Lab7 - C++ Stream Input/Output

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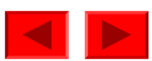

Lab7 - C++ Stream Input/Output

Outline

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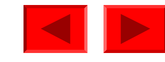

7.1 Introduction

- Overview common I/O features
- C++ I/O
  - Object oriented
    - References, function overloading, operator overloading
  - Type safe
    - I/O sensitive to data type
    - Error if types do not match
  - User-defined and standard types
    - Makes C++ extensible

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7.2 Streams

- Stream: sequence of bytes
  - Input: from device (keyboard, disk drive) to memory
  - Output: from memory to device (monitor, printer, etc.)
- I/O operations often bottleneck
  - Wait for disk drive/keyboard input
  - Low-level I/O
    - Unformatted (not convenient for people)
    - Byte-by-byte transfer
    - High-speed, high-volume transfers
  - High-level I/O
    - Formatted
    - Bytes grouped (into integers, characters, strings, etc.)
    - Good for most I/O needs

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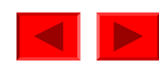

7.2.1 Classic Streams vs. Standard Streams

- Classic streams
  - Input/output **`char`**s (one byte)
  - Limited number of characters (ASCII)
- Standard stream libraries
  - Some languages need special alphabets
  - Unicode character set supports this
    - **`wchar_t`** character type
  - Can do I/O with Unicode characters

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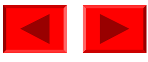

7.2.2 iostream Library Header Files

- **`iostream`** library
  - Has header files with hundreds of I/O capabilities
  - **`<iostream.h>`**
    - Standard input (**`cin`**)
    - Standard output (**`cout`**)
    - Unbuffered error (**`cerr`**)
    - Buffered error (**`clog`**)
  - **`<iomanip.h>`**
    - Formatted I/O with parameterized stream manipulators
  - **`<fstream.h>`**
    - File processing operations

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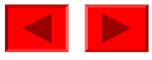

7.2.3 Stream Input/Output Classes and Objects

- **iostream** library has class templates for I/O
  - **basic_istream** (stream input)
  - **basic_ostream** (stream output)
  - **basic_iostream** (stream input and output)
- **typedef** declares alias for data type
  - **typedef Card *CardPtr;**
    - **CardPtr** synonym for **Card ***
  - **typedef**s **istream**, **ostream**, **iostream**
    - Allow **char** I/O
    - Use these **typedef**s in chapter

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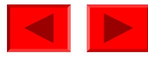
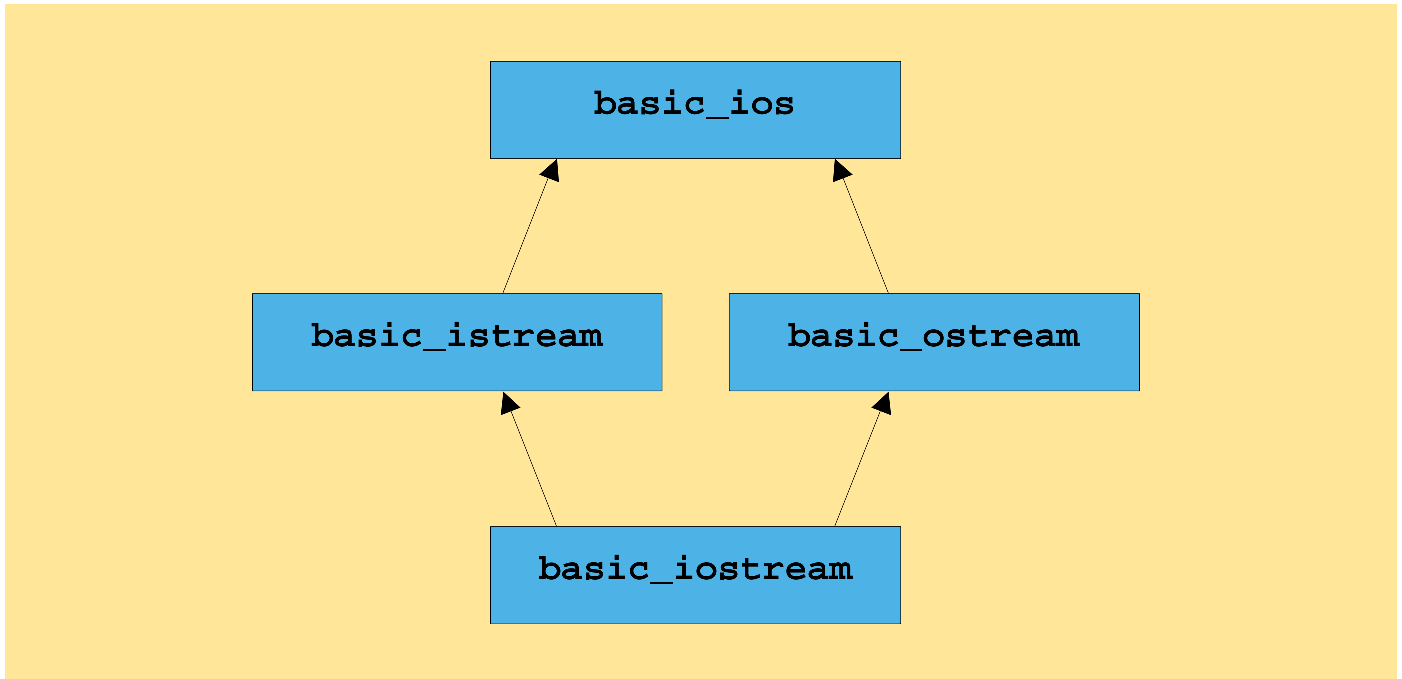


7.2.3 Stream Input/Output Classes and Objects

- Templates "derive" from **basic_ios**



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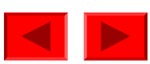

