

User name: Friderday912
   Rating: 3

--------------------
Average rating: 3.33333
```

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PARTICIPATION ACTIVITY 9.5.5: Reading and using data from a file.

Refer to the program above.

1) Which statement reads a full line of multiple strings from an input file?

- inFS >> lineString;
- getline(inFS, lineString);

2) What variables are declared to track the average rating?

- A single double
- Two integers
- Two integers and a double

Input stream errors

A ***stream error*** occurs when insertion or extraction fails, causing the stream to enter an error state. Ex: If a file has the string `two` but the program attempts to extract an integer, the extraction will fail and the stream will enter an error state.

An input stream may also enter an error state if a value extracted is too large (or small) to fit in the given variable. While in an error state, an input stream may: skip extraction, set the given variable to 0, or set the given variable to the maximum (or minimum) value of that variable's data type.

A stream internally uses several 1-bit error flags to track the state of the stream. A program can check a stream's error state using several stream functions that return the current state. A stream's error state is cleared using clear().

Table 9.5.1: Stream error state flags and functions to check error state.

Flag	Meaning	Function
goodbit	Indicates no error flags are set and the stream is good.	***good()*** returns true if no stream errors have occurred.
eofbit	Indicates if end-of-file reached on extraction.	***eof()*** returns value of eofbit, if end-of-file reached on extraction.
failbit	Indicates a logical error for the previous extraction or insertion operation.	***fail()*** returns true if either failbit or badbit is set, indicating an error for the previous stream operation.
badbit	Indicates an error occurred while reading or writing the stream, and the stream is bad. Further operations on the stream will fail.	***bad()*** returns true if badbit is set, indicating the stream is bad.

PARTICIPATION ACTIVITY 9.5.6: Check for errors while reading a file.

```
inFS.open("Reviews.txt");

if (!inFS.is_open()) {
   cout << "Could not open file Reviews.txt."<< endl;
}
```

Reviews.txt

```
lazydog28 ✓
5 ✓
```

```
while (!inFS.eof() && inFS.good()) {
   inFS >> userName;
   inFS >> userRating;

   if (!inFS.fail()) {
      userNames.push_back(userName);
      userRatings.push_back(userRating);
   }
}

// If end-of-file not reached, then an error occurred
if (!inFS.eof()) {
   cout << "Error reading Reviews.txt." << endl;
   exit(EXIT_FAILURE);
}
```

Vancity93 ✓ string
three ✗ int

stun7ning
4

inFS state bits

0	goodbit
0	eofbit
1	failbit
0	badbit

Error reading Reviews.txt.

Animation captions:

1. After the input stream opens the file, the program uses the good() function to ensure the stream is in an error free state.
2. The program expects the file to contain reviews in the format of a string followed by an integer.
3. After reading "Vancity93", the program tries to extract an integer, but the next character is the letter 't'. The extraction fails, and the stream's error state is updated by setting the goodbit to 0 and the failbit to 1.
4. The while loop terminates because inFS.good() now returns false. Then, as the end-of-file was not reached before the stream error occurred, the program outputs an error message and exits.

PARTICIPATION ACTIVITY 9.5.7: Stream error functions.

1) Which returns whether a logical error occurred with file input stream inFS?
   - inFS(fail)
   - inFS.fail()
   - fail(inFS)

2) Which function wouldn't be used to check cout's error state?
   - good()
   - bad()
   - eof()

CHALLENGE ACTIVITY 9.5.1: File input.

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Start

String mattressFileName is a file's name read from input. Open mattressFileName as an input file associated with ifstream dataFS.

▶ Click here for example

main.cpp | data1.txt | data2.txt | data3.txt

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

int main() {
   ifstream dataFS;
   string mattressFileName;
   int mattressCount;

   cin >> mattressFileName;

   /* Your code goes here */

   if (!dataFS.is_open()) {
      cout << mattressFileName << ": program exiting due to error" << endl;
```


1 2 3 4

Check Next level

Exploring further:

- fstream Reference Page from cplusplus.com

9.6 C++ example: Parsing and validating input files

The following program reads input from the teams.txt file, which contains a baseball team name on one line followed by an optional line with the number of wins and losses for the season. Some win/loss lines only have a single number representing the number of wins. The file may have any number of team name and win/loss lines.

Figure 9.6.1: Program that reads from teams.txt.

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

int main() {
   ifstream teamFS;
   string teamName;
   int numWins;
   int numLosses;

   teamFS.open("teams.txt");

   if (!teamFS.is_open()) {
      cout << "Could not open file teams.txt." <<
endl;
      return 1;
   }

   // Read first team name
   getline(teamFS, teamName);

   // Read until end-of-file
   while (!teamFS.fail()) {
      // Attempt to read wins
      teamFS >> numWins;

      if (teamFS.fail()) {
         // Win/loss line missing
         cout << teamName << " has no wins or
losses" << endl;
      }
      else {
         // Attempt to read losses
         teamFS >> numLosses;

         if (teamFS.fail()) {
            // No losses provided
            cout << teamName << " has " << numWins
<< " wins" << endl;
         }
         else {
            // Win and losses provided
            cout << teamName << " win average is "
                 << static_cast<double>(numWins) /
(numWins + numLosses) << endl;
         }

         // Remove newline
         teamFS.ignore();
      }

      // Clear the error state
      teamFS.clear();

      // Attempt to read next team
      getline(teamFS, teamName);
   }

   teamFS.close();

   return 0;
}
```


teams.txt

```
Arkansas Travelers
5 11
Vancouver Canadians
10 3
Columbus Clippers
Norfolk Tides
6
Rocky Mountain Vibes
8 8
```

