Chapter 21 - C++ Stream Input/Output

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Chapter 21 - C++ Stream Input/Output

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Objectives

- In this chapter, you will learn:
  - To understand how to use C++ object-oriented stream input/output.
  - To be able to format inputs and outputs.
  - To understand the stream I/O class hierarchy.
  - To understand how to input/output objects of user-defined types.
  - To be able to create user-defined stream manipulators.
  - To be able to determine the success or failure of input/output operations.
  - To be able to tie output streams to input streams.

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21.1 Introduction

- Many C++ I/O features are object-oriented
  - Use references, function overloading and operator overloading
- C++ uses type safe I/O
  - Each I/O operation is automatically performed in a manner sensitive to the data type
- Extensibility
  - Users may specify I/O of user-defined types as well as standard types

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21.2 Streams

- Stream
  - A transfer of information in the form of a sequence of bytes
- I/O Operations:
  - Input: A stream that flows from an input device (i.e.: keyboard, disk drive, network connection) to main memory
  - Output: A stream that flows from main memory to an output device (i.e.: screen, printer, disk drive, network connection)

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21.2 Streams

- I/O operations are a bottleneck
  - The time for a stream to flow is many times larger than the time it takes the CPU to process the data in the stream
- Low-level I/O
  - Unformatted
  - Individual byte unit of interest
  - High speed, high volume, but inconvenient for people
- High-level I/O
  - Formatted
  - Bytes grouped into meaningful units: integers, characters, etc.
  - Good for all I/O except high-volume file processing

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21.2.1 Iostream Library Header Files

- `iostream` library:
  - `<iostream.h>`: Contains `cin`, `cout`, `cerr` and `clog` objects
  - `<iomanip.h>`: Contains *parameterized stream manipulators*

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21.2.2 Stream Input/Output Classes and Objects

- `ios`:
  - `istream` and `ostream` inherit from `ios`
    - `iostream` inherits from `istream` and `ostream`.
- `<<` (left-shift operator)
  - Overloaded as *stream insertion operator*
- `>>` (right-shift operator)
  - Overloaded as *stream extraction operator*
  - Both operators used with `cin`, `cout`, `cerr`, `clog`, and with user-defined stream objects

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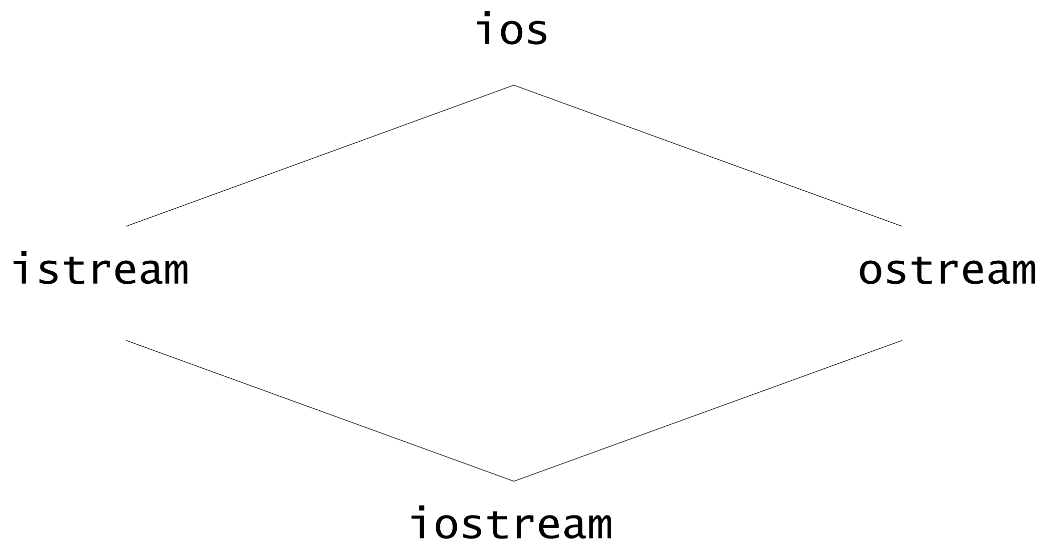
21.2.2 Stream Input/Output Classes and Objects

Figure 21.1 Portion of the stream I/O class hierarchy.



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21.2.2 Stream Input/Output Classes and Objects

- `istream`: input streams

  `cin >> grade;`

  - `cin` knows what type of data is to be assigned to `grade` (based on the type of `grade`).
- `ostream`: output streams
  - `cout << grade;`
    - **`cout`** knows the type of data to output
  - `cerr << errorMessage;`
    - Unbuffered - prints `errorMessage` immediately.
  - `clog << errorMessage;`
    - Buffered - prints `errorMessage` as soon as output buffer is full or flushed