7.2.3 Stream Input/Output Classes and Objects

- `<<` and `>>`
  - Stream insertion and extraction operators
- `cin`
  - `istream` object
  - Connected to standard input (usually keyboard)
  - `cin >> grade;`
    - Compiler determines data type of grade
    - Calls proper overloaded operator
    - No extra type information needed

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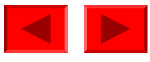

7.2.3 Stream Input/Output Classes and Objects

- **`cout`**
  - **`ostream`** object
  - Standard output (usually display screen)
  - **`cin << grade;`**
    - As with **`cin`**, no type information needed
- **`cerr`**, **`clog`**
  - **`ostream`** objects
  - Connected to standard error device
  - **`cerr`** outputs immediately
  - **`clog`** buffers output
    - Outputs when buffer full or flushed
    - Performance advantage (discussed in OS classes)

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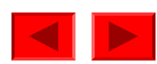

7.2.3 Stream Input/Output Classes and Objects

- C++ file processing similar
  - Class templates
    - **basic_ifstream** (file input)
    - **basic_ofstream** (file output)
    - **basic_fstream** (file I/O)
  - Specializations allow for **char** I/O
    - **typedef**s aliases for specializations
    - **ifstream**
    - **ofstream**
    - **fstream**

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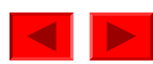
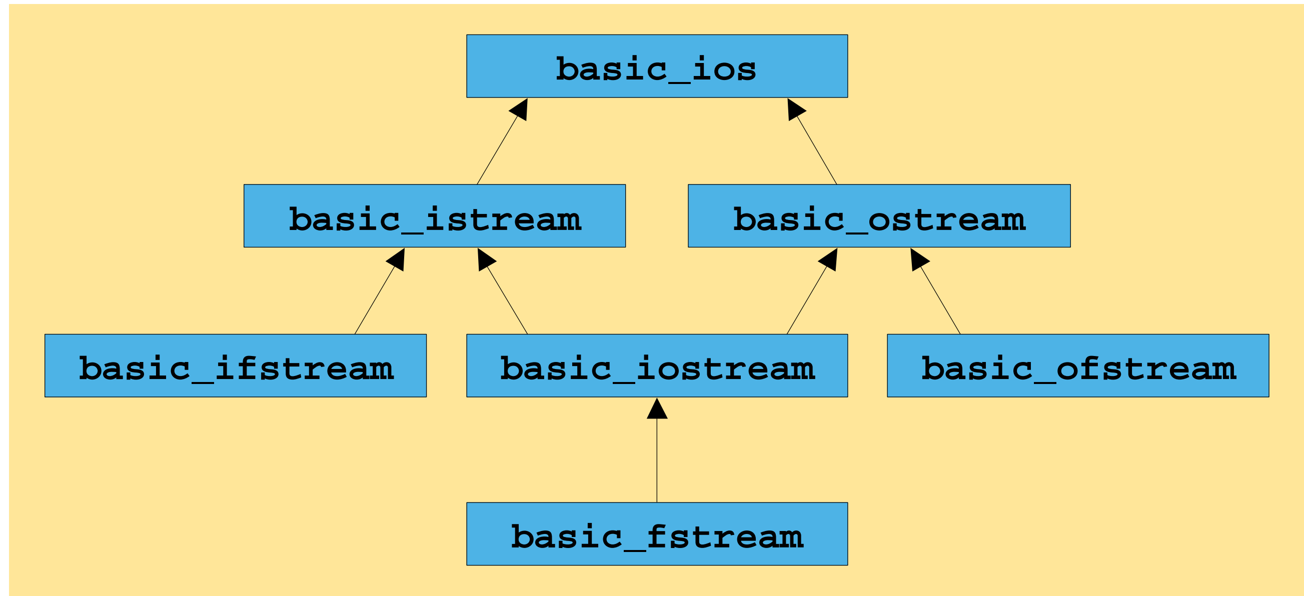


7.2.3 Stream Input/Output Classes and Objects

- Template hierarchy



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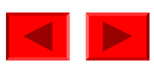

7.3 Stream Output

- Output
  - Use **`ostream`**
  - Formatted and unformatted
  - Standard data types (**`<<`**)
  - Characters (**`put`** function)
  - Integers (decimal, octal, hexadecimal)
  - Floating point numbers
    - Various precision, forced decimal points, scientific notation
  - Justified, padded data
  - Uppercase/lowercase control

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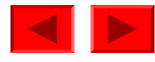

7.3.1 Output of char * Variables

- C++ determines data type automatically
  - Generally an improvement (over C)
  - Try to print value of a **`char *`**
    - Memory address of first character
- Problem
  - << overloaded to print null-terminated string
  - Solution: cast to **`void *`**
    - Use whenever printing value of a pointer
    - Prints as a hex (base 16) number

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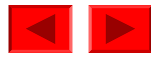

Outline

fig7_03.cpp (1 of 1)

fig7_03.cpp output (1 of 1)

```
1  // Fig. 7.3: fig7_03.cpp
2  // Printing the address stored in a char * variable.
3  #include <iostream>
4
5  using std::cout;
6  using std::endl;
7
8  int main()
9  {
10    char *word = "test";
11
12    // display value of char *, then display value of char
13    // static_cast to void *
14    cout << "Value of word is: " << word << endl
15         << "Value of static_cast< void * >( word ) is: "
16         << static_cast< void * >( word ) << endl;
17
18    return 0;
19
20 } // end main
```

To print the value of the pointer, we must cast to a **void ***. Otherwise, the string is printed.

```
Value of word is: test
Value of static_cast< void *>( word ) is: 0046C070
```

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7.3.2 Character Output using Member Function put

- **`put`** function
  - Outputs characters
    - **`cout.put( 'A' );`**
  - May be cascaded
    - **`cout.put( 'A' ).put( '\n' );`**
    - Dot operator (**`.`**) evaluates left-to-right
  - Can use numerical (ASCII) value
    - **`cout.put( 65 );`**
    - Prints **`'A'`**