```
Arkansas Travelers win
average is 0.3125
Vancouver Canadians win
average is 0.769231
Columbus Clippers has
no wins or losses
Norfolk Tides has 6
wins
Rocky Mountain Vibes
win average is 0.5
```

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PARTICIPATION ACTIVITY

9.6.1: Parsing input files.

1) What is output when the win/loss line is missing?
   - *Team* has no wins or losses
   - *Team* has *W* wins
   - *Team* win average is *A*

2) What is output when the loss number is missing?
   - *Team* has no wins or losses
   - *Team* has *W* wins
   - *Team* win average is *A*

3) Which istream member function is called to verify teams.txt is opened successfully?
   - fail()
   - clear()
   - is_open()

4) Which istream member function is called to verify a team name, win number, or loss number was successfully read?
   - fail()
   - clear()
   - ignore()

5) What is the last line output if `teamFS.clear()` is removed from the program?
   - Vancouver Canadians win average is 0.769231
   - Columbus Clippers has no wins or losses
   - Rocky Mountain Vibes win average is 0.5

9.7 File output

Opening and writing to a file

An ***ofstream***, short for "output file stream", is a class that supports writing to a file. The ofstream class inherits from ostream.

After declaring a variable of type ofstream, a file is opened using the ofstream's open() function. The ofstream's is_open() function is commonly called to check if the file opened successfully. If so, data can be written to the file using the << operator.

When all desired data is written, the ofstream's close() function is called to close the file.

Table 9.7.1: Basic steps for opening and writing a file.

Action	Sample code
Open the file helloWorld.txt for writing	`ofstream outFS;` `outFS.open("helloWorld.txt");`

Check to see if the file opened successfully	`if (!outFS.is_open()) {`
	`  // Do not proceed to code that writes to the file`
	`}`

Write the string "Hello World!" to the file	`outFS << "Hello World!" << endl;`
Close the file after writing all desired data	`outFS.close();`

PARTICIPATION ACTIVITY 9.7.1: Opening and writing to a file.

1) ofstream's open function takes _____.
   - 0 arguments
   - a string for a file name as an argument

2) If is_open() returns false, execution _____ proceed to code that writes to the file.
   - should
   - should not

3) Data can be written to the file _____.
   - before calling open()
   - after the file is opened successfully, but before the file is closed
   - at any time

Example: Writing a text file

Calling an ofstream's open() function makes an attempt to open the file. The file may fail to open due to things like file permissions or a full disk. The is_open() should be called to check if the file opened successfully. is_open() returns true if the file is open, false otherwise.

The file is created and is initially empty, if opened successfully. Data is written to the file, then the file is closed.

PARTICIPATION ACTIVITY 9.7.2: Writing to an output text file.

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

int main() {
   ofstream outFS; // Output file stream

   // Open file
   outFS.open("myoutfile.txt");

   if (!outFS.is_open()) {
      cout << "Could not open file myoutfile.txt." << endl;
      return 1;
   }

   // Write to file
   outFS << "Hello" << endl;
   outFS << "1 2 3" << endl;

   // Done with file, so close
   outFS.close();

   return 0;
}
```

Contents of myoutfile.txt:

```
Hello
1 2 3
```


Animation content:

Static figure:
Begin C++ code:
#include <iostream>
#include <fstream>
using namespace std;

int main() {
  ofstream outFS; // Output file stream

  // Open file
  outFS.open("myoutfile.txt");

  if (!outFS.is_open()) {
    cout << "Could not open file myoutfile.txt." << endl;
    return 1;
  }

  // Write to file
  outFS << "Hello" << endl;
  outFS << "1 2 3" << endl;

  // Done with file, so close
  outFS.close();

  return 0;
}
End C++ code.
An output text file labeled " Contents of myoutfile.txt:" contains two lines of output:
Hello

1 2 3
Step 1: An ofstream named outFS is declared, then myoutfile.txt is opened for writing. The file is initially empty.
The line of code, ofstream outFS; is highlighted and then the line outFS.open("myoutfile.txt"); is highlighted. An empty output text file appears.

Step 2: Since the file opened successfully, outFS.is_open() returns true.
The line of code, if (!outFS.is_open()) {, is highlighted. The text "is_open() returns true" is shown, indicating that the if statement condition is not met.

Step 3: Two lines of text are written to the file, then the file is closed.
Two lines of text are written to the file, then the file is closed. The lines of code, outFS << "Hello" << endl;
outFS << "1 2 3" << endl;, and outFS.close(); are highlighted and output text file now contains two lines of output:
Hello
1 2 3
The file is then closed.

Animation captions:

1. An ofstream named outFS is declared, then myoutfile.txt is opened for writing. The file is initially empty.
2. Since the file opened successfully, outFS.is_open() returns true.
3. Two lines of text are written to the file, then the file is closed.

PARTICIPATION ACTIVITY 9.7.3: Writing a text file.

1) In the code above, the statement `outFS.close()` is not executed if is_open() returns false.
   - True
   - False

2) Since no data is written, the code below never creates the myoutfile.txt file on disk.

```
outFS.open("myoutfile.txt");
outFS.close()
```

   - True
   - False

3) An ofstream should be closed using the close() function.

   - True
   - False

Example: Writing a simple HTML file

HTML files are used for web pages and consist of text content. Therefore, an HTML file can be written similar to a text file.

PARTICIPATION ACTIVITY 9.7.4: Writing simple html to a file and to the console.