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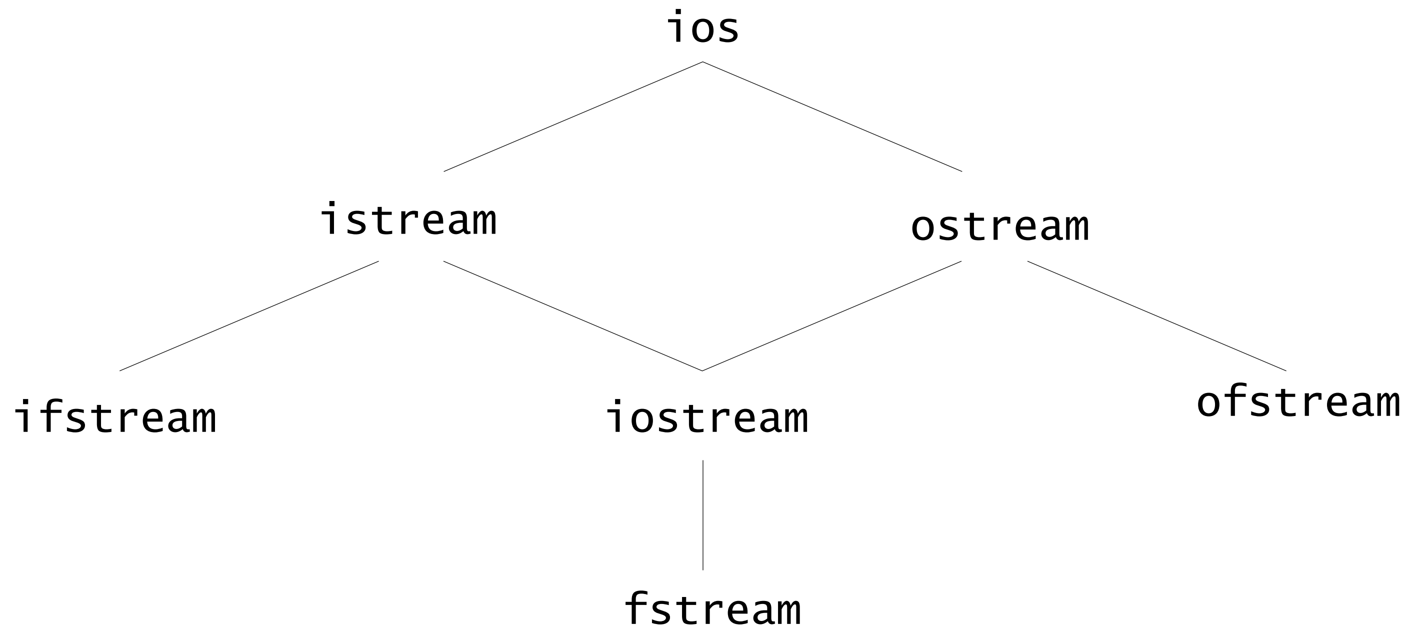
21.2.2 Stream Input/Output Classes and Objects

Figure 21.2 Portion of stream-I/O class hierarchy with key file-processing classes.



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21.3 Stream Output

- `ostream`: performs formatted and unformatted output
  - Uses `put` for characters and `write` for unformatted output
  - Output of integers in decimal, octal and hexadecimal
  - Varying precision for floating points
  - Formatted text outputs

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21.3.1 Stream-Insertion Operator

- `<<` is overloaded to output built-in types
  - Can also be used to output user-defined types
  - `cout << '\n';`
    - Prints newline character
  - `cout << endl;`
    - `endl` is a stream manipulator that issues a newline character and flushes the output buffer
  - `cout << flush;`
    - `flush` flushes the output buffer

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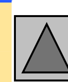
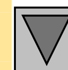

Outline

fig21_03.cpp

```
1  // Fig. 21.3: fig21_03.cpp
2  // Outputting a string using stream insertion.
3  #include <iostream>
4
5  using std::cout;
6
7  int main()
8  {
9     cout << "Welcome to C++!\n";
10
11     return 0;
12 } // end function main
```

Program Output

```
Welcome to C++!
```

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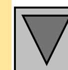

Outline

fig21_04.cpp

```
1  // Fig. 21.4: fig21_04.cpp
2  // Outputting a string using two stream insertions.
3  #include <iostream>
4
5  using std::cout;
6
7  int main()
8  {
9     cout << "Welcome to ";
10    cout << "C++!\n";
11
12    return 0;
13 } // end function main
```

Program Output

```
Welcome to C++!
```

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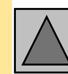
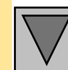

Outline

fig21_05.cpp

```
1  // Fig. 21.5: fig21_05.cpp
2  // Using the endl stream manipulator.
3  #include <iostream>
4
5  using std::cout;
6  using std::endl;
7
8  int main()
9  {
10    cout << "Welcome to ";
11    cout << "C++!";
12    cout << endl;   // end line stream manipulator
13
14    return 0;
15 } // end function main
```

Program Output

```
Welcome to C++!
```

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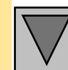

Outline

fig21_06.cpp

```
1  // Fig. 21.6: fig21_06.cpp
2  // Outputting expression values.
3  #include <iostream>
4
5  using std::cout;
6  using std::endl;
7
8  int main()
9  {
10    cout << "47 plus 53 is ";
11
12    // parentheses not needed; used for clarity
13    cout << ( 47 + 53 );       // expression
14    cout << endl;
15
16    return 0;
17 } // end function main
```

Program Output

```
47 plus 53 is 100
```

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21.3.2 Cascading Stream-Insertion/Extraction Operators

- `<<` : Associates from left to right, and returns a reference to its left-operand object (i.e. `cout`).
  - This enables cascading

```
cout << "How" << " are" << " you?";
```

Make sure to use parenthesis:

```
cout << "1 + 2 = " << (1 + 2);
```

NOT

```
cout << "1 + 2 = " << 1 + 2;
```

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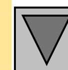
```
1  // Fig. 21.7: fig21_07.cpp
2  // Cascading the overloaded << operator.
3  #include <iostream>
4
5  using std::cout;
6  using std::endl;
7
8  int main()
9  {
10    cout << "47 plus 53 is " << ( 47 + 53 ) << endl;
11
12    return 0;
13 } // end function main
```



Outline

fig21_07.cpp

Program Output

```
47 plus 53 is 100
```

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21.3.3 Output of `char *` Variables

- << will output a variable of type `char *` as a string

- To output the address of the first character of that string, cast the variable as type `void *`

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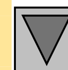