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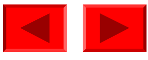

7.4 Stream Input

- Formatted and unformatted input
  - **`istream`**
- **`>>`** operator
  - Normally skips whitespace (blanks, tabs, newlines)
    - Can change this
  - Returns **`0`** when EOF encountered
    - Otherwise, returns reference to object
    - **`cin >> grade`**
  - State bits set if errors occur
    - Discussed in 7.7 and 7.8

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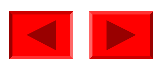

7.4.1 get and getline Member Functions

- **`get`** function
  - **`cin.get()`**
  - Returns one character from stream (even whitespace)
    - Returns **`EOF`** if end-of-file encountered
- End-of-file
  - Indicates end of input
    - *ctrl-z* on IBM-PCs
    - *ctrl-d* on UNIX and Macs
  - **`cin.eof()`**
    - Returns **`1`** (**`true`**) if EOF has occurred

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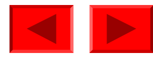

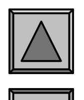

Outline

fig7_04.cpp (1 of 2)

```
1  // Fig. 7.4: fig7_04.cpp
2  // Using member functions get, put and eof.
3  #include <iostream>
4
5  using std::cout;
6  using std::cin;
7  using std::endl;
8
9  int main()
10 {
11    int character; // use int, because char cannot represent EOF
12
13    // prompt user to enter line of text
14    cout << "Before input, cin.eof() is "
15         << "Enter a sentence followed by
16
17    // use get to read each character; us
18    while ( ( character = cin.get() ) !=
19       cout.put( character );
20
21    // display end-of-file character
22    cout << "\nEOF in this system is: " << character << endl;
23    cout << "After input, cin.eof() is " << cin.eof() << endl;
24
25    return 0;
```

Function **get** (with no arguments) returns a single character input, unless **EOF** encountered.

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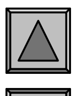
```
26
27 } // end main
```

```
Before input, cin.eof() is 0
Enter a sentence followed by end-of-file:
Testing the get and put member functions
Testing the get and put member functions
^Z

EOF in this system is: -1
After input cin.eof() is 1
```



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7.4.1 get and getline Member Functions

- **`get(charRef)`**
  - With character reference argument
  - Gets one character, stores in **`charRef`**
    - Returns reference to **`istream`**
    - If EOF, returns **`-1`**
- **`get(charArray, size, delimiter)`**
  - Reads until **`size-1`** characters read, or delimiter encountered
    - Default delimiter **`'\n'`**
    - Delimiter stays in input stream
      - Can remove with **`cin.get()`** or **`cin.ignore()`**
  - Makes array null-terminated

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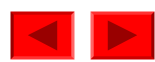

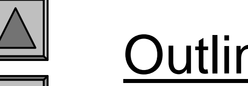

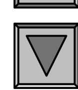


```
1  // Fig. 7.5: fig7_05.cpp
2  // Contrasting input of a string via cin and cin.get.
3  #include <iostream>
4
5  using std::cout;
6  using std::cin;
7  using std::endl;
8
9  int main()
10 {
11    // create two char arrays, each with 80 elements
12    const int SIZE = 80;
13    char buffer1[ SIZE ];
14    char buffer2[ SIZE ];
15
16    // use cin to input characters
17    cout << "Enter a sentence:" << endl;
18    cin >> buffer1;
19
20    // display buffer1 contents
21    cout << "\nThe string read with cin was
22         << buffer1 << endl << endl;
23
24    // use cin.get to input characters into buffer2
25    cin.get( buffer2, SIZE );
```

`cin` will only read until the first whitespace.

No delimiter specified, so the default (**`\n`**) is used.

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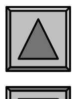

Outline

```
26
27    // display buffer2 contents
28    cout << "The string read with cin.get was:" << endl
29         << buffer2 << endl;
30
31    return 0;
32
33 } // end main
```

```
Enter a sentence:
Contrasting string input with cin and cin.get


The string read with cin was:
Contrasting


The string read with cin.get was:
 string input with cin and cin.get
```

fig7_05.cpp (2 of 2)

fig7_05.cpp output (1 of 1)

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7.4.1 get and getline Member Functions

- **`getline(array, size, delimiter)`**
  - Like last version of get
  - Reads **`size-1`** characters, or until delimiter found
    - Default **`\n`**
  - Removes delimiter from input stream
  - Puts null character at end of array

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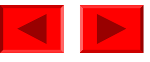

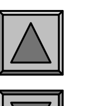

Outline

fig7_06.cpp
(1 of 1)

```
1  // Fig. 7.6: fig7_06.cpp
2  // Inputting characters using cin member function getline.
3  #include <iostream>
4
5  using std::cout;
6  using std::cin;
7  using std::endl;
8
9  int main()
10 {
11    const int SIZE = 80;
12    char buffer[ SIZE ]; // create array of 80 characters
13
14    // input characters in buffer via cin function getline
15    cout << "Enter a sentence:" << endl;
16    cin.getline( buffer, SIZE );
17
18    // display buffer contents
19    cout << "\nThe sentence entered is:" << endl << buffer << endl;
20
21    return 0;
22
23 } // end main
```

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```
Enter a sentence:
Using the getline member function

The sentence entered is:
Using the getline member function
```

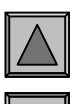

fig7_06.cpp
output (1 of 1)

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7.4.2 istream Member Functions peek, putback and ignore

- **`ignore()`**
  - Discards characters from stream (default 1)
  - Stops discarding once delimiter found
    - Default delimiter **`EOF`**
- **`putback()`**
  - Puts character obtained by **`get()`** back on stream
- **`peek()`**
  - Returns next character in stream, but does not remove

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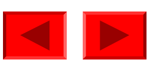

7.4.3 Type-Safe I/O

- **<<** and **>>**
  - Overloaded to accept data of specific types
- If unexpected data processed
  - Error bits set
  - User can test bits to see if I/O failed
    - More in section 7.8

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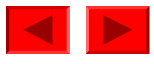

7.5 Unformatted I/O using read, write and gcount

- Unformatted I/O
  - **`read`** (member of **`istream`**)
    - Input raw bytes into character array
    - If not enough characters read, **`failbit`** set
    - **`gcount()`** returns number of characters read by last operation
  - **`write`** (**`ostream`**)
    - Output bytes from character array
      - Stops when null character found

