## C++ Reference dot com - HTML Help Edition

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## Frequently Asked Questions

## Can I get a copy of this site?

Here is an archived version of the site, updated daily.

## Can I [mirror/translate/put up my own version of/etc.] this site?

Sure, that would be great! All that we would ask is that you include a link back to this site so that people know where to get the most up-todate content.

## What? This is a wiki? Can I change stuff?

Absolutely. If you see something that is wrong, fix it. If you would like to add content, make sure it's not already there, and then edit away.

Just be gentle with your changes, and think before you type.

## Which wiki software does this site run?

cppreference.com is powered by DokuWiki.

## Who is this site meant for?

There are no "Introduction to Programming" tutorials here. This site is meant to be used by more-or-less experienced C++ programmers, who have a good idea of what they want to do and simply need to look up the syntax. If you're interested in learning C or $\mathrm{C}++$, try one of these sites:

- How C Programming Works


## - C Programming

- C++ Language Tutorial


## Does this site contain a complete and definitive list of everything I can do with C++?

Few things in life are absolute. Many C++ compilers have added or missing functionality. If you don't find what you are looking for here, don't assume that it doesn't exist. Do a search on Google for it.

## Some of the examples on this site don't work on my system. What's going on?

Most of the code on this site was compiled under Linux (Red Hat, Debian, or Ubuntu) with the GNU Compiler Collection. Since this site is merely a reference for the C++ specification, not every compiler will support every function listed here. For example,

- Header files change like mad. To include the necessary support for vectors, you might have to use any of these:

```
#include <vector>
#include <Vector>
#include <vector.h>
```

(according to the spec, the first of those should work, and the compiler should know enough to use it to reference the real vector header file.)

- Another header file issue is that newer compilers can use a more platform-independent commands to include standard C libraries. For example, you should be able to use

```
#include <cstdio>
```

instead of
\#include <stdio.h>

- All of the code on this site assumes that the correct namespace has been designated. If your compiler is a little old, then you might be able to get away with using simple statements like:

```
cout << "hello world!";
```

However, newer compilers require that you either use
std::cout << "hello world!";
or declare what namespace to use with the "using namespace" command.

- Certain popular compilers (like the one shipped with Microsoft's Visual $\mathrm{C}++$ ) have added alternative or additional functionality to the C++ Standard Template Library. For example, the MFC in Visual C++ provides you with the string type "CString", which has string functionality but is not part of the C++ STL.
...The list goes on and on. In other words, individual results may vary.


## You've got an error in this site.

If you find any errors in this reference, please feel free to fix them. Or you can contact us at comments@cppreference.com.

## What's up with this site?

Think of it as a community service, for geeks, by geeks.

## Preprocessor Commands

The C++ preprocessor runs before any other compilation happens.
Commands given to the preprocessor allow the programmer to define variables, perform text substitution, and test simple conditions.

| \# and \#\# | manipulate strings |
| :--- | :--- |
| \#define | define variables |
| \#error | display an error message |
| \#if, \#ifdef, \#ifndef, \#else, \#elif, and |  |
| \#endif | conditional operators |
| \#include | insert the contents of another file |
| \#line | set line and file information |
| \#pragma | implementation specific <br> command |
| \#undef | used to undefine variables |
| Predefined preprocessor variables | miscellaneous preprocessor <br> variables |

## C++ Operator Precedence

The operators at the top of this list are evaluated first. Operators within a group have the same precedence. All operators have left-to-right associativity unless otherwise noted.

| Operator | Description | Example |
| :---: | :---: | :---: |
| Group 1 (no associativity) |  |  |
| : | Scope resolution operator | Class::age = 2; |
| Group 2 |  |  |
| () | Function call | isdigit('1') |
| () | Member initalization | $\begin{aligned} & \text { c_tor(int } x \text {, int } y): \quad x(x), \\ & y(y * 10)\} ; \end{aligned}$ |
| [] | Array access | array[4] $=2$; |
| -> | Member access from a pointer | ptr->age $=34$; |
|  | Member access from an object | obj.age $=34$; |
| ++ | Post-increment | $\begin{aligned} & \text { for( int } i=0 ; i<10 ; i++) \\ & \text { cout } \ll i ; \end{aligned}$ |
| -- | Post-decrement | $\begin{aligned} & \text { for( int } \mathrm{i}=10 ; \mathrm{i}>0 ; \mathrm{i}-\mathrm{e}) \\ & \text { cout << i; } \end{aligned}$ |
| const_cast | Special cast | const_cast<type_to> (type_from); |
| dynamic_cast | Special cast | dynamic_cast<type_to> (type_from); |
| static_cast | Special cast | static_cast<type_to> (type_from); |
| reinterpret_cast | Special cast | reinterpret_cast<type_to> <type_from>; |
| typeid | Runtime type information | cout « typeid(var).name(); |


| ! | Group 3 (right-to-left associativity) |  |
| :---: | :---: | :---: |
|  | Logical negation | if( !done ) ... |
| not | Alternate spelling for ! |  |
| $\sim$ | Bitwise complement | flags $=\sim$ flags; |
| compl | Alternate spelling for ~ |  |
| ++ | Pre-increment | $\begin{aligned} & \operatorname{for}(i=0 ; i<10 ;++i) \text { cout } \\ & \ll i ; \end{aligned}$ |
| -- | Pre-decrement | $\begin{aligned} & \operatorname{for}(\mathrm{i}=10 ; i>0 ;-\mathrm{i}) \text { cout } \\ & \ll \mathrm{i} ; \end{aligned}$ |
| - | Unary minus | int $\mathrm{i}=-1$; |
| + | Unary plus | int $\mathrm{i}=+1$; |
| * | Dereference | int data $=$ *intPtr; |
| \& | Address of | int *intPtr = \&data; |
| new | Dynamic memory allocation | long *pVar = new long; |
| delete | Deallocating the memory | delete pVar; |
| (type) | Cast to a given type | int $\mathrm{i}=$ (int) floatNum; |
| sizeof | Return size of an object | int size = sizeof(floatNum); |
| Group 4 |  |  |
| ->* | Member pointer selector | ptr->*var = 24; |
| * | Member object selector | obj.*var = 24; |
| Group 5 |  |  |
| * | Multiplication | int $\mathrm{i}=2$ * 4; |
| 1 | Division | float $\mathrm{f}=10.0$ / 3.0; |
| \% | Modulus | int rem = 4 \% 3; |
| Group 6 |  |  |
| + | Addition | int $\mathrm{i}=2+3$; |
| - | Subtraction | int $\mathrm{i}=5-1$; |
| Group 7 |  |  |
| << | Bitwise shift left | int flags = $33 \ll 1$; |
|  |  |  |


| >> | Bitwise shift right | int flags = $33 \gg 1$; |
| :---: | :---: | :---: |
| Group 8 |  |  |
| < | Comparison less-than | if( $\mathrm{i}<42$ ) ... |
| <= | Comparison less-than-or-equal-to | if( $\mathrm{i}<=42$ ) ... |
| > | Comparison greater-than | if( i > 42) ... |
| >= | Comparison greater-than-or-equal-to | if( $\mathrm{i}>=42$ ) ... |
| Group 9 |  |  |
| == | Comparison equal-to | if( $\mathrm{i}==42$ ) ... |
| eq | Alternate spelling for == |  |
| != | Comparison not-equal-to | if( i ! 42 ) ... |
| not_eq | Alternate spelling for != |  |
| Group 10 |  |  |
| \& | Bitwise AND | flags $=$ flags \& 42; |
| bitand | Alternate spelling for \& |  |
| Group 11 |  |  |
| $\wedge$ | Bitwise exclusive OR (XOR) | flags $=$ flags ${ }^{\wedge} 42$; |
| xor | Alternate spelling for ${ }^{\wedge}$ |  |
| Group 12 |  |  |
| \| | Bitwise inclusive (normal) OR | flags = flags \| 42; |
| bitor | Alternate spelling for \| |  |
| Group 13 |  |  |
| \& \& | Logical AND | if( conditionA \&\& conditionB ) ... |
| and | Alternate spelling for \&\& |  |
| Group 14 |  |  |
| \|| | Logical OR | if( conditionA \|| conditionB ) ... |


| or | Alternate spelling for \|| |  |
| :---: | :---: | :---: |
| Group 15 (right-to-left associativity) |  |  |
| ? : | Ternary conditional (if-then-else) | int $\mathrm{i}=(\mathrm{a}>\mathrm{b})$ ? $\mathrm{a}: \mathrm{b}$; |
| Group 16 (right-to-left associativity) |  |  |
| $=$ | Assignment operator | int $\mathrm{a}=\mathrm{b}$; |
| += | Increment and assign | $\mathrm{a}+=3$; |
| -= | Decrement and assign | b -= 4; |
| *= | Multiply and assign | a * $=5$; |
| /= | Divide and assign | a $/=2$; |
| \%= | Modulo and assign | a \% = 3; |
| \&= | Bitwise AND and assign | flags \& = new_flags; |
| and_eq | Alternate spelling for \&= |  |
| $\wedge=$ | Bitwise exclusive or (XOR) and assign | flags ${ }^{\wedge}=$ new_flags; |
| xor_eq | Alternate spelling for ${ }^{\wedge}=$ |  |
| \|= | Bitwise normal OR and assign | flags \|= new_flags; |
| or_eq | Alternate spelling for $1=$ |  |
| <<= | Bitwise shift left and assign | flags <<= 2; |
| >>= | Bitwise shift right and assign | flags $\gg=2$; |
| Group 17 |  |  |
| throw | throw exception | throw EClass("Message"); |
|  |  | Group 18 |
| , | Sequential evaluation operator | $\begin{aligned} & \operatorname{for}(i=0, j=0 ; i<10 ; i++, \\ & j++) \ldots \end{aligned}$ |

## Order of Evaluation and of Side Effects

One important aspect of $\mathrm{C}++$ that is related to operator precedence is the order of evaluation and the order of side effects in expressions. In some circumstances, the order in which things happen is not defined. For example, consider the following code:

$$
\begin{aligned}
& \text { float } x=1 ; \\
& x=x /++x ;
\end{aligned}
$$

The value of $x$ is not guaranteed to be consistent across different compilers, because it is not clear whether the computer should evaluate the left or the right side of the division first. Depending on which side is evaluated first, $x$ could take a different value.

Furthermore, while $++x$ evaluates to $x+1$, the side effect of actually storing that new value in $x$ could happen at different times, resulting in different values for x .

The bottom line is that expressions like the one above are horribly ambiguous and should be avoided at all costs. When in doubt, break a single ambiguous expression into multiple expressions to ensure that the order of evaluation is correct.

## Constant Escape Sequences

The following escape sequences can be used to define certain special characters within strings:

| Escape Sequence |  |
| :--- | :--- |
| $I^{\prime}$ | Single quote |
| $I^{\prime \prime}$ | Double quote |
| $I I$ | Backslash |
| Innn | Octal number (nnn) |
| $I 0$ | Null character (really just the octal number zero) |
| la | Audible bell |
| Ib | Backspace |
| If | Formfeed |
| In | Newline |
| Ir | Carriage return |
| It | Horizontal tab |
| Iv | Vertical tab |
| Ixnnn | Hexadecimal number (nnn) |

An example of this is contained in the following code (which assumes that the newline character generates complete newlines, i.e. on Unix systems):

which would display

This
is
a
test
She said, "How are you?"

## ASCII Chart

The following chart contains the first 128 ASCII decimal, octal, hexadecimal and character codes.

| Decimal | Octal | Hex | Character | Description |
| :--- | :--- | :--- | :--- | :--- |
| 0 | 0 | 00 | NUL |  |
| 1 | 1 | 01 | SOH | start of header |
| 2 | 2 | 02 | STX | start of text |
| 3 | 3 | 03 | ETX | end of text |
| 4 | 4 | 04 | EOT | end of transmission |
| 5 | 5 | 05 | ENQ | enquiry |
| 6 | 6 | 06 | ACK | acknowledge |
| 7 | 7 | 07 | BEL | bell |
| 8 | 10 | 08 | BS | backspace |
| 9 | 11 | 09 | HT | horizontal tab |
| 10 | 12 | 0 A | LF | line feed |
| 11 | 13 | OB | VT | vertical tab |
| 12 | 14 | 0 C | FF | form feed |
| 13 | 15 | OD | CR | carriage return |
| 14 | 16 | 0 E | SO | shift out |
| 15 | 17 | OF | SI | shift in |
| 16 | 20 | 10 | DLE | data link escape |
| 17 | 21 | 11 | DC1 | no assignment, but usually XON |
| 18 | 22 | 12 | DC2 |  |
| 19 | 23 | 13 | DC3 | no assignment, but usually XOFF |
| 20 | 24 | 14 | DC4 |  |
| 21 | 25 | 15 | NAK | negative acknowledge |
| 22 | 26 | 16 | SYN | synchronous idle |
|  |  |  |  |  |
|  |  |  |  |  |


| 23 | 27 | 17 | ETB | end of transmission block |
| :--- | :--- | :--- | :--- | :--- |
| 24 | 30 | 18 | CAN | cancel |
| 25 | 31 | 19 | EM | end of medium |
| 26 | 32 | 1 A | SUB | substitute |
| 27 | 33 | 1 B | ESC | escape |
| 28 | 34 | 1 C | FS | file separator |
| 29 | 35 | 1 D | GS | group separator |
| 30 | 36 | 1 E | RS | record separator |
| 31 | 37 | 1F | US | unit separator |
| 32 | 40 | 20 | SPC | space |
| 33 | 41 | 21 | $!$ |  |
| 34 | 42 | 22 | " |  |
| 35 | 43 | 23 | \# |  |
| 36 | 44 | 24 | $\$$ |  |
| 37 | 45 | 25 | $\%$ |  |
| 38 | 46 | 26 | $\&$ |  |
| 39 | 47 | 27 |  |  |
| 40 | 50 | 28 | $($ |  |
| 41 | 51 | 29 | $)$ |  |
| 42 | 52 | 2 A | * |  |
| 43 | 53 | $2 B$ | + |  |
| 44 | 54 | 2 C |  |  |
| 45 | 55 | 2 D |  |  |
| 46 | 56 | 2 E |  |  |
| 47 | 57 | 2 F | 1 |  |
| 48 | 60 | 30 | 0 |  |
| 49 | 61 | 31 | 1 |  |
| 50 | 62 | 32 | 2 |  |
| 51 | 63 | 33 | 3 |  |
| 52 | 64 | 34 | 4 |  |
|  |  |  |  |  |


| 53 | 65 | 35 | 5 |
| :--- | :--- | :--- | :--- |
| 54 | 66 | 36 | 6 |
| 55 | 67 | 37 | 7 |
| 56 | 70 | 38 | 8 |
| 57 | 71 | 39 | 9 |
| 58 | 72 | 3 A | $:$ |
| 59 | 73 | $3 B$ | $;$ |
| 60 | 74 | $3 C$ | $<$ |
| 61 | 75 | $3 D$ | $=$ |
| 62 | 76 | 3 E | $>$ |
| 63 | 77 | $3 F$ | $?$ |
| 64 | 100 | 40 | $@$ |
| 65 | 101 | 41 | A |
| 66 | 102 | 42 | B |
| 67 | 103 | 43 | C |
| 68 | 104 | 44 | D |
| 69 | 105 | 45 | E |
| 70 | 106 | 46 | F |
| 71 | 107 | 47 | G |
| 72 | 110 | 48 | H |
| 73 | 111 | 49 | I |
| 74 | 112 | 4 A | J |
| 75 | 113 | $4 B$ | K |
| 76 | 114 | $4 C$ | L |
| 77 | 115 | $4 D$ | M |
| 78 | 116 | $4 E$ | N |
| 79 | 117 | 4 F | O |
| 80 | 120 | 50 | P |
| 81 | 121 | 51 | Q |
| 82 | 122 | 52 | R |
|  |  |  |  |


| 83 | 123 | 53 | S |
| :--- | :--- | :--- | :--- |
| 84 | 124 | 54 | T |
| 85 | 125 | 55 | U |
| 86 | 126 | 56 | V |
| 87 | 127 | 57 | W |
| 88 | 130 | 58 | X |
| 89 | 131 | 59 | Y |
| 90 | 132 | 5 A | Z |
| 91 | 133 | $5 B$ | l |
| 92 | 134 | 5 C | l |
| 93 | 135 | $5 D$ | l |
| 94 | 136 | 5 E | ^ |
| 95 | 137 | 5 F | - |
| 96 | 140 | 60 | - |
| 97 | 141 | 61 | a |
| 98 | 142 | 62 | b |
| 99 | 143 | 63 | c |
| 100 | 144 | 64 | d |
| 101 | 145 | 65 | e |
| 102 | 146 | 66 | f |
| 103 | 147 | 67 | g |
| 104 | 150 | 68 | h |
| 105 | 151 | 69 | i |
| 106 | 152 | 6 A |  |
| 107 | 153 | $6 B$ | k |
| 108 | 154 | $6 C$ | l |
| 109 | 155 | $6 D$ | m |
| 110 | 156 | $6 E$ | n |
| 111 | 157 | $6 F$ | o |
| 112 | 160 | 70 | p |
|  |  |  |  |


| 113 | 161 | 71 | q |
| :--- | :--- | :--- | :--- |
| 114 | 162 | 72 | r |
| 115 | 163 | 73 | s |
| 116 | 164 | 74 | t |
| 117 | 165 | 75 | u |
| 118 | 166 | 76 | v |
| 119 | 167 | 77 | w |
| 120 | 170 | 78 | x |
| 121 | 171 | 79 | y |
| 122 | 172 | $7 A$ | z |
| 123 | 173 | $7 B$ | \{ |
| 124 | 174 | $7 C$ |  |
| 125 | 175 | lD |  |
| 126 | 176 | 7E |  |
| 127 | 177 | 7F | DEL |

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## C++ Data Types

C++ programmers have access to the five data types for C : void, int, float, double, and char.

| Type | Description |
| :--- | :--- |
| void | associated with no data type |
| int | integer |
| float | floating-point number |
| double | double precision floating-point number |
| char | character |

In addition, C++ defines two more: bool and wchar_t.

| Type | Description |
| :--- | :--- |
| bool | Boolean value, true or false |
| wchar_t | wide character |

## Type Modifiers

Several of these types can be modified using the keywords signed, unsigned, short, and long. When one of these type modifiers is used by itself, a data type of int is assumed. A complete list of possible data types follows (equivalent types are displayed in the same row):

| integer types |  |
| :--- | :--- |
| bool |  |
| char | signed char |
| unsigned char |  |
| short | short int |$\quad$ signed short int 9.



## Type Sizes and Ranges

The size and range of any data type is compiler and architecture dependent. The "cfloat" (or "float.h") header file often defines minimum and maximum values for the various data types. You can use the sizeof operator to determine the size of any data type (frequently expressed as a number of bytes). However, many architectures implement data types of a standard size. ints and floats are often 32bit, chars 8-bit, and doubles are usually 64-bit. bools are often implemented as 8 -bit data types. long long type is 64 -bit.

Limits for numeric values are defined in the <limits> header. The templatized values of numeric_limits provide system-dependant numerical representations of the C++ data types. Use the appropriate function given the data type as the template argument as shown in the table below. Note that numeric_limits can be overloaded for userdefined types as well.

| Method | Return | Description |
| ---: | :--- | :--- |
| is_specialized | bool |  |


| radix | int | base of exponent |
| :--- | :--- | :--- |
| digits | int | number of radix digits in <br> mantissa |
| digits10 | int | number of base 10 digits <br> in mantissa |
| is_signed | bool | bool |
| is_integer | bool | smallest number that can <br> be respresented (not the <br> most negative) |
| is_exact | <type> | largest number |
| min | <type> | inherent representation <br> error value |
| max | <type> | maximum rounding <br> adjustment possible |
| epsilon | <type> | invalid number that does |
| not signal floating point |  |  |
| error |  |  |


| has_denorm_loss | bool |  |
| :--- | :--- | :--- |
| is_iec559 | bool | conforms to IEC-559 |
| is_bounded | bool |  |
| is_modulo | bool |  |
| traps | bool |  |
| tinyness_before | bool |  |
| round_style | float_round_style $\{$ <br> round_to_nearest,... <br> $\}$ |  |

The most common usage is in bounds checking, to determine the minimum and maximum values a data type can hold. The following code prints out the minimum and maximum values for a short on the system it is run.

```
    #include <limits>
std::cout << "Maximum short value: " << std::numeric_l.
std::cout << "Minimum short value: " << std::numeric_l.
4
```


## Reading Type Declarations

Simple type declarations are easy to understand:
int i

However, it can be tricky to parse a more complicated type declarations:

```
double **d[8]
char *(*(**foo [][8])())[] // augh! what is foo?
```

To understand the above declarations, follow three rules:

1. Start at the variable name (d or foo in the examples above)
2. End with the data type (double or char above)
3. Go right when you can, and left when you must. (Grouping parentheses can cause you to bounce left.)

For example:

| Expression | Meaning |
| :---: | :--- |
| double ${ }^{* * d[8] ;}$ |  |
| double $* * d[8] ;$ | d is ... double |
| double ${ }^{* * d[8] ;}$ d is an array of $8 \ldots$ double |  |
| double ${ }^{* * d[8] ;}$ | $d$ is an array of 8 pointer to ... double |
| double $* * d[8] ;$ | $d$ is an array of 8 pointer to pointer to double |

Another example:

| Expression | Meaning |
| :---: | :---: |
| $\begin{aligned} & \text { char *(* } \\ & \text { (**foo [][8]) } \\ & \text { ())[] } \end{aligned}$ |  |
| $\begin{aligned} & \text { char *(* } \\ & (* * \text { for [][8]) } \\ & \text { ())[] } \end{aligned}$ | foo is ... char |
| $\begin{aligned} & \text { char *(* } \\ & (* * \text { foo [][8]) } \\ & ())[] \end{aligned}$ | foo is an array of ... char |
| $\begin{aligned} & \text { char *(* } \\ & (* * \text { foo [][8]) } \\ & ())[] \end{aligned}$ | foo is an array of an array of $8 \ldots$ char |
| $\begin{aligned} & \text { char *(* } \\ & \text { (**foo [][8]) } \\ & \text { ())[] } \end{aligned}$ | foo is an array of an array of 8 pointer to ... char |
| $\begin{aligned} & \text { char *(* } \\ & (* * \text { foo [][8]) } \\ & \text { ())[] } \end{aligned}$ | foo is an array of an array of 8 pointer to pointer to ... char |
| $\begin{aligned} & \text { Char *(* } \\ & (* * f 00[][8]) \\ & ())[] \end{aligned}$ | foo is an array of an array of 8 pointer to pointer to function returning ... char |


| $\begin{aligned} & \text { char * }\left(\frac{*}{*}\right. \\ & (* * f 00[][8]) \\ & ())[] \end{aligned}$ | foo is an array of an array of 8 pointer to pointer to function returning pointer to ... char |
| :---: | :---: |
| $\begin{aligned} & \text { char *(* } \\ & \left(* * f_{00}[][8]\right) \\ & \text { ()) }[] \end{aligned}$ | foo is an array of an array of 8 pointer to pointer to function returning pointer to array of ... char |
| $\begin{aligned} & \text { char * }(* \\ & (* * f 00[][8]) \\ & ())[] \end{aligned}$ | foo is an array of an array of 8 pointer to pointer to function returning pointer to array of pointer to char |

For a much more detailed explanation, see Steve Friedl's excellent description of how to read C declarations at http://www.unixwiz.net/techtips/reading-cdecl.html.

## C++ Keywords

This is a list of reserved keywords in C++. Since they are used by the language, these keywords are not available for use by programmers.

| Keyword | Description |
| :--- | :--- |
| asm | insert an assembly instruction |
| auto | declare a local variable |
| bool | declare a boolean variable |
| break | break out of a loop |
| case | handleck of code in a switch statement |
| catch | declare a character variable |
| char | declare a class |
| class | declare immutable data or functions that do not <br> change data |
| const | cast from const variables |
| const_cast | default handler in a case statement |
| continue | make memory available |
| default | looping construct |
| delete | declare a double precision floating-point variable |
| do | perform runtime casts |
| double | alternate case for an if statement |
| dynamic_cast | create enumeration types |
| else | only use constructors when they exactly match |
| enum | allows template definitions to be separated from their <br> declarations |
| explicit | tell the compiler about variables defined elsewhere |
| export | the boolean value of false |
| extern | false |


| float | declare a floating-point variable |
| :--- | :--- |
| for | looping construct |
| friend | grant non-member function access to private data |
| goto | jump to a different part of the program |
| if | execute code based on the result of a test |
| inline | optimize calls to short functions |
| int | declare a integer variable |
| long | declare a long integer variable |
| mutable | override a const variable |
| namespace | partition the global namespace by defining a scope |
| new | allocate dynamic memory for a new variable |
| operator | create overloaded operator functions |
| private | declare private members of a class |
| protected | declare protected members of a class |
| public | declare public members of a class |
| register | request that a variable be optimized for speed |
| reinterpret_cast change the type of a variable |  |
| return | return from a function |
| short | declare a short integer variable |
| signed | modify variable type declarations |
| sizeof | return the size of a variable or type |
| static | create permanent storage for a variable |
| static_cast | perform a nonpolymorphic cast |
| struct | define a new structure |
| switch | execute code based on different possible values for a <br> variable <br> template <br> create generic functions <br> this |
| a pointer to the current object |  |
| true | throws an exception |
| the boolean value of true |  |


| try | execute code that can throw an exception |
| :--- | :--- |
| typedef | create a new type name from an existing type |
| typeid | describes an object |
| typename | declare a class or undefined type |
| union | a structure that assigns multiple variables to the same <br> memory location |
| unsigned | declare an unsigned integer variable <br> import complete or partial namespaces into the <br> current scope |
| using | create a function that can be overridden by a derived <br> class |
| virtual | declare functions or data with no associated data type |
| void | warn the compiler about variables that can be <br> modified unexpectedly |
| volatile | declare a wide-character variable |
| wchar_t | looping construct |
| while |  |

## Time Complexity

There are different measurements of the speed of any given algorithm. Given an input size of N , they can be described as follows:

| Name | Speed | Description | Formula | Example |
| :---: | :---: | :---: | :---: | :---: |
| factorial time | slower | takes an amount of time proportional to N raised to the Nth power | N! | Brute force solution to Traveling Salesman Problem |
| exponential time | slow | takes an amount of time proportional to a constant raised to the Nth power | $\mathrm{K}^{\mathrm{N}}$ | Brute force solution to Rubic's Cube |
| polynomial time | fast | takes an amount of time proportional to N raised to some constant power | $\mathrm{N}^{\mathrm{K}}$ | Comparison sorts (bubble, insertion, selection sort) |
| linearithmic time | faster | takes an amount of time between linear and polynomial | $\begin{gathered} N * \\ \log (N) \end{gathered}$ | The Linear logarithmic sorts (quicksort, heapsort, mergesort) |
| linear time | even faster | takes an amount of time directly proportional to N | K * N | Iterating through an array |
| logarithmic time | much faster | takes an amount of time proportional to the logarithm of N | $\begin{gathered} K^{*} \\ \log (N) \end{gathered}$ | Binary Search |
| constant time | fastest | takes a fixed amount of time, no matter how large the input is | K | Array index lookup |

## Complexity Analysis

A given operation can have different time complexities with different orders/sets of input. The different methods of time complexity analysis are as follows:

| Name | Description | Example |
| :--- | :--- | :--- |
| best-case | $\begin{array}{l}\text { A case where the operation } \\ \text { executes as fast as it possibly } \\ \text { can }\end{array}$ | $\begin{array}{l}\text { Bubblesort has a best-case } \\ \text { time complexity of } N\end{array}$ |
| average- | $\begin{array}{l}\text { A case where the operation } \\ \text { executes in a time } \\ \text { comparable to the majority of } \\ \text { possible cases }\end{array}$ | $\begin{array}{l}\text { Quicksort has an average- } \\ \text { case time complexity of } \mathrm{N}\end{array}$ |
| log(N) |  |  |$]$

Choosing the right algorithm depends upon which cases you expect your application to encounter. For example, an application that must protect itself from malicious input will avoid naive implementations of quicksort, which has a worst-case time complexity of $N^{2}$ despite having one of the fastest average-case time complexities compared to all other sorts.