Outline

fig21_08.cpp

```
1  // Fig. 21.8: fig21_08.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    const char *string = "test";
11
12    cout << "Value of string is: " << string
13         << "\nValue of static_cast< void * >( string ) is: "
14         << static_cast< void * >( string ) << endl;
15    return 0;
16 } // end function main
```

Program Output

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

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21.3.4 Character Output with Member Function `put`; Cascading `put`s

- `put` member function
  - Outputs one character to specified stream

    `cout.put( 'A');`
  - Returns a reference to the object that called it, so may be cascaded

    `cout.put( 'A' ).put( '\n' );`
  - May be called with an ASCII-valued expression

    `cout.put( 65 );`
    - Outputs `A`

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21.4 Stream Input

- `>>` (stream-extraction)
  - Used to perform stream input
  - Normally ignores whitespaces (spaces, tabs, newlines)
  - Returns zero (`false`) when `EOF` is encountered, otherwise returns reference to the object from which it was invoked (i.e. `cin`)

- `>>` controls the state bits of the stream
  - `failbit` set if wrong type of data input
  - `badbit` set if the operation fails

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21.4.1 Stream-Extraction Operator

- `>>` and `<<` have relatively high precedence
  - Conditional and arithmetic expressions must be contained in parentheses

- Popular way to perform loops

```
while (cin >> grade)
```

  - Extraction returns `0` (`false`) when `EOF` encountered, and loop ends

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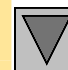
```
1 // Fig. 21.9: fig21_09.cpp
2 // Calculating the sum of two integers input from the keyboard
3 // with cin and the stream-extraction operator.
4 #include <iostream>
5
6 using std::cout;
7 using std::cin;
8 using std::endl;
9
10 int main()
11 {
12    int x, y;
13
14    cout << "Enter two integers: ";
15    cin >> x >> y;
16    cout << "Sum of " << x << " and " << y << " is: "
17         << ( x + y ) << endl;
18
19    return 0;
20 } // end function main
```

```
Enter two integers: 30 92
Sum of 30 and 92 is: 122
```



Outline

fig21_09.cpp

Program Output

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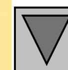

Outline

fig21_10.cpp

```
1 // Fig. 21.10: fig21_10.cpp
2 // Avoiding a precedence problem between the stream-insertion
3 // operator and the conditional operator.
4 // Need parentheses around the conditional expression.
5 #include <iostream>
6
7 using std::cout;
8 using std::cin;
9 using std::endl;
10
11 int main()
12 {
13    int x, y;
14
15    cout << "Enter two integers: ";
16    cin >> x >> y;
17    cout << x << ( x == y ? " is" : " is not" )
18         << " equal to " << y << endl;
19
20    return 0;
21 } // end function main
```

Program Output

```
Enter two integers: 7 5
7 is not equal to 5
```

```
Enter two integers: 8 8
8 is equal to 8
```

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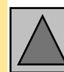
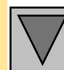

Outline

fig21_11.cpp

```
1  // Fig. 21.11: fig21_11.cpp
2  // Stream-extraction operator returning false on end-of-file.
3  #include <iostream>
4
5  using std::cout;
6  using std::cin;
7  using std::endl;
8
9  int main()
10 {
11    int grade, highestGrade = -1;
12
13    cout << "Enter grade (enter end-of-file to end): ";
14    while ( cin >> grade ) {
15       if ( grade > highestGrade )
16          highestGrade = grade;
17
18       cout << "Enter grade (enter end-of-file to end): ";
19    } // end while
20
21    cout << "\n\nHighest grade is: " << highestGrade << endl;
22    return 0;
23 } // end function main
```

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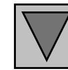
```
Enter grade (enter end-of-file to end): 67
Enter grade (enter end-of-file to end): 87
Enter grade (enter end-of-file to end): 73
Enter grade (enter end-of-file to end): 95
Enter grade (enter end-of-file to end): 34
Enter grade (enter end-of-file to end): 99
Enter grade (enter end-of-file to end): ^Z
Highest grade is: 99
```



Outline

Program Output

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21.4.2 `get` and `getline` Member Functions

- `cin.eof()`: returns `true` if end-of-file has occurred on `cin`
- `cin.get()`: inputs a character from stream (even white spaces) and returns it
- `cin.get( c )`: inputs a character from stream and stores it in `c`

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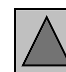
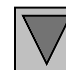
```
1  // Fig. 21.12: fig21_12.cpp
2  // Using member functions get, put and eof.
3  #include <iostream>
4
5  using std::cout;
6  using std::cin;
7  using std::endl;
8
9  int main()
10 {
11    char c;
12
13    cout << "Before input, cin.eof() is " << cin.eof()
14         << "\nEnter a sentence followed by end-of-file:\n";
15
16    while ( ( c = cin.get() ) != EOF )
17       cout.put( c );
18
19    cout << "\nEOF in this system is: " << c;
20    cout << "\nAfter input, cin.eof() is " << cin.eof() << endl;
21    return 0;
22 } // end function main
```





Outline

fig21_12.cpp

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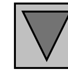
```
Before input, cin.eof() is 0
Enter a sentence followed by end-of-file:
Testing the get and put member functions
Testing the get and put member functions
^Z

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



Program Output

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21.4.2 `get` and `getline` Member Functions

- `cin.get(array, size)`:
  - Accepts 3 arguments: array of characters, the size limit, and a delimiter (default of `'\n'`).
  - Uses the array as a buffer
  - When the delimiter is encountered, it remains in the input stream
  - Null character is inserted in the array
  - Unless delimiter flushed from stream, it will stay there
- `cin.getline(array, size)`
  - Operates like `cin.get(buffer, size)` but it discards the delimiter from the stream and does not store it in array
  - Null character inserted into array

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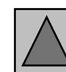
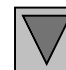

Outline

fig21_13.cpp