```
char buffer[] = "HAPPY BIRTHDAY";
cout.write( buffer, 10 );
```

  - Outputs first 10 characters

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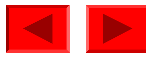

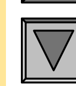

fig7_07.cpp
(1 of 1)

```
1  // Fig. 7.7: fig7_07.cpp
2  // Unformatted I/O using read, gcount and write.
3  #include <iostream>
4
5  using std::cout;
6  using std::cin;
7  using std::endl;
8
9  int main()
10 {
11    const int SIZE = 80;
12    char buffer[ SIZE ]; // create array of 80 characters
13
14    // use function read to input characters into buffer
15    cout << "Enter a sentence:" << endl;
16    cin.read( buffer, 20 );
17
18    // use functions write and gcount to display buffer characters
19    cout << endl << "The sentence entered was:" << endl;
20    cout.write( buffer, cin.gcount() );
21    cout << endl;
22
23    return 0;
24
25 } // end main
```

Get 20 characters from input stream. Display the proper number of characters using **`write`** and **`gcount`**.

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```
Enter a sentence:
Using the read, write, and gcount member functions
The sentence entered was:
Using the read, writ
```


fig7_07.cpp
output (1 of 1)

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7.6 Introduction to Stream Manipulators

- Stream manipulators perform formatting tasks
  - Field widths
  - Precisions
  - Format flags
  - Fill character in fields
  - Flushing streams
  - Inserting newline in output stream
  - Skipping whitespace in input stream

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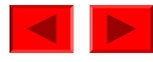

7.6.1 Integral Stream Base: dec, oct, hex and setbase

- Integers normally base 10 (decimal)
  - Stream manipulators to change base
    - **`hex`** (base 16)
    - **`oct`** (base 8)
    - **`dec`** (resets to base 10)
    - **`cout << hex << myInteger`**
  - **`setbase(newBase)`**
    - One of 8, 10, or 16
  - Base remains same until explicitly changed
- Parameterized stream manipulators
  - Use header **`<iomanip>`**
  - Take argument (like **`setbase`**)

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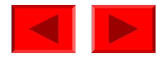

Outline

fig7_08.cpp
(1 of 2)

```
1  // Fig. 7.8: fig7_08.cpp
2  // Using stream manipulators hex, oct, dec and setbase.
3  #include <iostream>
4
5  using std::cout;
6  using std::cin;
7  using std::endl;
8  using std::hex;
9  using std::dec;
10 using std::oct;
11
12 #include <iomanip>
13
14 using std::setbase;
15
16 int main()
17 {
18    int number;
19
20    cout << "Enter a decimal number: ";
21    cin >> number; // input number
22
23    // use hex stream manipulator to show hexadecimal number
24    cout << number << " in hexadecimal is: " << hex
25         << number << endl;
```

Note usage of stream manipulator.

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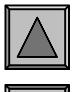

Outline

fig7_08.cpp (2 of 2)

fig7_08.cpp output (1 of 1)

```
26
27    // use oct stream manipulator to show octal number
28    cout << dec << number << " in octal is: "
29         << oct << number << endl;
30
31    // use setbase stream manipulator to show decimal number
32    cout << setbase( 10 ) << number << " in decimal is: "
33         << number << endl;
34
35    return 0;
36
37 } // end main
```

```
Enter a decimal number: 20
20 in hexadecimal is: 14
20 in octal is: 24
20 in decimal is: 20
```

`setbase` is a parameterized stream manipulator (it takes an argument).

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7.6.2 Floating-Point Precision (precision, setprecision)

- Set precision of floating point numbers
  - Number of digits to right of decimal
  - **`setprecision`** stream manipulator
    - Pass number of decimal points
    - **`cout << setprecision(5)`**
  - **`precision`** member function
    - **`cout.precision(newPrecision)`**
    - With no arguments, returns current precision
  - Settings remain until changed explicitly

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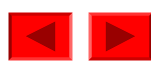

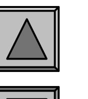

Outline

fig7_09.cpp
(1 of 2)

```
1   // Fig. 7.9: fig7_09.cpp
2   // Controlling precision of floating-point values.
3   #include <iostream>
4
5   using std::cout;
6   using std::cin;
7   using std::endl;
8   using std::fixed;
9
10  #include <iomanip>
11
12  using std::setprecision;
13
14  #include <cmath>  // sqrt prototype
15
16  int main()
17  {
18     double root2 = sqrt( 2.0 ); // calculate square root of 2
19     int places;
20
21     cout << "Square root of 2 with
22          << "Precision set by ios_
23          << "precision:" << endl;
24
25     cout << fixed; // use fixed precision
```

Use fixed precision, not scientific notation (more details in 12.7).

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Outline

fig07_09.cpp

```
26
27    // display square root using ios_base function precision
28    for ( places = 0; places <= 9; places++ ) {
29       cout.precision( places );
30       cout << root2 << endl;
31    }
32
33    cout << "\nPrecision set by stream-manipulator "
34         << "setprecision:" << endl;
35
36    // set precision for each digit, then display square root
37    for ( places = 0; places <= 9; places++ )
38       cout << setprecision( places ) << root2 << endl;
39
40    return 0;
41
42 } // end main
```

Note format of function **`precision`** and parameterized stream manipulator **`setprecision`**.