## Credits

As described in the Frequently Asked Questions, cppreference.com is a wiki. That means credit for this site goes to you, the internet user. Thanks! Every little change, no matter how small, helps out.

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Table of Contents
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## The Standard C Library

C++ programmers have access to a variety of functions from the standard C libraries, as defined in ISO/IEC 9899:1990 (known as C90). All of the functions in these libraries are defined in the std namespace.

## C Library Functions

The following is a list of standard C library functions, grouped roughly by functionality:

- Standard C I/O
- Standard C String \& Character
- Standard C Math
- Standard C Date \& Time
- Standard C Memory
- Other standard C functions

Alternatively, there is a list of all standard C library functions.

## Standard C Header Files

The functions above are defined in the following 18 header files:

- <cassert>
- <ciso646>
- <csetjmp>
- <cstdio>
- <ctime>
- <cctype>
- <climits>
- <csignal>
- <cstdlib>
- <cwchar>
- <cerrno>
- <clocale>
- <cstdarg>
- <cstring>
- <cwctype>
- <cfloat>
- <cmath>
- <cstddef>

When including header files for the standard C libraries, it is preferable to use the cfile notation instead of the file.h notation. For example, the stdio. h header file should be included using this command:

```
#include <cstdio>
```

The file. h notation works, but it is mainly meant for backwards compatibility. The difference between the cfile and file.h notation is that functions included via the file. h notation will appear in the global namespace instead of the std namespace.

See also: The 2005 C99 working paper from the Approved Standards of working group 14.

All C Functions

| \# and \#\# | manipulate strings |
| :--- | :--- |
| \#define | define variables |
| \#error | display an error message |
| \#if, \#ifdef, \#ifndef, <br> \#else, \#elif, \#endif | conditional operators |
| \#include | insert the contents of another file |
| \#line | set line and file information |
| \#pragma | implementation specific command |
| \#undef | used to undefine variables |
| Predefined <br> preprocessor variables | miscellaneous preprocessor variables |
| abort | stops the program |
| abs | absolute value |
| acos | arc cosine |
| asctime | arc sine |
| asin | stops the program if an expression isn't true |
| assert | arc tangent <br> quadrants |
| atan | sets a function to be called when the program <br> exits |
| atan2 | converts a string to a double |
| atexit | converts a string to an integer |
| atof | converts a string to a long |
| atoi | allocates and clears a two-dimensional chunk <br> of memory |
| atol | bsearch |
| calloc | arm |


| ceil | the smallest integer not less than a certain <br> value |
| :--- | :--- |
| clearerr | clears errors |
| clock | returns the amount of time that the program <br> has been running |
| cos | cosine |
| cosh | returns a specifically formatted version of the <br> time |
| ctime | the difference between two times |
| difftime | returns the quotient and remainder of a <br> division |
| div | stop the program |
| exit | absolute value for floating-point numbers |
| exp | close a file |
| true if at the end-of-file |  |
| fclose | checks for a file error |
| feof | writes the contents of the output buffer |
| ferror | get a character from a stream |
| fflush | get the file position indicator |
| fgetc | get a string of characters from a stream |
| fgetpos | returns the largest integer not greater than a |
| given value |  |
| fgets | returns the remainder of a division |
| floor | open a file |
| print formatted output to a file |  |
| fopen | write a character to a file |
| fprintf | rearns preving to a file |
| fputc | fputs |
| fread |  |
|  |  |


| free | operating system |
| :--- | :--- |
| freopen | open an existing stream with a different name |
| frexp | decomposes a number into scientific notation |
| fscanf | read formatted input from a file |
| fseek | move to a specific location in a file |
| fsetpos | move to a specific location in a file |
| ftell | write to a file |
| fwrite | read a character from a file |
| getc | read a character from STDIN |
| getchar | ret enviornment information about a variable |
| getenv | returns a pointer to the current Greenwich <br> Mean Time <br> gets |
| gmtime if a character is alphanumeric |  |
| isalnum | true if a character is alphabetic |
| isalpha | true if a character is a control character |
| iscntrl | true if a character is a digit |
| isdigit | true if a character is a graphical character |
| isgraph | true if a character is lowercase |
| islower | true if a character is a printing character |
| isprint | true if a character is punctuation |
| ispunct | true if a character is a space character |
| isspace | true if a character is an uppercase character |
| isupper | true if a character is a hexidecimal character |
| isxdigit | absolute value for long integers |
| labs | computes a number in scientific notation |
| Idexp | returns the quotient and remainder of a <br> division, in long integer form |
| Idiv | returns a pointer to the current time |
| localtime |  |
|  |  |


| log | natural logarithm |
| :--- | :--- |
| longjmp | natural logarithm, in base 10 |
| start execution at a certain point in the |  |
| program |  |$|$| malloc | allocates memory |
| :--- | :--- |
| memchr | charaches an array for the first occurance of a |
| memcmp | compares two buffers |
| memcpy | moves one buffer to another |
| memmove | fills a buffer with a character |
| memset | decomposes a number into integer and <br> fractional parts |
| mktime | displays a string version of the current error to <br> STDERR |
| modf | returns a given number raised to another |
| number |  |


| scanf | read formatted input from STDIN |
| :--- | :--- |
| setbuf | set the buffer for a specific stream |
| setjmp | set execution to start at a certain point |
| setlocale | sets the current locale |
| setvbuf | register a function as a signal handler |
| signal | sine |
| sin | hyperbolic sine |
| sinh | square root |
| sprintf | read formatted output to a buffer |
| sqrt | concatenated input from a buffer |
| srand | finds the first occurance of a character in a <br> string |
| sscanf | compares two strings |
| strcat | compares two strings in accordance to the <br> current locale |
| strchr | copies one string to another |
| strcmp | searches one string for any characters in <br> another |
| strcoll | returns a text version of a given error code |
| strcpy | returns individual elements of the date and <br> time |
| strcspn | returns the length of a given string |
| strerror | concatenates a certain amount of characters <br> of two strings |
| strftime | compares a certain amount of characters of <br> two strings |
| strlen | one string to another |
| strncat | strncmp |
| strncpy | sef characters from |
|  |  |


| strpbrk | finds the first location of any character in one <br> string, in another string |
| :--- | :--- |
| strrchr | finds the last occurance of a character in a <br> string |
| strspn | returns the length of a substring of characters <br> of a string |
| strstr | finds the first occurance of a substring of <br> characters |
| strtod | converts a string to a double |
| strtok | finds the next token in a string |
| strtol | converts a string to a long |
| strtoul | converts a substring so that it can be used by <br> string comparison functions |
| strxfrm | perform a system call |
| tangent |  |
| system | hyperbolic tangent |
| tan | returns the current calendar time of the system |
| tanh | return a pointer to a temporary file |
| time | return a unique filename |
| tmpfile | converts a character to lowercase |
| tmpnam | converts a character to uppercase |
| tolower | puts a character back into a stream |
| toupper | use variable length parameter lists |
| ungetc | write formatted output with variable argument <br> lists |
| va_arg | vprintf, vfprintf, and <br> vsprintf |

## Standard C Date \& Time

| asctime | a textual version of the time |
| :--- | :--- |
| clock | returns the amount of time that the program has been <br> running |
| ctime | returns a specifically formatted version of the time |
| difftime | the difference between two times |
| gmtime | returns a pointer to the current Greenwich Mean Time |
| localtime | returns a pointer to the current time |
| mktime | returns the calendar version of a given time |
| setlocale | sets the current locale |
| strftime | returns individual elements of the date and time |
| time | returns the current calendar time of the system |

## Standard C I/O

These functions provide an alternative to the C++ stream-based IO classes.

| clearerr | clears errors |
| :--- | :--- |
| fclose | close a file |
| feof | true if at the end-of-file |
| ferror | checks for a file error |
| fflush | writes the contents of the output buffer |
| fgetc | get a character from a stream |
| fgetpos | get the file position indicator |
| fgets | get a string of characters from a stream |
| fopen | print formatted output to a file |
| fprintf | write a character to a file |
| fputc | write a string to a file |
| fputs | read from a file |
| fread | read formatted input from a file |
| freopen | move to a specific location in a file |
| fscanf | move to a specific location in a file |
| fseek | returns the current file position indicator |
| fsetpos | write to a file |
| ftell | read a character from a file |
| fwrite | read a character from stdin |
| getc | read a string from stdin |
| getchar | displays a string version of the current error to |
| stderr |  |
| gets | write formatted output to stdout |
| perror |  |
| printf |  |


| putc | write a character to a stream |
| :--- | :--- |
| putchar | write a character to stdout |
| puts | write a string to stdout |
| remove | erase a file |
| rename | rename a file |
| rewind | move the file position indicator to the beginning |
| scanf | read formatted input from stdin |
| setbuf | set the buffer for a specific stream |
| setvbuf | write formated output to a buffer (with bound <br> checking) |
| snprintf | write formatted output to a buffer |
| sprintf | read formatted input from a buffer |
| sscanf | return a pointer to a temporary file |
| tmpfile | puts a character back into a stream |
| tmpnam | write formatted output with variable argument <br> lists |
| ungetc | gets formatted input from stdin with variable <br> argument lists |
| vprintf, vfprintf, and |  |
| vsprintf | vscanf, vfscanf, and <br> vsscanf |

## Standard C Math

| abs | absolute value |
| :--- | :--- |
| acos | arc cosine |
| asin | arc sine |
| atan | arc tangent |
| atan2 | arc tangent, using signs to determine quadrants |
| ceil | the smallest integer not less than a certain value |
| cos | cosine |
| cosh | hyperbolic cosine |
| div | returns the quotient and remainder of a division |
| exp | returns "e" raised to a given power |
| fabs | absolute value for floating-point numbers |
| floor | returns the largest integer not greater than a given value |
| fmod | returns the remainder of a division |
| frexp | decomposes a number into scientific notation |
| labs | absolute value for long integers |
| Idexp | computes a number in scientific notation |
| Idiv | returns the quotient and remainder of a division, in long integer <br> form <br> log <br> natural logarithm (to base e) <br> log10 common logarithm (to base 10) |
| modf | decomposes a number into integer and fractional parts |
| pow | returns a given number raised to another number |
| sin | sine |
| sinh | hyperbolic sine |
| sqrt | square root |
| tan | tangent |
| tanh | hyperbolic tangent |
|  |  |

## Compiling with gcc

In order to use some of the above functions, certain versions of the gcc compiler require the math library to be explicitly linked in using the - lm command-line option.

## Standard C Memory

calloc allocates and clears a two-dimensional chunk of memory
free returns previously allocated memory to the operating system malloc allocates memory
realloc changes the size of previously allocated memory

## Other Standard C Functions

| abort | stops the program |
| :--- | :--- |
| assert | stops the program if an expression isn't true |
| atexit | sets a function to be called when the program exits |
| bsearch | perform a binary search |
| exit | stop the program |
| getenv | get enviornment information about a variable |
| longjmp | start execution at a certain point in the program |
| qsort | perform a quicksort |
| raise | send a signal to the program |
| rand | returns a pseudorandom number |
| setjmp | set execution to start at a certain point |
| signal | register a function as a signal handler |
| srand | initialize the random number generator |
| system | have the default command interpreter execute a command |
| va_arg | use variable length parameter lists |

## Standard C String and Character

| atof | converts a string to a double |
| :--- | :--- |
| atoi | converts a string to an integer |
| atol | converts a string to a long |
| isalnum | true if a character is alphanumeric |
| isalpha | true if a character is alphabetic |
| iscntrl | true if a character is a control character |
| isdigit | true if a character is a digit |
| isgraph | true if a character is a graphical character |
| islower | true if a character is lowercase |
| isprint | true if a character is a printing character |
| ispunct | true if a character is punctuation |
| isspace | true if a character is a space character |
| isupper | true if a character is an uppercase character |
| isxdigit | true if a character is a hexidecimal character |
| memchr | searches an array for the first occurance of a character |
| memcmp | compares two buffers |
| memcpy | copies one buffer to another |
| memmove | moves one buffer to another |
| memset | fills a buffer with a character |
| strcat | concatenates two strings |
| strchr | finds the first occurance of a character in a string |
| strcmp | compares two strings |
| strcoll | compares two strings in accordance to the current locale |
| strcpy | copies one string to another |
| strcspn | searches one string for any characters in another |
| strerror | returns a text version of a given error code |
| strlen | returns the length of a given string |
|  |  |


| strncat | concatenates a certain amount of characters of two strings |
| :--- | :--- |
| strncmp | compares a certain amount of characters of two strings |
| strncpy | copies a certain amount of characters from one string to <br> another |
| strpbrk | finds the first location of any character in one string, in <br> another string |
| strrchr | finds the last occurance of a character in a string |
| strspn | returns the length of a substring of characters of a string |
| strstr | finds the first occurance of a substring of characters |
| strtod | converts a string to a double |
| strtok | finds the next token in a string |
| strtol | converts a string to a long |
| strtoul | converts a string to an unsigned long |
| strxfrm | converts a substring so that it can be used by string <br> comparison functions |
| tolower | converts a character to lowercase |
| toupper | converts a character to uppercase |

## asctime

Syntax:

```
#include <ctime>
char *asctime( const struct tm *ptr );
```

The function asctime() converts the time in the struct 'ptr' to a character string of the following format: day month date hours:minutes:seconds year

An example:

## Mon Jun 26 12:03:53 2000

Related Topics: clock, ctime, difftime, gmtime, localtime, mktime, time

## clock

Syntax:

```
#include <ctime>
clock_t clock( void );
```

The clock() function returns the processor time since the program started, or - 1 if that information is unavailable. To convert the return value to seconds, divide it by CLOCKS_PER_SEC. (Note: if your compiler is POSIX compliant, then CLOCKS_PER_SEC is always defined as 1000000.)

Related Topics: asctime, ctime, time

## ctime

Syntax:

```
#include <ctime>
char *ctime( const time_t *time );
```

The ctime() function converts the calendar time time to local time of the format:
day month date hours:minutes:seconds year
using ctime() is equivalent to
asctime( localtime( tp ) );

Related Topics: asctime, clock, gmtime, localtime, mktime, time

## datime

## Example:

```
int datime(int *year,int *mon, int *day)
{
    int i,days;
    int flg,tbl[]={0,31,28,31,30,31,30,31,31,30,31,30,31}
    if (*year%4 == 0) {
        if (*year%400 == 0) flg=1;
        else if (*year%100 == 0) flg=0;
        else flg=1;
    }
    tbl[2]+=flg;
    if (*day &lt; 1) *day=1;
    if (*mon &lt; 1) *mon=1;
    if (*day &gt; tbl[*mon]) {*day=1;(*mon)++ ;}
    if (*mon &gt; 12) {*mon=1;(*year)++;}
    days=*day-1;for (i=1;i &lt; *mon;i++) days+=tbl[i];
    return days;
}
4
```


## difftime

Syntax:

```
\#include <ctime> double difftime( time_t time2, time_t time1 );
```

The function difftime() returns time2-time1, in seconds.

Related Topics: asctime, gmtime, localtime, time

## gmtime

Syntax:

```
#include <ctime>
struct tm *gmtime( const time_t *time );
```

The gmtime() function returns the given time in Coordinated Universal Time (usually Greenwich mean time), unless it's not supported by the system, in which case NULL is returned. Watch out for static_return.

Related Topics: asctime, ctime, difftime, localtime, mktime, strftime, time

## localtime

Syntax:

```
#include <ctime>
struct tm *localtime( const time_t *time );
```

The function localtime() converts calendar time time into local time.

The struct that is returned is statically allocated, and should not be deleted.

For example, the following code uses several of the time-related functions to display the current time:

```
time_t theTime;
time( &theTime ); // get the calendar time
tm *t = localtime( &theTime ); // convert to local
cout << "The time is: " << asctime(t);
```

The above code might display this output:
The time is: Fri Oct 17 08:54:41 2008
Related Topics: asctime, ctime, difftime, gmtime, strftime, time

## mktime

Syntax:

```
#include <ctime>
time_t mktime( struct tm *time );
```

The mktime function converts the local time in time to calendar time, and returns it.

The elements tm_wday and tm_yday of the struct time are recalculated and reset based on the other elements of the struct.

If there is an error, -1 is returned and tm_yday and tm_wday remain unchanged.

Related Topics: asctime, ctime, gmtime, time

## setlocale

Syntax:

```
    #include <clocale>
    char *setlocale( int category, const char * locale );
4.
```

The setlocale function is used to set and retrieve the current locale. If locale is NULL, the current locale is returned. Otherwise, locale is used to set the locale for the given category.

The argument category can have the following values:

| Value | Description |
| :--- | :--- |
| LC_ALL | All of the locale |
| LC_TIME | Date and time formatting |
| LC_NUMERIC | Number formatting |
| LC_COLLATE | String collation and regular expression matching |
| LC_CTYPE | Regular expression matching, conversion, case- <br> sensitive comparison, wide character functions, and <br> character classification. |
| LC_MESSAGES | For natural language messages |

## strftime

Syntax:
\#include <ctime>
size_t strftime( char *str, size_t maxsize, const cha 4

The function strftime() formats date and time information from time to a format specified by fmt, then stores the result in str (up to maxsize characters).

Certain codes may be used in fmt to specify different types of time:

| Code | Meaning |
| :---: | :---: |
| \%a | abbreviated weekday name (e.g. Fri) |
| \%A | full weekday name (e.g. Friday) |
| \%b | abbreviated month name (e.g. Oct) |
| \%B | full month name (e.g. October) |
| \%c | the standard date and time string |
| \%d | day of the month, as a number (1-31) |
| \%H | hour, 24 hour format (0-23) |
| \%I | hour, 12 hour format (1-12) |
| \%j | day of the year, as a number (1-366) |
| \%m | month as a number (1-12). Note: some versions of Microsoft Visual C++ may use values that range from 0-11. |
| \%M | minute as a number (0-59) |
| \%p | locale's equivalent of AM or PM |
| \%S | second as a number (0-59) |
| \%U | week of the year, (0-53), where week 1 has the first Sunday |
| \%w | weekday as a decimal (0-6), where Sunday is 0 |
| \%W | week of the year, (0-53), where week 1 has the first Monday |


| $\% \mathrm{x}$ | standard date string |
| :--- | :--- |
| $\% \mathrm{X}$ | standard time string |
| $\% \mathrm{y}$ | year in decimal, without the century (0-99) |
| $\% \mathrm{Y}$ | year in decimal, with the century |
| $\% Z$ | time zone name |
| $\% \%$ | a percent sign |

The strftime() function returns the number of characters put into str, or zero if an error occurs.

Related Topics: gmtime, localtime, time

## time

Syntax:

```
#include <ctime>
time_t time( time_t *time );
```

The function time() returns the current time, or -1 if there is an error. If the argument 'time' is given, then the current time is stored in 'time'.

Related Topics: asctime, clock, ctime, difftime, gmtime, localtime, mktime, (Other Standard C Functions) srand, strftime

## clearerr

Syntax:

```
#include <cstdio>
void clearerr( FILE *stream );
```

The clearerr function resets the error flags and EOF indicator for the given stream. When an error occurs, you can use perror() to figure out which error actually occurred.

Related Topics: feof, ferror, perror

## fclose

Syntax:

```
#include <cstdio>
int fclose( FILE *stream );
```

The function fclose() closes the given file stream, deallocating any buffers associated with that stream. fclose() returns 0 upon success, and EOF otherwise.

Related Topics: fflush, fopen, freopen, setbuf

## feof

Syntax:

```
#include <cstdio>
int feof( FILE *stream );
```

The function feof() returns a nonzero value if the end of the given file stream has been reached.

Related Topics: clearerr, ferror, getc, perror, putc

## ferror

Syntax:

```
#include <cstdio>
int ferror( FILE *stream );
```

The ferror() function looks for errors with stream, returning zero if no errors have occured, and non-zero if there is an error. In case of an error, use perror() to determine which error has occured.

Related Topics: clearerr, feof, perror

## fflush

## Syntax:

```
#include <cstdio>
int fflush( FILE *stream );
```

If the given file stream is an output stream, then fflush() causes the output buffer to be written to the file.

If the given stream is of the input type, then the behavior of fflush() is undefined.
fflush() is useful when debugging, if a program segfaults before it has a chance to write output to the screen. Calling fflush(stdout) directly after debugging output will ensure that your output is displayed at the correct time.

```
printf( "Before first call\n" );
fflush( stdout );
shady_function();
printf( "Before second call\n" );
fflush( stdout );
dangerous_dereference();
```

See also: http://c-faq.com/stdio/stdinflush.html
Related Topics: fclose, fopen, fread, fpurge, fwrite, getc, putc

## fgetc

Syntax:

```
#include <cstdio>
int fgetc( FILE *stream );
```

The fgetc() function returns the next character from stream, or EOF if the end of file is reached or if there is an error.

Related Topics: fopen, fputc, fread, fwrite, getc, getchar, gets, putc

## fgetpos

Syntax:

```
#include <cstdio>
int fgetpos( FILE *stream, fpos_t *position );
```

The fgetpos() function stores the file position indicator of the given file stream in the given position variable. The position variable is of type fpos_t (which is defined in cstdio) and is an object that can hold every possible position in a FILE. fgetpos() returns zero upon success, and a non-zero value upon failure.

Related Topics: fseek, fsetpos, ftell

## fgets

Syntax:

```
#include <cstdio>
char *fgets( char *str, int num, FILE *stream );
```

The function fgets() reads up to num-1 characters from the given file stream and dumps them into str. The string that fgets() produces is always NULL- terminated. fgets() will stop when it reaches the end of a line, in which case str will contain that newline character. Otherwise, fgets() will stop when it reaches num - 1 characters or encounters the EOF character. fgets() returns str on success, and NULL on an error.

Related Topics: fputs, fscanf, gets, scanf

## fopen

Syntax:

```
#include <cstdio>
FILE *fopen( const char *fname, const char *mode );
```

The fopen() function opens a file indicated by fname and returns a stream associated with that file. mode is used to determine how the file will be treated (i.e. for input, output, etc).

If there is an error, fopen() returns NULL.

| Mode | Meaning |
| :--- | :--- |
| "r" | Open a text file for reading |
| "w" | Create a text file for writing |
| "a" | Append to a text file |
| "rb" | Open a binary file for reading |
| "wb" | Create a binary file for writing |
| "ab" | Append to a binary file |
| "r+" | Open a text file for read/write |
| "w+" | Create a text file for read/write |
| "a+" | Open a text file for read/write |
| "rb+" | Open a binary file for read/write |
| "wb+" | Create a binary file for read/write |
| "ab+" | Open a binary file for read/write |

An example:

```
int ch;
FILE *input = fopen( "stuff", "r" );
ch = getc( input );
```

Related Topics: fclose, fflush, fgetc, fputc, fread, freopen, fseek, fwrite, getc, getchar, setbuf

## fprintf

Syntax:


The fprintf() function sends information (the arguments) according to the specified format to the file indicated by stream. fprintf() works just like printf() as far as the format goes. The return value of fprintf() is the number of characters outputted, or a negative number if an error occurs. An example:

```
char name[] = "Mary";
FILE *out = fopen( "output.txt", "w" );
if( out != NULL )
    fprintf( out, "Hello %s\n", name );
```

Related Topics: fputc, fputs, fscanf, printf, sprintf

## fpurge

Syntax:

```
#include <cstdio>
int fpurge(FILE* stream);
```

The function fpurge() erases any input or output buffered in the given stream. For output streams this discards any unwritten output. For input streams this discards any input read from the underlying object but not yet obtained via getc(); this includes any text pushed back via ungetc().

The fpurge() function is non-standard, and is not recommended even on systems where it's provided.

```
printf( "Before first call\n" );
fpurge( stdout );
shady_function();
printf( "Before second call\n" );
fpurge( stdout );
dangerous_dereference();
```

Related Topics: fclose, fopen, fread, fwrite, fflush, getc, putc

## fputc

Syntax:

```
#include <cstdio>
int fputc( int ch, FILE *stream );
```

The function fputc() writes the given character ch to the given output stream. The return value is the character, unless there is an error, in which case the return value is EOF.

Related Topics: fgetc, fopen, fprintf, fread, fwrite, getc, getchar, putc

## fputs

Syntax:

```
#include <cstdio>
int fputs( const char *str, FILE *stream );
```

The fputs() function writes an array of characters pointed to by str to the given output stream. The return value is non-negative on success, and EOF on failure.

Related Topics: fgets, fprintf, fscanf, gets, puts

## fread

Syntax:


The function fread() reads num number of objects (where each object is size bytes) and places them into the array pointed to by buffer.

The data comes from the given input stream.
The return value of the function is the number of things read. You can use feof or ferror to figure out if an error occurs.

Related Topics: fflush, fgetc, fopen, fputc, fscanf, fwrite, getc, feof, ferror

## freopen

Syntax:


The freopen() function is used to reassign an existing stream to a different file and mode. After a call to this function, the given file stream will refer to fname with access given by mode. The return value of freopen() is the new stream, or NULL if there is an error.

The mode argument shall be used just as in fopen.
Related Topics: fclose, fopen

## fscanf

Syntax:
\#include <cstdio>
int fscanf( FILE *stream, const char *format, ... );
The function fscanf() reads data from the given file stream in a manner exactly like scanf(). The return value of fscanf() is the number of variables that are actually assigned values, or EOF if no assignments could be made.

Related Topics: fgets, fprintf, fputs, fread, fwrite, scanf, sscanf

## fseek

Syntax:

```
#include <cstdio>
int fseek( FILE *stream, long offset, int origin );
```

The function fseek() sets the file position data for the given stream.
The origin value should have one of the following values (defined in cstdio):

| Name | Explanation |
| :--- | :--- |
| SEEK_SET | Seek from the start of the file |
| SEEK_CUR | Seek from the current location |
| SEEK_END | Seek from the end of the file |

fseek() returns zero upon success, non-zero on failure. You can use fseek() to move beyond a file, but not before the beginning. Using fseek() clears the EOF flag associated with that stream.

Related Topics: fgetpos, fopen, fsetpos, ftell, rewind, fread

## fsetpos

Syntax:

```
#include <cstdio>
int fsetpos( FILE *stream, const fpos_t *position );
```

The fsetpos() function moves the file position indicator for the given stream to a location specified by the position object. fpos_t is defined in cstdio. The return value for fsetpos() is zero upon success, non-zero on failure.

Related Topics: fgetpos, fseek, ftell

## ftell

## Syntax:

```
#include <cstdio>
long ftell( FILE *stream );
```

The ftell() function returns the current file position for stream, or -1 if an error occurs.

Related Topics: fgetpos, fseek, fsetpos

## fwrite

Syntax:


The fwrite() function writes, from the array buffer, count objects of size size to stream. The return value is the number of objects written.

Related Topics: fflush, fgetc, fopen, fputc, fread, fscanf, getc

## getc

Syntax:

```
#include <cstdio>
int getc( FILE *stream );
```

The getc() function returns the next character from stream, or EOF if the end of file is reached. getc() is identical to fgetc(). For example:

```
int ch;
FILE *input = fopen( "stuff", "r" );
ch = getc( input );
while( ch != EOF ) {
        printf( "%c", ch );
        ch = getc( input );
}
```

Related Topics: feof, fflush, fgetc, fopen, fputc, fread, fwrite, putc, ungetc

## getchar

Syntax:

```
#include <cstdio>
int getchar( void );
```

The getchar() function returns the next character from stdin, or EOF if the end of file is reached.