```
1  // Fig. 21.13: fig21_13.cpp
2  // Contrasting input of a string with 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    const int SIZE = 80;
12    char buffer1[ SIZE ], buffer2[ SIZE ];
13
14    cout << "Enter a sentence:\n";
15    cin >> buffer1;
16    cout << "\nThe string read with cin was:\n"
17         << buffer1 << "\n\n";
18
19    cin.get( buffer2, SIZE );
20    cout << "The string read with cin.get was:\n"
21         << buffer2 << endl;
22
23    return 0;
24 } // end function main
```

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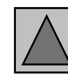
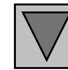
```
Enter a sentence:
Contrasting string input with cin and cin.get

The string read with cin was:
Contrasting

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

Program Output

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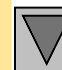

Outline

fig21_14.cpp

```
1  // Fig. 21.14: fig21_14.cpp
2  // Character input with 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 SIZE = 80;
12    char buffer[ SIZE ];
13
14    cout << "Enter a sentence:\n";
15    cin.getline( buffer, SIZE );
16
17    cout << "\nThe sentence entered is:\n" << buffer << endl;
18    return 0;
19 } // end function main
```

Program Output

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

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

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21.4.3 `istream` Member Functions `peek`, `putback` and `ignore`

- `ignore` member function
  - Skips over a designated number of characters (default of one)
  - Terminates upon encountering a designated delimiter (default is `EOF`, skips to the end of the file)
- `putback` member function
  - Places the previous character obtained by `get` back in to the stream.
- `peek`
  - Returns the next character from the stream without removing it

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21.4.4 Type-Safe I/O

- << and >> operators
  - Overloaded to accept data of different types
  - When unexpected data encountered, error flags set
  - Program stays in control

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21.5 Unformatted I/O with `read`, `gcount` and `write`

- `read` and `write` member functions
  - Unformatted I/O
  - Input/output raw bytes to or from a character array in memory
  - Since the data is unformatted, the functions will not terminate at a `newline` character for example
    - Instead, like `getline`, they continue to process a designated number of characters
  - If fewer than the designated number of characters are read, then the failbit is set
- `gcount`:
  - Returns the total number of characters read in the last input operation

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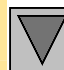

Outline

fig21_15.cpp

```
1  // Fig. 21.15: fig21_15.cpp
2  // Unformatted I/O with 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 ];
13
14    cout << "Enter a sentence:\n";
15    cin.read( buffer, 20 );
16    cout << "\nThe sentence entered was:\n";
17    cout.write( buffer, cin.gcount() );
18    cout << endl;
19    return 0;
20 } // end function main
```

Program Output

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

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21.6 Stream Manipulators

- Stream manipulator capabilities
  - Setting field widths
  - Setting precisions
  - Setting and unsetting format flags
  - Setting the fill character in fields
  - Flushing streams
  - Inserting a newline in the output stream and flushing the stream
  - Inserting a null character in the output stream and skipping whitespace in the input stream

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

- `oct`, `hex` or `dec`:
  - Change base of which integers are interpreted from the stream.

  Example:

  ```
  int n = 15;
   cout << hex << n;
  ```

  - Prints "`F`"
- `setbase`:
  - Changes base of integer output
  - Load `<iomanip>`
  - Accepts an integer argument (`10`, `8`, or `16`)

    ```
    cout << setbase(16) << n;
    ```

  - Parameterized stream manipulator - takes an argument

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```
1 // Fig. 21.16: fig21_16.cpp
2 // Using hex, oct, dec and setbase stream manipulators.
3 #include <iostream>
4
5 using std::cout;
6 using std::cin;
7 using std::endl;
8
9 #include <iomanip>
10
11 using std::hex;
12 using std::dec;
13 using std::oct;
14 using std::setbase;
15
16 int main()
17 {
18    int n;
19
20    cout << "Enter a decimal number: ";
21    cin >> n;
22
```

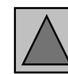
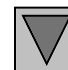

fig21_16.cpp (Part 1 of 2)

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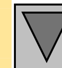

fig21_16.cpp (Part 2 of 2)

```
23    cout << n << " in hexadecimal is: "
24         << hex << n << '\n'
25         << dec << n << " in octal is: "
26         << oct << n << '\n'
27         << setbase( 10 ) << n << " in decimal is: "
28         << n << endl;
29
30    return 0;
31 } // end function main
```

Program Output

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

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21.6.2 Floating-Point Precision (`precision`, `setprecision`)

- `precision`
  - Member function
  - Sets number of digits to the right of decimal point

    ```
    cout.precision(2);
    ```
  - `cout.precision()` returns current precision setting
- setprecision
  - Parameterized stream manipulator
  - Like all parameterized stream manipulators, `<iomanip>` required
  - Specify precision:

    ```
    cout << setprecision(2) << x;
    ```
- For both methods, changes last until a different value is set

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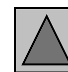
```
1 // Fig. 21.17: fig21_17.cpp
2 // Controlling precision of floating-point values
3 #include <iostream>
4
5 using std::cout;
6 using std::cin;
7 using std::endl;
8
9 #include <iomanip>
10
11 using std::ios;
12 using std::setiosflags;
13 using std::setprecision;
14
15 #include <cmath>
16
17 int main()
18 {
19    double root2 = sqrt( 2.0 );
20    int places;
21
22    cout << setiosflags( ios::fixed )
23         << "Square root of 2 with precisions 0-9.\n"
24         << "Precision set by the "
25         << "precision member function:" << endl;
26
```



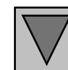


fig21_17.cpp (Part 1 of 2)

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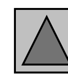
```
27    for ( places = 0; places <= 9; places++ ) {
28       cout.precision( places );
29       cout << root2 << '\n';
30    } // end for
31
32    cout << "\nPrecision set by the "
33         << "setprecision manipulator:\n";
34
35    for ( places = 0; places <= 9; places++ )
36       cout << setprecision( places ) << root2 << '\n';
37
38    return 0;
39 } // end function main
```



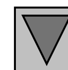


fig21_17.cpp (Part 2 of 2)

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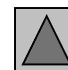
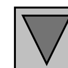
```
Square root of 2 with precisions 0-9.
Precision set by the precision member function:
1
1.4
1.41
1.414
1.4142
1.41421
1.414214
1.4142136
1.41421356
1.414213562