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fig7_09.cpp
output (1 of 1)

```
Square root of 2 with precisions 0-9.
Precision set by ios_base member-function precision:
1
1.4
1.41
1.414
1.4142
1.41421
1.414214
1.4142136
1.41421356
1.414213562

Precision set by stream-manipulator setprecision:
1
1.4
1.41
1.414
1.4142
1.41421
1.414214
1.4142136
1.41421356
1.414213562
```

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7.6.3 Field Width (width, setw)

- `width` member function (base class `ios_base`)
  - `cin.width(5)`
  - Sets field width
    - Number of character positions for output
    - Maximum number of characters that should be input
  - Returns previous width
  - Fill characters/Padding
    - Used when output too small for width
    - Large outputs are printed (not truncated)
  - Can also use `setw` stream manipulator
- When reading to `char` arrays
  - Reads 1 less character (leave room for null)

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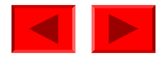

Outline

fig7_10.cpp
(1 of 2)

```
1   // Fig. 7.10: fig7_10.cpp
2   // Demonstrating member function width.
3   #include <iostream>
4
5   using std::cout;
6   using std::cin;
7   using std::endl;
8
9   int main()
10  {
11     int widthValue = 4;
12     char sentence[ 10 ];
13
14     cout << "Enter a sentence:" <<
15     cin.width( 5 ); // input only 5
16
17     // set field width, then display characters based on that width
18     while ( cin >> sentence ) {
19        cout.width( widthValue++ );
20        cout << sentence << endl;
21        cin.width( 5 ); // input 5 more characters from sentence
22     } // end while
23
24     return 0;
```

Reads up to 4 characters, stops when whitespace read.

Increment the output width.

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```
25
26  } // end main
```

```
Enter a sentence:
This is a test of the width member function
This
   is
     a
   test
      of
      the
      widt
          h
        memb
           er
          func
           tion
```

fig7_10.cpp (2 of 2)

fig7_10.cpp output (1 of 1)

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7.6.4 Programmer-Defined Manipulators

- User-defined stream manipulators
  - Nonparameterized
  - Example

```
ostream& bell( ostream& output )
{
  return output << '\a';  // issue system beep
}
```

  - `\a` - bell
  - `\r` - carriage return
  - `\t` - tab

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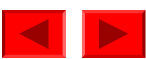

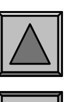

Outline

```
1  // Fig. 7.11: fig7_11.cpp
2  // Creating and testing programmer-defined, nonparameterized
3  // stream manipulators.
4  #include <iostream>
5
6  using std::ostream;
7  using std::cout;
8  using std::flush;
9
10 // bell manipulator (using escape sequence \a)
11 ostream& bell( ostream& output )
12 {
13    return output << '\a';  // issue system beep
14 }
15
16 // carriageReturn manipulator (using escape sequence \r)
17 ostream& carriageReturn( ostream& output )
18 {
19    return output << '\r';  // issue carriage return
20 }
21
```

fig7_11.cpp
(1 of 3)

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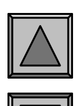

fig7_11.cpp
(2 of 3)

```
22 // tab manipulator (using escape sequence \t)
23 ostream& tab( ostream& output )
24 {
25    return output << '\t';  // issue tab
26 }
27
28 // endLine manipulator (using escape sequence \n and member
29 // function flush)
30 ostream& endLine( ostream& output )
31 {
32    return output << '\n' << flush;  // issue end of line
33 }
34
35 int main()
36 {
37    // use tab and endLine manipulators
38    cout << "Testing the tab manipulator:" << endLine
39         << 'a' << tab << 'b' << tab << 'c' << endLine;
40
41    cout << "Testing the carriageReturn and bell manipulators:"
42         << endLine << "..........";
43
44    cout << bell; // use bell manipulator
45
```

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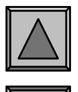


```
46     // use carriageReturn and endLine manipulators
47     cout << carriageReturn << "-----" << endLine;
48
49     return 0;
50
51  } // end main
```

```
Testing the tab manipulator:
a       b       c
Testing the carriageReturn and bell manipulators:
-----.....
```

fig7_11.cpp (3 of 3)

fig7_11.cpp output (1 of 1)

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7.7 Stream Format States and Stream Manipulators

- Many stream manipulators for formatting
  - Coming up next
  - All inherit from **`ios_base`**

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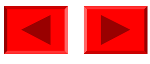

7.7.1 Trailing Zeros and Decimal Points (showpoint)

- **`showpoint`**
  - Forces decimal number to print with trailing zeros
  - For decimal number 79.0
    - 79 without **`showpoint`**
    - 79.000000 with **`showpoint`** (up to level of precision)
  - Reset with **`noshowpoint`**

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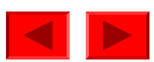

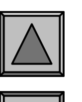

Outline

```
1  // Fig. 7.13: fig7_13.cpp
2  // Using showpoint to control the printing of
3  // trailing zeros and decimal points for doubles.
4  #include <iostream>
5
6  using std::cout;
7  using std::endl;
8  using std::showpoint;
9
10 int main()
11 {
12    // display double values with default stream format
13    cout << "Before using showpoint" << endl
14         << "9.9900 prints as: " << 9.9900 << endl
15         << "9.9000 prints as: " << 9.9000 << endl
16         << "9.0000 prints as: " << 9.0000 << endl << endl;
17
18    // display double value after showpoint
19    cout << showpoint
20         << "After using showpoint" << endl
21         << "9.9900 prints as: " << 9.9900 << endl
22         << "9.9000 prints as: " << 9.9000 << endl
23         << "9.0000 prints as: " << 9.0000 << endl;
24
25    return 0;
```

fig7_13.cpp
(1 of 2)

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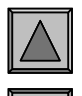


```
26
27  } // end main
```

```
Before using showpoint
9.9900 prints as: 9.99
9.9000 prints as: 9.9
9.0000 prints as: 9