Related Topics: fgetc, fopen, fputc, putc

## gets

Syntax:

```
#include <cstdio>
char *gets( char *str );
```

The gets() function reads characters from stdin and loads them into str, until a newline or EOF is reached. The newline character is translated into a null termination. The return value of gets() is the read-in string, or NULL if there is an error. Note that gets() does not perform bounds checking, and thus risks overrunning str. For a similar (and safer) function that includes bounds checking, see fgets().

Related Topics: fgetc, fgets, fputs, puts

## perror

## Syntax:

```
#include <cstdio>
void perror( const char *str );
```

The perror() function prints str and an implementation-defined error message corresponding to the global variable errno. For example:

```
char* input_filename = "not_found.txt";
FILE* input = fopen( input_filename, "r" );
if( input == NULL ) {
    char error_msg[255];
    sprintf( error_msg, "Error opening file '%s'", inpu
    perror( error_msg );
    exit( -1 );
}
4.
```

If the file called not_found.txt is not found, this code will produce the following output:


Related Topics: clearerr, feof, ferror

## printf

Syntax:

```
#include <cstdio>
int printf( const char *format, ... );
```

The printf() function prints output to stdout, according to format and other arguments passed to printf(). The string format consists of two types of items - characters that will be printed to the screen, and format commands that define how the other arguments to printf() are displayed. Basically, you specify a format string that has text in it, as well as "special" characters that map to the other arguments of printf(). For example, this code

displays the following output:

## Hello Bob, you are 21 years old

The \%s means, "insert the first argument, a string, right here." The \%d indicates that the second argument (an integer) should be placed there. There are different \%-codes for different variable types, as well as options to limit the length of the variables and whatnot.

| Code | Format |
| :--- | :--- |
| \%c | character |
| \%d | signed integers |
| \%i | signed integers |
| \%e | scientific notation, with a lowercase "e" |


| \%E | scientific notation, with a uppercase "E" |
| :--- | :--- |
| $\% f$ | floating point |
| $\% g$ | use \%e or \%f, whichever is shorter |
| $\% G$ | use \%E or \%f, whichever is shorter |
| $\% \mathrm{o}$ | octal |
| \%s | a string of characters |
| \%u | unsigned integer |
| \%x | unsigned hexadecimal, with lowercase letters |
| \%X | unsigned hexadecimal, with uppercase letters |
| \%p | a pointer |
| \%n | the argument shall be a pointer to an integer into which is placed <br> the number of characters written so far |

An integer placed between a \% sign and the format command acts as a minimum field width specifier, and pads the output with spaces or zeros to make it long enough. If you want to pad with zeros, place a zero before the minimum field width specifier:
\%012d

You may also specify the minimum field width in an int variable if instead of a number you put the * sign:

```
int width = 12;
int age = 100;
printf("%*d", width, age);
```

You can also include a precision modifier, in the form of a N where N is some number, before the format command:

$$
\% 012.4 \mathrm{~d}
$$

The precision modifier has different meanings depending on the format command being used:

- With \%e, \%E, and \%f, the precision modifier lets you specify the number of decimal places desired. For example, $\% 12.6$ f will display a floating number at least 12 digits wide, with six decimal places.
- With $\%$ g and $\%$ G, the precision modifier determines the maximum number of significant digits displayed.
- With \%s, the precision modifier simply acts as a maximum field length, to complement the minimum field length that precedes the period.

As with field width specifier, you may use an int variable to specify the precision modifier by using the * sign:

```
const char* msg = "Hello printf";
int string_size = strlen (msg);
printf("msg: %.*s", string_size, msg);
```

All of printf()'s output is right-justified, unless you place a minus sign right after the $\%$ sign. For example,

## $\%-12.4 f$

will display a floating point number with a minimum of 12 characters, 4 decimal places, and left justified.

You may modify the \%d, \%i, \%o, \%u, and \%x type specifiers with the letter I and the letter h to specify long and short data types (e.g. \%hd means a short integer).

The \%e, \%f, and \%g type specifiers can have the letter I before them to indicate that a double follows. The \%g, \%f, and \%e type specifiers can be preceded with the character '\#' to ensure that the decimal point will be present, even if there are no decimal digits.

The use of the '\#' character with the \%x type specifier indicates that the
hexidecimal number should be printed with the ' $0 x$ ' prefix.
The use of the '\#' character with the \%o type specifier indicates that the octal value should be displayed with a 0 prefix.

Inserting a plus sign '+' into the type specifier will force positive values to be preceded by a '+' sign. Putting a space character ' ' there will force positive values to be preceded by a single space character.

You can also include constant escape sequences in the output string. The return value of printf() is the number of characters printed, or a negative number if an error occurred.

Related Topics: fprintf, puts, scanf, sprintf

## putc

Syntax:

```
#include <cstdio>
int putc( int ch, FILE *stream );
```

The putc() function writes the character ch to stream. The return value is the character written, or EOF if there is an error. For example:

```
int ch;
FILE *input, *output;
input = fopen( "tmp.c", "r" );
output = fopen( "tmpCopy.c", "w" );
ch = getc( input );
while( ch != EOF ) {
    putc( ch, output );
    ch = getc( input );
}
fclose( input );
fclose( output );
```

generates a copy of the file tmp.c called tmpCopy.c.
Related Topics: feof, fflush, fgetc, fputc, getc, getchar, putchar, puts

## putchar

Syntax:

```
#include <cstdio>
int putchar( int ch );
```

The putchar() function writes ch to stdout. The code
putchar( ch );
is the same as
putc( ch, stdout );

The return value of putchar() is the written character, or EOF if there is an error.

Related Topics: putc

## puts

Syntax:

```
#include <cstdio>
int puts( char *str );
```

The function puts() writes str to stdout. puts() returns non-negative on success, or EOF on failure.

Related Topics: fputs, gets, printf, putc

## remove

Syntax:

```
#include <cstdio>
int remove( const char *fname );
```

The remove() function erases the file specified by fname. The return value of remove() is zero upon success, and non-zero if there is an error.

Related Topics: rename

## rename

Syntax:


The function rename() changes the name of the file oldfname to newfname. The return value of rename() is zero upon success, nonzero on error.

Related Topics: remove

## rewind

Syntax:

```
#include <cstdio>
void rewind( FILE *stream );
```

The function rewind() moves the file position indicator to the beginning of the specified stream, also clearing the error and EOF flags associated with that stream.

Related Topics: fseek

## scanf

Syntax:

```
#include <cstdio>
int scanf( const char *format, ... );
```

The scanf() function reads input from stdin, according to the given format, and stores the data in the other arguments. It works a lot like printf().

The format string consists of control characters, whitespace characters, and non- whitespace characters. The control characters are preceded by a \% sign, and are as follows:

| Control <br> Character | Explanation |
| :--- | :--- |
| \%c | a single character |
| \%d | a decimal integer |
| \%i | an integer |
| \%e, \%f, \%g | a floating-point number |
| \%lf | a double |
| \%o | an octal number |
| \%s | a string |
| \%x | a hexadecimal number |
| \%p | a pointer |
| \%n | an integer equal to the number of characters read <br> so far |
| \%u | an unsigned integer |
| \%[] | a set of characters |
| \%\% | a percent sign |

scanf() reads the input, matching the characters from format. When a control character is read, it puts the value in the next variable.
Whitespace (tabs, spaces, etc) are skipped. Non-whitespace characters are matched to the input, then discarded. If a number comes between the \% sign and the control character, then only that many characters will be converted into the variable. If scanf() encounters a set of characters, denoted by the \%[] control character, then any characters found within the brackets are read into the variable. The return value of scanf() is the number of variables that were successfully assigned values, or EOF if there is an error.

The following code snippet uses scanf() to read an int, float, and a double from the user. Note that the variable arguments to scanf() are passed in by address, as denoted by the ampersand (\&) preceding each variable:

```
int i;
float f;
double d;
printf( "Enter an integer: " );
scanf( "%d", &i );
printf( "Enter a float: " );
scanf( "%f", &f );
printf( "Enter a double: " );
scanf( "%lf", &d );
printf( "You entered %d, %f, and %f\n", i, f, d );
```

Related Topics: fgets, fscanf, printf, sscanf

## setbuf

Syntax:

```
#include <cstdio>
void setbuf( FILE *stream, char *buffer );
```

The setbuf() function sets stream to use buffer, or, if buffer is null, turns off buffering. If a non-standard buffer size is used, it should be BUFSIZ characters long.

Related Topics: fclose, fopen, setvbuf

## setvbuf

Syntax:


The function setvbuf() sets the buffer for stream to be buffer, with a size of size. mode can be:

* _IOFBF, which indicates full buffering * _IOLBF, which means line buffering * _IONBF, which means no buffering

Related Topics: setbuf

## snprintf

Syntax:


The snprintf() function is just like sprintf(), except that the length of the buffer is given. This prevents buffer overflows.

The return value is the number of characters written. If the output was truncated due to buff_size limit then the return value is the number of characters (not including the trailing ' 10 ') which would have been written to the final string if enough space had been available.

Related Topics: sprintf, atof, atoi, atol, fprintf, printf

## sprintf

Syntax:
\#include <cstdio>
int sprintf( char *buffer, const char *format, ... );

The sprintf() function is just like printf(), except that the output is sent to buffer. The return value is the number of characters written. For example:

```
char string[50];
int file_number = 0;
sprintf( string, "file.%d", file_number );
file_number++;
output_file = fopen( string, "w" );
```

Note that sprintf() does the opposite of a function like atoi() - where atoi() converts a string into a number, sprintf() can be used to convert a number into a string. For example, the following code uses sprintf() to convert an integer into a string of characters:

```
char result[100];
int num = 24;
sprintf( result, "%d", num );
```

This code is similar, except that it converts a floating-point number into an array of characters:

```
char result[100];
float fnum = 3.14159;
sprintf( result, "%f", fnum );
```

Note that this function does not check the bounds of the buffer and
therefore creates the risk of a buffer overflow. A secure alternative is snprintf

Related Topics: snprintf, atof, atoi, atol, fprintf, printf

## sscanf

Syntax:


The function sscanf() is just like scanf(), except that the input is read from buffer.

Related Topics: fscanf, scanf

## tmpfile

Syntax:

$$
\begin{aligned}
& \text { \#include <cstdio> } \\
& \text { FILE *tmpfile( void ); }
\end{aligned}
$$

The function tmpfile() opens a temporary file with an unique filename and returns a pointer to that file. If there is an error, null is returned.

Related Topics: tmpnam

## tmpnam

Syntax:

```
#include <cstdio>
char *tmpnam( char *name );
```

The tmpnam() function creates an unique filename and stores it in name. tmpnam () can be called up to TMP_MAX times.

Related Topics: tmpfile

## ungetc

Syntax:

```
#include <cstdio>
int ungetc( int ch, FILE *stream );
```

The function ungetc() puts the character ch back in stream.
Related Topics: getc, (C++ I/O) putback

## vprintf, vfprintf, and vsprintf

Syntax:

```
    #include <cstdarg>
    #include <cstdio>
    int vprintf( char *format, va_list arg_ptr );
    int vfprintf( FILE *stream, const char *format, va_li
    int vsprintf( char *buffer, char *format, va_list arg.
|
```

These functions are very much like printf(), fprintf(), and sprintf(). The difference is that the argument list is a pointer to a list of arguments. va_list is defined in cstdarg, and is also used by va_arg. For example:

```
void error( char *fmt, ... ) {
    va_list args;
    va_start( args, fmt );
    fprintf( stderr, "Error: " );
    vfprintf( stderr, fmt, args );
    fprintf( stderr, "\n" );
    va_end( args );
    exit( 1 );
}
```


## vscanf, vfscanf and vsscanf

Syntax:

```
    #include <cstdarg>
    #include <cstdio>
    int vscanf( char *format, va_list arg_ptr );
    int vfscanf( FILE *stream, const char *format, va_lis
    int vsscanf( char *buffer, char *format, va_list arg_
|
```

These functions are very much like scanf(), fscanf(), and sscanf(). The difference is that the argument list is a pointer to a list of arguments. va_list is defined in cstdarg, and is also used by va_arg. For example:

```
int scanf_( char *fmt, ... ) {
    va_list args;
    va_start( args, fmt );
    int r = vscanf(frmt, args);
    scanf("%*[^\n]"), getchar(); //Empty buffer
    va_end( args );
    return r;
}
```


## abs

Syntax:

```
#include <cstdlib>
int abs( int num );
```

The abs() function returns the absolute value of num. For example:

```
int magic_number = 10;
cout << "Enter a guess: ";
cin >> x;
cout << "Your guess was " << abs( magic_number - x )
    magic number." << endl;
4 !
```

Related Topics: fabs, labs

## acos

Syntax:

```
#include <cmath>
double acos( double arg );
```

The acos() function returns the arc cosine of arg, which will be in the range [0, pi]. arg should be between -1 and 1 . If arg is outside this range, acos() returns NAN and raises a floating-point exception.

Related Topics: asin, atan, atan2, cos, cosh, sin, sinh, tan, tanh

## asin

Syntax:

```
#include <cmath>
double asin( double arg );
```

The asin() function returns the arc sine of arg, which will be in the range [- pi/2, +pi/2]. arg should be between -1 and 1. If arg is outside this range, asin() returns NAN and raises a floating-point exception.

Related Topics: acos, atan, atan2, cos, cosh, sin, sinh, tan, tanh

## atan

## Syntax:

```
#include <cmath>
double atan( double arg );
```

The function atan() returns the arc tangent of arg, which will be in the range [-pi/2, +pi/2].

Related Topics: acos, asin, atan2, cos, cosh, sin, sinh, tan, tanh

## atan2

Syntax:

```
#include <cmath>
double atan2( double y, double x );
```

The atan2() function computes the arc tangent of $y / x$, using the signs of the arguments to compute the quadrant of the return value. The returned values are in the range [-pi, pi]. Note the order of the arguments passed to this function.

Related Topics: acos, asin, atan, cos, cosh, sin, sinh, tan, tanh

## ceil

Syntax:

```
#include <cmath>
double ceil( double num );
```

The ceil() function returns the smallest integer no less than num. For example,

$$
\begin{aligned}
& y=6.04 ; \\
& x=\operatorname{ceil}(\mathrm{y}) ;
\end{aligned}
$$

would set x to 7.0 .

Related Topics: floor, fmod

## COS

Syntax:

```
#include <cmath>
double cos( double arg );
```

The $\cos ()$ function returns the cosine of arg, where arg is expressed in radians. The return value of $\cos ()$ is in the range $[-1,1]$. If arg is infinite, $\cos ()$ will return NAN and raise a floating-point exception.

Related Topics: acos, asin, atan, atan2, cosh, sin, sinh, tan, tanh

## cosh

Syntax:

```
#include <cmath>
double cosh( double arg );
```

The function cosh() returns the hyperbolic cosine of arg.

Related Topics: acos, asin, atan, atan2, cos, sin, sinh, tan, tanh

## div

Syntax:
\#include <cstdlib> div_t div( int numerator, int denominator );

The function $\operatorname{div}()$ returns the quotient and remainder of the operation numerator / denominator. The div_t structure is defined in cstdlib, and has at least:

```
int quot; // The quotient
int rem; // The remainder
```

For example, the following code displays the quotient and remainder of $x / y$ :


Related Topics: Idiv

## exp

Syntax:

> \#include <cmath>
> double exp( double arg );

The $\exp ()$ function returns e (2.7182818) raised to the argth power.
Related Topics: log, pow, sqrt

## fabs

Syntax:

```
#include <cmath>
double fabs( double arg );
```

The function fabs() returns the absolute value of arg.
Related Topics: abs, fmod, labs
double factorial (float num) \{
if(num > 1)
return num*factorial(num-1);
return 1;
\}

## floor

Syntax:

```
#include <cmath>
double floor( double arg );
```

The function floor() returns the largest integer not greater than arg. For example,

$$
\begin{aligned}
& y=6.04 ; \\
& x=\text { floor }(y) \text { ) }
\end{aligned}
$$

would result in $x$ being set to 6.0.
Related Topics: ceil, fmod

## fmod

Syntax:
\#include <cmath>
double fmod( double $x$, double $y$ );
The fmod() function returns the remainder of $\mathrm{x} / \mathrm{y}$.
Related Topics: ceil, fabs, floor

Purpose：Change a float number to a string with n numbers proceeding the dot and $n$ numbers come after the dot．

```
==ニ==ニ==ニ==ニ=============================================
```

void fmtchg(float a,char *str,int n,int m) \{
int i,j,ctr,sign;long d;
char c,*tmp;

```
ctr=0;tmp=str;sign=0;
if (a < 0.0) {sign=-1;a=-a;ctr++;}
for (i=0;i < m;i++) a=a*10.0;d=a+0.5;i=0;
while(1) {
if (d == 0L && i > m) break;
    j=d%10L;*tmp++='0'+j;d/=10L;i++;if (++ctr >= n) br&
    if (i == m) {*tmp++='.';if (++ctr >= n) break;}
}
```

if (sign == -1) *tmp++='-';
while (ctr++ < n) *tmp++=' ';*tmp='\0';
for (i=0;i < n/2;i++) \{
c=*(str+i) ;*(str+i)=*(tmp-i-1);*(tmp-i-1)=c;
\}
\}

## frexp

Syntax:

```
#include <cmath>
double frexp( double num, int* exp );
```

The function frexp() is used to decompose num into two parts: a mantissa between 0.5 and 1 (returned by the function) and an exponent returned as exp. Scientific notation works like this:

$$
\text { num }=\text { mantissa * (2 ^ exp) }
$$

Related Topics: Idexp, modf
int hexchk(char *chr) \{
int c;

```
while (*chr != '\0') {
    c=*chr++;
    //printf("%d,%c%x\r\n", c,c,c);
    //if (c == ' ') continue;
    //else if (c >= '0' && c <= '9') continue;
    //else if (c >= 'a' && c <= 'f') continue;
    //else if (c >= 'A' && c <= 'F') continue;
    if (c >= '0' && c <= '9') continue;
    else return 1;
}
return 0;
```

\}

## labs

Syntax:
\#include <cstdlib>
long labs( long num );
The function labs() returns the absolute value of num.
Related Topics: abs, fabs

## Idexp

Syntax:

> \#include <cmath>
> double ldexp( double num, int exp );

The $\operatorname{ldexp}()$ function returns num * ( $\left.2^{\wedge} \exp \right)$. And get this: if an overflow occurs, HUGE_VAL is returned.

Related Topics: frexp, modf

## Idiv

Syntax:

```
#include <cstdlib>
ldiv_t ldiv( long numerator, long denominator );
```

Testing: adiv_t, div_t, Idiv_t. The Idiv() function returns the quotient and remainder of the operation numerator / denominator. The Idiv_t structure is defined in cstdlib and has at least:

```
long quot; // the quotient
long rem; // the remainder
```

Related Topics: div

## log

Syntax:

```
#include <cmath>
double log( double num );
```

The function $\log ()$ returns the natural (base e) logarithm of num. There's a domain error if num is negative, a range error if num is zero. In order to calculate the logarithm of $x$ to an arbitrary base $b$, you can use:

$$
\text { double answer }=\log (x) / \log (b) \text {; }
$$

Related Topics: exp, log10, pow, sqrt

## $\log 10$

Syntax:

> \#include <cmath>
> double log10( double num );

The log10() function returns the base 10 (or common) logarithm for num. There's a domain error if num is negative, a range error if num is zero.

Related Topics: log

## modf

Syntax:

```
#include <cmath>
double modf( double num, double *i );
```

The function modf() splits num into its integer and fraction parts. It returns the fractional part and loads the integer part into i.

Related Topics: frexp, Idexp

## pow

Syntax:

```
#include <cmath>
double pow( double base, double exp );
```

The pow() function returns base raised to the expth power. There's a domain error if base is zero and exp is less than or equal to zero. There's also a domain error if base is negative and exp is not an integer. There's a range error if an overflow occurs.

Related Topics: exp, log, sqrt

## $\sin$

Syntax:

```
#include <cmath>
double sin( double arg );
```

The function sin returns the sine of arg, where arg is given in radians. The return value of sin will be in the range [-1,1]. If arg is infinite, sin will return NAN and raise a floating-point exception.

One possible way to approximate the sine function using the Taylor series takes advantage of the fact that $\sin (x)=x-x^{3} / 3!+x^{5} / 5!-x^{7} / 7!+$ ..., yielding the following code:

```
long factrl(int n) {
    long la = 1;
    for( int i = 2; i <= n; i++ ) la *= i;
    return la;
}
float sin2(float x) {
    int i;
    float y=x ,r=x;
    for( int i=0; i < 10; i++ ) {
        y *= -x*x;
        r += 1.0 / factrl( 1+2*(i+1) ) * y;
    }
    return r;
}
float sin(float theta) {
    float sign = 1, x = theta/M_PI;
    if (x < 0.0) {
        sign = -1;
        x = -x;
    }
    int i = static_cast<int>(x+0.5);
    float a = x-i;
    if( (i-i/2*2) != 0 ) sign = -sign;
    return sign * sin2(a*M_PI);
}
```

Related Topics: acos, asin, atan, atan2, cos, cosh, sinh, tan, tanh

## sinh

Syntax:

```
#include <cmath>
double sinh( double arg );
```

The function $\sinh ()$ returns the hyperbolic sine of arg.
Related Topics: acos, asin, atan, atan2, cos, cosh, sin, tan, tanh

$$
\sin (x)=x-x 3 / 3!+x 5 / 5!-x 7 / 7!\ldots
$$

// float $\sin ($ float theta) $\{$ int $i ;$ float sign, $x, a ;$ //

```
x=theta/M_PI;if (x < 0.0) {sign=-1;x=-x;} else sign=+1;
i=(int)(x+0.5);a=x-i;if ((i-i/2*2) != 0) sign=-sign;
return sign*sin2(a*M_PI);
```

\} // float sin2(float $x$ ) \{ int i;float $y, r ; / /$

```
r=x;y=x;
for (i=0;i < 10;i++) {y*=-x*x;r+=1.0/factrl(1+2*(i+1))*y;}
return r;
|
```

\} // long factrl(int n) \{ int i; long la;la=1;for (i=2;i $\Leftarrow \mathbf{n ; i + + ) ~ l a * = i ; r e t u r n ~}$ la; \} I/

## sqrt

Syntax:
\#include <cmath>
double sqrt( double num );
The sqrt() function returns the square root of num. If num is negative, a domain error occurs.

Related Topics: exp, log, pow

## tan

Syntax:

```
#include <cmath>
double tan( double arg );
```

The tan() function returns the tangent of arg, where arg is given in radians. If arg is infinite, $\tan ()$ will return NAN and raise a floating-point exception.

Related Topics: acos, asin, atan, atan2, cos, cosh, sin, sinh, tanh

## tanh

Syntax:

```
#include <cmath>
double tanh( double arg );
```

The function tanh() returns the hyperbolic tangent of arg.

Related Topics: acos, asin, atan, atan2, cos, cosh, sin, sinh, tan
float expdcm(int y) \{

```
int i;float a;
a=1.0;if (y > 0) for (i=0;i < y;i++) a*=10.0;
    if (y < 0) for (i=0;i > y;i--) a/=10.0;
return a;
```

\}
int cvalue(char *str,float *a,int *intflg) \{

```
int c,ist,err;
int ix,ie;
int ictr1,ictr2;
```

float dx;

- a=0.0;*intflg=ON;
ie=0;ist=0;err=0;

```
ictr1=0;ictr2=0;
```

```
while ((c=(*str++)) != '\0') {
    if (c >= '0' && c <= '9') { //only (
    ix=c-'0';dx=ix;
    if (ist >= 0 && ist <= 2) {
                                *a=*a*10.0+dx;
                                if (ictr1 != 0 || c != '0') ictr1+-
                                ist=2;
    }
    else if (ist >= 3 && ist <= 4) {
        ictr2++;
        *a=*a+dx*expdcm(-ictr2);
        ist=4;
        intflg=OFF;
    }
    else {
        err=3;*a=0.0;
                                return err;
    }
    }
4 - 
    else if (c == '.') {
    if (ist >= 0 && ist <= 2) {
                                    ist=3;
                                    *intflg=OFF;
    }
        else { //:
        err=7;*a=0.0;
                        return err;
    }
    }
    else { //t
        err=1;*a=0.0;
        return err;
    }
}
if ((ist >= 2 && ist <= 4)) {
4|
```

- a=*a*expdcm(ie);
err=0;

```
                        if ((*a-(int)(*a)) != 0.0) *intflg=OFF;
                        return err;
    }
    else {
        err=2;*a=0.0;
        return err;
    }
}
=============================================================
Purpose: Change a string to a float number
```



``` int value(char *str,float *a) \{
```

```
    int intflg;
```

    int intflg;
    return cvalue(str,a,&intflg);
    }

```

\section*{calloc}

Syntax:
```

\#include <cstdlib>
void* calloc( size_t num, size_t size );

```

The calloc() function returns a pointer to space for an array of num objects, each of size size. The newly allocated memory is initialized to zero. calloc() returns NULL if there is an error.

Related Topics: free, malloc, realloc

\section*{free}

Syntax:
```

\#include <cstdlib>
void free( void* ptr );

```

The free() function deallocates the space pointed to by ptr, freeing it up for future use. ptr must have been used in a previous call to malloc(), calloc(), or realloc(). An example:
```

typedef struct data_type {
int age;
char name[20];
} data;
data *willy;
willy = (data*) malloc( sizeof(*willy) );
free( willy );

```

Related Topics: calloc, delete, malloc, new, realloc

\section*{malloc}

Syntax:
```

\#include <cstdlib>
void *malloc( size_t size );

```

The function malloc() returns a pointer to a chunk of memory of size size, or NULL if there is an error. The memory pointed to will be on the heap, not the stack, so make sure to free it when you are done with it. An example:

Related Topics: calloc, delete, free, new, realloc

\section*{realloc}

Syntax:
```

\#include <cstdlib>
void *realloc( void *ptr, size_t size );

```

The realloc() function changes the size of the object pointed to by ptr to the given size. size can be any size, larger or smaller than the original. The return value is a pointer to the new space, or NULL if there is an error. If ptr is NULL, realloc() acts just like malloc, creating a new memory space and returning the pointer to that new location.

Related Topics: calloc, free, malloc

\section*{abort}

Syntax:

> \#include <cstdlib> void abort( void );

The function abort() terminates the current program. Depending on the implementation, the return value can indicate failure.

Related Topics: assert, atexit, exit

\section*{assert}

Syntax:
\[
\begin{aligned}
& \text { \#include <cassert> } \\
& \text { assert( exp ); }
\end{aligned}
\]

The assert() macro is used to test for errors. If exp evaluates to zero, assert () writes information to stderr and exits the program. If the macro NDEBUG is defined, the assert() macros will be ignored.

Related Topics: abort

\section*{atexit}

Syntax:
```

\#include <cstdlib>
int atexit( void (*func)(void) );

```

The function atexit() causes the function pointed to by func to be called when the program terminates. You can make multiple calls to atexit() (at least 32, depending on your compiler) and those functions will be called in reverse order of their establishment. The return value of atexit() is zero upon success, and non-zero on failure.

Related Topics: abort, exit

\section*{bsearch}

Syntax:
```

    #include <cstdlib>
    void *bsearch( const void *key, const void *buf, size.
    int (*compare)(const void *, const void *) );
    |

```

The bsearch() function searches buf[0] to buf[num-1] for an item that matches key, using a binary search. The function compare should return negative if its first argument is less than its second, zero if equal, and positive if greater. The items in the array buf should be in ascending order. The return value of bsearch() is a pointer to the matching item, or NULL if none is found.

Related Topics: qsort

\section*{exit}

Syntax:
```

\#include <cstdlib>
void exit( int exit_code );

```

The exit() function stops the program. exit_code is passed on to be the return value of the program, where usually zero indicates success and non-zero indicates an error.

Related Topics: abort, atexit, system

\section*{getenv}

Syntax:
```