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

void writeHTMLFile(ostream& outStream, string innerHTML) {
   outStream << "<!DOCTYPE html>" << endl;
   outStream << "<html>" << endl;
   outStream << "  <body>" << endl;
   outStream << "    <p>" << innerHTML << "</p>" << endl;
   outStream << "  </body>" << endl;
   outStream << "</html>" << endl;
}

int main() {
   string htmlParagraph = "Hello <b>HTML</b> world!";

   // Open an output file stream
   ofstream outFS;
   outFS.open("simple.html");

   if (!outFS.is_open()) {
      cout << "Could not open file simple.html." << endl;
      return 1;
   }

   // Write to, and then close, file
   writeHTMLFile(outFS, htmlParagraph);
   outFS.close();

   // Use the same function, writeHTMLFile, to write to cout
   writeHTMLFile(cout, htmlParagraph);
   return 0;
}
```

Console:

```
<!DOCTYPE html>
<html>
 <body>
   <p>Hello <b>HTML</b> world!</p>
 </body>
</html>
```


simple.html file contents:

```
<!DOCTYPE html>
<html>
 <body>
   <p>Hello <b>HTML</b> world!</p>
 </body>
</html>
```

Animation content:

Static figure:
Begin C++ code:
#include <iostream>
#include <fstream>
#include <string>
using namespace std;

void writeHTMLFile(ostream& outStream, string innerHTML) {
  outStream << "<!DOCTYPE html>" << endl;
  outStream << "<html>" << endl;
  outStream << " <body>" << endl;
  outStream << "   " << innerHTML << " " << endl;
  outStream << " </body>" << endl;
  outStream << "</html>" << endl;
}

int main() {
  string htmlParagraph = "Hello HTML world!";

  // Open an output file stream
  ofstream outFS;
  outFS.open("simple.html");

```
  if (!outFS.is_open()) {
        cout << "Could not open file simple.html." << endl;
        return 1;
  }

  // Write to, and then close, file
  writeHTMLFile(outFS, htmlParagraph);
  outFS.close();
  // Use the same function, writeHTMLFile, to write to cout
  writeHTMLFile(cout, htmlParagraph);
  return 0;
}
```


End C++ code.
An output console titles “Console:” containing six lines of output is shown
Begin output lines:

```
<!DOCTYPE html>
<html>
 <body>
  <p>Hello <b>HTML</b> world!</p>
 </body>
</html>
```

End output lines.
An output file is titles “simple.html file contents:” is shown:
Begin simple.html file contents:

```
<!DOCTYPE html>
<html>
 <body>
  <p>Hello <b>HTML</b> world!</p>
 </body>
</html>
```

End simple.html file contents.

Step 1: Output file simple.html is opened for writing.
The line of code, string htmlParagraph = "Hello HTML world!"; is highlighted. Next, the lines of code,

```
ofstream outFS;
  outFS.open("simple.html");

  if (!outFS.is_open()) {
        cout << "Could not open file simple.html." << endl;
        return 1;
  }
```

Is highlighted and an empty box labeled "simple.html file contents" appears.

Step 2: Since ofstream inherits from ostream and outFS is an ofstream, outFS can be passed by reference as an argument to writeHTMLFile().
The line of code, writeHTMLFile(outFS, htmlParagraph);, is highlighted. The line of code, ofstream is highlighted in lines void writeHTMLFile(ostream& outStream, string innerHTML)and ofstream outFS; indicating the passing reference.

Step 3: writeHTMLFile() writes HTML content to the file, then the file is closed.

The lines of code in the writeHTMLFile function are highlighted
Begin C++ code:

```
void writeHTMLFile(ostream& outStream, string innerHTML) {
  outStream << "<!DOCTYPE html>" << endl;
  outStream << "<html>" << endl;
  outStream << "  <body>" << endl;
  outStream << "        <p>" << innerHTML << "</p>" << endl;
  outStream << "  </body>" << endl;
  outStream << "</html>" << endl;
}
```

End C++ code.
The lines of HTML code appear in the box labeled "simple.html file contents:".
Begin simple.html file contents:

```
<!DOCTYPE html>
<html>
 <body>
  <p>Hello <b>HTML</b> world!</p>
 </body>
</html>
```

End simple.html file contents.
The line of code outFS.close(); is highlighted, closing the file.

Step 4:
The line of code, writeHTMLFile(cout, htmlParagraph);, is highlighted and lines of output appear in the box labeled “Console:”
Begin output lines:

```
<!DOCTYPE html>
<html>
 <body>
  <p>Hello <b>HTML</b> world!</p>
 </body>
</html>
```

End output lines.
The line of code, return 0;, is highlighted.

Animation captions:

1. Output file simple.html is opened for writing.
2. Since ofstream inherits from ostream and outFS is an ofstream, outFS can be passed by reference as an argument to writeHTMLFile().
3. writeHTMLFile() writes HTML content to the file, then the file is closed.
4. cout can also be passed to writeHTMLFile(), since cout is an ostream instance. The same content is written to the console.

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PARTICIPATION ACTIVITY 9.7.5: Writing a simple HTML file.

1) writeHTMLFile can write to either outFS or cout because both are instances of a class that inherits from ____.

- ofstream
- ostream
- string

2) The ____ operator allows writing a string to an ostream.

- >>
- <<
- +

3) A better implementation of writeHTMLFile would close the stream.

- True
- False

CHALLENGE ACTIVITY 9.7.1: File output.

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Start

Integer cabinetCount and string friendName are read from input. An ofstream named outFS is declared and the file named data.txt is opened. Write the following to the opened file:

- "Memo:"
- cabinetCount followed by " cabinets for " and friendName

End each output with a newline.

Ex: If the input is `18 Hania`, then data.txt contains:

```
Memo:
18 cabinets for Hania
```

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

int main() {
   ofstream outFS;
   int cabinetCount;
   string friendName;

   cin >> cabinetCount;
   cin >> friendName;

   outFS.open("data.txt");
   if (!outFS.is_open()) {
      cout << "data.txt" << " could not be opened" << endl;
```


1 2 3

Check Next level

9.8 C++ example: Saving and retrieving program data

The following program reads restaurant reviews from the reviews.txt file into a vector of strings. The user is prompted to enter additional reviews, which are appended to the string vector. Each time a new review is entered, the complete list of reviews are output to the console.