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

Program Output

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21.6.3 Field Width(`setw`, `width`)

- `ios` `width` member function
  - Sets field width (number of character positions a value should be output or number of characters that should be input)
  - Returns previous width
  - If values processed are smaller than width, fill characters inserted as padding
  - Values are not truncated - full number printed
  - `cin.width(5);`
- `setw` stream manipulator

```
cin >> setw(5) >> string;
```

- Remember to reserve one space for the null character

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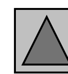
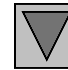

fig21_18.cpp

```
1  // fig21_18.cpp
2  // Demonstrating the width member function
3  #include <iostream>
4
5  using std::cout;
6  using std::cin;
7  using std::endl;
8
9  int main()
10 {
11    int w = 4;
12    char string[ 10 ];
13
14    cout << "Enter a sentence:\n";
15    cin.width( 5 );
16
17    while ( cin >> string ) {
18       cout.width( w++ );
19       cout << string << endl;
20       cin.width( 5 );
21    } // end while
22
23    return 0;
24 } // end function main
```

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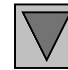
```
Enter a sentence:
This is a test of the width member function
This
   is
     a
   test
      of
      the
      widt
          h
        memb
           er
          func
           tion
```



Outline

Program Output

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21.6.4 User-Defined Manipulators

- We can create our own stream manipulators
  - `bell`
  - `ret` (carriage return)
  - `tab`
  - `endLine`

- Parameterized stream manipulators
  - Consult installation manuals

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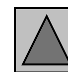
```
1 // Fig. 21.19: fig21_19.cpp
2 // Creating and testing user-defined, nonparameterized
3 // stream manipulators.
4 #include <iostream>
5
6 using std::ostream;
7 using std::cout;
8 using std::flush;
9
10 // bell manipulator (using escape sequence \a)
11 ostream& bell( ostream& output ) { return output << '\a'; }
12
13 // ret manipulator (using escape sequence \r)
14 ostream& ret( ostream& output ) { return output << '\r'; }
15
16 // tab manipulator (using escape sequence \t)
17 ostream& tab( ostream& output ) { return output << '\t'; }
18
19 // endLine manipulator (using escape sequence \n
20 // and the flush member function)
21 ostream& endLine( ostream& output )
22 {
23    return output << '\n' << flush;
24 } // end function endLine
25
```



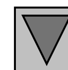


fig21_19.cpp (Part 1 of 2)

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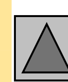
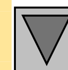

Outline

fig21_19.cpp (Part 2 of 2)

```
26 int main()
27 {
28    cout << "Testing the tab manipulator:" << endLine
29         << 'a' << tab << 'b' << tab << 'c' << endLine
30         << "Testing the ret and bell manipulators:"
31         << endLine << "..........";
32    cout << bell;
33    cout << ret << "-----" << endLine;
34    return 0;
35 } // end function main
```

Program Output

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

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21.7 Stream Format States

- Format flags
  - Specify formatting to be performed during stream I/O operations
- `setf`, `unsetf` and `flags`
  - Member functions that control the flag settings

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21.7.1 Format State Flags

- Format State Flags
  - Defined as an enumeration in class `ios`
  - Can be controlled by member functions
  - `flags` - specifies a value representing the settings of all the flags
    - Returns `long` value containing prior options
  - `setf` - one argument, "ors" flags with existing flags
  - `unsetf` - unsets flags
  - `setiosflags` - parameterized stream manipulator used to set flags
  - `resetiosflags` - parameterized stream manipulator, has same functions as `unsetf`
- Flags can be combined using bitwise OR (`|`)

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21.7.1 Format State Flags

Format state flag	Description
`ios::skipws`	Skip whitespace characters on an input stream.
`ios::left`	Left-justify output in a field. Padding characters appear to the right if necessary.
`ios::right`	Right-justify output in a field. Padding characters appear to the left if necessary.
`ios::internal`	Indicate that a number's sign should be left-justified in a field and a number's magnitude should be right-justified in that same field (i.e., padding characters appear between the sign and the number).
`ios::dec`	Specify that integers should be treated as decimal (base 10) values.
`ios::oct`	Specify that integers should be treated as octal (base 8) values.
`ios::hex`	Specify that integers should be treated as hexadecimal (base 16) values.
`ios::showbase`	Specify that the base of a number is to be output ahead of the number (a leading `0` for octals; a leading `0x` or `0X` for hexadecimals).
`ios::showpoint`	Specify that floating-point numbers should be output with a decimal point. This is normally used with `ios::fixed` to guarantee a certain number of digits to the right of the decimal point.
`ios::uppercase`	Specify that uppercase letters (i.e., `X` and `A` through `F`) should be used in the hexadecimal integer and that uppercase `E` should be used when representing a floating-point value in scientific notation.
`ios::showpos`	Specify that positive and negative numbers should be preceded by a `+` or `-` sign, respectively.
`ios::scientific`	Specify output of a floating-point value in scientific notation.
`ios::fixed`	Specify output of a floating-point value in fixed-point notation with a specific number of digits to the right of the decimal point.