After using showpoint
9.9900 prints as: 9.99000
9.9000 prints as: 9.90000
9.0000 prints as: 9.00000
```

Without **`showpoint`**, trailing zeros are removed.

fig7_13.cpp (2 of 2)

fig7_13.cpp output (1 of 1)

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7.7.2 Justification (left, right and internal)

- **`left`** stream manipulator
  - Left-justified, padding to right
  - **`Right`** stream manipulator
    - Right-justified, padding to left
  - Can set padding/fill character
    - Next section
- **`internal`**
  - Number's sign left-justified
  - Number's value right-justified

    `+          123`
  - **`showpos`** forces sign to print
    - Remove with **`noshowpos`**

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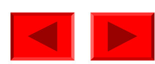

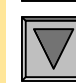

Outline

fig7_14.cpp
(1 of 2)

```
1   // Fig. 7.14: fig7_14.cpp
2   // Demonstrating left justification and right justification.
3   #include <iostream>
4
5   using std::cout;
6   using std::endl;
7   using std::left;
8   using std::right;
9
10  #include <iomanip>
11
12  using std::setw;
13
14  int main()
15  {
16     int x = 12345;
17
18     // display x right justified (default)
19     cout << "Default is right justified:" << endl
20          << setw( 10 ) << x;
21
22     // use left manipulator to display x left justified
23     cout << "\n\nUse std::left to left justify x:\n"
24          << left << setw( 10 ) << x;
25
```

Right- and left-justify **x** (within a width of 10).

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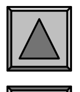

Outline

```
26     // use right manipulator to display x right justified
27     cout << "\n\nUse std::right to right justify x:\n"
28          << right << setw( 10 ) << x << endl;
29
30     return 0;
31
32  } // end main
```

```
Default is right justified:
     12345

Use std::left to left justify x:
12345

Use std::right to right justify x:
     12345
```

fig7_14.cpp (2 of 2)

fig7_14.cpp output (1 of 1)

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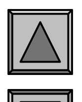

Outline

```
1   // Fig. 7.15: fig7_15.cpp
2   // Printing an integer with internal spacing and plus sign.
3   #include <iostream>
4
5   using std::cout;
6   using std::endl;
7   using std::internal;
8   using std::showpos;
9
10  #include <iomanip>
11
12  using std::setw;
13
14  int main()
15  {
16     // display value with internal spacing and plus sign
17     cout << internal << showpos << setw( 10 ) << 123 << endl;
18
19     return 0;
20
21  } // end main
```

Note use of **`internal`** and **`showpos`**.

```
+      123
```

fig7_15.cpp (1 of 1)

fig7_15.cpp output (1 of 1)

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7.7.3 Padding (fill, setfill)

- Set fill character used in padding
  - **`fill`** member function
    - **`cout.fill('*')`**
  - **`setfill`** stream manipulator
    - **`setfill( '^' )`**

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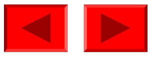

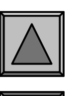

Outline

```
1  // Fig. 7.16: fig7_16.cpp
2  // Using member-function fill and stream-manipulator setfill
3  // to change the padding character for fields larger the
4  // printed value.
5  #include <iostream>
6
7  using std::cout;
8  using std::endl;
9  using std::showbase;
10 using std::left;
11 using std::right;
12 using std::internal;
13 using std::hex;
14 using std::dec;
15
16 #include <iomanip>
17
18 using std::setw;
19 using std::setfill;
20
```

fig7_16.cpp (1 of 3)

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```
21 int main()
22 {
23    int x = 10000;
24
25    // display x
26    cout << x << " printed as int right and left justified\n"
27         << "and as hex with internal justification.\n"
28         << "Using the default pad character (space):" << endl;
29
30    // display x with plus sign
31    cout << showbase << setw( 10 ) << x << endl;
32
33    // display x with left justification
34    cout << left << setw( 10 ) << x << endl;
35
36    // display x as hex with internal justification
37    cout << internal << setw( 10 ) << hex << x << endl << endl;
38
39    cout << "Using various padding c
40
41    // display x using padded charac
42    cout << right;
43    cout.fill( '*' );
44    cout << setw( 10 ) << dec << x << endl;
45
```

Note use of member function **fill**.

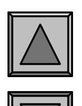

fig7_16.cpp
(2 of 3)

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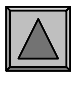

Outline

```
46     // display x using padded characters (left justification)
47     cout << left << setw( 10 ) << setfill( '%' ) << x << endl;
48
49     // display x using padded characters (internal justification)
50     cout << internal << setw( 10 ) << setfill( '^' ) << hex
51          << x << endl;
52
53     return 0;
54
55  } // end main
```

```
10000 printed as int right and left justified
and as hex with internal justification.
Using the default pad character (space):
     10000
10000
0x    2710

Using various padding characters:
*****10000
10000%%%%%
0x^^^^2710
```

fig7_16.cpp (3 of 3)

fig7_16.cpp output (1 of 1)

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7.7.4 Integral Stream Base (dec, oct, hex, showbase)

- Print integer in various bases
  - **dec**, **oct**, **hex**
- Stream extraction
  - Decimal numbers default
  - Preceding **0** for octal
  - Preceding **0x** or **0X** for hex
- **showbase**
  - Forces base of number to be shown
  - Remove with **noshowbase**

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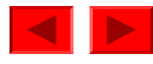

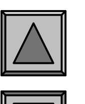


```
1  // Fig. 7.17: fig7_17.cpp
2  // Using stream-manipulator showbase.
3  #include <iostream>
4
5  using std::cout;
6  using std::endl;
7  using std::showbase;
8  using std::oct;
9  using std::hex;
10
11 int main()
12 {
13    int x = 100;
14
15    // use showbase to show numbe
16    cout << "Printing integers pr                                l
17         << showbase;
18
19    cout << x << endl;        // print decimal value
20    cout << oct << x << endl; // print octal value
21    cout << hex << x << endl; // print hexadecimal value
22
23    return 0;
24
25 } // end main
```