Figure 9.8.1: Program that reads restaurant reviews from reviews.txt.

```
#include <iostream>
#include <fstream>
#include <string>
#include <vector>
using namespace std;

void ReadReviews(vector<string> &reviewList)
{
   ifstream reviewsFS;
   string review;

   reviewsFS.open("reviews.txt");

   if (!reviewsFS.is_open()) {
      cout << "Could not open file
reviews.txt." << endl;
   }
   else {
      getline(reviewsFS, review);
      while (!reviewsFS.fail()) {
         reviewList.push_back(review);
         getline(reviewsFS, review);
      }

      reviewsFS.close();
   }
}

void DisplayReviews(const vector<string>
&reviewList) {
   cout << endl << "Reviews:" << endl;
   for (int i = 0; i < reviewList.size();
i++) {
      cout << i + 1 << ". " <<
reviewList.at(i) << endl;
   }
   cout << endl;
}

int main() {
   vector<string> reviewList;
   string newReview;

   // Read reviews from file into reviews
vector and display
   ReadReviews(reviewList);
   DisplayReviews(reviewList);

   cout << "Enter new review or QUIT:" <<
endl;
   getline(cin, newReview);
   while (newReview != "QUIT") {
      // Add new reviews to the vector and
display new list
      reviewList.push_back(newReview);
      DisplayReviews(reviewList);

      cout << "Enter new review or QUIT:" <<
endl;
      getline(cin, newReview);
   }

   return 0;
}
```

reviews.txt

```
The salads are really good.
Service was a little slow, but
the food was decent.
My favorite place in town!
```



```
Reviews:
1. The salads are really good.
2. Service was a little slow,
but the food was decent.
3. My favorite place in town!

Enter new review or QUIT:
Prices are good for the amount
of food you get.

Reviews:
1. The salads are really good.
2. Service was a little slow,
but the food was decent.
3. My favorite place in town!
4. Prices are good for the
amount of food you get.

Enter new review or QUIT:
QUIT
```

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PARTICIPATION ACTIVITY 9.8.1: Saving and retrieving program data.

1) How many reviews appear on each line in reviews.txt?

- 1
- 2
- All

2) If the user typed a second review in the example run above instead of QUIT, what would be the size of the reviews vector sent to DisplayReviews()?

- 3
- 4
- 5

3) If the user runs the program above, enters 2 reviews, quits, and runs the program a second time, how many reviews will initially be displayed?

- 3
- 4
- 5

PARTICIPATION ACTIVITY 9.8.2: Save the reviews.

The program is not saving new user reviews, so a new function SaveReviews() should be called after the user enters QUIT to save the reviews vector to reviews.txt.

```
void SaveReviews(const vector<string> &reviews) {
   __A__ reviewsFS;
   reviewsFS.__B__;

   for (int i = 0; i < reviews.size(); i++) {
      __C__ << reviews.at(i) << endl;
   }

   reviewsFS.__D__;
}
```

Enter the correct code that replaces the letters in the SaveReview() function above.

1) A's replacement?

Check Show answer

2) B's replacement?

Check Show answer

3) C's replacement?

Check Show answer

4) D's replacement?

Check Show answer

9.9 Overloading stream operators

Overloading the << operator

The C++ << operator is known as the ***insertion operator***. A C++ class can overload the insertion operator by creating a member function named operator<<.

Ex: A VoteCounter class may count a vote for a candidate by using the << operator. The candidate's name is passed as a string argument, and the VoteCounter object is returned. So the member function declaration is `VoteCounter& operator<<(const string& candidateName);`.

Figure 9.9.1: VoteCounter class demo.

```
#include <iostream>
#include <queue>
using namespace std;

class VoteCounter
{
private:
   int ACount, BCount, CCount;
public:
   VoteCounter() { ACount = BCount = CCount = 0; }
   VoteCounter& operator<<(const string& candidateName);
   string GetResults();
};

VoteCounter& VoteCounter::operator<<(const string& candidateName) {
   if ("Candidate A" == candidateName)
      ACount++;
   else if ("Candidate B" == candidateName)
      BCount++;
   else if ("Candidate C" == candidateName)
      CCount++;

   return *this;
}

string VoteCounter::GetResults() {
   if (ACount > BCount) {
      if (ACount > CCount)
         return "Candidate A wins!";
      else if (ACount < CCount)
         return "Candidate C wins!";
      else
         return "Tie between candidates A & C!";
   }
   else if (ACount < BCount) {
      if (BCount > CCount)
         return "Candidate B wins!";
      else if (BCount < CCount)
         return "Candidate C wins!";
      else
         return "Tie between candidates B & C!";
   }
   else {
      if (BCount == CCount)
         return "Tie between all 3 candidates!";
      else
         return "Tie between candidates A & B!";
   }
}

int main() {
   const string candidateNames[] = {
      "Candidate A", "Candidate B", "Candidate C"
   };
   const int voteIndices[] = {
      2, 1, 0, 1, 2, 0, 0, 1, 2, 1, 0, 1, 0, 0, 1, 2, 0, 0, 1
   };
   const int voteCount = sizeof(voteIndices) / sizeof(int);

   // Cast the votes
   cout << "Counting votes..." << endl;
   VoteCounter counter;
   for (int i = 0; i < voteCount; i++) {
      int voteIndex = voteIndices[i];
      counter << candidateNames[voteIndex];
   }

   // Reveal the winner
   cout << counter.GetResults() << endl;

   return 0;
}
```