\#include <cstdlib>
char *getenv( const char *name );

```

The function getenv() returns environmental information associated with name, and is very implementation dependent. NULL is returned if no information about name is available.

Related Topics: system

\section*{longjmp}

Syntax:
```

\#include <csetjmp>
void longjmp( jmp_buf envbuf, int status );

```

The function longjmp() causes the program to start executing code at the point of the last call to setjmp(). envbuf is usually set through a call to setjmp(). status becomes the return value of setjmp() and can be used to figure out where longjmp() came from. status should not be set to zero.

Related Topics: setjmp

\section*{qsort}

Syntax:


The qsort() function sorts buf (which contains num items, each of size size) using Quicksort. The compare function is used to compare the items in buf. compare should return negative if the first argument is less than the second, zero if they are equal, and positive if the first argument is greater than the second. qsort() sorts buf in ascending order.

For example, the following bit of code uses qsort() to sort an array of integers:
```

    int compare_ints( const void* a, const void* b ) {
    int* arg1 = (int*) a;
    int* arg2 = (int*) b;
    if( *arg1 < *arg2 ) return -1;
    else if( *arg1 == *arg2 ) return 0;
    else return 1;
    }
int array[] = { -2, 99, 0, -743, 2, 3, 4 };
int array_size = 7;
printf( "Before sorting: " );
for( int i = 0; i < array_size; i++ ) {
printf( "%d ", array[i] );
}
printf( "\n" );
qsort( array, array_size, sizeof(int), compare_ints );
printf( "After sorting: " );
for( int i = 0; i < array_size; i++ ) {
printf( "%d ", array[i] );
}
printf( "\n" );
4

```

When run, this code displays the following output:
```

Before sorting: -2 99 0 -743 2 3 4
After sorting: -743 -2 0 2 3 4 99

```

Related Topics: bsearch, sort

\section*{raise}

Syntax:
```

\#include <csignal>
int raise( int signal );

```

The raise() function sends the specified signal to the program. Some signals:
\begin{tabular}{|l|l|}
\hline \multicolumn{1}{|c|}{ Signal } & \multicolumn{1}{c|}{ Meaning } \\
\hline SIGABRT & Termination error \\
\hline SIGFPE & Floating pointer error \\
\hline SIGILL & Bad instruction \\
\hline SIGINT & User pressed CTRL-C \\
\hline SIGSEGV & Illegal memory access \\
\hline SIGTERM & Terminate program \\
\hline
\end{tabular}

The return value is zero upon success, nonzero on failure.
Related Topics: signal

\section*{rand}

\section*{Syntax:}
```

\#include <cstdlib>
int rand( void );

```

The function rand() returns a pseudorandom integer between zero and RAND_MAX. An example:
```

srand( time(NULL) );
for( i = 0; i < 10; i++ )
printf( "Random number \#%d: %d\n", i, rand() );

```

Related Topics: srand

\section*{setjmp}

Syntax:
```

\#include <csetjmp>
int setjmp( jmp_buf envbuf );

```

The setjmp() function saves the system stack in envbuf for use by a later call to longjmp(). When you first call setjmp(), its return value is zero. Later, when you call longjmp(), the second argument of longjmp() is what the return value of setjmp() will be. Confused? Read about longjmp().

Related Topics: longjmp

\section*{signal}

Syntax:


The signal() function sets func to be called when signal is recieved by your program. func can be a custom signal handler, or one of these macros (defined in the csignal header file):
\begin{tabular}{|c|c|}
\hline Macro & Explanation \\
\hline SIG_DFL & default signal handling \\
\hline SIG_IGN & ignore the signal \\
\hline
\end{tabular}

Some basic signals that you can attach a signal handler to are:
\begin{tabular}{|l|l|}
\hline \multicolumn{1}{|c|}{ Signal } & \multicolumn{1}{c|}{ Description } \\
\hline SIGTERM & Generic stop signal that can be caught. \\
\hline SIGINT & Interrupt program, normally ctrl-c. \\
\hline SIGQUIT & Interrupt program, similar to SIGINT. \\
\hline SIGKILL & Stops the program. Cannot be caught. \\
\hline SIGHUP & Reports a disconnected terminal. \\
\hline
\end{tabular}

The return value of signal() is the address of the previously defined function for this signal, or SIG_ERR is there is an error.

For example, the following example uses the signal() function to call an arbitrary number of functions when the user aborts the program. The functions are stored in a vector, and a single "clean-up" function calls each function in that vector of functions when the program is aborted:
```

loid f1() {
void f2() {
cout << "calling f2()..." << endl;
}
typedef void(*endFunc)(void);
vector<endFunc> endFuncs;
void cleanUp( int dummy ) {
for( unsigned int i = 0; i < endFuncs.size(); i++ )
endFunc f = endFuncs.at(i);
(*f)();
}
exit(-1);
}
int main() {
// connect various signals to our clean-up function
signal( SIGTERM, cleanUp );
signal( SIGINT, cleanUp );
signal( SIGQUIT, cleanUp );
signal( SIGHUP, cleanUp );
// add two specific clean-up functions to a list of
endFuncs.push_back( f1 );
endFuncs.push_back( f2 );
// loop until the user breaks
while( 1 );

Related Topics: raise

## srand

Syntax:

```
#include <cstdlib>
void srand( unsigned seed );
```

The function srand() is used to seed the random sequence generated by rand(). For any given seed, rand() will generate a specific "random" sequence over and over again.

```
srand( time(NULL) );
for( i = 0; i < 10; i++ )
    printf( "Random number #%d: %d\n", i, rand() );
```

Related Topics: rand, (Standard C Date \& Time) time

## system

Syntax:

```
#include <cstdlib>
int system( const char *command );
```

The system() function runs the given command by passing it to the default command interpreter. The return value is usually zero if the command executed without errors. If command is NULL, system() will test to see if there is a command interpreter available. Non-zero will be returned if there is a command interpreter available, zero if not.

Related Topics: exit, getenv

## va_arg

Syntax:

```
#include <cstdarg>
type va_arg( va_list argptr, type );
void va_end( va_list argptr );
void va_start( va_list argptr, last_parm );
```

The va_arg() macros are used to pass a variable number of arguments to a function.

1. First, you must have a call to va_start() passing a valid va_list and the mandatory argument that directly precedes the '...' argument of the function. If you only have one mandatory argument, it is that argument. You must have at least one mandatory argument. This argument can be anything; one way to use it is to have it be an integer describing the number of parameters being passed.
2. Next, you call va_arg() passing the va_list and the type of the argument to be returned. The return value of va_arg() is the current parameter.
3. Repeat calls to va_arg() for however many arguments you have.
4. Finally, a call to va_end() passing the va_list is necessary for proper cleanup.

For example:

```
int sum( int num, ... ) {
        int answer = 0;
        va_list argptr;
        va_start( argptr, num );
        for( ; num > 0; num-- ) {
            answer += va_arg( argptr, int );
        }
        va_end( argptr );
        return( answer );
}
int main( void ) {
        int answer = sum( 4, 4, 3, 2, 1 );
        printf( "The answer is %d\n", answer );
        return( 0 );
}
```

This code displays 10 , which is $4+3+2+1$.
Here is another example of variable argument function, which is a simple printing function:

```
void my_printf( char *format, ... ) {
    va_list argptr;
    va_start( argptr, format );
    while( *format != '\0' ) {
        // string
        if( *format == 's' ) {
            char* s = va_arg( argptr, char * );
            printf( "Printing a string: %s\n", s );
        }
        // character
        else if( *format == 'c' ) {
            char c = (char) va_arg( argptr, int );
            printf( "Printing a character: %c\n", c );
            break;
        }
        // integer
        else if( *format == 'd' ) {
            int d = va_arg( argptr, int );
            printf( "Printing an integer: %d\n", d );
        }
        *format++;
    }
    va_end( argptr );
}
int main( void ) {
    my_printf( "sdc", "This is a string", 29, 'X' );
    return( 0 );
\imath return(0 );
\nabla
```

This code displays the following output when run:

```
Printing a string: This is a string
Printing an integer: 29
Printing a character: X
```


## atof

Syntax:

```
#include <cstdlib>
double atof( const char *str );
```

The function atof() converts str into a double, then returns that value. str must start with a valid number, but can be terminated with any nonnumerical character, other than " $E$ " or "e". For example,

$$
x=\text { atof( "42.0 is the answer" ); }
$$

results in $x$ being set to 42.0.
Related Topics: atoi, atol, sprintf, strtod

## atoi

Syntax:

```
#include <cstdlib>
int atoi( const char *str );
```

The atoi() function converts str into an integer, and returns that integer. str should start with whitespace or some sort of number, and atoi() will stop reading from str as soon as a non-numerical character has been read. For example:

```
int i;
i = atoi( "512" );
i = atoi( "512.035" );
i = atoi( " 512.035" );
i = atoi( " 512+34" );
i = atoi( " 512 bottles of beer on the wall" );
```

All five of the above assignments to the variable i would result in it being set to 512. If the conversion cannot be performed, then atoi() will return zero:


You can use sprintf() to convert a number into a string.

Related Topics: atof, atol, O) sprintf

## atol

Syntax:

```
#include <cstdlib>
long atol( const char *str );
```

The function atol() converts str into a long, then returns that value. atol() will read from str until it finds any character that should not be in a long. The resulting truncated value is then converted and returned. For example,
x = atol( "1024.0001" );
results in $x$ being set to 1024 L .
Related Topics: atof, atoi, sprintf, strtol

## isalnum

Syntax:

```
#include <cctype>
```

int isalnum( int ch );

The function isalnum() returns non-zero if its argument is a numeric digit or a letter of the alphabet. Otherwise, zero is returned.


Related Topics: isalpha, iscntrl, isdigit, isgraph, isprint, ispunct, isspace, isxdigit

## isalpha

Syntax:

```
#include <cctype>
int isalpha( int ch );
```

The function isalpha() returns non-zero if its argument is a letter of the alphabet. Otherwise, zero is returned.


Related Topics: isalnum, iscntrl, isdigit, isgraph, isprint, ispunct, isspace, isxdigit

## iscntrl

## Syntax:

```
#include <cctype>
int iscntrl( int ch );
```

The iscntrl() function returns non-zero if its argument is a control character (between 0 and $0 \times 1 \mathrm{~F}$ or equal to $0 \times 7 \mathrm{~F}$ ). Otherwise, zero is returned.

Related Topics: isalnum, isalpha, isdigit, isgraph, isprint, ispunct, isspace, isxdigit

## isdigit

Syntax:

```
#include <cctype>
int isdigit( int ch );
```

The function isdigit() returns non-zero if its argument is a digit between 0 and 9 . Otherwise, zero is returned.

```
char c;
scanf( "%c", &c );
if( isdigit(c) )
    printf( "You entered the digit %c\n", c );
```

Related Topics: isalnum, isalpha, iscntrl, isgraph, isprint, ispunct, isspace, isxdigit

## isgraph

Syntax:

```
#include <cctype>
int isgraph( int ch );
```

The function isgraph() returns non-zero if its argument is any printable character other than a space (if you can see the character, then isgraph() will return a non-zero value). Otherwise, zero is returned.

Related Topics: isalnum, isalpha, iscntrl, isdigit, isprint, ispunct, isspace, isxdigit

## islower

Syntax:

```
#include <cctype>
int islower( int ch );
```

The islower() function returns non-zero if its argument is a lowercase letter. Otherwise, zero is returned.

Related Topics: isupper

## isprint

Syntax:

```
#include <cctype>
int isprint( int ch );
```

The function isprint() returns non-zero if its argument is a printable character (including a space). Otherwise, zero is returned.

Related Topics: isalnum, isalpha, iscntrl, isdigit, isgraph, ispunct, isspace

## ispunct

Syntax:

```
#include <cctype>
int ispunct( int ch );
```

The ispunct() function returns non-zero if its argument is a printing character but neither alphanumeric nor a space. Otherwise, zero is returned.

Related Topics: isalnum, isalpha, iscntrl, isdigit, isgraph, isprint, isspace, isxdigit

## isspace

Syntax:

```
#include <cctype>
int isspace( int ch );
```

The isspace() function returns non-zero if its argument is some sort of space (i.e. single space, tab, vertical tab, form feed, carriage return, or newline). Otherwise, zero is returned.

Related Topics: isalnum, isalpha, iscntrl, isdigit, isgraph, isprint, ispunct, isxdigit

## isupper

Syntax:

```
#include <cctype>
int isupper( int ch );
```

The isupper() function returns non-zero if its argument is an uppercase letter. Otherwise, zero is returned.

Related Topics: islower, tolower

## isxdigit

Syntax:
\#include <cctype>
int isxdigit( int ch );
The function isxdigit() returns non-zero if its argument is a hexidecimal digit (i.e. A-F, a-f, or 0-9). Otherwise, zero is returned.

Related Topics: isalnum, isalpha, iscntrl, isdigit, isgraph, ispunct, isspace

## memchr

Syntax:


The memchr() function looks for the first occurrence of ch within count characters in the array pointed to by buffer. The return value points to the location of the first occurrence of ch, or NULL if ch isn't found. For example:

```
char names[] = "Alan Bob Chris X Dave";
if( memchr(names,'X',strlen(names)) == NULL )
    printf( "Didn't find an X\n" );
else
    printf( "Found an X\n" );
```

Related Topics: memcmp, memcpy, strstr

## memcmp

Syntax:


The function memcmp() compares the first count characters of buffer1 and buffer2. The return values are as follows:

| Value | Explanation |
| :--- | :--- |
| less than 0 | buffer1 is less than buffer2 |
| equal to 0 | buffer1 is equal to buffer2 |
| greater than 0 | buffer1 is greater than buffer2 |

Related Topics: memchr, memcpy, memset, strcmp

## memcpy

## Syntax:



The function memcpy() copies count characters from the array from to the array to.

The return value of memcpy() is to.
The behavior of memcpy() is undefined if to and from overlap.
Related Topics: memchr, memcmp, memmove, memset, strcpy, strlen, strncpy

## memmove

Syntax:


The memmove() function is identical to memcpy(), except that it works even if to and from overlap.

Related Topics: memcpy, memset

## memset

Syntax:

```
#include <cstring>
void* memset( void* buffer, int ch, size_t count );
```

The function memset() copies ch into the first count characters of buffer, and returns buffer. memset() is useful for intializing a section of memory to some value. For example, this command:

```
const int ARRAY_LENGTH;
char the_array[ARRAY_LENGTH];
```

...
// zero out the contents of the_array memset( the_array, '\0', ARRAY_LENGTH );
...is a very efficient way to set all values of the_array to zero.

The table below compares two different methods for initializing an array of characters: a for-loop versus memset(). As the size of the data being initialized increases, memset() clearly gets the job done much more quickly:

| Input size | Initialized with a for-loop | Initialized with memset() |
| :--- | :--- | :--- |
| 1000 | 0.016 | 0.017 |
| 10000 | 0.055 | 0.013 |
| 100000 | 0.443 | 0.029 |
| 1000000 | 4.337 | 0.291 |

Related Topics: memcmp, memcpy, memmove

## strcat

Syntax:

```
#include <cstring>
char *strcat( char *str1, const char *str2 );
```

The strcat() function concatenates str2 onto the end of str1, and returns str1. For example:

```
printf( "Enter your name: " );
scanf( "%s", name );
title = strcat( name, " the Great" );
printf( "Hello, %s\n", title );
```

Note that strcat() does not perform bounds checking, and thus risks overrunning str1 or str2. For a similar (and safer) function that includes bounds checking, see strncat().

Related Topics: strchr, strcmp, strcpy, strncat, Another set of related (but non-standard) functions are strlcpy_and_strlcat.

## strchr

Syntax:

```
#include <cstring>
char *strchr( const char *str, int ch );
```

The function strchr() returns a pointer to the first occurence of ch in str, or NULL if ch is not found.

Related Topics: strcat, strcmp, strcpy, strlen, strncat, strncmp, strncpy, strpbrk, strspn, strstr, strtok

## strcmp

Syntax:

```
#include <cstring>
int strcmp( const char *str1, const char *str2 );
```

The function strcmp() compares str1 and str2, then returns:

| Return value | Explanation |
| :--- | :--- |
| less than 0 | str1 is less than str2 |
| equal to 0 | str1 is equal to str2 |
| greater than 0 | str1 is greater than str2 |

For example:

```
printf( "Enter your name: " );
scanf( "%s", name );
if( strcmp( name, "Mary" ) == 0 ) {
    printf( "Hello, Dr. Mary!\n" );
}
```

Note that if str1 or str2 are missing a null-termination character, then strcmp () may not produce valid results. For a similar (and safer) function that includes explicit bounds checking, see strncmp().

Related Topics: memcmp, strcat, strchr, strcoll, strcpy, strlen, strncmp, strxfrm

## strcoll

Syntax:

```
#include <cstring>
int strcoll( const char *str1, const char *str2 );
```

The strcoll function compares str1 and str2, much like strcmp. However, strcoll performs the comparison using the locale specified by the setlocale function.

Related Topics: setlocale, strcmp, strxfrm

## strcpy

Syntax:

```
#include <cstring>
char *strcpy( char *to, const char *from );
```

The $\operatorname{strcpy}()$ function copies characters in the string from to the string to, including the null termination. The return value is to. Note that $\operatorname{strcpy}()$ does not perform bounds checking, and thus risks overrunning from or to. For a similar (and safer) function that includes bounds checking, see strncpy().

Related Topics: memcpy, strcat, strchr, strcmp, strncmp, strncpy, Another set of related (but non-standard) functions are strlcpy_and_strlcat.

## strcspn

Syntax:


The function strcspn() returns the index of the first character in str1 that matches any of the characters in str2.

Related Topics: strpbrk, strrchr, strstr, strtok

## strerror

Syntax:

```
#include <cstring>
char *strerror( int num );
```

The function strerror() returns an implementation defined string corresponding to num.

## strlcat

Warning: Non-standard function!
Syntax:


An attempt of the BSD people to "fix" strncat. There is a reason this function is not in any ISO standard. It is not a clear improvement over strncat, but rather an "overload" with different tradeoffs.

## Original description:

Appends src to string dst of size siz (unlike strncat, siz is the full size of dst, not space left).
At most siz-1 characters will be copied.
Always NUL terminates (unless strlen(dst) > siz).
Returns strlen(src) + MIN(siz, strlen(initial dst)) If retval >= siz, truncation occurred.

Related Topics: memcpy, strchr, strncpy, strncat, strncmp
Another related (but non-standard) function is strlcpy.

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## strlcpy

Warning: Non-standard function!
Syntax:


An attempt of the BSD people to "fix" strncpy. There is a reason this function is not in any ISO standard. See explanation after the description.

## Original description:

Copy src to string dst of size siz.
At most siz-1 characters will be copied.
Always NUL terminates (unless siz == 0).
Returns strlen(src); if retval >= siz, truncation occurred.

## Why stricpy is not an improvement, but rather a different, and quite possibly worse compromise:

Perceived advantages of strlcpy are:

1. the target is (nearly) always NUL terminated
2. the target is not filled up with zero characters

The first "advantage" is supposed to make programs more robust by ensuring that the resulting strings are always NUL terminated. First of all, they aren't, because the size argument can be 0 , in which case the code cannot write the terminating NUL character. This fact is already a hint that stricpy is not a very well designed function. Even if we ignore that flaw for a moment, there is more to it.

The good and warm feeling of security that strlcpy may give its user is actually nothing more, than hiding an error. And hiding an error is never a good idea. strncpy has a very blunt and effective way of reporting if the copy operation failed: it does not NUL terminate its target string. This means, that 2 hours after the strncpy call that went unchecked (without error handling), it is still clearly visible (in memory) what has happened. Our buffer has no terminating zero character. However 2 hours after strlcpy (buf,"assume", 3); nothing whatsoever will show that the copy has failed, and the call went unchecked. In the lucky case, it will just result in overwriting some files or some mysteriously failed operations. In the very lucky case it will result in immediate damage. For example the overwritten files are important, and so the unchecked return value results in a crash or other system failure later on. Why is this luckier? Because we know there is a bug, even though strlcpy has tried its best to hide it.

Not much different from strncpy you might say. You do not check the return value, you get problems. Except that with strncpy a look at the dump will tell you exactly what the problem is. No NUL termination. With strlcpy all you see is a C-string, with no indication that it has been truncated.

The second "advantage" seems to be more straightforward. If I copy 5 bytes into a 42K buffer, strncpy will write nearly 42K for no reason whatsoever, because we are only possibly interested in the NUL after the 5 characters and the NUL at the end of the buffer. That may be a perforance hit you do not want to pay. If you meet such a rare situation while coding ask yourself: what is the maximum size for what I am copying? Is this the only thing that may go into that large buffer? It may well turn out that instead of 42*1024, you actually need 255 bytes max. for that filename you are copying. Depending on your situation, zeroing out a few bytes more might as well worth the trouble: you can use an ISO standard function.

So while there are corner cases when strlcpy may actually be a lot faster than strncpy, it is also true the other way around. The designers of strlcpy have made the unfortunate decision of ignoring the golden rule of: do one thing (and do that well). strlcpy does not report only whether or not the copy was successful. Nope. It reports also the size of the input. Who asked for that? This means, that if our hypothetical situation above is reversed, strlcpy will read 42K characters to find the length of the input, while it had only 5 bytes it could write. The caller may not even be interested in the length of the input. The caller just wants to give an error message saying "The filename is too long". A malicious entity figures this out and may just start sending large strings and slow down a server tenfold.

So even the second, not-so-controversial "benefit" of strlcpy over strncpy is questionable at best, and bogus at worse.

Related Topics: memcpy, strchr, strncpy, strncat, strncmp
Another related (but non-standard) function is strlcat.

## strlen

Syntax:

```
#include <cstring>
size_t strlen( char *str );
```

The strlen() function returns the length of str (determined by the number of characters before null termination).

Related Topics: memcpy, strchr, strcmp, strncmp

## strncat

Syntax:


The function strncat() concatenates at most count characters of str2 onto str1, adding a null termination. The resulting string is returned.

Related Topics: strcat, strchr, strncmp, strncpy
Another set of related (but non-standard) functions are strlcpy and strlcat.

## strncmp

Syntax:


The strncmp() function compares at most count characters of str1 and str2. The return value is as follows:

| Return value | Explanation |
| :--- | :--- |
| less than 0 | str1 is less than str2 |
| equal to 0 | str1 is equal to str2 |
| greater than 0 | str1 is greater than str2" |

If there are less than count characters in either string, then the comparison will stop after the first null termination is encountered.

Related Topics: strchr, strcmp, strcpy, strlen, strncat, strncpy

## strncpy

Syntax:

```
        #include <cstring>
        char *strncpy( char *to, const char *from, size_t cou
        namespace std {
        using ::strncpy;
    }
|
```

The strncpy function copies at most count characters of from to the string to. If from has less than count characters, the remainder is padded with '10' characters. The return value is the resulting string.

Warning: If you read the definition carefully, you will see that strncpy may not NULL terminate the resulting string! This is a surprise to many people, but it has a very good reason, and leads us to the idiomatic use of strncpy:

```
    #include <cstring>
    #include <cstdlib>
    int main(int agrc, char *argv[]) {
    if (argc!=2) { return EXIT_FAILURE; }
    char buff[6];
    strncpy(buff, argv[1], sizeof(buff));
    // Here comes the idiomatic part, that
    // must not be missing from code using strncpy:
    if (buff[sizeof(buff)-1] != '\0') {
        // We have overflow. You may decide to give an err
        return EXIT_FAILURE;
        // or to truncate your string:
        buff[sizeof(buff)-1]='\0';
    }
    // but in any case, make sure that at this line
    // you string is NULL (zero) terminated!
}
```

1

The use of strncpy in itself does not result in safer code. It has to be used correctly (as above), otherwise a later code, which assumes that a buffer of 6 may contain maximum 5 characters, will fail, and may fail in a way that results in a security risk (crash or worse).

Related Topics: memcpy, strchr, strcpy, strncat, strncmp
Another set of related (but non-standard) functions are strlcpy and strlcat.

## strpbrk

Syntax:

```
#include <cstring>
char* strpbrk( const char* str1, const char* str2 );
```

The function strpbrk() returns a pointer to the first occurrence in str1 of any character in str2, or NULL if no such characters are present.

Related Topics: (C++ Algorithms) find_first_of, strchr, strcspn, strrchr, strspn, strstr, strtok

## strrchr

Syntax:

```
#include <cstring>
char *strrchr( const char *str, int ch );
```

The function strrchr() returns a pointer to the last occurrence of ch in str, or NULL if no match is found.

Related Topics: strcspn, strpbrk, strspn, strstr, strtok

## strspn

Syntax:

```
#include <cstring>
size_t strspn( const char *str1, const char *str2 );
```

The strspn() function returns the index of the first character in str1 that doesn't match any character in str2.

Related Topics: strchr, strpbrk, strrchr, strstr, strtok

## strstr

Syntax:

```
#include <cstring>
char *strstr( const char *str1, const char *str2 );
```

The function strstr() returns a pointer to the first occurrence of str2 in str1, or NULL if no match is found. If the length of str2 is zero, then strstr () will simply return str1. For example, the following code checks for the existence of one string within another string:

```
    char* str1 = "this is a string of characters";
    char* str2 = "a string";
    char* result = strstr( str1, str2 );
    if( result == NULL ) printf( "Could not find '%s' in
    else printf( "Found a substring: '%s'\n", result );
|
```

When run, the above code displays this output:
Found a substring: 'a string of characters'
Related Topics: memchr, strchr, strcspn, strpbrk, strrchr, strspn, strtok

## strtod

Syntax:

```
#include <cstdlib>
double strtod( const char *start, char **end );
```

The function strtod() returns whatever it encounters first in start as a double. end is set to point at whatever is left in start after that double. If overflow occurs, strtod() returns either HUGE_VAL or -HUGE_VAL.

Related Topics: atof

## strtok

Syntax:

```
#include <cstring>
char *strtok( char *str1, const char *str2 );
```

The strtok() function returns a pointer to the next "token" in str1, where str2 contains the delimiters that determine the token. strtok() returns NULL if no token is found. In order to convert a string to tokens, the first call to strtok() should have str1 point to the string to be tokenized. All calls after this should have str1 be NULL. For example:

```
    char str[] = "now \# is the time for all \# good men t
their country";
    char delims[] = "\#";
    char *result = NULL;
    result = strtok( str, delims );
    while( result != NULL ) \{
        printf( "result is \"\%s\"\n", result );
        result = strtok( NULL, delims );
    \}
1
```

The above code will display the following output:

```
result is "now "
result is " is the time for all "
result is " good men to come to the "
result is " aid of their country"
```

Related Topics: strchr, strcspn, strpbrk, strrchr, strspn, strstr

## strtol

Syntax:


The strtol() function returns whatever it encounters first in start as a long, doing the conversion to base if necessary. end is set to point to whatever is left in start after the long. If the result can not be represented by a long, then strtol() returns either LONG_MAX or LONG_MIN. Zero is returned upon error.

Related Topics: atol, strtoul

## strtoul

Syntax:


The function strtoul() behaves exactly like strtol(), except that it returns an unsigned long rather than a mere long.