Fig. 21.20 Format state flags.

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21.7.2 Trailing Zeros and Decimal Points (`ios::showpoint`)

- `ios::showpoint`
  - Forces a float with an integer value to be printed with its decimal point and trailing zeros

```
cout.setf(ios::showpoint)
cout << 79;
```

`79` will print as `79.00000`

- Number of zeros determined by precision settings

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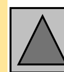
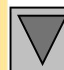

Outline

fig21_21.cpp

```
1  // Fig. 21.21: fig21_21.cpp
2  // Controlling the printing of trailing zeros and decimal
3  // points for floating-point values.
4  #include <iostream>
5
6  using std::cout;
7  using std::endl;
8
9  #include <iomanip>
10
11  using std::ios;
12
13  #include <cmath>
14
15  int main()
16  {
17     cout << "Before setting the ios::showpoint flag\n"
18          << "9.9900 prints as: " << 9.9900
19          << "\n9.9000 prints as: " << 9.9000
20          << "\n9.0000 prints as: " << 9.0000
21          << "\n\nAfter setting the ios::showpoint flag\n";
22     cout.setf( ios::showpoint );
23     cout << "9.9900 prints as: " << 9.9900
24          << "\n9.9000 prints as: " << 9.9000
25          << "\n9.0000 prints as: " << 9.0000 << endl;
26     return 0;
27  } // end function main
```

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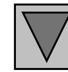

Program Output

```
Before setting the ios::showpoint flag
9.9900 prints as: 9.99
9.9000 prints as: 9.9
9.0000 prints as: 9

After setting the ios::showpoint flag
9.9900 prints as: 9.99000
9.9000 prints as: 9.90000
9.0000 prints as: 9.00000
```

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21.7.3 Justification (`ios::left`, `ios::right`, `ios::internal`)

- `ios::left`
  - Fields to left-justified with padding characters to the right
- `ios::right`
  - Default setting
  - Fields right-justified with padding characters to the left
- Character used for padding set by
  - `fill` member function
  - `setfill` parameterized stream manipulator
  - Default character is space

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21.7.3 Justification (`ios::left`, `ios::right`, `ios::internal`)

- `internal` flag
  - Number's sign left-justified
  - Number's magnitude right-justified
  - Intervening spaces padded with the fill character
- `static` data member `ios::adjustfield`
  - Contains `left`, `right` and `internal` flags
  - `ios::adjustfield` must be the second argument to `setf` when setting the `left`, `right` or `internal` justification flags

```
cout.setf( ios::left, ios::adjustfield);
```

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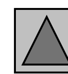
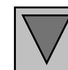

Outline

fig21_22.cpp (Part 1 of 2)

```
1 // Fig. 21.22: fig21_22.cpp
2 // Left-justification and right-justification.
3 #include <iostream>
4
5 using std::cout;
6 using std::endl;
7
8 #include <iomanip>
9
10 using std::ios;
11 using std::setw;
12 using std::setiosflags;
13 using std::resetiosflags;
14
15 int main()
16 {
17    int x = 12345;
18
19    cout << "Default is right justified:\n"
20         << setw(10) << x << "\n\nUSING MEMBER FUNCTIONS"
21         << "\nUse setf to set ios::left:\n" << setw(10);
22
```

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```
23     cout.setf( ios::left, ios::adjustfield );
24     cout << x << "\nUse unsetf to restore default:\n";
25     cout.unsetf( ios::left );
26     cout << setw( 10 ) << x
27          << "\n\nUSING PARAMETERIZED STREAM MANIPULATORS"
28          << "\nUse setiosflags to set ios::left:\n"
29          << setw( 10 ) << setiosflags( ios::left ) << x
30          << "\nUse resetiosflags to restore default:\n"
31          << setw( 10 ) << resetiosflags( ios::left )
32          << x << endl;
33     return 0;
34  } // end function main
```

Program Output

```
Default is right justified:
     12345

USING MEMBER FUNCTIONS
Use setf to set ios::left:
12345
Use unsetf to restore default:
     12345

USING PARAMETERIZED STREAM MANIPULATORS
Use setiosflags to set ios::left:
12345
Use resetiosflags to restore default:
     12345
```

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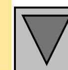

Outline

fig21_23.cpp

```
1  // Fig. 21.23: fig21_23.cpp
2  // Printing an integer with internal spacing and
3  // forcing the plus sign.
4  #include <iostream>
5
6  using std::cout;
7  using std::endl;
8
9  #include <iomanip>
10
11 using std::ios;
12 using std::setiosflags;
13 using std::setw;
14
15 int main()
16 {
17    cout << setiosflags( ios::internal | ios::showpos )
18         << setw( 10 ) << 123 << endl;
19    return 0;
20 } // end function main
```

Program Output

```
+       123
```

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21.7.4 Padding (`fill`, `setfill`)

- `fill` member function
  - Specifies the fill character
  - Space is default
  - Returns the prior padding character

```
cout.fill('*');
```

- `setfill` manipulator
  - Also sets fill character

```
cout << setfill ('*');
```

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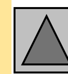
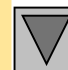

fig21_24.cpp (Part 1 of 2)