Forces numbers to be printed with a preceding **0** (if octal) or **0x** (if hexadecimal).

fig7_17.cpp
(1 of 1)

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```
Printing integers preceded by their base:
100
0144
0x64
```

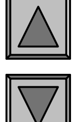

fig7_17.cpp
output (1 of 1)

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7.7.5 Floating-Point Numbers; Scientific and Fixed Notation (scientific, fixed)

- Stream manipulator **`scientific`**
  - Forces scientific notation
    - **`1.946000e+009`**
- Stream manipulator **`fixed`**
  - Forces fixed point format
  - Prints number of decimals specified by precision
    - **`1946000000.000000`**
- If no manipulator specified
  - Format of number determines how it appears

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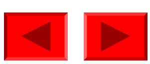

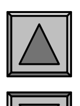

Outline

```
1  // Fig. 7.18: fig7_18.cpp
2  // Displaying floating-point values in system default,
3  // scientific and fixed formats.
4  #include <iostream>
5
6  using std::cout;
7  using std::endl;
8  using std::scientific;
9  using std::fixed;
10
11 int main()
12 {
13    double x = 0.001234567;
14    double y = 1.946e9;
15
16    // display x and y in default format
17    cout << "Displayed in default format:" << endl
18         << x << '\t' << y << endl;
19
20    // display x and y in scientific format
21    cout << "\nDisplayed in scientific format:" << endl
22         << scientific << x << '\t' << y << endl;
23
```

Note differing initializations, and use of the **`scientific`** stream manipulator.

fig7_18.cpp (1 of 2)

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```
24     // display x and y in fixed format
25     cout << "\nDisplayed in fixed format:" << endl
26          << fixed << x << '\t' << y << endl;
27
28     return 0;
29
30  } // end main
```

```
Displayed in default format:
0.00123457      1.946e+009

Displayed in scientific format:
1.234567e-003   1.946000e+009

Displayed in fixed format:
0.001235        1946000000.000000
```

Note difference between the default, fixed, and scientific formats.

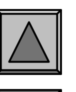

fig7_18.cpp (2 of 2)

fig7_18.cpp output (1 of 1)

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7.7.6 Uppercase/Lowercase Control (uppercase)

- Stream manipulator **`uppercase`**
  - Uppercase E in scientific notation
    - **`1E10`**
  - Uppercase X in hex notation and uppercase hex letters
    - **`0XABCD`**
  - By default, lowercase
  - Reset with **`nouppercase`**

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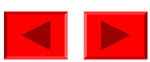

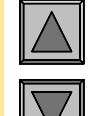

Outline

fig7_19.cpp
output (1 of 1)

```
1   // Fig. 7.19: fig7_19.cpp
2   // Stream-manipulator uppercase.
3   #include <iostream>
4
5   using std::cout;
6   using std::endl;
7   using std::uppercase;
8   using std::hex;
9
10  int main()
11  {
12     cout << "Printing uppercase letters in scientific" << endl
13          << "notation exponents and hexadecimal values:" << endl;
14
15     // use std:uppercase to display uppercase letters;
16     // use std::hex to display hexadecimal values
17     cout << uppercase << 4.345e10 << endl << hex << 123456789
18          << endl;
19
20     return 0;
21
22  } // end main
```

Force uppercase format.

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```
Printing uppercase letters in scientific
notation exponents and hexadecimal values:
4.345E+010
75BCD15
```

fig7_19.cpp
output (1 of 1)

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7.7.7 Specifying Boolean Format (boolalpha)

- Data type **bool**
  - Values **true** or **false**
  - Outputs **0** (**false**) or **1** (**true**) when used with **<<**
    - Displayed as integers
- Stream manipulator **boolalpha**
  - Display strings **"true"** and **"false"**
  - Reset with **noboolalpha**

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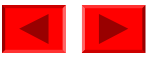

Outline

fig7_20.cpp
(1 of 2)

```
1  // Fig. 7.20: fig7_20.cpp
2  // Demonstrating stream-manipulators boolalpha and noboolalpha.
3  #include <iostream>
4
5  using std::cout;
6  using std::endl;
7  using std::cin;
8  using std::boolalpha;
9  using std::noboolalpha;
10
11 int main()
12 {
13    bool booleanValue = true;
14
15    // display default true booleanValue
16    cout << "booleanValue is " << booleanValue << endl;
17
18    // display booleanValue after using boolalpha
19    cout << "booleanValue (after using boolalpha) is "
20         << boolalpha << booleanValue << endl << endl;
21
22    cout << "switch booleanValue and use noboolalpha" << endl;
23    booleanValue = false; // change booleanValue
24    cout << noboolalpha << endl; // use noboolalpha
25
```

`bool` variables can be `false` or `true`. Note use of the `boolalpha` stream manipulator.

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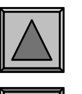

Outline

```
26     // display default false booleanValue after using noboolalpha
27     cout << "booleanValue is " << booleanValue << endl;
28
29     // display booleanValue after using boolalpha again
30     cout << "booleanValue (after using boolalpha) is "
31          << boolalpha << booleanValue << endl;
32
33     return 0;
34
35  } // end main
```

```
booleanValue is 1
booleanValue (after using boolalpha) is true

switch booleanValue and use noboolalpha

booleanValue is 0
booleanValue (after using boolalpha) is false
```

fig7_20.cpp (2 of 2)

fig7_20.cpp output (1 of 1)

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7.7.8 Setting and Resetting the Format State via Member-Function flags

- Can save/restore format states
  - After apply many changes, may want to restore original
- Member function **`flags`**
  - **`cout.flags()`**
  - With no argument
    - Returns current state as **`fmtflags`** object
      - Namespace **`ios_base`**
    - Represents format state
  - With **`fmtflags`** argument
    - Sets state
    - Returns previous state

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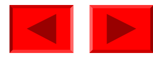