Related Topics: strtol
int lftrm(char* str) \{

```
    int len = 0;
    char* tmp;
    len = (int)strlen(str);
    if(0 == len) return len;
    tmp = str;
    while(len > 0){
        if(0x20 == *tmp){
                        tmp++; len--;
        }
        else if(len > 1){
            if((char)0x81 == *tmp && (char)0x40 == *(tmp+:
                        tmp += 2; len -= 2;
            }
            else break;
        }
        else break;
    }
    strcpy(str, tmp);
    return len;
|
```

\} int rgttrm(char* str) \{

```
    int len;
    char* tmp;
    len = (int)strlen(str);
    if(0 == len) return len;
    tmp = str+len-1;
    while(len > 0){
        if(0x20 == *tmp){
            *tmp = '\0';
            tmp--; len--;
        }
        else if(len > 1){
            if((char)0x40 == *tmp && (char)0x81 == *(tmp-1
                *tmp = '\0'; *(tmp+1) = '\0';
                        tmp -= 2; len -= 2;
            }
            else break;
        }
        else break;
    }
    //strcpy(str, tmp);
        return len;
4
} char *strtrm(char* str) {
    int len;
    char ch;
    lfttrm(str);
    rgttrm(str);
    return str;
}
```


## strxfrm

Syntax:


The strxfrm() function manipulates the first num characters of str2 and stores them in str1. The result is such that if a strcoll() is performed on str1 and the old str2, you will get the same result as with a strcmp(). Related Topics: strcmp, strcoll

## tolower

Syntax:

```
#include <cctype>
int tolower( int ch );
```

The function tolower() returns the lowercase version of the character ch.
Related Topics: isupper, toupper

## toupper

Syntax:

```
#include <cctype>
int toupper( int ch );
```

The toupper() function returns the uppercase version of the character ch.

Related Topics: tolower

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C++ Standard Template Library

The C++ STL (Standard Template Library) is a generic collection of class templates and algorithms that allow programmers to easily implement standard data structures like queues, lists, and stacks.

## Data Structures

The C++ STL provides programmers with the following constructs, grouped into three categories:

- Sequences
- C++ Vectors
- C++ Lists
- C++ Double-Ended Queues
- Container Adapters
- C++ Stacks
- C++ Queues
- C++ Priority Queues
- Associative Containers
- C++ Bitsets
- C++ Maps
- C++ Multimaps
- C++ Sets
- C++ Multisets

The idea behind the C++ STL is that the hard part of using complex data structures has already been completed. If a programmer would like to use a stack of integers, all one has to do is use this code:

```
stack<int> myStack;
```

With minimal effort, one can now push and pop integers onto this stack. Through the magic of C++ Templates, one could specify any data type, not just integers. The STL Stack class will provide generic functionality of a stack, regardless of the data in the stack.

## Algorithms

In addition, the STL also provides a bunch of useful algorithms - such as binary_search, sort, and for_each - that can be used on a variety of data structures.

## Iterators

C++ Iterators provide a generic way of iterating over the STL data structures.

## Function Objects

The <functional> header file defines methods related to the creation of function objects.

## Memory

The <memory> header file provides simple memory management structures like auto_ptr.

## Utility

There are several generic utility methods like make_pair in the <utility> header file.

## C++ Containers

The C++ Containers (C++ Vectors, C++ Lists, etc.) are generic vessels capable of holding many different types of data. For example, the following statement creates a vector of integers:

```
vector<int> v;
```

Containers can hold standard objects (like the int in the above example) as well as custom objects, as long as the objects in the container meet a few requirements:

1. The object must have a default constructor,
2. an accessible destructor, and
3. an accessible assignment operator.

When describing the functions associated with these various containers, this website defines the word TYPE to be the object type that the container holds. For example, in the above statement, TYPE would be int. Similarily, when referring to containers associated with pairs of data (C++ Maps for example) key_type and value_type are used to refer to the key and value types for that container.

## C++ Iterators

Iterators are used to access members of the container classes, and can be used in a similar manner to pointers. For example, one might use an iterator to step through the elements of a vector. There are several different types of iterators:

| Iterator | Description |
| :--- | :--- |
| input_iterator | Read values with forward movement. These can <br> be incremented, compared, and dereferenced. |
| output_iterator | Write values with forward movement. These can <br> be incremented and dereferenced. |
| forward_iterator | Read or write values with forward movement. <br> These combine the functionality of input and <br> output iterators with the ability to store the <br> iterators value. |
| bidirectional_iterator | Read and write values with forward and backward <br> movement. These are like the forward iterators, <br> but you can increment and decrement them. |
| random_iterator | Read and write values with random access. <br> These are the most powerful iterators, combining <br> the functionality of bidirectional iterators with the <br> ability to do pointer arithmetic and pointer <br> comparisons. |
| reverse_iterator | Either a random iterator or a bidirectional iterator <br> that moves in reverse direction. |

Each of the container classes is associated with a type of iterator, and each of the STL algorithms uses a certain type of iterator.

For example, vectors are associated with random-access iterators, which means that they can use algorithms that require random access. Since random-access iterators encompass all of the characteristics of
the other iterators, vectors can use algorithms designed for other iterators as well.

The following code creates and uses an iterator with a vector:

```
vector<int> the_vector;
vector<int>::iterator the_iterator;
for( int i=0; i < 10; i++ ) the_vector.push_back(i);
int total = 0;
the_iterator = the_vector.begin();
while( the_iterator != the_vector.end() ) {
    total += *the_iterator;
    ++the_iterator;
}
cout << "Total=" << total << endl;
```

Notice that you can access the elements of the container by dereferencing the iterator.

Related topics:
http://www.oreillynet.com/pub/a/network/2005/10/18/what-is-iterator-in-c-plus-plus.html

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## C++ Header Files

This page lists the various header files that are available in standard C++, grouped by topic.

## STL Containers

| <bitset> | Provides the specialized container class std:: bitset, a bit <br> array. |
| :--- | :--- |
| <deque> | Provides the container class template std::deque, a double- <br> ended queue. |
| <list> | Provides the container class template std::list, a doubly- <br> linked list. |
| <map> | Provides the container class templates std::map and <br> std::multimap, an associative array and multimap. |
| <queue> | Provides the container adapter class std::queue, a single- <br> ended queue. |
| <set> | Provides the container class templates std::set and <br> std::multiset, sorted associative containers or sets. |
| <stack> | Provides the container adapter class std::stack, a stack. |
| <vector> | Provides the container class template std::vector, a dynamic <br> array. |

## General STL

| <algorithm> | Provides definitions of many container algorithms. |
| :--- | :--- |
| <functional> | Provides several function objects, designed for use with |
| the standard algorithms. |  |$|$| <iterator> | Provides classes and templates for working with <br> iterators. |
| :--- | :--- |


| <locale> | Provides classes and templates for working with locales. |
| :--- | :--- |
| <memory> | Provides facilities for memory management in C++, <br> including the class template std:::auto_ptr. |
| <stdexcept> | Contains standard exception classes such as <br> std::logic_error and std::runtime_error, both derived from <br> std::exception. |
| <utility> | Provides the template class std:: pair, for working with <br> pairs (two-member tuples) of objects. |

## C++ Strings

<string> Provides the C++ standard string classes and templates.

## C++ Streams and Input/Output

| <fstream> | Provides facilities for file-based input and output. |
| :--- | :--- |
| <ios> | Provides several types and functions basic to the <br> operation of iostreams. |
| <iostream> | Provides C++ input and output fundamentals. |
| <iosfwd> | Provides forward declarations of several I/O-related <br> class templates. |
| <iomanip> | Provides facilities to manipulate output formatting, such <br> as the base used when formatting integers and the <br> precision of floating point values. |
| <istream> | Provides the template class std::istream and other <br> supporting classes for input. |
| <ostream> | Provides the template class std::ostream and other <br> supporting classes for output. |
| <sstream> | Provides the template class std::sstream and other <br> supporting classes for string manipulation. |
| <streambuf> |  |

## Numerics

| <complex> | Provides class template std::complex and associated |
| :--- | :--- |
| functions for working with complex numbers. |  |

## Language Support

| <exception> | Provides several types and functions related to <br> exception handling, including std::exception, the base <br> class of all exceptions thrown by the Standard Library. |
| :--- | :--- |
| <limits> | Provides the template class std::numeric_limits, used for <br> describing properties of fundamental numeric types. |
| <new> | Provides operators new and delete and other functions <br> and types composing the fundamentals of C++ memory <br> management. |
|  | Provides facilities for working with C++ run-time type <br> information. |
| <typeinfo> |  |

## C Standard Library

Each header from the C standard library is included in the C++ standard library under a different name, generated by removing the .h, and adding a 'c' at the start, for example time. $h$ becomes ctime. The only difference between these headers and the traditional C standard library headers is that where possible the functions should be placed into the std: : namespace (although few compilers actually do this). In ISO C, functions in standard library are allowed to be implemented by macros, which is not allowed by ISO C++.

- <cassert>
- <cctype>
- <cerrno>
- <cfloat>
- <climits>
- <cmath>
- <csetjmp>
- <csignal>
- <cstdlib>
- <cstddef>
- <cstdarg>
- <cstdio>
- <cstring>
- <ctime>
- <cwchar>
- <cwctype>

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## Exceptions

## Handling

The <exception> header provides functions and classes for exception control. One basic class is exception:

```
class exception
{
public:
    exception() throw();
    exception(const exception&) throw();
    exception& operator=(const exception&) throw();
    virtual ~exception() throw();
    virtual const char *what() const throw();
};
```


## Standard Exceptions

The <stdexcept> header provides a small hierarchy of exception classes that can be thrown or caught:

- exception
- logic_error
- domain_error
- invalid_argument
- length_error
- out_of_range
- runtime_error
- range_error
- overflow_error
- underflow_error

Logic errors are thrown if the program has internal errors that are caused by the user of a function. And in theory preventable.
Runtime errors are thrown if the cause is beyond the program and can't be predict by user of a function.

C++ Algorithms

| accumulate | sum up a range of elements |
| :--- | :--- |
| adjacent_difference | compute the differences between adjacent <br> elements in a range |
| adjacent_find | finds two items adjacent to each other <br> determine if an element exists in a certain <br> range |
| binary_search | copy some range of elements to a new <br> location |
| copy | copy a range of elements in backwards <br> order |
| copy_backward | return the number of elements matching a <br> given value <br> return the number of elements for which a <br> predicate is true |
| count | determine if two sets of elements are the <br> same |
| count_if | search for a range of elements that are all <br> equal to a certain element |
| equal | assign a range of elements a certain value |
| equal_range | assign a value to some number of elements <br> find a value in a given range <br> fillfind the last sequence of elements in a <br> certain range |
| fill_n | search for any one of a set of elements <br> find the first element for which a certain <br> predicate is true |
| find_end | apply a function to a range of elements <br> saves the result of a function in a range <br> find_first_of <br> find_if <br> sor_each <br> function the result of N applications of a <br> generate <br> generate_n |


| includes | returns true if one set is a subset of another |
| :--- | :--- |
| inner_product | compute the inner product of two ranges of <br> elements |
| inplace_merge | merge two ordered ranges in-place |
| is_heap | returns true if a range is sorted in ascending <br> order |
| is_sorted | swaps the elements pointed to by two <br> iterators |
| iter_swap | returns true if one range is lexicographically <br> less than another |
| lexicographical_comparch for the first place that a value can be |  |
| inserted while preserving order |  |$|$| creates a heap out of a range of elements |
| :--- |
| rewer_bound |
| rake_heap |
| returns the largest element in a range |
| max_element |
| merge |
| returns the smaller of two elements |
| min |
| returns the smallest element in a range |
| mismatch |
| finds the first position where two ranges |
| differ |


| pop_heap | remove the largest element from a heap |
| :---: | :---: |
| prev_permutation | generates the next smaller lexicographic permutation of a range of elements |
| push_heap | add an element to a heap |
| random_shuffle | randomly re-order elements in some range |
| remove | remove elements equal to certain value |
| remove_copy | copy a range of elements omitting those that match a certian value |
| remove_copy_if | create a copy of a range of elements, omitting any for which a predicate is true |
| remove_if | remove all elements for which a predicate is true |
| replace | replace every occurrence of some value in a range with another value |
| replace_copy | copy a range, replacing certain elements with new ones |
| replace_copy_if | copy a range of elements, replacing those for which a predicate is true |
| replace_if | change the values of elements for which a predicate is true |
| reverse | reverse elements in some range |
| reverse_copy | create a copy of a range that is reversed |
| rotate | move the elements in some range to the left by some amount |
| rotate_copy | copy and rotate a range of elements |
| search | search for a range of elements |
| search_n | search for $N$ consecutive copies of an element in some range |
| set_difference | computes the difference between two sets |
| set_intersection | computes the intersection of two sets |
| set_symmetric_difference | computes the symmetric difference between two sets |
|  |  |


| set_union | computes the union of two sets |
| :--- | :--- |
| sort | sort a range into ascending order |
| sort_heap | turns a heap into a sorted range of elements |
| stable_partition | divide elements into two groups while <br> preserving their relative order |
| stable_sort | sort a range of elements while preserving <br> order between equal elements |
| swap | swap the values of two objects |
| swap_ranges | swaps two ranges of elements |
| transform | applies a function to a range of elements <br> remove consecutive duplicate elements in a <br> range |
| unique | create a copy of some range of elements <br> that contains no consecutive duplicates |
| unique_copy | searches for the last possible location to <br> insert an element into an ordered range |
| upper_bound |  |

## C++ Bitsets

C++ Bitsets give the programmer a set of bits as a data structure. Bitsets can be manipulated by various binary operators such as logical AND, OR, and so on.

| Constructors | create new bitsets |
| :--- | :--- |
| Operators | compare and assign bitsets |
| any | true if any bits are set |
| count | returns the number of set bits |
| flip | reverses the bitset |
| none | true if no bits are set |
| reset | sets bits to zero |
| set | sets bits |
| size | number of bits that the bitset can hold |
| test | returns the value of a given bit |
| to_string | string representation of the bitset |
| to_ulong | returns an integer representation of the bitset |

## C++ Double-ended Queues

Double-ended queues (or deques) are similar to vectors, except that they allow fast insertions and deletions at both the beginning and the end of the container.

C++ deques are commonly implemented as dynamically allocated arrays that can grow at both ends. This guarantees constant time access, amortized constant time insertion and deletion at either end of the deque, and linear time insertion and deletion from the middle of the deque.

| Constructors | create deques and initialize them with some data |
| :--- | :--- |
| Operators | compare, assign, and access elements of a deque |
| assign | assign elements to a deque |
| at | returns an element at a specific location |
| back | returns a reference to last element of a deque |
| begin | returns an iterator to the beginning of the deque |
| clear | removes all elements from the deque |
| empty | true if the deque has no elements |
| end | returns an iterator just past the last element of a deque |
| erase | removes elements from a deque |
| front | returns a reference to the first element of a deque |
| insert | inserts elements into the deque |
| max_size | returns the maximum number of elements that the deque <br> can hold |
| pop_back | removes the last element of a deque |
| pop_front | removes the first element of the deque |
| push_back | add an element to the end of the deque |
| push_front | add an element to the front of the deque |
|  |  |


| rbegin | returns a reverse_iterator to the end of the deque |
| :--- | :--- |
| rend | returns a reverse_iterator to the beginning of the deque |
| resize | change the size of the deque |
| size | returns the number of items in the deque |
| swap | swap the contents of this deque with another |

## Notes

The name deque is pronounced "deck", and stands for "double-ended queue." Knuth reports that the name was coined by E. J. Schweppe. See section 2.2.1 of Knuth for more information about deques. (D. E. Knuth, The Art of Computer Programming. Volume 1: Fundamental Algorithms, second edition. Addison-Wesley, 1973.)

## C++ I/O

The <iostream> library automatically defines a few standard objects:

- cout, an object of the ostream class, which displays data to the standard output device.
- cerr, another object of the ostream class that writes unbuffered output to the standard error device.
- clog, like cerr, but uses buffered output.
- cin, an object of the istream class that reads data from the standard input device.

The <fstream> library allows programmers to do file input and output with the ifstream and ofstream classes. C++ programmers can also do input and output from strings by using the stringstream class.

Some of the behavior of the C++ I/O streams (precision, justification, etc) may be modified by manipulating various I/O stream format flags.

| I/O Constructors | constructors |
| :--- | :--- |
| bad | true if an error occurred |
| clear | clear and set status flags |
| close | close a stream |
| eof | true if at the end-of-file |
| exceptions | set the stream to throw exceptions on errors |
| fail | true if an error occurred |
| fill | manipulate the default fill character |
| flags | access or manipulate io_stream_format_flags |
| flush | empty the buffer |
| gcount | number of characters read during last input |
| get | read characters |


| getline | read a line of characters |
| :--- | :--- |
| good | true if no errors have occurred |
| ignore | read and discard characters |
| open | open a new stream |
| peek | check the next input character |
| precision | manipulate the precision of a stream |
| put | write characters |
| putback | return characters to a stream |
| rdstate | returns the state flags of the stream |
| read | read data into a buffer |
| seekg | perform random access on an input stream |
| seekp | set format flags |
| setf | read |
| sync_with_stdio | synchronize with standard I/O |
| tellg | read output stream pointers |
| tellp | clear io_stream_format_flags |
| unsetf | access and manipulate the minimum field width |
| width | write characters |
| write |  |

## C++ Stacks

The C++ Stack is a container adapter that gives the programmer the functionality of a stack - specifically, a FILO (first-in, last-out) data structure.

| Constructors | construct a new stack |
| :--- | :--- |
| empty | true if the stack has no elements |
| pop | removes the top element of a stack |
| push | adds an element to the top of the stack |
| size | returns the number of items in the stack |
| top | returns the top element of the stack |

## C++ Strings

The string class provides a useful way to manipulate and store sequences of characters, and is defined in the std namespace in the <string> header file.

| Constructors | create strings from arrays of characters and other <br> strings |
| :--- | :--- |
| Operators | concatenate strings, assign strings, use strings for <br> l/O, compare strings |
| append | append characters and strings onto a string |
| assign | give a string values from strings of characters and <br> other C+ strings <br> returns the character at a specific location |
| at | returns an iterator to the beginning of the string |
| begin | returns a non-modifiable standard C character array <br> version of the string |
| c_str | returns the number of characters that the string can <br> hold |
| capacity | removes all characters from the string |
| clear | compares two strings |
| compare | copies characters from a string into an array |
| returns a pointer to the first character of a string |  |
| data | true if the string has no characters |
| empty | returns an iterator just past the last character of a <br> string |
| end | removes characters from a string |
| erase | find characters in the string |
| find | find_first_not_of find first absence of characters |
| find_first_of | find first occurrence of characters |
| find_last_not_of find last absence of characters |  |


| find_last_of | find last occurrence of characters |
| :--- | :--- |
| getline | read data from an I/O stream into a string |
| insert | insert characters into a string |
| length | returns the length of the string |
| max_size | returns the maximum number of characters that the <br> string can hold |
| push_back | add a character to the end of the string |
| rbegin | returns a reverse_iterator to the end of the string |
| rend | returns a reverse_iterator to the beginning of the |
| string |  |

## C++ String Streams

String streams are similar to the <iostream> and <fstream> libraries, except that string streams allow you to perform I/O on strings instead of streams. The <sstream> library provides functionality similar to sscanf and sprintf in the standard C library.

Three main classes are available in <sstream>:

- stringstream - allows input and output
- istringstream - allows input only
- ostringstream - allows output only

String streams are actually subclasses of iostreams, so all of the functions available for iostreams are also available for stringstream.
See the C++ I/O functions for more information.
In addition, string streams also supply the following functions:

| Constructors | create new string streams |
| :--- | :--- |
| Operators | read from and write to string streams |
| rdbuf | get the buffer for a string stream |
| str | get or set the stream's string |

## C++ Sets

The C++ Set is an associative STL container that contains a sorted set of unique objects.

| Constructors | default methods to allocate, copy, and deallocate sets |
| :--- | :--- |
| Operators | assign and compare sets |
| begin | returns an iterator to the beginning of the set |
| clear | removes all elements from the set |
| count | returns the number of elements matching a certain key |
| empty | true if the set has no elements |
| end | returns an iterator just past the last element of a set |
| equal_range | returns iterators to the first and just past the last <br> elements matching a specific key |
| erase | removes elements from a set |
| find | returns an iterator to specific elements |
| insert | insert items into a set |
| key_comp | returns the function that compares keys |
| lower_bound | returns an iterator to the first element greater than or <br> equal to a certain value |
| max_size | returns the maximum number of elements that the set <br> can hold |
| rbegin | returns a reverse_iterator to the end of the set |
| rend | returns a reverse_iterator to the beginning of the set |
| size | returns the number of items in the set |
| swap | swap the contents of this set with another |
| upper_bound | returns an iterator to the first element greater than a <br> certain value |
| value_comp | returns the function that compares values |

## C++ Queues

The C++ Queue is a container adapter that gives the programmer a FIFO (first- in, first-out) data structure.

| Constructors | construct a new queue |
| :--- | :--- |
| back | returns a reference to last element of a queue |
| empty | true if the queue has no elements |
| front | returns a reference to the first element of a queue |
| pop | removes the first element of a queue |
| push | adds an element to the end of the queue |
| size | returns the number of items in the queue |

## C++ Priority Queues

C++ Priority Queues are like queues, but the elements inside the queue are ordered by some predicate.

| Constructors | construct a new priority queue |
| :--- | :--- |
| empty | true if the priority queue has no elements |
| pop | removes the top element of a priority queue |
| push | adds an element to the end of the priority queue |
| size | returns the number of items in the priority queue |
| top | returns the top element of the priority queue |

## C++ Multisets

C++ Multisets are like sets, in that they are associative containers containing a sorted set of objects, but differ in that they allow duplicate objects.

| Multiset <br> Constructors | default methods to allocate, copy, and deallocate <br> multisets |
| :--- | :--- |
| Multiset <br> Operators | assign and compare multisets |
| begin | returns an iterator to the beginning of the multiset |
| clear | removes all elements from the multiset |
| count | returns the number of elements matching a certain key |
| empty | true if the multiset has no elements <br> returns an iterator just past the last element of a <br> multiset |
| end | returns iterators to the first and just past the last <br> elements matching a specific key |
| equal_range | removes elements from a multiset |
| erase | returns an iterator to specific elements |
| find | returns the function that compares keys |
| insert | returns an iterator to the first element greater than or <br> equal to a certain value |
| key_comp | returns the maximum number of elements that the <br> multiset can hold |
| lower_bound |  |
| max_size | returns a reverse_iterator to the end of the multiset |
| rbegin | returns a reverse_iterator to the beginning of the <br> multiset |
| rend | returns the number of items in the multiset |
| size | swap the contents of this multiset with another |
| swap |  |


| upper_bound | returns an iterator to the first element greater than a <br> certain value |
| :--- | :--- |
| value_comp | returns the function that compares values |

## C++ Multimaps

C++ Multimaps are like maps, in that they are sorted associative containers, but differ from maps in that they allow duplicate keys.

| Constructors | default methods to allocate, copy, and deallocate multimaps |
| :---: | :---: |
| Operators | assign and compare multimaps |
| begin | returns an iterator to the beginning of the multimap |
| clear | removes all elements from the multimap |
| count | returns the number of elements matching a certain key |
| empty | true if the multimap has no elements |
| end | returns an iterator just past the last element of a multimap |
| equal_range | returns iterators to the first and just past the last elements matching a specific key |
| erase | removes elements from a multimap |
| find | returns an iterator to specific elements |
| insert | inserts items into a multimap |
| key_comp | returns the function that compares keys |
| lower_bound | returns an iterator to the first element greater than or equal to a certain value |
| max_size | returns the maximum number of elements that the multimap can hold |
| rbegin | returns a reverse_iterator to the end of the multimap |
| rend | returns a reverse_iterator to the beginning of the multimap |
| size | returns the number of items in the multimap |
| swap | swap the contents of this multimap with another |
| upper_bound | returns an iterator to the first element greater than a certain value |

value_comp |returns the function that compares values

## C++ Vectors

Vectors contain contiguous elements stored as an array.

Accessing members of a vector or appending elements can be done in constant time, whereas locating a specific value or inserting elements into the vector takes linear time.

| Constructors | create vectors and initialize them with some data |
| :--- | :--- |
| Operators | compare, assign, and access elements of a vector |
| assign | assign elements to a vector |
| at | returns an element at a specific location |
| back | returns a reference to last element of a vector |
| begin | returns an iterator to the beginning of the vector |
| capacity | returns the number of elements that the vector can hold |
| clear | removes all elements from the vector |
| empty | true if the vector has no elements |
| end | returns an iterator just past the last element of a vector |
| erase | removes elements from a vector |
| front | returns a reference to the first element of a vector |
| insert | inserts elements into the vector |
| max_size | returns the maximum number of elements that the vector <br> can hold |
| pop_back | removes the last element of a vector |
| push_back | add an element to the end of the vector |
| rbegin | returns a reverse_iterator to the end of the vector |
| rend | returns a reverse_iterator to the beginning of the vector |
| reserve | sets the minimum capacity of the vector |
| resize | change the size of the vector |
| size | returns the number of items in the vector |
|  |  |

swap $\quad$ swap the contents of this vector with another

## Notes:

Note that a boolean vector (vector<bool>) is a specialization of the vector template that is designed to use less memory. A normal boolean variable usually uses one byte of memory, but a boolean vector should use only one bit per boolean value.

## The <utility> header file

The <utility> header file defines several miscellaneous utilities:

| pair | definition of a pair of values |
| :--- | :--- |
| make_pair | create a pair |

More information at: http://www.cplusplus.com/reference/misc/utility/

## STL Memory Utilities

auto_ptr create pointers that automatically destroy objects

More information can be found at
http://www.cplusplus.com/reference/misc/.

## C++ Maps

C++ Maps are sorted associative containers that contain unique key/value pairs. For example, you could create a map that associates a string with an integer, and then use that map to associate the number of days in each month with the name of each month.

| Map Constructors <br> \& Destructors | default methods to allocate, copy, and deallocate <br> maps |
| :--- | :--- |
| Map operators | assign, compare, and access elements of a map |
| Map typedefs | typedefs of a map |
| begin | returns an iterator to the beginning of the map |
| clear | removes all elements from the map <br> key |
| count | true if the map has no elements <br> returns an iterator just past the last element of a <br> map |
| empty | returns iterators to the first and just past the last <br> elements matching a specific key |
| end | removes elements from a map |
| equal_range | returns an iterator to specific elements <br> insert items into a map |
| erase | returns the function that compares keys |
| find | returns an iterator to the first element greater than <br> or equal to a certain value |
| insert | returns the maximum number of elements that the <br> map can hold |
| key_comp | returns a reverse_iterator to the end of the map <br> lower_bound <br> max_size <br> returns a reverse_iterator to the beginning of the <br> map |
| rend |  |


| size | returns the number of items in the map |
| :--- | :--- |
| swap | swap the contents of this map with another |
| upper_bound | returns an iterator to the first element greater than <br> a certain value |
| value_comp | returns the function that compares values |

C++ Lists

Lists are sequences of elements stored in a linked list. Compared to vectors, they allow fast insertions and deletions, but slower random access.

| Constructors | create lists and initialize them with some data |
| :--- | :--- |
| Operators | assign and compare lists |
| assign | assign elements to a list |
| back | returns a reference to last element of a list |
| begin | returns an iterator to the beginning of the list |
| clear | removes all elements from the list |
| empty | true if the list has no elements |
| end | returns an iterator just past the last element of a list |
| erase | removes elements from a list |
| front | returns a reference to the first element of a list |
| insert | inserts elements into the list |
| max_size | returns the maximum number of elements that the list <br> can hold |
| merge | merge two lists |
| pop_back | removes the last element of a list |
| pop_front | removes the first element of the list |
| push_back | add an element to the end of the list |
| push_front | add an element to the front of the list |
| rbegin | returns a reverse_iterator to the end of the list |
| remove | removes elements from a list |
| remove_if | removes elements conditionally |
| rend | returns a reverse_iterator to the beginning of the list |
| resize | change the size of the list |
| reverse | reverse the list |


| size | returns the number of items in the list |
| :--- | :--- |
| sort | sorts a list into ascending order |
| splice | merge two lists in constant time |
| swap | swap the contents of this list with another |
| unique | removes consecutive duplicate elements |

## Preprocessor Conditionals

```
#if, #ifdef, #ifndef, #else, #elif, #endif
```

These six preprocessor commands give simple logic control to the compiler. As a file is being compiled, you can use these commands to cause certain lines of code to be included or not included.

```
#if expression
```

If the value of expression is true, then the code that immediately follows the command will be compiled.