```
1 // Fig. 21.24: fig21_24.cpp
2 // Using the fill member function and the setfill
3 // manipulator to change the padding character for
4 // fields larger than the values being printed.
5 #include <iostream>
6
7 using std::cout;
8 using std::endl;
9
10 #include <iomanip>
11
12 using std::ios;
13 using std::setw;
14 using std::hex;
15 using std::dec;
16 using std::setfill;
17
18 int main()
19 {
20    int x = 10000;
21
```

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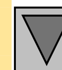

fig21_24.cpp (Part 1 of 2)

```
22      cout << x << " printed as int right and left justified\n"
23           << "and as hex with internal justification.\n"
24           << "Using the default pad character (space):\n";
25      cout.setf( ios::showbase );
26      cout << setw( 10 ) << x << '\n';
27      cout.setf( ios::left, ios::adjustfield );
28      cout << setw( 10 ) << x << '\n';
29      cout.setf( ios::internal, ios::adjustfield );
30      cout << setw( 10 ) << hex << x;
31
32      cout << "\n\nUsing various padding characters:\n";
33      cout.setf( ios::right, ios::adjustfield );
34      cout.fill( '*' );
35      cout << setw( 10 ) << dec << x << '\n';
36      cout.setf( ios::left, ios::adjustfield );
37      cout << setw( 10 ) << setfill( '%' ) << x << '\n';
38      cout.setf( ios::internal, ios::adjustfield );
39      cout << setw( 10 ) << setfill( '^' ) << hex << x << endl;
40      return 0;
41  } // end function main
```

Program Output

```
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
```

21.7.5- Integral Stream Base (`ios::dec`, `ios::oct`, `ios::hex`, `ios::showbase`)

- `ios::basefield` static member
  - Used similarly to `ios::adjustfield` with `setf`
  - Includes the `ios::oct`, `ios::hex` and `ios::dec` flag bits
  - Specify that integers are to be treated as octal, hexadecimal and decimal values
  - Default is decimal
  - Default for stream extractions depends on form inputted
    - Integers starting with `0` are treated as octal
    - Integers starting with `0x` or `0X` are treated as hexadecimal
  - Once a base specified, settings stay until changed

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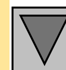

fig21_25.cpp

```
1  // Fig. 21.25: fig21_25.cpp
2  // Using the ios::showbase flag
3  #include <iostream>
4
5  using std::cout;
6  using std::endl;
7
8  #include <iomanip>
9
10 using std::ios;
11 using std::setiosflags;
12 using std::oct;
13 using std::hex;
14
15 int main()
16 {
17    int x = 100;
18
19    cout << setiosflags( ios::showbase )
20         << "Printing integers preceded by their base:\n"
21         << x << '\n'
22         << oct << x << '\n'
23         << hex << x << endl;
24    return 0;
25 } // end function main
```

Program Output

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

21.7.6 Floating-Point Numbers; Scientific Notation (`ios::scientific`, `ios::fixed`)

- `ios::scientific`
  - Forces output of a floating point number in scientific notation:
    - `1.946000e+009`
- `ios::fixed`
  - Forces floating point numbers to display a specific number of digits to the right of the decimal (specified with `precision`)

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21.7.6 Floating-Point Numbers; Scientific Notation (`ios::scientific`, `ios::fixed`)

- `static` data member `ios::floatfield`
  - Contains `ios::scientific` and `ios::fixed`
  - Used similarly to `ios::adjustfield` and `ios::basefield` in `setf`
    - `cout.setf(ios::scientific, ios::floatfield);`
  - `cout.setf(0, ios::floatfield)` restores default format for outputting floating-point numbers

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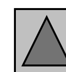
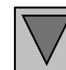

Outline

fig21_26.cpp

```
1  // Fig. 21.26: fig21_26.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::ios;
9
10 int main()
11 {
12    double x = .001234567, y = 1.946e9;
13
14    cout << "Displayed in default format:\n"
15         << x << '\t' << y << '\n';
16    cout.setf( ios::scientific, ios::floatfield );
17    cout << "Displayed in scientific format:\n"
18         << x << '\t' << y << '\n';
19    cout.unsetf( ios::scientific );
20    cout << "Displayed in default format after unsetf:\n"
21         << x << '\t' << y << '\n';
22    cout.setf( ios::fixed, ios::floatfield );
23    cout << "Displayed in fixed format:\n"
24         << x << '\t' << y << endl;
25    return 0;
26 } // end function main
```

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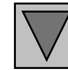
```
Displayed in default format:
0.00123457      1.946e+009
Displayed in scientific format:
1.234567e-003   1.946000e+009
Displayed in default format after unsetf:
0.00123457      1.946e+009
Displayed in fixed format:
0.001235        1946000000.000000
```



Outline

Program Output

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21.7.7 Uppercase/Lowercase Control (`ios::uppercase`)

- `ios::uppercase`
  - Forces uppercase `E` to be output with scientific notation
    `4.32E+010`
  - Forces uppercase `X` to be output with hexadecimal numbers, and causes all letters to be uppercase
    `75BDE`

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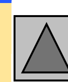
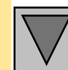
```
1 // Fig. 21.27: fig21_27.cpp
2 // Using the ios::uppercase flag
3 #include <iostream>
4
5 using std::cout;
6 using std::endl;
7
8 #include <iomanip>
9
10 using std::setiosflags;
11 using std::ios;
12 using std::hex;
13
14 int main()
15 {
16    cout << setiosflags( ios::uppercase )
17         << "Printing uppercase letters in scientific\n"
18         << "notation exponents and hexadecimal values:\n"
19         << 4.345e10 << '\n' << hex << 123456789 << endl;
20    return 0;
21 } // end function main
```





Outline

fig21_27.cpp

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

Program Output

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21.7.8 Setting and Resetting the Format Flags (flags, setiosflags, resetiosflags)

- `flags` member function
  - Without argument, returns the current settings of the format flags (as a `long` value)
  - With a `long` argument, sets the format flags as specified
    - Returns prior settings
- `setf` member function
  - Sets the format flags provided in its argument
  - Returns the previous flag settings as a `long` value
  - Unset the format using `unsetf` member function