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```
Counting votes...
Candidate A wins!
```

PARTICIPATION ACTIVITY 9.9.1: VoteCounter << operator.

1) The statement `counter << "candidate c";` would count a vote for candidate C.
   - True
   - False

2) The statement `counter << "Candidate A" << "Candidate B";` would count 2 votes, one for candidate A and another for candidate B.
   - True
   - False

3) If the operator<< member function's return type were changed to void and the return statement removed, a compiler error would occur.
   - True
   - False

Overloading the >> operator

The C++ >> operator is known as the ***extraction operator***. A C++ class can overload the extraction operator by creating a member function named operator>>.

Ex: The WaitingLine class uses the insertion operator to add a string to the back of the line and the extraction operator to remove a string from the front of the line.

Figure 9.9.2: WaitingLine class.

```
class WaitingLine
{
public:
   WaitingLine& operator<<(const string& name) {
      // Add the name to the end of the line
      line.push(name);

      cout << name << " enters the back of the line" << endl;

      return *this;
   }
   WaitingLine& operator>>(string& frontName) {
      // Copy the name at the front of the line to frontName, then
remove
      frontName = line.front();
      line.pop();

      return *this;
   }

   queue<string> line;
};
```


PARTICIPATION ACTIVITY 9.9.2: The insertion and extraction operators add and remove from the WaitingLine object.

```
#include <iostream>
#include <queue>
using namespace std;

// WaitingLine class omitted

int main() {
   WaitingLine line1;
   line1 << "Lion";
   line1 << "Tiger";
   line1 << "Bear";

   string name;
   for (int i = 0; i < 2; i++) {
      line1 >> name;
      cout << name << " exits the front of the line" << endl;
   }

   // Add "Duck" and "Goose" to the back of the line
   line1 << "Duck";
   line1 << "Goose";

   for (int i = 0; i < 3; i++) {
      line1 >> name;
      cout << name << " exits the front of the line" << endl;
   }

   cout << "Exiting main" << endl;
   return 0;
}
```

Console:

```
Lion enters the back of the line
Tiger enters the back of the line
Bear enters the back of the line
Lion exits the front of the line
Tiger exits the front of the line
Duck enters the back of the line
Goose enters the back of the line
Bear exits the front of the line
Duck exits the front of the line
Goose exits the front of the line
Exiting main
```


Animation content:

Static figure: A code block and an output console are displayed.
Begin C++ code:
#include <iostream>
#include <queue>

```
using namespace std;

// WaitingLine class omitted

int main() {
  WaitingLine line1;
  line1 << "Lion";
  line1 << "Tiger";
  line1 << "Bear";

  string name;
  for (int i = 0; i < 2; i++) {
    line1 >> name;
    cout << name << " exits the front of the line" << endl;
  }

  // Add "Duck" and "Goose" to the back of the line
  line1 << "Duck";
  line1 << "Goose";

  for (int i = 0; i < 3; i++) {
    line1 >> name;
    cout << name << " exits the front of the line" << endl;
  }

  cout << "Exiting main" << endl;
  return 0;
}
```


End C++ code.

Step 1: Three strings are inserted into the waiting line using the insertion operator: Lion, Tiger, and Bear. The line of code, WaitingLine line1;, is highlighted. The lines of code, line1 << "Lion";, line1 << "Tiger";, line1 << "Bear";, are highlighted and the output console now contains three lines of output:

Lion enters the back of the line
Tiger enters the back of the line
Bear enters the back of the line

The text, line1:, appears below the output console with three items:

Lion
Tiger
Bear

Step 2: Lion and Tiger are removed using the extraction operator. The lines of code, string name;, for (int i = 0; i < 2; i++) {, line1 >> name;, cout << name << " exits the front of the line" << endl;, }, are highlighted and Lion is removed from line1 and the text, Lion exits the front of the line, is output to the console. Tiger is then removed from line1 and the text, Tiger exits the front of the line, is output to the console.

Step 3: Duck and Goose are added to the back of the line with the insertion operator. The lines of code, line1 << "Duck";, line1 << "Goose";, are highlighted and the text, Duck enters the back of the line, Goose enters the back of the line, are output to the console. line1 now contains three items:

Bear
Duck
Goose

Step 4: The remaining strings are removed from the waiting line with the extraction operator. The lines of code, for (int i = 0; i < 3; i++) {, line1 >> name;, cout << name << " exits the front of the line" << endl;, }, are highlighted and the text, Bear exits the front of the line, Duck exits the front of the line,

Goose exits the front of the line, are output to the console. Bear, Duck, and Goose are removed from line1. The line of code, cout << "Exiting main" << endl;, is highlighted and the text, Exiting main, is output to the console.

Animation captions:

1. Three strings are inserted into the waiting line using the insertion operator: Lion, Tiger, and Bear.
2. Lion and Tiger are removed using the extraction operator.
3. Duck and Goose are added to the back of the line with the insertion operator.
4. The remaining strings are removed from the waiting line with the extraction operator.

PARTICIPATION ACTIVITY 9.9.3: Overloading the extraction operator.

1) WaitingLine's extraction operator adds a string to the front of the line.
   - True
   - False

2) WaitingLine's insertion operator adds a string to the front of the line.
   - True
   - False

3) WaitingLine's extraction operator removes an empty string if the line is empty.
   - True
   - False

Extending cin and cout

By default, a programmer-defined C++ class does not work with cin and cout. Statements like `cin >> line1` or `cout << line1`, where line1 is a WaitingLine object, cause a compiler error. But the functionality of cin and cout can be extended by implementing certain friend functions in the C++ class.

Figure 9.9.3: WaitingLine class with stream friend functions.