## \#ifdef macro

If the macro has been defined by a \#define statement, then the code immediately following the command will be compiled.

```
#ifndef macro
```

If the macro has not been defined by a \#define statement, then the code immediately following the command will be compiled.

A few side notes: The command \#elif is simply a horribly truncated way to say "elseif" and works like you think it would. You can also throw in a "defined" or "!defined" after an \#if to get added functionality.

Here's an example of all these:

```
#ifdef DEBUG
    cout << "This is the test version, i=" << i << end
#else
    cout << "This is the production version!" << endl;
#endif
```

1. 

You might notice how that second example could make debugging a lot easier than inserting and removing a million "cout"s in your code.

Related topics: \#define

## Predefined preprocessor variables

Syntax:

```
__LINE__
__FILE
    DATE
    TIME
```

$\qquad$

``` cplusplus
STDC
```

The following variables can vary by compiler, but generally work:

- The $\qquad$ LINE $\qquad$ and $\qquad$ FILE $\qquad$ variables represent the current line and current file being processed.
- The __DATE__ variable contains the current date, in the form month/day/year. This is the date that the file was compiled, not necessarily the current date.
- The __TIME__ variable represents the current time, in the form hour:minute:second. This is the time that the file was compiled, not necessarily the current time.
- The __cplusplus variable is only defined when compiling a C++ program. In some older compilers, this is also called c_plusplus.
- The __STDC__ variable is defined when compiling a C program, and may also be defined when compiling $\mathrm{C}++$.


## GCC-specific variables

The following are GCC-specific variables. While they are not specifically preprocessor macros they are magic and can be used the same way:

- __FUNCTION__ is another name for __func__
- The __PRETTY_FUNCTION__ contains the type signature of the function as well as its bare name.


## \# and \#\#

The \# and \#\# preprocessor operators are used with the \#define macro.

- Using \# causes the first argument after the \# to be returned as a string in quotes.
- Using \#\# concatenates what's before the \#\# with what's after it.

For example, the command

```
#define to_string( s ) # s
```

will make the compiler turn this command

```
cout << to_string( Hello World! ) << endl;
```

into

```
cout << "Hello World!" << endl;
```

Here is an example of the \#\# command:

```
#define concatenate( x, y ) x ## y
...
int xy = 10;
...
```

This code will make the compiler turn

```
cout << concatenate( x, y ) << endl;
```

into

$$
\text { cout } \ll x y \ll \text { endl; }
$$

which will, of course, display '10' to standard output.

Related topics: \#define

## \#define

Syntax:

## \#define macro-name replacement-string

The \#define command is used to make substitutions throughout the file in which it is located. In other words, \#define causes the compiler to go through the file, replacing every occurrence of macro-name with replacement-string. The replacement string stops at the end of the line.

Here's a typical use for a \#define (at least in C):

```
#define TRUE 1
#define FALSE 0
int done = 0;
while( done != TRUE ) {
    }
```

Another feature of the \#define command is that it can take arguments, making it rather useful as a pseudo-function creator. Consider the following code:


It's generally a good idea to use extra parentheses when using complex macros. Notice that in the above example, the variable " $x$ " is always within it's own set of parentheses. This way, it will be evaluated in
whole, before being compared to 0 or multiplied by -1 . Also, the entire macro is surrounded by parentheses, to prevent it from being contaminated by other code. If you're not careful, you run the risk of having the compiler misinterpret your code. Here is an example of how to use the \#define command to create a general purpose incrementing for loop that prints out the integers 1 through 20:

```
#define count_up( v, low, high ) \
    for( (v) = (low); (v) <= (high); (v)++ )
...
int i;
count_up( i, 1, 20 ) {
    printf( "i is %d\n", i );
}
```

Related topics: \# and \#\#, \#if,...,\#endif, \#undef

## \#error

## Syntax:

## \#error message

The \#error command simply causes the compiler to stop when it is encountered. When an \#error is encountered, the compiler spits out the line number and whatever message is. This command is mostly used for debugging.

## \#include

Syntax:

```
#include <filename>
#include "filename"
```

This command slurps in a file and inserts it at the current location. The main difference between the syntax of the two items is that if filename is enclosed in angled brackets, then the compiler searches for it somehow. If it is enclosed in quotes, then the compiler doesn't search very hard for the file.

While the behavior of these two searches is up to the compiler, usually the angled brackets means to search through the standard library directories, while the quotes indicate a search in the current directory. The spiffy new C++ \#include commands don't need to map directly to filenames, at least not for the standard libraries. That's why you can get away with

```
#include <iostream>
```

...and not have the compiler choke on you.

## \#line

Syntax:
\#line line_number "filename"
The \#line command is simply used to change the value of the LINE and FILE variables. The filename is optional. The LINE and FILE variables represent the current file and which line is being read. The command

$$
\text { \#line } 10 \text { "main.cpp" }
$$

...changes the current line number to 10 , and the current file to "main.cpp".

## \#pragma

## \#pragma lexems

The \#pragma command gives the programmer the ability to tell the compiler to do certain things. Since the \#pragma command is implementation specific, uses vary from compiler to compiler. One option might be to trace program execution.

Below are some compiler families, the operating system on which they're found and the pragma directives which are part of that implementation

# GNU C Compiler (GCC) - GNU/Linux, BSD, GNU/Herd, GNU/Darwin/Mac OS X, Windows (MinGW) 

## redefine_extname

## \#pragma redefine_extname printf prnt

Gives C functions a different programmer defined symbol when translated to assembly language.

## extern_prefix



Prefixes all external function assembly symbols with the string prefix. another \#pragma extern_prefix will end prefixing of externals.

## pack

\#pragma pack(64) // optimize all subsequent classes

Packing is an optimization method that makes the members of structures, classes, and unions align to a factor of the packing boundary. This usually makes it easier (thus faster) for the processor to access data since it's packed to align with what the processor is used to dealing with, however it costs memory by having random unnecessary garbage data inserted to align the code with the pack. the numerical value in parenthesis must be a factor of $2(2,4,8,16$, $32,64 \ldots$ ) There are other ways to use "pack" and they're described below but above is the simplest and most common way. you can use

```
#pragma pack() /* with empty parenthesis */
```

to reset the packing to the compiler default.
$\leftarrow$ \#pragma pack(push) and \#pragma pack(pop) are on the way, I'm still researching them and their functionality. -/>
$\leftarrow$ This document is still under construction, I intend to continue adding compilers and their pragma options instead of leaving this largely blank. -GinoMan -/>

## \#undef

The \#undef command undefines a previously defined macro variable, such as a variable defined by a \#define.

Related topics: \#define

## asm

Syntax:

```
asm( "instruction" );
```

The asm command allows you to insert assembly language commands directly into your code. Various different compilers allow differing forms for this command, such as

```
asm {
    instruction-sequence
}
```

or

```
asm( instruction );
```


## auto

The keyword auto is used to declare local variables with automatic (i.e. not static) storage duration.

The auto keyword is purely optional and rarely used.
Use of auto is not recommended, as in new C++ standard it will be used for other purposes.

Related Topics: register, static

## bool

The keyword bool is used to declare Boolean logic variables; that is, variables which can be either true or false. For example, the following code declares a boolean variable called done, initializes it to false, and then loops until that variable is set to true.

```
bool done = false;
while( !done ) {
}
```

Also see the data types page.
Related Topics: char, double, false, float, int, long, short, signed, true, unsigned, wchar_t

## break

The break keyword is used to break out of a do, for, or while loop. It is also used to finish each clause of a switch statement, keeping the program from "falling through" to the next case in the code. An example:

```
while( x < 100 ) {
    if( x < 0 )
        break;
    cout << x << endl;
    X++;
}
```

A given break statement will break out of only the closest loop, no further. If you have a triply-nested for loop, for example, you might want to include extra logic or a goto statement to break out of the loop.

Related Topics: continue, do, for, goto, switch, while

## case

The case keyword is used to test a variable against a certain value in a switch statement.

Related Topics: default, switch

Table of Contents
A comparison of the C++ casting operators Deficiencies of the old C-style cast Different operators for different uses

## A comparison of the C++ casting operators

In addition to the C-style casting operator (provided for backwards compatibility) the C++ standard defines four additional casting operators:

- static_cast
- const_cast
- dynamic_cast
- reinterpret_cast

The purpose of these new casting operators is to provide better type checking. Their use is encouraged over the old C-style casting operator.

## Deficiencies of the old C-style cast

Two forms of the C-style cast are supported in C++:

```
int age = (int) sqrt( foo / 3.25 );
int age = int( sqrt(foo/3.25 ) );
```

However, using the same syntax for a variety of different casting operations can make the intent of the programmer unclear.

Furthermore, it can be difficult to find a specific type of cast in a large codebase.

Finally, the generality of the C-style cast is can be overkill for situations where all that is needed is a simple conversion. The ability to select between several different casting operators of differing degrees of power can prevent programmers from inadvertently casting to an incorrect type.

## Different operators for different uses

The four casting operators in C++ can be used in different cases, where each is most appropriate:
static_cast is the most useful cast. It can be used to perform any implicit cast. When an implicit conversion loses some information, some compilers will produce warnings, and static_cast will eliminate these warnigs. Making implicit conversion thru static_cast is also useful to resolve ambiguity or to clarify the conversion presence. It also can be used to call an unary constructor, declared as explicit. It also can be used to cast up and down a class hierarchy, like dynamic_cast, except that no runtime checking is performed.
const_cast is used to apply or remove const or volatile qualifier from a variable.
dynamic_cast is used on polymorphic pointers or references to move up or down a class hierarchy. Note that dynamic_cast performs runtime-checks: if the object's type is not the one expected, it will return NULL during a pointer-cast and throw a std::bad_cast exception during a reference-cast.
reinterpret_cast is used to perform conversions between unrelated types, like conversion between unrelated pointers and references or conversion between an integer and a pointer.

Old-style cast may correspond to static_cast, reinterpret_cast or const_cast, or even a combination of them. This means that none of these casting operators is as powerful as old-style cast.

Related links: http://www.acm.org/crossroads/xrds3-1/ovp3-1.html

## catch

The catch statement handles exceptions generated by the throw statement.

Related Topics: throw, try

The char keyword is used to declare character variables. For more information about variable types, see the data types page.

Related Topics: bool, double, float, int, long, short, signed, unsigned, void, wchar_t

## class

Syntax:

```
class class-name : inheritance-list {
private-members-list;
protected:
protected-members-list;
public:
public-members-list;
} object-list;
```

The class keyword allows you to create new classes. class-name is the name of the class that you wish to create, and inheritance-list is an optional list of classes inherited by the new class.

Members of the class are private by default, unless listed under either the protected or public labels. object-list can be used to immediately instantiate one or more instances of the class, and is also optional.

For example:

```
class Date {
    int Day;
    int Month;
    int Year;
public:
    void display();
};
```

Related Topics: friend, private, protected, public, struct, this, typename, union, virtual

## const

The const keyword can be used to tell the compiler that a certain variable should not be modified once it has been initialized. It can also be used to declare functions of a class that do not alter any class data.

Related Topics: const_cast, mutable

## const_cast

Syntax:

```
TYPE const_cast<TYPE> (object);
```

The const_cast keyword can be used to remove the const or volatile property from an object. The target data type must be the same as the source type, except (of course) that the target type doesn't have to have the same const qualifier.

For example, the following code uses const_cast to remove the const qualifier from a object:

```
class Foo {
public:
    void func() {} // a non-const member function
};
void someFunction( const Foo& f ) {
    f.func(); // compile error: cannot call a non-cons
        // function on a const reference
    Foo &fRef = const_cast<Foo&>(f);
    fRef.func(); // okay
}
```

Related Topics: const, dynamic_cast, reinterpret_cast, static_cast, A comparison of the C++ casting operators

## continue

The continue statement can be used to bypass iterations of a given loop. For example, the following code will display all of the numbers between 0 and 20 except 10:

```
for( int i = 0; i < 21; i++ ) {
        if( i == 10 ) {
            continue;
    }
    cout << i << " ";
}
```

Related Topics: break, do, for, while

## default

A default case in the switch statement.

Related Topics: case, switch

## delete

Syntax:

```
delete p;
delete[] pArray;
```

The delete operator frees the memory pointed to by p . The argument should have been previously allocated by a call to new or 0 . The second form of delete should be used to delete an array. If (in either forms) the argument is 0 , nothing is done.

Related Topics: free, malloc, new

## do

Syntax:

```
do {
statement-list;
} while( condition );
```

The do construct evaluates the given statement-list repeatedly, until condition becomes false. Note that every do loop will evaluate its statement list at least once, because the terminating condition is tested at the end of the loop.

Related Topics: break, continue, for, while

## double

The double keyword is used to declare double precision floating-point variables. Also see the data types page.

Related Topics: bool, char, float, int, long, short, signed, unsigned, void, wchar_t

## dynamic_cast

Syntax:

```
TYPE& dynamic_cast<TYPE&> (object);
TYPE* dynamic_cast<TYPE*> (object);
```

The dynamic_cast keyword casts a datum from one pointer or reference type to another, performing a runtime check to ensure the validity of the cast.

If you attempt to cast to a pointer type, and that type is not an actual type of the argument object, then the result of the cast will be NULL.

If you attempt to cast to a reference type, and that type is not an actual type of the argument object, then the cast will throw a std::bad_cast exception.

```
    struct A {
        virtual void f() { }
    };
    struct B : public A { };
    struct C { };
    void f () {
        A a;
        B b;
        A* ap = &b;
        B* b1 = dynamic_cast<B*> (&a); // NULL, because 'a'
        B* b2 = dynamic_cast<B*> (ap); // 'b'
        C* c = dynamic_cast<C*> (ap); // NULL.
        A& ar = dynamic_cast<A&> (*ap); // Ok.
        B& br = dynamic_cast<B&> (*ap); // Ok.
        C& cr = dynamic_cast<C&> (*ap); // std::bad_cast
    }
|
```

Related Topics: const_cast, reinterpret_cast, static_cast, A comparison of the C++ casting operators

## else

The else keyword is used as an alternative case for the if statement.
Related Topics: if

## enum

Syntax:
enum name \{name-list\} var-list;
The enum keyword is used to create an enumerated type named name that consists of the elements in name-list. The var-list argument is optional, and can be used to create instances of the type along with the declaration. For example, the following code creates an enumerated type for colors:

```
enum ColorT {red, orange, yellow, green, blue, indig
ColorT c1 = indigo;
if( c1 == indigo ) {
    cout << "c1 is indigo" << endl;
}
```

In the above example, the effect of the enumeration is to introduce several new constants named red, orange, yellow, etc. By default, these constants are assigned consecutive integer values starting at zero. You can change the values of those constants, as shown by the next example:

```
enum ColorT { red = 10, blue = 15, green };
...
ColorT c = green;
cout << "c is " << c << endl;
```

When executed, the above code will display the following output:

$$
\text { c is } 16
$$

Note that the above examples will only work with C++ compilers. If
you're working in regular C , you will need to specify the enum keyword whenever you create an instance of an enumerated type:

```
enum ColorT { red = 10, blue = 15, green };
enum ColorT c = green; // note the aditional enum
printf( "c is %d\n", c );
|

\section*{explicit}

When a constructor is specified as explicit, no automatic conversion will be used with that constructor - but parameters passed to the constructor may still be converted. For example:
```

    struct foo {
        explicit foo( int a )
            : a_( a )
    { }
    int a_;
    };
int bar( const foo \& f ) {
return f.a_;
}
bar( 1 ); // fails because an implicit conversion fr
// is forbidden by explicit.
bar( foo( 1 ) ); // works -- explicit call to explic.
bar( static_cast<foo>( 1 ) ); // works -- call to ex
bar( foo( 1.0 ) ); // works -- explicit call to expl.
// with automatic conversion from
4

```

\section*{export}

The export keyword is intended to allow definitions of C++ templates to be separated from their declarations. While officially part of the C++ standard, the export keyword is only supported by a few compilers (such as the Comeau C++ compiler) and is not supported by such mainstream compilers as GCC and Visual C++.

\section*{extern}

The extern keyword is used to inform the compiler about variables declared outside of the current scope. Variables described by extern statements will not have any space allocated for them, as they should be properly defined elsewhere.

Extern statements are frequently used to allow data to span the scope of multiple files.

When applied to function declarations, the additional " C " or " \(\mathrm{C}++\) " string literal will change name mangling when compiling under the opposite language. That is,
```

extern "C" int plain_c_func(int param);

```
allows C++ code to execute a C library function plain_c_func.
See also: extern "LANG" Linkage Issues

\section*{false}

The Boolean value of "false".

Related Topics: bool, true

\section*{float}

The float keyword is used to declare floating-point variables. Also see the data types page.

Related Topics: bool, char, double, int, long, short, signed, unsigned, void, wchar_t

\section*{Syntax:}
```

for( initialization; test-condition; increment ) {
statement-list;
}

```

The for construct is a general looping mechanism consisting of 4 parts:
1. the initialization, which consists of 0 or more comm initialization statements
2. the test-condition, which is evaluated to determine the for loop will continue
3. the increment, which consists of 0 or more comma-del. increment variables
4. and the statement-list, which consists of 0 or more be executed each time the loop is executed.

For example:


Related Topics: break, continue, do, if, while

\section*{friend}

The friend keyword allows classes or functions not normally associated with a given class to have access to the private data of that class.

Related Topics: class

\section*{goto}

Syntax:
```

goto labelA;

```
...
labelA:
The goto statement causes the current thread of execution to jump to the specified label. While the use of the goto statement is generally considered harmful, it can occasionally be useful. For example, it may be cleaner to use a goto to break out of a deeply-nested for loop, compared to the space and time that extra break logic would consume.

Related Topics: break

\section*{if}

Syntax:
```

if( conditionA ) {
statement-listA;
}
else if( conditionB ) {
statement-listB;
}
..
else {
statement-listN;
}

```

The if construct is a branching mechanism that allows different code to execute under different conditions. The conditions are evaluated in order, and the statement-list of the first condition to evaluate to true is executed. If no conditions evaluate to true and an else statement is present, then the statement list within the else block will be executed. All of the else blocks are optional.

Related Topics: else, for, switch, while

\section*{inline}

Syntax:
```

inline int functionA( int a ) {
}

```

The inline keyword requests that the compiler expand a given function in place, as opposed to inserting a call to that function. The inline keyword is a request, not a command, and the compiler is free to ignore it for whatever reason.

When a function declaration is included in a class definition, the compiler should try to automatically inline that function. No inline keyword is necessary in this case.

\section*{int}

The int keyword is used to declare integer variables. Also see the data types page.

Related Topics: bool, char, double, float, long, short, signed, unsigned, void, wchar_t

\section*{long}

The long keyword is a data type modifier that is used to declare long integer variables. For more information on long, see the data types page.

Related Topics: bool, char, double, float, int, short, signed, void

\section*{mutable}

The mutable keyword overrides any enclosing const statement. A mutable member of a const object can be modified.

Related Topics: const

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namespace anonymous namespace namespace alias

\section*{namespace}

Syntax:
```

namespace name {
declaration-list;
}

```

The namespace keyword allows you to create a new scope. The name is optional, and can be omitted to create an unnamed namespace. Once you create a namespace, you'll have to refer to it explicitly or use the using keyword. Example code:
```

namespace CartoonNameSpace {
int HomersAge;
void incrementHomersAge() {
HomersAge++;
}
}
int main() {
CartoonNameSpace::HomersAge = 39;
CartoonNameSpace::incrementHomersAge();
cout << CartoonNameSpace::HomersAge << endl;
}

```

\section*{anonymous namespace}

A namespace without a name called anonymous namespace. For such a namespace, an unique name will be generated for each translation unit. It is not possible to apply the using keyword to anonymous namespaces, so an anonymous namespace works as if the using keyword has been applied to it.
```

namespace {
declaration-list;
}

```

\section*{namespace alias}

You can create new names (aliases) for namespaces, including nested namespaces.
```

namespace identifier = namespace-specifier;

```

Related Topics: using

\section*{new}

\section*{Syntax:}
```

pointer = new type;
pointer = new type( initializer );
pointer = new type[size];
pointer = new( arg-list ) type...

```

The new operator (valid only in C++) allocates a new chunk of memory to hold a variable of type type and returns a pointer to that memory. An optional initializer can be used to initialize the memory. Allocating arrays can be accomplished by providing a size parameter in brackets. The optional arg-list parameter can be used with any of the other formats to pass a variable number of arguments to an overloaded version of new(). For example, the following code shows how the new() function can be overloaded for a class and then passed arbitrary arguments:


If an int is 4 bytes and a double is 8 bytes, the above code generates
the following output when run:


Related Topics: delete, free, malloc

\section*{operator}

Syntax:
```

return-type class-name::operator\#(parameter-list) {
}
return-type operator\#(parameter-list) {
}

```

The operator keyword is used to overload operators. The sharp sign (\#) listed above in the syntax description represents the operator which will be overloaded. If part of a class, the class-name should be specified. For unary operators, parameter-list should be empty, and for binary operators, parameter- list should contain the operand on the right side of the operator (the operand on the left side is passed as this). For the non-member operator overload function, the operand on the left side should be passed as the first parameter and the operand on the right side should be passed as the second parameter. You cannot overload the \#, \#\#, ., :, .*, or ? tokens.

Related Topics: this

\section*{private}

Private data of a class can only be accessed by members of that class, except when friend is used. The private keyword can also be used to inherit a base class privately, which causes all public and protected members of the base class to become private members of the derived class.

Related Topics: class, protected, public

\section*{protected}

Protected data are private to their own class but can be inherited by derived classes. The protected keyword can also be used as an inheritance specifier, which causes all public and protected members of the base class to become protected members of the derived class.

Related Topics: class, private, public

\section*{public}

Public data in a class are accessible to everyone. The public keyword can also be used as an inheritance specifier, which causes all public and protected members of the base class to become public and protected members of the derived class.

Related Topics: class, private, protected

\section*{register}

The register keyword requests that a variable be optimized for speed, and fell out of common use when computers became better at most code optimizations than humans.

Related Topics: auto

\section*{reinterpret_cast}

Syntax:

> TYPE reinterpret_cast<TYPE> (object);

The reinterpret_cast operator changes one data type into another. It should be used to cast between incompatible pointer types.

Related Topics: const_cast, dynamic_cast, static_cast, A comparison of the C++ casting operators

\section*{return}

Syntax:
```

return;
return( value );

```

The return statement causes execution to jump from the current function to whatever function called the current function. An optional value can be returned. A function may have more than one return statement.

\section*{short}

The short keyword is a data type modifier that is used to declare short integer variables. See the data types page.

Related Topics: bool, char, double, float, int, long, signed, unsigned, void, wchar_t

\section*{signed}

The signed keyword is a data type modifier that is usually used to declare signed char variables. See the data types page.

Related Topics: bool, char, double, float, int, long, short, unsigned, void, wchar_t

\section*{sizeof}

The sizeof operator is a compile-time operator that returns the size of the argument passed to it. The size is a multiple of the size of a char, which on many personal computers is 1 byte (or 8 bits). The number of bits in a char is stored in the CHAR_BIT constant defined in the <climits> header file. For example, the following code uses sizeof to display the sizes of a number of variables:
```

struct EmployeeRecord {
int ID;
int age;
double salary;
EmployeeRecord* boss;
};
cout << "sizeof(int): " << sizeof(int) << endl
<< "sizeof(float): " << sizeof(float) << endl
<< "sizeof(double): " << sizeof(double) << endl
<< "sizeof(char): " << sizeof(char) << endl
<< "sizeof(EmployeeRecord): " << sizeof(Employee

```
int i;
float f;
double d;
char c;
EmployeeRecord er;
```

cout << "sizeof(i): " << sizeof(i) << endl
<< "sizeof(f): " << sizeof(f) << endl
<< "sizeof(d): " << sizeof(d) << endl
<< "sizeof(c): " << sizeof(c) << endl
<< "sizeof(er): " << sizeof(er) << endl;

```
4

On some machines, the above code displays this output:
```

sizeof(int): 4
sizeof(float): 4
sizeof(double): 8
sizeof(char): 1
sizeof(EmployeeRecord): 20
sizeof(i): 4
sizeof(f): 4
sizeof(d): 8
sizeof(c): 1
sizeof(er): 20

```

Note that sizeof can either take a variable type (such as int) or a variable name (such as i in the example above). It is also important to note that the sizes of various types of variables can change depending on what system you're on. Check out a_description_of_the_C_and C++_data types for more information. The parentheses around the argument are only required if you are using sizeof with a variable type (e.g. sizeof(int)). Parentheses can be left out if the argument is a variable or array (e.g. sizeof x, sizeof myArray).

Related Topics: C++_Data_Types

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\section*{static}

The static keyword can be used in four different ways:
1. to create permanent storage for local variables in a function,
2. to create a single copy of class data,
3. to declare member functions that act like a non-member functions, and
4. to specify internal linkage.

\section*{Permanent storage}

Static local variables keep their value between function calls. For example, in the following code, a static variable inside a function is used to keep track of how many times that function has been called:
```

void foo() {
static int counter = 0;
cout << "foo has been called " << ++counter << " times)
}
int main() {
for( int i = 0; i < 10; ++i ) foo();
}
4

```

\section*{Single copy of class data}

When used in a class data member, all instantiations of that class share one copy of the variable.
```

class Foo {
public:
Foo() {
++numFoos;
cout << "We have now created " << numFoos << " instal
}
private:
static int numFoos;
};
int Foo::numFoos = 0; // allocate memory for numFoos, al
int main() {
Foo f1;
Foo f2;
Foo f3;
}
|

```

In the example above, the static class variable numFoos is shared between all three instances of the Foo class (f1, f2 and f3) and keeps a count of the number of times that the Foo class has been instantiated.

\section*{Class functions callable without an object}

When used in a class function member, the function does not take an instantiation as an implicit this parameter, instead behaving like a free function. This means that static class functions can be called without creating instances of the class:
```

class Foo {
public:
Foo() {
++numFoos;
cout << "We have now created " << numFoos << " instal
}
static int getNumFoos() {
return numFoos;
}
private:
static int numFoos;
};
int Foo::numFoos = 0; // allocate memory for numFoos, al
int main() {
Foo f1;
Foo f2;
Foo f3;
cout << "So far, we've made " << Foo::getNumFoos() <<
}

```


\section*{Internal linkage}

When used on a free function, a global variable, or a global constant, it specifies internal linkage (as opposed to extern, which specifies external linkage). Internal linkage limits access to the data or function to the current file.

Related: extern

\section*{static_cast}

Syntax:

\section*{TYPE static_cast<TYPE> (object);}

The static_cast keyword can be used for any normal conversion between types. This includes any casts between numeric types, casts of pointers and references up the hierarchy, conversions with unary constructor, conversions with conversion operator. For conversions between numeric types no runtime checks if data fits the new type is performed. Conversion with unary constructor would be performed even if it is declared as explicit

It can also cast pointers or references down and across the hierarchy as long as such conversion is avaliable and unambiguous. No runtime checks are performed.

Related Topics: const_cast, dynamic_cast, reinterpret_cast, A comparison of the C++ casting operators

\section*{struct}

Syntax:
```

struct struct-name : inheritance-list {
public-members-list;
protected:
protected-members-list;
private:
private-members-list;
} object-list;

```

Structs are like `classes`, except that by default members of a struct are public rather than private. In C, structs can only contain data and are not permitted to have inheritance lists.

The object list is optional - structs may be defined without actually instantiating any new objects.

For example, the following code creates a new datatype called Date (which contains three integers) and also creates an instance of Date called today:
```

struct Date {
int day;
int month;
int year;
} today;
int main() {
today.day = 4;
today.month = 7;
today.year = 1776;
}

```

Related Topics: class, union

\section*{switch}

Syntax:
```

switch( expression ) {
case A:
statement list;
break;
case B:
statement list;
break;
...
case N:
statement list;
break;
default:
statement list;
break;
}

```

The switch statement allows you to test an expression for many values, and is commonly used as a replacement for multiple if()...else if()...else if()... statements. break statements are required between each case statement, otherwise execution will "fall-through" to the next case statement. The default case is optional. If provided, it will match any case not explicitly covered by the preceding cases in the switch statement. For example:
```

char keystroke = getch();
switch( keystroke ) {
case 'a':
case 'b':
case 'c':
case 'd':
KeyABCDPressed();
break;
case 'e':
KeyEPressed();
break;
default:
UnknownKeyPressed();
break;
}

```

Related Topics: break, case, default, if

\section*{template}

Syntax:


Templates are used to create generic functions and generic classes and can operate on data without knowing the nature of that data. They accomplish this by using a placeholder data-type for which many other data types can be substituted. Example code: For example, the following code uses a template to define a generic swap function that can swap two variables of any type:
```

template<class X> void genericSwap( X \&a, X \&b ) {
X tmp;
tmp = a;
a = b;
b = tmp;
}
int main(void) {
int num1 = 5;
int num2 = 21;
cout << "Before, num1 is " << num1 << " and num2 i
genericSwap( num1, num2 );
cout << "After, num1 is " << num1 << " and num2 is
char c1 = 'a';
char c2 = 'z';
cout << "Before, c1 is " << c1 << " and c2 is " <<
genericSwap( c1, c2 );
cout << "After, c1 is " << c1 << " and c2 is " <<
...
return( 0 );
}
4.

```

The next template is used to descibe a generic class:
```