```
long previousFlagSettings =
    cout.setf( ios::showpoint | ios::showpos );
```

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21.7.8 Setting and Resetting the Format Flags (`flags`, `setiosflags`, `resetiosflags`)

- `setf` with two `long` arguments

  ```
  cout.setf( ios::left, ios::adjustfield );
  ```

  clears the bits of `ios::adjustfield` then sets `ios::left`

  – This version of setf can be used with
  – `ios::basefield (ios::dec, ios::oct, ios::hex)`
  – `ios::floatfield (ios::scientific, ios::fixed)`
  – `ios::adjustfield (ios::left, ios::right, ios::internal )`

- `unsetf`
  – Resets specified flags
  – Returns previous settings

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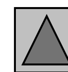
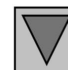

Outline

fig21_28.cpp (Part 1 of 2)

```
1 // Fig. 21.28: fig21_28.cpp
2 // Demonstrating the flags member function.
3 #include <iostream>
4
5 using std::cout;
6 using std::endl;
7 using std::ios;
8
9
10 int main()
11 {
12    int i = 1000;
13    double d = 0.0947628;
14
15    cout << "The value of the flags variable is: "
16         << cout.flags()
17         << "\nPrint int and double in original format:\n"
18         << i << '\t' << d << "\n\n";
19    long originalFormat =
20            cout.flags( ios::oct | ios::scientific );
21    cout << "The value of the flags variable is: "
22         << cout.flags()
23         << "\nPrint int and double in a new format\n"
24         << "specified using the flags member function:\n"
25         << i << '\t' << d << "\n\n";
```

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```
26    cout.flags( originalFormat );
27    cout << "The value of the flags variable is: "
28         << cout.flags()
29         << "\nPrint values in original format again:\n"
30         << i << '\t' << d << endl;
31    return 0;
32 } // end function main
```

```
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: 12000
Print int and double in a new format
specified using the flags member function:
1750    9.476280e-002

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

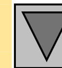

fig21_28.cpp (Part 2 of 2)

Program Output

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21.8 Stream Error States

- `eofbit`
  - Set for an input stream after end-of-file encountered
  - `cin.eof()` returns `true` if end-of-file has been encountered on `cin`
- `failbit`
  - Set for a stream when a format error occurs
  - `cin.fail()` - returns `true` if a stream operation has failed
  - Normally possible to recover from these errors

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21.8 Stream Error States

- `badbit`
  - Set when an error occurs that results in data loss
  - `cin.bad()` returns `true` if stream operation failed
  - normally nonrecoverable
- `goodbit`
  - Set for a stream if neither `eofbit`, `failbit` or `badbit` are set
  - `cin.good()` returns `true` if the `bad`, `fail` and `eof` functions would all return false.
  - I/O operations should only be performed on “good” streams
- `rdstate`
  - Returns the state of the stream
  - Stream can be tested with a `switch` statement that examines all of the state bits
  - Easier to use `eof`, `bad`, `fail`, and `good` to determine state

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21.8 Stream Error States

- `clear`
  - Used to restore a stream's state to "good"
  - `cin.clear()` clears `cin` and sets `goodbit` for the stream
  - `cin.clear( ios::failbit )` actually sets the `failbit`
    - Might do this when encountering a problem with a user-defined type
- Other operators
  - `operator!`
    - Returns `true` if `badbit` or `failbit` set
  - `operator void*`
    - Returns `false` if `badbit` or `failbit` set
  - Useful for file processing

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```
1  // Fig. 21.29: fig21_29.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 x;
12    cout << "Before a bad input operation:"
13         << "\ncin.rdstate(): " << cin.rdstate()
14         << "\n    cin.eof(): " << cin.eof()
15         << "\n   cin.fail(): " << cin.fail()
16         << "\n    cin.bad(): " << cin.bad()
17         << "\n   cin.good(): " << cin.good()
18         << "\n\nExpects an integer, but enter a character: ";
19    cin >> x;
20
21    cout << "\nAfter a bad input operation:"
22         << "\ncin.rdstate(): " << cin.rdstate()
23         << "\n    cin.eof(): " << cin.eof()
24         << "\n   cin.fail(): " << cin.fail()
25         << "\n    cin.bad(): " << cin.bad()
26         << "\n   cin.good(): " << cin.good() << "\n\n";
27
```

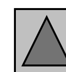
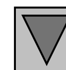

fig21_29.cpp (Part 1 of 2)

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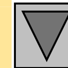

Outline

fig21_29.cpp (Part 2 of 2)

```
28    cin.clear();
29
30    cout << "After cin.clear()"
31         << "\ncin.fail(): " << cin.fail()
32         << "\ncin.good(): " << cin.good() << endl;
33    return 0;
34 } // end function main
```

Program Output

```
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
```

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21.9 Tying an Output Stream to an Input Stream

- `tie` member function
  - Synchronize operation of an `istream` and an `ostream`
  - Outputs appear before subsequent inputs
  - Automatically done for `cin` and `cout`
- `inputStream.tie( &outputStream );`
  - Ties `inputStream` to `outputStream`
  - `cin.tie( &cout)` done automatically
- `inputStream.tie( 0 );`
  - Unties `inputStream` from an output stream

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