```
1  // Fig. 7.21: fig7_21.cpp
2  // Demonstrating the flags member function.
3  #include <iostream>
4
5  using std::cout;
6  using std::endl;
7  using std::oct;
8  using std::scientific;
9  using std::showbase;
10 using std::ios_base;
11
12 int main()
13 {
14    int integerValue = 1000;
15    double doubleValue = 0.0947628;
16
17    // display flags value, int and double values (original format)
18    cout << "The value of the flags variable is: " << cout.flags()
19         << "\nPrint int and double in original format:\n"
20         << integerValue << '\t' << doubleValue << endl << endl;
21
22    // use cout flags function to save original format
23    ios_base::fmtflags originalFormat = cout.flags();
24    cout << showbase << oct << scientific; // change format
25
```

Save original format using function **flags**.

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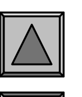

Outline

fig7_21.cpp
(2 of 2)

```
26     // display flags value, int and double values (new format)
27     cout << "The value of the flags variable is: " << cout.flags()
28          << "\nPrint int and double in a new format:\n"
29          << integerValue << '\t' << doubleValue << endl << endl;
30
31     cout.flags( originalFormat ); // restore format
32
33     // display flags value, int and double values (original format)
34     cout << "The restored value of the flags variable is: "
35          << cout.flags()
36          << "\nPrint values in original format again:\n"
37          << integerValue << '\t' << doubleValue << endl;
38
39     return 0;
40
41  } // end main
```

Restore original format.

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```
The value of the flags variable is: 513
Print int and double in original format:
1000    0.0947628

The value of the flags variable is: 012011
Print int and double in a new format:
01750   9.476280e-002

The restored value of the flags variable is: 513
Print values in original format again:
1000    0.0947628
```

fig7_21.cpp
output (1 of 1)

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7.8 Stream Error States

- Test state of stream using bits
  - **`eofbit`** set when EOF encountered
    - Function **`eof`** returns **`true`** if **`eofbit`** set
    - **`cin.eof()`**
  - **`failbit`** set when error occurs in stream
    - Data not lost, error recoverable
    - Function **`fail`** returns **`true`** if set
  - **`badbit`** set when data lost
    - Usually nonrecoverable
    - Function **`bad`**
  - **`goodbit`** set when **`badbit`**, **`failbit`** and **`eofbit`** off
    - Function **`good`**

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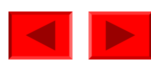

7.8 Stream Error States

- Member functions
  - **`rdstate()`**
    - Returns error state of stream
    - Can test for **`goodbit`**, **`badbit`**, etc.
    - Better to test using **`good()`**, **`bad()`**
  - **`clear()`**
    - Default argument **`goodbit`**
    - Sets stream to "good" state, so I/O can continue
    - Can pass other values
      - **`cin.clear( ios::failbit )`**
      - Sets **`failbit`**
      - Name "clear" seems strange, but correct

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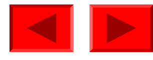

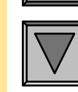

fig7_22.cpp
(1 of 2)

```
1  // Fig. 7.22: fig7_22.cpp
2  // Testing error states.
3  #include <iostream>
4
5  using std::cout;
6  using std::endl;
7  using std::cin;
8
9  int main()
10 {
11    int integerValue;
12
13    // display results of cin functions
14    cout << "Before a bad input operation:"
15         << "\ncin.rdstate(): " << cin.rdstate()
16         << "\n    cin.eof(): " << cin.eof()
17         << "\n   cin.fail(): " << cin.fail()
18         << "\n    cin.bad(): " << cin.bad()
19         << "\n   cin.good(): " << cin.good()
20         << "\n\nExpects an integer, but enter a character: ";
21
22    cin >> integerValue; // enter character value
23    cout << endl;
24
```

Output the original states using the member functions.

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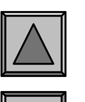

Outline

fig7_22.cpp (2 of 2)

```
25     // display results of cin functions after bad input
26     cout << "After a bad input operation:"
27          << "\ncin.rdstate(): " << cin.rdstate()
28          << "\n    cin.eof(): " << cin.eof()
29          << "\n   cin.fail(): " << cin.fail()
30          << "\n    cin.bad(): " << cin.bad()
31          << "\n   cin.good(): " << cin.good() << endl << endl;
32
33     cin.clear(); // clear stream
34
35     // display results of cin functions after clearing cin
36     cout << "After cin.clear()"
37          << "\ncin.fail(): " << cin.fail()
38          << "\ncin.good(): " << cin.good() << endl;
39
40     return 0;
41
42  } // end main
```

Note the use of **clear**.

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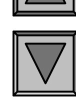
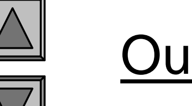


```
Before a bad input operation:
cin.rdstate(): 0
    cin.eof(): 0
   cin.fail(): 0
    cin.bad(): 0
   cin.good(): 1

Expects an integer, but enter a character: A

After a bad input operation:
cin.rdstate(): 2
    cin.eof(): 0
   cin.fail(): 1
    cin.bad(): 0
   cin.good(): 0

After cin.clear()
cin.fail(): 0
cin.good(): 1
```

fig7_22.cpp
output (1 of 1)

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7.9 Tying an Output Stream to an Input Stream

- Problem with buffered output
  - Interactive program (prompt user, he/she responds)
  - Prompt needs to appear before input proceeds
    - Buffered outputs only appear when buffer fills or flushed
- Member function **`tie`**
  - Synchronizes streams
  - Outputs appear before subsequent inputs
  - Automatically done for **`cin`** and **`cout`**, but could write
    - **`cin.tie( &cout )`**
  - Need to explicitly tie other I/O pairs
  - To untie
    - **`inputStream.tie( 0 )`**

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