\#include <cassert>
const unsigned int maxSize = 20;
template<class T>
class simpleStack
{
public:
simpleStack(): amount(0) {}
bool empty() const { return amount == 0; }
bool full() const { return amount == maxSize; }
unsigned int size() const { return amount; }
void clear() { amount = 0; }
const T\& top() const;
void pop();
void push( const T \&x);
private:
unsigned int amount;
T array[ maxSize ];
};
template<class T>
const T\& simpleStack<T>::top() const
{
assert( !empty() );
return array[ amount - 1 ];
}
template<typename T> /*it's allowed and equal to replac\epsilon
void simpleStack<T>: : pop()
{
assert( !empty() );
--amount;
4}

```

Related Topics: typename

\section*{this}

The this keyword is a pointer to the current object. All member functions of a class have a this pointer.

Related Topics: class, operator

\section*{throw}

Syntax:
```

try {
statement list;
}
catch( typeA arg ) {
statement list;
}
catch( typeB arg ) {
statement list;
}
catch( typeN arg ) {
statement list;
}

```

The throw statement is part of the C++ mechanism for exception handling. This statement, together with the try and catch statements, the C++ exception handling system gives programmers an elegant mechanism for error recovery.

You will generally use a try block to execute potentially error-prone code. Somewhere in this code, a throw statement can be executed, which will cause execution to jump out of the try block and into one of the catch blocks.

A
```

catch (...)
{

```
will catch any throw without considering what kind of object was thrown and without giving access to the thrown object.

\section*{Writing}
```

throw

```

Within a catch block will re throw what ever was caught.
Example:
```

try {
cout << "Before throwing exception" << endl;
if (cout.fail())
{
throw 42;
}
cout << "Shouldn't ever see this" << endl;
}
catch( int error ) {
cerr << "Error: caught exception " << error << end
}
4.

```

Related Topics: catch, try

\section*{true}

The Boolean value of "true".

Related Topics: bool, false

\section*{try}

The try statement attempts to execute exception-generating code. See the throw statement for more details.

Related Topics: catch, throw

\section*{typedef}

Syntax:

\section*{typedef existing-type new-type;}

The typedef keyword allows you to create a new alias for an existing data type. This is often useful if you find yourself using a unwieldy data type - you can use typedef to create a shorter, easier-to-use name for that data type. For example:
```

typedef unsigned int* pui_t;
// data1 and data2 have the same type
pui_t data1;
unsigned int* data2;

```

\section*{typeid}

Syntax:

\section*{typeid( object );}

The typeid operator returns a reference to a type_info object that describes `object`.

\section*{typename}

The typename keyword can be used to describe an undefined type or in place of the class keyword in a template declaration.

Related Topics: class, template

\section*{union}

Syntax:
```

union union-name {
public-members-list;
private:
private-members-list;
} object-list;

```

A union is like a class, except that all members of a union share the same memory location and are by default public rather than private. For example:
```

union Data {
int i;
char c;
};

```

Related Topics: class, struct

\section*{unsigned}

The unsigned keyword is a data type modifier that is usually used to declare unsigned int variables. See the data types page.

Related Topics: bool, char, double, float, int, short, signed, void, wchar_t

\section*{using}

The using keyword is used to import a namespace (or parts of a namespace) into the current scope. Example code: For example, the following code imports the entire std namespace into the current scope so that items within that namespace can be used without a preceeding "std::".
using namespace std;
Alternatively, the next code snippet just imports a single element of the std namespace into the current namespace:
```

using std::cout;

```

Related Topics: namespace

\section*{virtual}

Syntax:
```

virtual return-type name( parameter-list );
virtual return-type name( parameter-list ) = 0;

```

The virtual keyword can be used to create virtual functions, which can be overridden by derived classes.
- A virtual function indicates that a function can be overridden in a subclass, and that the overridden function will actually be used.
- When a base object pointer points to a derived object that contains a virtual function, the decision about which version of that function to call is based on the type of object pointed to by the pointer, and this process happens at runtime.
- A base object can point to different derived objects and have different versions of the virtual function run.

If the function is specified as a pure virtual function (denoted by the \(=\) 0 ), it must be overridden by a derived class.

For example, the following code snippet shows how a child class can override a virtual method of its parent, and how a non-virtual method in the parent cannot be overridden:
```

class Base {
public:
void nonVirtualFunc() {
cout << "Base: non-virtual function" << endl;
}
virtual void virtualFunc() {
cout << "Base: virtual function" << endl;
}
};
class Child : public Base {
public:
void nonVirtualFunc() {
cout << "Child: non-virtual function" << endl;
}
void virtualFunc() {
cout << "Child: virtual function" << endl;
}
};
int main() {
Base* basePointer = new Child();
basePointer->nonVirtualFunc();
basePointer->virtualFunc();
return 0;
}

```

When run, the above code displays:

Base: non-virtual function Child: virtual function

Related Topics: class

\section*{void}

The void keyword is used to denote functions that return no value, or generic variables which can point to any type of data. Void can also be used to declare an empty parameter list. Also see the data types page.

Related Topics: char, double, float, int, long, short, signed, unsigned, wchar_t

\section*{volatile}

The volatile keyword is an implementation-dependent modifier, used when declaring variables, which prevents the compiler from optimizing those variables. Volatile should be used with variables whose value can change in unexpected ways (i.e. through an interrupt), which could conflict with optimizations that the compiler might perform.

\section*{wchar_t}

The keyword wchar_t is used to declare wide character variables. Also see the data types page.

Related Topics: bool, char, double, float, int, short, signed, unsigned, void

\section*{while}

Syntax:
```

while( condition ) {
statement-list;
}

```

The while keyword is used as a looping construct that will evaluate the statement-list as long as condition is true. Note that if the condition starts off as false, the statement-list will never be executed. (You can use a do loop to guarantee that the statement-list will be executed at least once.) For example:
```

bool done = false;
while( !done ) {
ProcessData();
if( StopLooping() ) {
done = true;
}
}

```

Related Topics: break, continue, do, for, if

\section*{accumulate}

Syntax:


The accumulate function computes the sum of val and all of the elements in the range [start,end).

If the binary function \(f\) if specified, it is used instead of the + operator to perform the summation.
accumulate runs in linear time.

Related Topics: adjacent_difference, count, inner_product, partial_sum

\section*{adjacent_difference}

Syntax:
```

    #include <numeric>
    iterator adjacent_difference( iterator start, iterato
    iterator adjacent_difference( iterator start, iterato
    | ! \

```

The adjacent_difference() function calculates the differences between adjacent elements in the range [start,end) and stores the result starting at result. If a binary function \(f\) is given, it is used instead of the operator to compute the differences. adjacent_difference() runs in linear time.

Related Topics: accumulate, count, inner_product, partial_sum

\section*{adjacent_find}

Syntax:
\#include <algorithm>
iterator adjacent_find( iterator start, iterator end
iterator adjacent_find( iterator start, iterator end,

The adjacent_find() function searches between start and end for two consecutive identical elements. If the binary predicate pr is specified, then it is used to test whether two elements are the same or not. The return value is an iterator that points to the first of the two elements that are found. If no matching elements are found, the returned iterator points to end. For example, the following code creates a vector containing the integers between 0 and 10 with 7 appearing twice in a row. adjacent_find() is then used to find the location of the pair of 7's:
```

    vector<int> v1;
    for( int i = 0; i < 10; i++ ) {
        v1.push_back(i);
        // add a duplicate 7 into v1
        if( i == 7 ) {
            v1.push_back(i);
        }
    }
    vector<int>::iterator result;
    result = adjacent_find( v1.begin(), v1.end() );
    if( result == v1.end() ) {
        cout << "Did not find adjacent elements in v1" << en
    }
    else {
        cout << "Found matching adjacent elements starting a
    endl;
    }
    4) 
```

Related Topics: find, find_end, find_first_of, find_if, unique, unique_copy

\section*{binary_search}

\section*{Syntax:}
```

\#include <algorithm>
bool binary_search( iterator start, iterator end, con
bool binary_search( iterator start, iterator end, con

```
1

The binary_search() function searches from start to end for val. The elements between start and end that are searched should be in ascending order as defined by the < operator. Note that a binary search will not work unless the elements being searched are in order.

If val is found, binary_search() returns true, otherwise false. If the function \(f\) is specified, then it is used to compare elements.
binary_search() runs in logarithmic time.
For example, the following code uses binary_search() to determine if the integers 0-9 are in an array of integers:
```

int nums[] = { -242, -1, 0, 5, 8, 9, 11 };
int start = 0;
int end = 7;
for( int i = 0; i < 10; i++ ) {
if( binary_search( nums+start, nums+end, i ) ) {
cout << "nums[] contains " << i << endl;
} else {
cout << "nums[] DOES NOT contain " << i << endl;
}
}

```

When run, this code displays the following output:
```

nums[] contains 0
nums[] DOES NOT contain 1
nums[] DOES NOT contain 2
nums[] DOES NOT contain 3
nums[] DOES NOT contain 4
nums[] contains 5
nums[] DOES NOT contain 6
nums[] DOES NOT contain 7
nums[] contains 8
nums[] contains 9

```

Related Topics: equal_range, is_sorted, lower_bound, partial_sort, partial_sort_copy, sort, stable_sort, upper_bound

\section*{copy}

Syntax:


The copy() function copies the elements between start and end to dest. In other words, after copy() has run,
```

*dest == *start
*(dest+1) == *(start+1)
*(dest+2) == *(start+2)
...
*(dest+N) == *(start+N)

```

The return value is an iterator to the last element copied. copy() runs in linear time.

For example, the following code uses copy() to copy the contents of one vector to another:
```

vector<int> from_vector;
for( int i = 0; i < 10; i++ ) {
from_vector.push_back( i );
}
vector<int> to_vector(10);
copy( from_vector.begin(), from_vector.end(), to_vecto
cout << "to_vector contains: ";
for( unsigned int i = 0; i < to_vector.size(); i++ ) {
cout << to_vector[i] << " ";
}
cout << endl;

```

Related Topics: copy_backward, copy_n, generate, remove_copy, swap, transform

\section*{copy_backward}

Syntax:
\#include <algorithm>
iterator copy_backward( iterator start, iterator end,
copy_backward() is similar to copy, in that both functions copy elements from start to end to dest. The copy_backward() function , however, starts depositing elements at dest and then works backwards, such that:
```

*(dest-1) == *(end-1)
*(dest-2) == *(end-2)
*(dest-3) == *(end-3)
*(dest-N) == *(end-N)

```

The following code uses copy_backward() to copy 10 integers into the end of an empty vector:
```

vector<int> from_vector;
for( int i = 0; i < 10; i++ ) {
from_vector.push_back( i );
}
vector<int> to_vector(15);
copy_backward( from_vector.begin(), from_vector.end(),
cout << "to_vector contains: ";
for( unsigned int i = 0; i < to_vector.size(); i++ ) {
cout << to_vector[i] << " ";
}
cout << endl;

```

The above code produces the following output:
to_vector contains: 000000123456789
Related Topics: copy, copy_n, swap

\section*{copy_n}

This function was part of the original SGI STL library, but never has been a part of ISO C++.

\section*{count}

Syntax:


The count() function returns the number of elements between start and end that match val.

For example, the following code uses count() to determine how many integers in a vector match a target value:
```

vector<int> v;
for( int i = 0; i < 10; i++ ) {
v.push_back( i );
}
int target_value = 3;
int num_items = count( v.begin(), v.end(), target_valu
cout << "v contains " << num_items << " items matching
endl;

```

The above code displays the following output:
```

v contains 1 items matching 3

```

Related Topics: accumulate, adjacent_difference, count_if, inner_product, partial_sum

\section*{count if}

Syntax:
\#include <algorithm>
size_t count_if( iterator start, iterator end, UnaryP 4.

The count_if() function returns the number of elements between start and end for which the predicate p returns true.

For example, the following code uses count_if() with a predicate that returns true for the integer 3 to count the number of items in an array that are equal to 3 :
```

int nums[] = { 0, 1, 2, 3, 4, 5, 9, 3, 13 };
int start = 0;
int end = 9;
int target_value = 3;
int num_items = count_if( nums+start,
nums+end,
bind2nd(equal_to<int>(), target_val
cout << "nums[] contains " << num_items << " items mat
target_value << endl;

```

When run, the above code displays the following output:
```

nums[] contains 2 items matching 3

```

Related Topics: count

\section*{equal}

Syntax:
```

    #include <algorithm>
    bool equal( iterator start1, iterator end1, iterator
    bool equal( iterator start1, iterator end1, iterator
    |

```

The equal() function returns true if the elements in two ranges are the same. The first range of elements are those between start1 and end1. The second range of elements has the same size as the first range but starts at start2.

If the binary predicate \(p\) is specified, then it is used instead of \(==\) to compare each pair of elements.

For example, the following code uses equal() to compare two vectors of integers:
```

vector<int> v1;
for( int i = 0; i < 10; i++ ) {
v1.push_back( i );
}
vector<int> v2;
for( int i = 0; i < 10; i++ ) {
v2.push_back( i );
}
if( equal( v1.begin(), v1.end(), v2.begin() ) ) {
cout << "v1 and v2 are equal" << endl;
} else {
cout << "v1 and v2 are NOT equal" << endl;
}

```

Related Topics: find_if, lexicographical_compare, mismatch, search

\section*{equal_range}

Syntax:


The equal_range() function returns the range of elements between first and last that are equal to val. This function assumes that the elements between first and last are in order according to comp, if it is specified, or the < operator otherwise.
equal_range() can be thought of as a combination of the lower_bound and upper_bound functions, since the first of the pair of iterators that it returns is what lower_bound returns and the second iterator in the pair is what upper_bound returns.

For example, the following code uses equal_range() to determine all of the possible places that the number 8 can be inserted into an ordered vector of integers such that the existing ordering is preserved:
```

    vector<int> nums;
    nums.push_back( -242 );
    nums.push_back( -1 );
    nums.push_back( 0 );
    nums.push_back( 5 );
    nums.push_back( 8 );
    nums.push_back( 8 );
    nums.push_back( 11 );
    pair<vector<int>::iterator, vector<int>::iterator> res
    int new_val = 8;
    result = equal_range( nums.begin(), nums.end(), new_va
    cout << "The first place that " << new_val << " could
        << *result.first << ", and the last place that it
        << *result.second << endl;
    4.\square

```

The above code produces the following output:
The first place that 8 could be inserted is before 8 ,
and the last place that it could be inserted is before

Related Topics: binary_search, lower_bound, upper_bound

\section*{fill}

Syntax:


The function fill() assigns val to all of the elements between start and end.

For example, the following code uses fill() to set all of the elements of a vector of integers to -1 :
```

vector<int> v1;
for( int i = 0; i < 10; i++ ) {
v1.push_back( i );
}
cout << "Before, v1 is: ";
for( unsigned int i = 0; i < v1.size(); i++ ) {
cout << v1[i] << " ";
}
cout << endl;
fill( v1.begin(), v1.end(), -1 );
cout << "After, v1 is: ";
for( unsigned int i = 0; i < v1.size(); i++ ) {
cout << v1[i] << " ";
}
cout << endl;

```

When run, the above code displays:
```

Before, v1 is: 0 1 2 3 4 5 6 7 8 9
After, v1 is: -1 -1 -1 -1 -1 -1 -1 -1 -1 -1

```

Related Topics: fill_n, generate, transform

\section*{fill_n}

Syntax:
```

    #include <algorithm>
    #include <algorithm>
    iterator fill_n( iterator start, size_t n, const TYPE,
    |

```

The fill_n() function is similar to fill. Instead of assigning val to a range of elements, however, fill_n() assigns val to the first \(n\) elements starting at start.

For example, the following code uses fill_n() to assign -1 to the first half of a vector of integers:
```

vector<int> v1;
for( int i = 0; i < 10; i++ ) {
v1.push_back( i );
}
cout << "Before, v1 is: ";
for( unsigned int i = 0; i < v1.size(); i++ ) {
cout << v1[i] << " ";
}
cout << endl;
fill_n( v1.begin(), v1.size()/2, -1 );
cout << "After, v1 is: ";
for( unsigned int i = 0; i < v1.size(); i++ ) {
cout << v1[i] << " ";
}
cout << endl;

```

When run, this code displays:

Before, v1 is: 01223456789
After, v1 is: -1 -1 -1 -1 -15 \begin{tabular}{l}
6 \\
\hline
\end{tabular}
Related Topics: fill

\section*{find}

\section*{Syntax:}


The find() algorithm looks for an element matching val between start and end. If an element matching val is found, the return value is an iterator that points to that element. Otherwise, the return value is an iterator that points to end.

For example, the following code uses find to search a vector of integers for the number 3 :
```

int num_to_find = 3;
vector<int> v1;
for( int i = 0; i < 10; i++ ) {
v1.push_back(i);
}
vector<int>::iterator result;
result = find( v1.begin(), v1.end(), num_to_find );
if( result == v1.end() ) {
cout << "Did not find any element matching " << num_
}
else {
cout << "Found a matching element: " << *result << e
}

```

In the next example, shown below, the find function is used on an array of integers. This example shows how the C++ STL algorithms can be
used to manipulate arrays and pointers in the same manner that they manipulate containers and iterators:
```

    int nums[] = { 3, 1, 4, 1, 5, 9 };
    int num_to_find = 5;
    int start = 0;
    int end = 2;
    int* result = find( nums + start, nums + end, num_to_f
    if( result == nums + end ) {
        cout << "Did not find any number matching " << num_t
    } else {
        cout << "Found a matching number: " << *result << en
    }
    4

```

Related Topics: adjacent_find, find_end, find_first_of, find_if, mismatch, search

\section*{find_end}

Syntax:
\#include <algorithm>
iterator find_end( iterator start, iterator end, iter
iterator find_end( iterator start, iterator end, iter

The find_end() function searches for the sequence of elements denoted by seq_start and seq_end. If such a sequence if found between start and end, an iterator to the first element of the last found sequence is returned. If no such sequence is found, an iterator pointing to end is returned.

If the binary predicate bp is specified, then it is used to when elements match.

For example, the following code uses find_end() to search for two different sequences of numbers. The the first chunk of code, the last occurence of " 123 " is found. In the second chunk of code, the sequence that is being searched for is not found:
```

    int nums[] = { 1, 2, 3, 4, 1, 2, 3, 4, 1, 2, 3, 4 };
    int* result;
    int start = 0;
    int end = 11;
    int target1[] = { 1, 2, 3 };
    result = find_end( nums + start, nums + end, target1 +
    if( *result == nums[end] ) {
cout << "Did not find any subsequence matching { 1,
} else {
cout << "The last matching subsequence is at: " << *
}
int target2[] = { 3, 2, 3 };
result = find_end( nums + start, nums + end, target2 +
if( *result == nums[end] ) {
cout << "Did not find any subsequence matching { 3,
} else {
cout << "The last matching subsequence is at: " << *
}

Related Topics: adjacent_find, find, find_first_of, find_if, search_n

## find_first_of

## Syntax:

\#include <algorithm>
iterator find_first_of( iterator start, iterator end,
iterator find_first_of( iterator start, iterator end,

The find_first_of() function searches for the first occurence of any element between find_start and find_end. The data that are searched are those between start and end.

If any element between find_start and find_end is found, an iterator pointing to that element is returned. Otherwise, an iterator pointing to end is returned.

For example, the following code searches for a 9, 4, or 7 in an array of integers:

```
int nums[] = { 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 };
int* result;
int start = 0;
int end = 10;
int targets[] = { 9, 4, 7 };
result = find_first_of( nums + start, nums + end, targ
if( *result == nums[end] ) {
    cout << "Did not find any of { 9, 4, 7 }" << endl;
} else {
    cout << "Found a matching target: " << *result << en
}
```

4

Related Topics: adjacent_find, find, find_end, find_if, strpbrk

## find_if

## Syntax:

```
    #include <algorithm>
    iterator find_if( iterator start, iterator end, UnPre
4.
```

The find_if() function searches for the first element between start and end for which the unary predicate up returns true.

If such an element is found, an iterator pointing to that element is returned. Otherwise, an iterator pointing to end is returned.

For example, the following code uses find_if() and a "greater-than-zero" unary predicate to the first positive, non-zero number in a list of numbers:

```
    int nums[] = { 0, -1, -2, -3, -4, 342, -5 };
int* result;
int start = 0;
int end = 7;
    result = find_if( nums + start, nums + end, bind2nd(gr
if( *result == nums[end] ) {
    cout << "Did not find any number greater than zero"
} else {
    cout << "Found a positive non-zero number: " << *res
}
```

Related Topics: adjacent_find, equal, find, find_end, find_first_of, search_n

## for_each

Syntax:

```
    #include <algorithm>
    UnaryFunction for_each( iterator start, iterator end,
4
```

The for_each() algorithm applies the function $f$ to each of the elements between start and end. The return value of for_each() is $f$.

For example, the following code snippets define a unary function then use it to increment all of the elements of an array:

```
template<class TYPE> struct increment : public unary_f
    void operator() (TYPE& x) {
        x++;
    }
};
...
int nums[] = {3, 4, 2, 9, 15, 267};
const int N = 6;
cout << "Before, nums[] is: ";
for( int i = 0; i < N; i++ ) {
    cout << nums[i] << " ";
}
cout << endl;
for_each( nums, nums + N, increment<int>() );
cout << "After, nums[] is: ";
for( int i = 0; i < N; i++ ) {
    cout << nums[i] << " ";
}
cout << endl;
```

The above code displays the following output:
Before, nums[] is: 342915267
After, nums[] is: 4531016268

## generate

Syntax:


The generate() function runs the Generator function object $g$ a number of times, saving the result of each execution in the range [start,end).

For example, the following code uses generate() to fill a vector with random numbers using the standard C library rand function:

```
    vector<int> v(5);
    generate(v.begin(), v.end(), rand); // Using the C fu
    // Depending on the compiler you may need to put &ran
    cout << "v: ";
    for (size_t i = 0; i < v.size(); ++i)
        cout << v[i] << ' ';
    cout << endl;
4.
```

Related Topics: copy, fill, generate_n, transform

## generate_n

Syntax:


The generate_n() function runs the Generator function object g num times, saving the result of each execution in result, (result+1), etc.

Related Topics: generate

## includes

Syntax:


The includes() algorithm returns true if every element in [start2,end2) is also in [start1,end1). Both of the given ranges must be sorted in ascending order and must not contain duplicate elements.

By default, the < operator is used to compare elements. If the strict weak ordering function object cmp is given, then it is used instead.
includes() runs in linear time.
Related Topics: set_difference, set_intersection, set_symmetric_difference, set_union

## inner_product

## Syntax:



The inner_product function computes the inner product of [start1, end1) and a range of the same size starting at start2.
inner_product() runs in linear time.
For example, the following code shows how inner_product (or, alternatively, accumulate) can be used to compute the sums of squares of some data:

```
// Examples of std::accumulate and std::inner_product fre
#include <functional>
#include <iostream>
#include <numeric>
#include <string>
#include <valarray>
#include <vector>
typedef std::valarray<double> xyz;
// Xyz output operator
std::ostream & operator<<(std::ostream & os, xyz const &
    os << '(';
    char const * sep = "";
    for( size_t i = 0; i != pt.size(); sep = ", ", ++i )
            os << sep << pt[i];
    }
    os << ')';
    return os;
}
// Bitwise or function, for use in reductions
unsigned bit_or(unsigned u, unsigned v) {
    return u | v;
}
// create and return a triangle
std::vector<xyz> create_triangle() {
    std::vector<xyz> pts;
    double const p[9] = {1.,1.,0.,1.,0.,1.,0.,1.,1.};
    pts.push_back(xyz(p + 0, 3));
    pts.push_back(xyz(p + 3, 3));
    pts.push_back(xyz(p + 6, 3));
    return pts:
```

When run, this code generates the following output:

```
sum(a) 6
prod(a) 6
sum_sqs(a) 14
dot(a, b) 10
concat(s) http://wordaligned.org
any(t) true
centroid(tri) (0.666667, 0.666667, 0.666667)
bitor(m) 0x2a
```

Related Topics: accumulate, adjacent_difference, count, partial_sum

## inplace_merge

Syntax:


The inplace_merge() function is similar to the merge() function, but instead of creating a new sorted range of elements, inplace_merge() alters the existing ranges to perform the merge in-place.

Related Topics: merge

## is_heap

Syntax:
\#include <algorithm>
bool is_heap( iterator start, iterator end );
bool is_heap( iterator start, iterator end, StrictWea

The is_heap() function returns true if the given range [start,end) is a heap.

If the strict weak ordering comparison function object cmp is given, then it is used instead of the < operator to compare elements.
is_heap() runs in linear time.
Related Topics: make_heap, pop_heap, push_heap, sort_heap

## is_sorted

Syntax:

```
    #include <algorithm>
    bool is_sorted( iterator start, iterator end );
    bool is_sorted( iterator start, iterator end, StrictW
4 - 
```

The is_sorted() algorithm returns true if the elements in the range [start,end) are sorted in ascending order.

By default, the < operator is used to compare elements. If the strict weak order function object cmp is given, then it is used instead.
is_sorted() runs in linear time.
Related Topics: binary_search, partial_sort, partial_sort_copy, sort, stable_sort

## iter_swap

Syntax:

```
#include <algorithm>
inline void iter_swap( iterator a, iterator b );
```

A call to iter_swap() exchanges the values of two elements exactly as a call to
swap( *a, *b );
would.

Related Topics: swap, swap_ranges

## lexicographical_compare

Syntax:
\#include <algorithm>
bool lexicographical_compare( iterator start1, iterat
bool lexicographical_compare( iterator start1, iterat

The lexicographical_compare() function returns true if the range of elements [start1,end1) is lexicographically less than the range of elements [start2,end2).

If you're confused about what lexicographic means, it might help to know that dictionaries are ordered lexicographically.
lexicographical_compare() runs in linear time.
Related Topics: equal, lexicographical_compare_3way, mismatch, search

## lexicographical_compare_3way

This function was part of the original SGI STL library, but never has been a part of ISO C++.

## lower_bound

Syntax:


The lower_bound() function is a type of binary_search(). This function searches for the first place that val can be inserted into the ordered range defined by first and last that will not mess up the existing ordering. This function requires the elements to be in order.