```
class WaitingLine
{
public:
   WaitingLine& operator<<(const string& name) {
      // Add the name to the end of the line
      line.push(name);

      cout << name << " enters the back of the line" << endl;

      return *this;
   }

   WaitingLine& operator>>(string& frontName) {
      // Copy the name at the front of the line to frontName, then
remove
      frontName = line.front();
      line.pop();

      return *this;
   }

   friend ostream& operator<<(ostream& out, const WaitingLine& line)
{
      out << "(front)";
      queue<string> lineCopy = line.line;
      while (!lineCopy.empty()) {
         string lineItem = lineCopy.front();
         lineCopy.pop();
         out << " " << lineItem;
      }
      out << " (back)";
      return out;
   }

   friend istream& operator>>(istream& in, WaitingLine& line) {
      string inString;
      in >> inString;
      line << inString;
      return in;
   }

   queue<string> line;
};
```


PARTICIPATION ACTIVITY 9.9.4: Using cin and cout with the WaitingLine class.

```
int main() {
   WaitingLine line1;

   // Get user input to add an item to the line
   cin >> line1;

   // Add a 2nd item to the line
   line1 << "Item_2";

   cout << "Line: " << line1 << endl;
   return 0;
}
```

Console:

```
one
one enters the back of the line
Item_2 enters the back of the line
Line: (front) one Item_2 (back)
```


Animation content:

Static figure: A code block and a console are displayed.
Begin C++ code:

```
int main() {
   WaitingLine line1;

   // Get user input to add an item to the line
   cin >> line1;

   // Add a 2nd item to the line
   line1 << "Item_2";

   cout << "Line: " << line1 << endl;
   return 0;
}
```

End C++ code.
Step 1: Since friend istream& operator>> is implemented in the WaitingLine class, cin >> line1 can be used to get input from the user and add to the line. The line of code, cin >> line1;, is highlighted and the text, (user is typing), appears below the console while the text, one, appears in the console one character at a time. The text, one enters the back of the line, is output to the console.
Step 2: A second, hard-coded string is added to the list. cout is then used to display the full list. The line of code, line1 << "Item_2";, is highlighted and the text, Item_2 enters the back of the line, is output to the console. The line of code, cout << "Line: " << line1 << endl;, is highlighted and the text, Line: (front) one Item_2 (back), is output to the console. The line of code, return 0;, is highlighted and the program finishes.

Animation captions:

1. Since friend istream& operator>> is implemented in the WaitingLine class, cin >> line1 can be used to get input from the user and add to the line.
2. A second, hard-coded string is added to the list. cout is then used to display the full list.

PARTICIPATION ACTIVITY 9.9.5: Using cin and cout with the WaitingLine class.

1) The statement `cin >> line1` calls the _____ function.
   - friend ostream& operator<<
   - friend istream& operator>>
   - WaitingLine& operator>>

2) Objects other than cout can be used to write WaitingLine contents. The statement `file1 << line1` would work provided file1 is an instance of _____.
   - ostream
   - istream
   - WaitingLine

3) In the animation above, the user could have typed `one two` instead of `one`, thus adding ____, to line1.

- two strings, "one" and "two"
- one string, "one two"
- one string, "one"

9.10 LAB: Parsing dates

Complete main() to read dates from input, one date per line. Each date's format must be as follows: March 1, 1990. Any date not following that format is incorrect and should be ignored. Use the substr() function to parse the string and extract the date. The input ends with -1 on a line alone. Output each correct date as: 3-1-1990.

Ex: If the input is:

```
March 1, 1990
April 2 1995
7/15/20
December 13, 2003
-1
```

then the output is:

```
3-1-1990
12-13-2003
```

Use the provided GetMonthAsInt() function to convert a month string to an integer. If the month string is valid, an integer in the range 1 to 12 inclusive is returned, otherwise 0 is returned. Ex: `GetMonthAsInt("February")` returns 2 and `GetMonthAsInt("7/15/20")` returns 0.

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LAB ACTIVITY | 9.10.1: LAB: Parsing dates | 0 / 10

main.cpp — Load default template...

```
#include <iostream>
#include <string>

using namespace std;

int GetMonthAsInt(string month) {
   int monthInt = 0;

   if (month == "January")
      monthInt = 1;
   else if (month == "February")
      monthInt = 2;
   else if (month == "March")
      monthInt = 3;
   else if (month == "April")
```

Develop mode | Submit mode

Run your program as often as you'd like, before submitting for grading. Below, type any needed input values in the first box, then click **Run program** and observe the program's output in the second box.

Enter program input (optional)

If your code requires input values, provide them here.

Run program

Input (from above) → main.cpp (Your program) → Output (shown below)

Program output displayed here

Coding trail of your work What is this?

```
History of your effort will appear here once you begin working
on this zyLab.
```

9.11 LAB: File name change

A photographer is organizing a photo collection about the national parks in the US and would like to annotate the information about each of the photos into a separate set of files. Write a program that reads the name of a text file containing a list of photo file names. The program then reads the photo file names from the text file, replaces the "_photo.jpg" portion of the file names with "_info.txt", and outputs the modified file names.

Assume the unchanged portion of the photo file names contains only letters and numbers, and the text file stores one photo file name per line. If the text file is empty, the program produces no output.

Ex: If the input of the program is:

```
ParkPhotos.txt
```

and the contents of ParkPhotos.txt are:

```
Acadia2003_photo.jpg
AmericanSamoa1989_photo.jpg
BlackCanyonoftheGunnison1983_photo.jpg
CarlsbadCaverns2010_photo.jpg
CraterLake1996_photo.jpg
GrandCanyon1996_photo.jpg
IndianaDunes1987_photo.jpg
LakeClark2009_photo.jpg
Redwood1980_photo.jpg
VirginIslands2007_photo.jpg
Voyageurs2006_photo.jpg
WrangellStElias1987_photo.jpg
```

the output of the program is:

```
Acadia2003_info.txt
AmericanSamoa1989_info.txt
BlackCanyonoftheGunnison1983_info.txt
CarlsbadCaverns2010_info.txt
CraterLake1996_info.txt
GrandCanyon1996_info.txt
IndianaDunes1987_info.txt
LakeClark2009_info.txt
Redwood1980_info.txt
VirginIslands2007_info.txt
Voyageurs2006_info.txt
WrangellStElias1987_info.txt
```


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LAB ACTIVITY | 9.11.1: LAB: File name change | 0 / 10

Downloadable files

ParkPhotos.txt **Download**

main.cpp **Load default template...**

```
1  #include <iostream>
2  #include <cstring>
3  #include <fstream>
4
5  // Include any necessary libraries here.
6
7  using namespace std;
8
9  int main() {
10
11    /* Type your code here. */
12
13    return 0;
14 }
15
```

Develop mode | **Submit mode**

Run your program as often as you'd like, before submitting for grading. Below, type any needed input values in the first box, then click **Run program** and observe the program's output in the second box.

Enter program input (optional)

If your code requires input values, provide them here.

Run program Input (from above) → **main.cpp** (Your program) → Output (shown below)

Program output displayed here

Coding trail of your work What is this?

```
History of your effort will appear here once you begin working
on this zyLab.
```


9.12 LAB: Course Grade

Write a program that reads the student information from a tab separated values (tsv) file. The program then creates a text file that records the course grades of the students. Each row of the tsv file contains the Last Name, First Name, Midterm1 score, Midterm2 score, and the Final score of a student. A sample of the student information is provided in StudentInfo.tsv. Assume the number of students is at least 1 and at most 20. Assume also the last names and first names do not contain whitespaces.

The program performs the following tasks:

- Read the file name of the tsv file from the user.
- Open the tsv file and read the student information.
- Compute the average exam score of each student.
- Assign a letter grade to each student based on the average exam score in the following scale:
  - A: 90 =< x
  - B: 80 =< x < 90
  - C: 70 =< x < 80
  - D: 60 =< x < 70
  - F: x < 60
- Compute the average of each exam.
- Output the last names, first names, exam scores, and letter grades of the students into a text file named report.txt. Output one student per row and separate the values with a tab character.
- Output the average of each exam, with two digits after the decimal point, at the end of report.txt. Hint: Use the setprecision manipulator to format the output.

Ex: If the input of the program is:

```
StudentInfo.tsv
```

and the contents of StudentInfo.tsv are:

```
Barrett    Edan    70  45  59
Bradshaw    Reagan  96  97  88
Charlton    Caius   73  94  80
Mayo    Tyrese  88  61  36
Stern    Brenda  90  86  45
```


the file report.txt should contain:

```
Barrett    Edan    70  45  59  F
Bradshaw    Reagan  96  97  88  A
Charlton    Caius   73  94  80  B
Mayo    Tyrese  88  61  36  D
```

```
Stern    Brenda  90  86  45  C

Averages: midterm1 83.40, midterm2 76.60, final 61.60
```

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LAB ACTIVITY | 9.12.1: LAB: Course Grade | 0 / 10

Downloadable files

StudentInfo.tsv Download

main.cpp Load default template...

```
1  #include <string>
2  #include <iostream>
3  #include <iomanip>
4  #include <fstream>
5  #include <vector>
6  using namespace std;
7
8  int main() {
9
10    /* TODO: Declare any necessary variables here. */
11
12
13    /* TODO: Read a file name from the user and read the tsv file here. */
14
15
```

Develop mode | Submit mode

Run your program as often as you'd like, before submitting for grading. Below, type any needed input values in the first box, then click **Run program** and observe the program's output in the second box.

Enter program input (optional)

If your code requires input values, provide them here.

Run program Input (from above) → main.cpp (Your program) → Output (shown below)

Program output displayed here

Coding trail of your work What is this?

History of your effort will appear here once you begin working on this zyLab.

9.13 LAB: Parsing food data

Given a text file containing the availability of food items, write a program that reads the information from the text file and outputs the available food items. The program should first read the name of the text file from the user. The program then should read the text file, line by line. If a food is available, the program should output the available food item in the following format: name (category) -- description

Assume the text file contains the category, name, description, and availability of at least one food item, separated by a tab character ('\t').

Hints: Use the find() function to find the index of a tab character in each row of the text file. Use the substr() function to extract the text separated by the tab characters.

Ex: If the input of the program is:

```
food.txt
```

and the contents of food.txt are:

```
Sandwiches    Ham sandwich    Classic ham sandwich    Available
Sandwiches    Chicken salad sandwich  Chicken salad sandwich  Not available
Sandwiches    Cheeseburger    Classic cheeseburger    Not available
Salads    Caesar salad    Chunks of romaine heart lettuce dressed with lemon juice
Available
Salads    Asian salad Mixed greens with ginger dressing, sprinkled with sesame    Not
available
Beverages    Water   16oz bottled water  Available
Beverages    Coca-Cola   16oz Coca-Cola  Not available
Mexican food    Chicken tacos   Grilled chicken breast in freshly made tortillas    Not
available
Mexican food    Beef tacos  Ground beef in freshly made tortillas   Available
Vegetarian    Avocado sandwich    Sliced avocado with fruity spread   Not available
```

the output of the program is:

```
Ham sandwich (Sandwiches) -- Classic ham sandwich
Caesar salad (Salads) -- Chunks of romaine heart lettuce dressed with lemon juice
Water (Beverages) -- 16oz bottled water
Beef tacos (Mexican food) -- Ground beef in freshly made tortillas
```


LAB ACTIVITY | 9.13.1: LAB: Parsing food data | 0 / 10

Downloadable files

food.txt **Download**

main.cpp **Load default template...**

```
1 #include <iostream>
2 #include <fstream>
3
4 using namespace std;
5
```

```
int main() {

   /* Type your code here. */

   return 0;
}
```


Develop mode | Submit mode

Run your program as often as you'd like, before submitting for grading. Below, type any needed input values in the first box, then click **Run program** and observe the program's output in the second box.

Enter program input (optional)

If your code requires input values, provide them here.

Run program

Input (from above) → main.cpp (Your program) → Output (shown below)

Program output displayed here

Coding trail of your work What is this?

History of your effort will appear here once you begin working on this zyLab.

9.14 LAB: Thesaurus

Given a set of text files containing synonyms for different words, complete the program to output the synonyms for a specific word. Each text file contains synonyms for the word specified in the file's name, and each row within the file lists the word's synonyms that begin with the same letter, separated by a space.

The program should read a word and a letter from the user and open the text file associated with the input word. The program then should output all the synonyms that begin with the input letter, one synonym per line. If no synonyms that begin with the input letter are found, the program should output a message indicating so.

Ex: If the input of the program is:

```
educate c
```

the program opens the file educate.txt, which contains:

```
brainwash brief
civilize coach cultivate
develop discipline drill
```

```
edify enlighten exercise explain
foster
improve indoctrinate inform instruct
mature
nurture
rear
school
train tutor
```


then the program outputs:

```
civilize
coach
cultivate
```

Ex: If the input of the program is:

```
educate a
```

then the program outputs:

```
No synonyms for educate begin with a.
```


LAB ACTIVITY | 9.14.1: LAB: Thesaurus | 0 / 10

Downloadable files

educate.txt **Download**

main.cpp **Load default template...**

```
1  #include <iostream>
2  #include <fstream>
3  using namespace std;
4
5  int main() {
6
7     /* Type your code here. */
8
9     return 0;
10 }
11
```

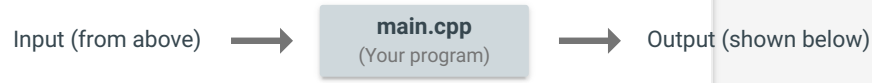

Develop mode **Submit mode**

Run your program as often as you'd like, before submitting for grading. Below, type any needed input values in the first box, then click **Run program** and observe the program's output in the second box.

Enter program input (optional)

If your code requires input values, provide them here.

Run program



Program output displayed here

Coding trail of your work What is this?

```
History of your effort will appear here once you begin working
on this zyLab.
```

9.15 LAB: Movie show time display

Write a program that reads movie data from a CSV (comma separated values) file and output the data in a formatted table. The program first reads the name of the CSV file from the user. The program then reads the CSV file and outputs the contents according to the following requirements:

- Each row contains the title, rating, and all showtimes of a unique movie.
- A space is placed before and after each vertical separator ('|') in each row.
- Column 1 displays the movie titles and is left justified with a minimum of 44 characters.
- If the movie title has more than 44 characters, output the first 44 characters only.
- Column 2 displays the movie ratings and is right justified with a minimum of 5 characters.
- Column 3 displays all the showtimes of the same movie, separated by a space.

Each row of the CSV file contains the showtime, title, and rating of a movie. Assume data of the same movie are grouped in consecutive rows.

Hints: Use the find() function to find the index of a comma in each row of the text file. Use the substr() function to extract texts separated by the commas.

Ex: If the input of the program is:

```
movies.csv
```

and the contents of movies.csv are:


```
16:40,Wonders of the World,G
20:00,Wonders of the World,G
19:00,Journey to Space ,PG-13
12:45,Buffalo Bill And The Indians or Sitting Bull's History Lesson,PG
15:00,Buffalo Bill And The Indians or Sitting Bull's History Lesson,PG
19:30,Buffalo Bill And The Indians or Sitting Bull's History Lesson,PG
10:00,Adventures of Lewis and Clark,PG-13
14:30,Adventures of Lewis and Clark,PG-13
19:00,Halloween,R
```

the output of the program is:

```
Wonders of the World                          |     G | 16:40 20:00
Journey to Space                              | PG-13 | 19:00
Buffalo Bill And The Indians or Sitting Bull  |    PG | 12:45 15:00 19:30
Adventures of Lewis and Clark                 | PG-13 | 10:00 14:30
Halloween                                     |     R | 19:00
```

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LAB ACTIVITY | 9.15.1: LAB: Movie show time display | 0 / 10

Downloadable files

movies.csv Download

main.cpp Load default template...

```
1  #include <iostream>
2  #include <cstring>
3  #include <iomanip>
4  #include <fstream>
5  using namespace std;
6
7  int main() {
8
9     /* Type your code here. */
10
11    return 0;
12 }
13
```

Develop mode | Submit mode

Run your program as often as you'd like, before submitting for grading. Below, type any needed input values in the first box, then click **Run program** and observe the program's output in the second box.

Enter program input (optional)

If your code requires input values, provide them here.

Run program

Input (from above) → main.cpp (Your program) → Output (shown below)

Program output displayed here

Coding trail of your work What is this?

```
History of your effort will appear here once you begin working
on this zyLab.
```


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