The return value of lower_bound() is an iterator that points to the location where val can be safely inserted. Unless the comparison function $f$ is specified, the < operator is used for ordering.

For example, the following code uses lower_bound() to insert the number 7 into an ordered vector of integers:

```
vector<int> nums;
nums.push_back( -242 );
nums.push_back( -1 );
nums.push_back( 0 );
nums.push_back( 5 );
nums.push_back( 8 );
nums.push_back( 8 );
nums.push_back( 11 );
cout << "Before nums is: ";
for( unsigned int i = 0; i < nums.size(); i++ ) {
    cout << nums[i] << " ";
}
cout << endl;
vector<int>::iterator result;
int new_val = 7;
result = lower_bound( nums.begin(), nums.end(), new_va
nums.insert( result, new_val );
cout << "After, nums is: ";
for( unsigned int i = 0; i < nums.size(); i++ ) {
    cout << nums[i] << " ";
}
cout << endl;

The above code produces the following output:
```

Before nums is: -242 -1 0 5 8 8 11
After, nums is: -242 -1 0 5 7 8 8 11

```
lower_bound() runs in logarithmic time.
Related Topics: binary_search, equal_range, upper_bound

\section*{make_heap}

Syntax:
```

    #include <algorithm>
    void make_heap( iterator start, iterator end );
    void make_heap( iterator start, iterator end, StrictW
    1

The make_heap() function turns the given range of elements [start,end) into a heap.

If the strict weak ordering comparison function object cmp is given, then it is used instead of the < operator to compare elements.
make_heap() runs in linear time.
Related Topics: is_heap, pop_heap, push_heap, sort_heap

## max

## Syntax:

\#include <algorithm>
const TYPE\& max( const TYPE\& $x$, const TYPE\& $y$ ) ;
const TYPE\& max (const TYPE\& $x$, const TYPE\& $y$, BinPre

The max() function returns the greater of $x$ and $y$.
If the binary predicate $p$ is given, then it will be used instead of the $<$ operator to compare the two elements.

For example, the following code snippet displays various uses of the $\max ()$ function:


When run, this code displays:

```
Max of 1 and 9999 is 9999
Max of 'a' and 'b' is b
Max of 3.14159 and 2.71828 is 3.14159
```

Related Topics: max_element, min, min_element

## max_element

## Syntax:

```
    #include <algorithm>
    iterator max_element( iterator start, iterator end );
    iterator max_element( iterator start, iterator end, Bin
4
```

The max_element() function returns an iterator to the largest element in the range [start,end).

If the binary predicate $p$ is given, then it will be used instead of the $<$ operator to determine the largest element.

For example, the following code uses the max_element() function to determine the largest integer in an array and the largest character in a vector of characters:

```
int array[] = { 3, 1, 4, 1, 5, 9 };
unsigned int array_size = sizeof(array) / sizeof(array[
cout << "Max element in array is " << *max_element(arra
vector<char> v;
v.push_back('a'); v.push_back('b'); v.push_back('c'); v
cout << "Max element in the vector v is " << *max_eleme
```

1

When run, the above code displays this output:

```
Max element in array is 9
Max element in the vector v is d
```

Related Topics: max, min, min_element

## merge

## Syntax:



The merge() function combines two sorted ranges [start1,end1) and [start2,end2) into a single sorted range, stored starting at result. The return value of this function is an iterator to the end of the merged range.

If the strict weak ordering function object cmp is given, then it is used in place of the < operator to perform comparisons between elements. merge() runs in linear time.

Related Topics: inplace_merge, set_union, sort

## min

## Syntax:



The $\min ()$ function, unsurprisingly, returns the smaller of $x$ and $y$.
By default, the < operator is used to compare the two elements. If the binary predicate $p$ is given, it will be used instead.

Related Topics: max, max_element, min_element

## min_element

Syntax:

```
    #include <algorithm>
    iterator min_element( iterator start, iterator end );
    iterator min_element( iterator start, iterator end, B
|
```

The min_element() function returns an iterator to the smallest element in the range [start,end).

If the binary predicate $p$ is given, then it will be used instead of the $<$ operator to determine the smallest element.

Related Topics: max, max_element, min

## mismatch

## Syntax:

```
    #include <algorithm>
    pair <iterator1,iterator2> mismatch( iterator start1,
    pair <iterator1,iterator2> mismatch( iterator start1,
```

1

The mismatch() function compares the elements in the range defined by [start1,end1) to the elements in a range of the same size starting at start2.

The return value of mismatch() is the first location where the two ranges differ.

If the optional binary predicate $p$ is given, then it is used to compare elements from the two ranges.

The mismatch() algorithm runs in linear time.
Related Topics: equal, find, lexicographical_compare, search

## next_permutation

Syntax:

```
    #include <algorithm>
    bool next_permutation( iterator start, iterator end )
    bool next_permutation( iterator start, iterator end,
```

1

The next_permutation() function attempts to transform the given range of elements [start,end) into the next lexicographically greater permutation of elements. If it succeeds, it returns true, otherwise, it returns false.

If a strict weak ordering function object cmp is provided, it is used in lieu of the < operator when comparing elements.

Related Topics: prev_permutation, random_sample, random_sample_n, random_shuffle

## nth_element

Syntax:
\#include <algorithm>
void nth_element( iterator start, iterator middle, it
void nth_element (iterator start, iterator middle, it

The nth_element() function semi-sorts the range of elements defined by [start,end). It puts the element that middle points to in the place that it would be if the entire range was sorted, and it makes sure that none of the elements before that element are greater than any of the elements that come after that element.
nth_element() runs in linear time on average.
Related Topics: partial_sort

## partial_sort

Syntax:
\#include <algorithm>
void partial_sort( iterator start, iterator middle, i
void partial_sort( iterator start, iterator middle, i

The partial_sort() function arranges the first N elements of the range [start,end) in ascending order. N is defined as the number of elements between start and middle.

By default, the < operator is used to compare two elements. If the strict weak ordering comparison function cmp is given, it is used instead.

Related Topics: binary_search, is_sorted, nth_element, partial_sort_copy, sort, stable_sort

## partial_sort_copy

Syntax:
\#include <algorithm>
iterator partial_sort_copy( iterator start, iterator
iterator partial_sort_copy( iterator start, iterator

The partial_sort_copy() algorithm behaves like partial_sort(), except that instead of partially sorting the range in-place, a copy of the range is created and the sorting takes place in the copy. The initial range is defined by [start,end) and the location of the copy is defined by [result_start,result_end).
partial_sort_copy() returns an iterator to the end of the copied, partiallysorted range of elements.

Related Topics: binary_search, is_sorted, partial_sort, sort, stable_sort

## partial_sum

Syntax:
\#include <numeric>
iterator partial_sum( iterator start, iterator end, i
iterator partial_sum( iterator start, iterator end, i

The partial_sum() function calculates the partial sum of a range defined by [start,end), storing the output at result.
start is assigned to *result, the sum of *start and *(start + 1) is assigned to *(result + 1), etc.
partial_sum() runs in linear time.
Related Topics: accumulate, adjacent_difference, count, inner_product

## partition

Syntax:


The partition() algorithm re-orders the elements in [start,end) such that the elements for which the predicate $p$ returns true come before the elements for which $p$ returns false.

In other words, partition() uses p to divide the elements into two groups. The return value of partition() is an iterator to the first element for which p returns false.
parition() runs in linear time.
Related Topics: stable_partition

## pop_heap

Syntax:

```
    #include <algorithm>
    void pop_heap( iterator start, iterator end );
    void pop_heap( iterator start, iterator end, StrictWe.
```

1

The pop_heap() function removes the largest element (defined as the element at the front of the heap) from the given heap.

If the strict weak ordering comparison function object cmp is given, then it is used instead of the < operator to compare elements.
pop_heap() runs in logarithmic time.

Related Topics: is_heap, make_heap, push_heap, sort_heap

## prev_permutation

Syntax:

```
    #include <algorithm>
    bool prev_permutation( iterator start, iterator end )
    bool prev_permutation( iterator start, iterator end,
```

1

The prev_permutation() function attempts to transform the given range of elements [start,end) into the next lexicographically smaller permutation of elements. If it succeeds, it returns true, otherwise, it returns false.

If a strict weak ordering function object cmp is provided, it is used instead of the < operator when comparing elements.

Related Topics: next_permutation, random_sample, random_sample_n, random_shuffle

## push_heap

Syntax:

```
    #include <algorithm>
    void push_heap( iterator start, iterator end );
    void push_heap( iterator start, iterator end, StrictW
```

1

The push_heap() function adds an element (defined as the last element before end) to a heap (defined as the range of elements between [start,"end-1).

If the strict weak ordering comparison function object cmp is given, then it is used instead of the < operator to compare elements.
push_heap() runs in logarithmic time.
Related Topics: is_heap, make_heap, pop_heap, sort_heap

## random_sample

This function was part of the original SGI STL library, but never has been a part of ISO C++.

## random_sample_n

This function was part of the original SGI STL library, but never has been a part of ISO C++.

## random_shuffle

Syntax:
\#include <algorithm>
void random_shuffle( iterator start, iterator end );
void random_shuffle( iterator start, iterator end, Ra

The random_shuffle() function randomly re-orders the elements in the range [start,end). If a random number generator function object rnd is supplied, it will be used instead of an internal random number generator.

Related Topics: next_permutation, prev_permutation, random_sample, random_sample_n

## remove

Syntax:


The remove() algorithm removes all of the elements in the range [start,end) that are equal to val.

The return value of this function is an iterator after the last element of the new sequence that should contain no elements equal to val.

The remove() function runs in linear time.
Related Topics: remove_copy, remove_copy_if, remove_if, unique, unique_copy

## remove_copy

Syntax:


The remove_copy() algorithm copies the range [start,end) to result but omits any elements that are equal to val.
remove_copy() returns an iterator to the end of the new range, and runs in linear time.

Related Topics: copy, remove, remove_copy_if, remove_if

## remove_copy_if

Syntax:


The remove_copy_if() function copies the range of elements [start,end) to result, omitting any elements for which the predicate function $p$ returns true. The return value of remove_copy_if() is an iterator the end of the new range.
remove_copy_if() runs in linear time.
Related Topics: remove, remove_copy, remove_if

## remove_if

Syntax:


The remove_if() function removes all elements in the range [start,end) for which the predicate $p$ returns true.

The return value of this function is an iterator to the last element of the pruned range.
remove_if() runs in linear time.
remove_if() cannot be used with associative containers like set<> or map<>.

Related Topics: remove, remove_copy, remove_copy_if

## replace

Syntax:


The replace() function sets every element in the range [start,end) that is equal to old_value to have new_value instead.
replace() runs in linear time.
Related Topics: replace_copy, replace_copy_if, replace_if

## replace_copy

Syntax:


The replace_copy() function copies the elements in the range [start,end) to the destination result. Any elements in the range that are equal to old_value are replaced with new_value.

Related Topics: replace

## replace_copy_if

Syntax:


The replace_copy_if() function copies the elements in the range [start,end) to the destination result. Any elements for which the predicate $p$ is true are replaced with new_value.

Related Topics: replace

## replace_if

Syntax:


The replace_if() function assigns every element in the range [start,end) for which the predicate function $p$ returns true the value of new_value.

This function runs in linear time.

Related Topics: replace

## reverse

Syntax:

```
#include <algorithm>
void reverse( iterator start, iterator end );
```

The reverse() algorithm reverses the order of elements in the range [start,end).

Related Topics: reverse_copy

## reverse_copy

Syntax:


The reverse_copy() algorithm copies the elements in the range [start,end) to result such that the elements in the new range are in reverse order.

The return value of the reverse_copy() function is an iterator the end of the new range.

Related Topics: reverse

## rotate

Syntax:


The rotate() algorithm moves the elements in the range [start,end) such that the middle element is now where start used to be, (middle+1) is now at (start+1), etc.

The return value of rotate() is an iterator to start + (end-middle). rotate() runs in linear time.

Related Topics: rotate_copy

## rotate_copy

Syntax:


The rotate_copy() algorithm is similar to the rotate() algorithm, except that the range of elements is copied to result before being rotated.

Related Topics: rotate

## search

Syntax:
\#include <algorithm>
iterator search( iterator start1, iterator end1, iter
iterator search( iterator start1, iterator end1, iter

The search() algorithm looks for the elements [start2,end2) in the range [start1,end1). If the optional binary predicate $p$ is provided, then it is used to perform comparisons between elements.

If search() finds a matching subrange, then it returns an iterator to the beginning of that matching subrange. If no match is found, an iterator pointing to end1 is returned.

In the worst case, search() runs in quadratic time, on average, it runs in linear time.

Related Topics: equal, find, lexicographical_compare, mismatch, search_n

## search_n

Syntax:

```
    #include <algorithm>
    iterator search_n( iterator start, iterator end, size.
    iterator search_n( iterator start, iterator end, size.
```

1

The search_n() function looks for num occurances of val in the range [start,end).

If num consecutive copies of val are found, search_n() returns an iterator to the beginning of that sequence. Otherwise it returns an iterator to end.

If the optional binary predicate $p$ is given, then it is used to perform comparisons between elements.

This function runs in linear time.

Related Topics: find_end, find_if, search

## set_difference

Syntax:
\#include <algorithm>
iterator set_difference( iterator start1, iterator en
iterator set_difference( iterator start1, iterator en

The set_difference() algorithm computes the difference between two sets defined by [start1,end1) and [start2,end2) and stores the difference starting at result.

Both of the sets, given as ranges, must be sorted in ascending order.

The return value of set_difference() is an iterator to the end of the result range.

If the strict weak ordering comparison function object cmp is not specified, set_difference() will use the < operator to compare elements.

Related Topics: includes, set_intersection, set_symmetric_difference, set_union

## set_intersection

Syntax:
\#include <algorithm>
iterator set_intersection( iterator start1, iterator
iterator set_intersection( iterator start1, iterator

The set_intersection() algorithm computes the intersection of the two sets defined by [start1,end1) and [start2,end2) and stores the intersection starting at result.

Both of the sets, given as ranges, must be sorted in ascending order.
The return value of set_intersection() is an iterator to the end of the intersection range.
set_intersection() runs in linear time.
If the strict weak ordering comparison function object cmp is not specified, set_intersection() will use the < operator to compare elements.

Related Topics: includes, set_difference, set_symmetric_difference, set_union

## set_symmetric_difference

Syntax:

```
    #include <algorithm>
    iterator set_symmetric_difference( iterator start1, i
    iterator set_symmetric_difference( iterator start1, i
|
```

The set_symmetric_difference() algorithm computes the symmetric difference of the two sets defined by [start1,end1) and [start2,end2) and stores the difference starting at result.

Both of the sets, given as ranges, must be sorted in ascending order.

The return value of set_symmetric_difference() is an iterator to the end of the result range.

If the strict weak ordering comparison function object cmp is not specified, set_symmetric_difference() will use the < operator to compare elements.

Related Topics: includes, set_difference, set_intersection, set_union

## set_union

Syntax:
\#include <algorithm>
iterator set_union( iterator start1, iterator end1, i
iterator set_union( iterator start1, iterator end1, i

The set_union() algorithm computes the sorted union of the two sorted ranges [start1,end1) and [start2,end2) and stores it starting at result.

The return value of set_union() is an iterator to the end of the union range.
set_union() runs in linear time.
Related Topics: includes, merge, set_difference, set_intersection, set_symmetric_difference

## sort

Syntax:

```
#include <algorithm>
void sort( iterator start, iterator end );
void sort( iterator start, iterator end, StrictWeakOr
```

1

The sort() algorithm sorts the elements in the range [start,end) into ascending order. If two elements are equal, there is no guarantee what order they will be in.

If the strict weak ordering function object cmp is given, then it will be used to compare two objects instead of the < operator.

The algorithm behind sort() is the introsort algorithm. sort() runs in $\mathrm{O}(\mathrm{N}$ $\log (\mathrm{N}))$ time (average and worst case) which is faster than polynomial time but slower than linear time.

For example, the following code sorts a vector of integers into ascending order:

```
vector<int> v;
v.push_back( 23 );
v.push_back( -1 );
v.push_back( 9999 );
v.push_back( 0 );
v.push_back( 4 );
cout << "Before sorting: ";
for( unsigned int i = 0; i < v.size(); i++ ) {
    cout << v[i] << " ";
}
cout << endl;
sort( v.begin(), v.end() );
cout << "After sorting: ";
for( unsigned int i = 0; i < v.size(); i++ ) {
    cout << v[i] << " ";
}
cout << endl;
```

When run, the above code displays this output:

```
Before sorting: 23 -1 9999 0 4
After sorting: -1 0 4 23 9999
```

Alternatively, the following code uses the sort() function to sort a normal array of integers, and displays the same output as the previous example:

```
int array[] = { 23, -1, 9999, 0, 4 };
unsigned int array_size = 5;
cout << "Before sorting: ";
for( unsigned int i = 0; i < array_size; i++ ) {
    cout << array[i] << " ";
}
cout << endl;
sort( array, array + array_size );
cout << "After sorting: ";
for( unsigned int i = 0; i < array_size; i++ ) {
    cout << array[i] << " ";
}
cout << endl;
```

This next example shows how to use sort() with a user-specified comparison function. The function cmp is defined to do the opposite of the < operator. When sort() is called with cmp used as the comparison function, the result is a list sorted in descending, rather than ascending, order:

```
bool cmp( int a, int b ) {
    return a > b;
}
vector<int> v;
for( int i = 0; i < 10; i++ ) {
    v.push_back(i);
}
cout << "Before: ";
for( int i = 0; i < 10; i++ ) {
    cout << v[i] << " ";
}
cout << endl;
sort( v.begin(), v.end(), cmp );
cout << "After: ";
for( int i = 0; i < 10; i++ ) {
    cout << v[i] << " ";
}
cout << endl;
```

Related Topics: binary_search, is_sorted, merge, partial_sort, partial_sort_copy, stable_sort, qsort

## sort_heap

Syntax:

```
#include <algorithm>
void sort_heap( iterator start, iterator end );
void sort_heap( iterator start, iterator end, StrictW
```

1

The sort_heap() function turns the heap defined by [start,end) into a sorted range.

If the strict weak ordering comparison function object cmp is given, then it is used instead of the < operator to compare elements.

Related Topics: is_heap, make_heap, pop_heap, push_heap

## stable_partition

Syntax:


The stable_partition() function behaves similarily to partition(). The difference between the two algorithms is that stable_partition() will preserve the initial ordering of the elements in the two groups.

Related Topics: partition

## stable_sort

Syntax:
\#include <algorithm>
void stable_sort( iterator start, iterator end );
void stable_sort( iterator start, iterator end, Stric

The stable_sort() algorithm is like the sort() algorithm, in that it sorts a range of elements into ascending order. Unlike sort(), however, stable_sort() will preserve the original ordering of elements that are equal to each other.

This functionality comes at a small cost, however, as stable_sort() takes a few more comparisons that sort() in the worst case: $\mathrm{N}(\log \mathrm{N})^{\wedge} 2$ instead of $N \log N$.

Related Topics: binary_search, is_sorted, partial_sort, partial_sort_copy, sort

## swap

Syntax:

$$
\begin{aligned}
& \text { \#include <algorithm> } \\
& \text { void swap( Assignable\& a, Assignable\& b ); }
\end{aligned}
$$

The swap() function swaps the values of a and b. swap() expects that its arguments will conform to the Assignable model; that is, they should have a copy constructor and work with the = operator. This function performs one copy and two assignments.

Related Topics: copy, copy_backward, copy_n, iter_swap, swap_ranges

## swap_ranges

Syntax:


The swap_ranges() function exchanges the elements in the range [start1,end1) with the range of the same size starting at start2.

The return value of swap_ranges() is an iterator to start2 + (end1start1).

Related Topics: iter_swap, swap

## transform

Syntax:

```
    #include <algorithm>
    iterator transform( iterator start, iterator end, ite
    iterator transform( iterator start1, iterator end1, i
|
```

The transform() algorithm applies the function $f$ to some range of elements, storing the result of each application of the function in result.

The first version of the function applies $f$ to each element in [start,end) and assigns the first output of the function to result, the second output to (result+1), etc.

The second version of the transform() works in a similar manner, except that it is given two ranges of elements and calls a binary function on a pair of elements.

For example, the following code uses transform() to convert a string to uppercase using the standard C library toupper function:

```
string s("hello");
transform(s.begin(), s.end(), s.begin(), toupper);
cout << s << endl;
```

The above code displays the following output:

## HELLO

Related Topics: copy, fill, generate

## unique

Syntax:
\#include <algorithm>
iterator unique( iterator start, iterator end );
iterator unique( iterator start, iterator end, BinPre

The unique() algorithm removes all consecutive duplicate elements from the range [start,end). If the binary predicate $p$ is given, then it is used to test two elements to see if they are duplicates.

The return value of unique() is an iterator to the end of the modified range.
unique() runs in linear time.
Related Topics: adjacent_find, remove, unique_copy

## unique_copy

Syntax:

```
    #include <algorithm>
    iterator unique_copy( iterator start, iterator end, i
    iterator unique_copy( iterator start, iterator end, i
```

1

The unique_copy() function copies the range [start,end) to result, removing all consecutive duplicate elements. If the binary predicate $p$ is provided, then it is used to test two elements to see if they are duplicates.

The return value of unique_copy () is an iterator to the end of the new range.
unique_copy() runs in linear time.
Related Topics: adjacent_find, remove, unique

## upper_bound

Syntax:
\#include <algorithm>
iterator upper_bound( iterator start, iterator end, C
iterator upper_bound( iterator start, iterator end, $C$

The upper_bound() algorithm searches the ordered range [start,end) for the last location that val could be inserted without disrupting the order of the range. This function requires the elements to be in order.

If the strict weak ordering function object cmp is given, it is used to compare elements instead of the < operator.
upper_bound() runs in logarithmic time.
Related Topics: binary_search, equal_range, lower_bound

## any

## Syntax:

> \#include <bitset> bool any();

The any() function returns true if any bit of the bitset is 1 , otherwise, it returns false.

Related Topics: count, none

## Bitset Constructors

Syntax:

```
#include <bitset>
bitset();
bitset( unsigned long val );
```

Bitsets can either be constructed with no arguments or with an unsigned long number val that will be converted into binary and inserted into the bitset.

When creating bitsets, the number given in the place of the template determines how long the bitset is.

For example, the following code creates two bitsets and displays them:

```
// create a bitset that is 8 bits long
bitset<8> bs;
// display that bitset
for( int i = (int) bs.size()-1; i >= 0; i-- ) {
    cout << bs[i] << " ";
}
cout << endl;
// create a bitset out of a number
bitset<8> bs2( (long) 131 );
// display that bitset, too
for( int i = (int) bs2.size()-1; i >= 0; i-- ) {
    cout << bs2[i] << " ";
}
cout << endl;
```


## Bitset Operators

Syntax:

```
#include <bitset>
    !=, ==, &=, ^=, |=, ~, <<=, >>=, []
```

These operators all work with bitsets. They can be described as follows:

- != returns true if the two bitsets are not equal.
- == returns true if the two bitsets are equal.
- \&= performs the AND operation on the two bitsets.
- $\wedge=$ performs the XOR operation on the two bitsets.
- |= performs the OR operation on the two bitsets.
- ~ reverses the bitset (same as calling flip())
- «= shifts the bitset to the left
- »= shifts the bitset to the right
- $[x]$ returns a reference to the xth bit in the bitset.

For example, the following code creates a bitset and shifts it to the left 4 places:

```
// create a bitset out of a number
bitset<8> bs2( (long) 131 );
cout << "bs2 is " << bs2 << endl;
// shift the bitset to the left by 4 digits
bs2 <<= 4;
cout << "now bs2 is " << bs2 << endl;
```

When the above code is run, it displays:

```
bs2 is 10000011
now bs2 is 00110000
```


## count

Syntax:

```
#include <bitset>
size_type count();
```

The function count() returns the number of bits that are set to 1 in the bitset.

Related Topics: any

## flip

Syntax:

```
#include <bitset>
bitset<N>& flip();
bitset<N>& flip( size_t pos );
```

The flip() function inverts all of the bits in the bitset, and returns the bitset. If pos is specified, only the bit at position pos is flipped.

## none

Syntax:

```
#include <bitset>
bool none();
```

The none() function only returns true if none of the bits in the bitset are set to 1 .

Related Topics: any

## reset

Syntax:

```
#include <bitset>
bitset<N>& reset();
bitset<N>& reset( size_t pos );
```

The reset() function clears all of the bits in the bitset, and returns the bitset. If pos is specified, then only the bit at position pos is cleared.

## set

Syntax:

```
#include <bitset>
bitset<N>& set();
bitset<N>& set( size_t pos, bool val=true );
```

The set() function sets all of the bits in the bitset, and returns the bitset. If pos is specified, then only the bit at position pos is set. If val is specified, then the bit is set or reset depending on the value of val.

## size

Syntax:

> \#include <bitset>
> size_t size();

The size() function returns the number of bits that the bitset can hold.

## test

Syntax:

```
#include <bitset>
bool test( size_t pos );
```

The function test() returns the value of the bit at position pos.

## to_string

Syntax:

> \#include <bitset> string to_string();

The to_string() function returns a string representation of the bitset.
Related Topics: to_ulong

## to_ulong

Syntax:

```
#include <bitset>
unsigned long to_ulong();
```

The function to_ulong() returns the bitset, converted into an unsigned long integer.

Related Topics: to_string

## assign

## Syntax:

```
    #include <deque>
    void assign( size_type num, const TYPE& val );
    void assign( input_iterator start, input_iterator end
|
```

The assign() function either gives the current deque the values from start to end, or gives it num copies of val.

This function will destroy the previous contents of the deque.
For example, the following code uses assign() to put 10 copies of the integer 42 into a deque:

```
deque<int> dq;
dq.assign( 10, 42 );
for( int i = 0; i < dq.size(); i++ ) {
    cout << dq[i] << " ";
}
cout << endl;
```

The above code displays the following output:

$$
42424242424242424242
$$

The next example shows how assign() can be used to copy one deque to another:

```
deque<int> dq1;
for( int i = 0; i < 10; i++ ) {
    dq1.push_back( i );
}
deque<int> dq2;
dq2.assign( dq1.begin(), dq1.end() );
for( int i = 0; i < dq2.size(); i++ ) {
    cout << dq2[i] << " ";
}
cout << endl;
```

When run, the above code displays the following output:

$$
0123456789
$$

Related Topics: insert, push_back, push_front

## at

## Syntax:

```
#include <deque>
TYPE& at( size_type loc );
const TYPE& at( size_type loc ) const;
```

The at() function returns a reference to the element in the deque at index loc. The at() function is safer than the [ operator, because it won't let you reference items outside the bounds of the deque.

For example, consider the following code:

```
deque<int> v( 5, 1 );
for( int i = 0; i < 10; i++ ) {
    cout << "Element " << i << " is " << dq[i] << endl;
}
```

This code overrunns the end of the deque, producing potentially dangerous results. The following code would be much safer:

```
    deque<int> v( 5, 1 );
    for( int i = 0; i < 10; i++ ) {
        cout << "Element " << i << " is " << dq.at(i) << end
    }
4.
```

Instead of attempting to read garbage values from memory, the at() function will realize that it is about to overrun the deque and will throw an exception.

Related Topics: [] operator

## back

Syntax:

```
#include <deque>
TYPE& back();
const TYPE& back() const;
```

The back() function returns a reference to the last element in the deque. For example:

```
    deque<int> dq;
    for( int i = 0; i < 5; i++ ) {
        dq.push_back(i);
    }
    cout << "The first element is " << dq.front()
        << " and the last element is " << dq.back() << en
|
```

This code produces the following output:
The first element is 0 and the last element is 4
The back() function runs in constant time.
Related Topics: front, pop_back

## begin

Syntax:

```
#include <deque>
iterator begin();
const_iterator begin() const;
```

The function begin() returns an iterator to the first element of the deque. begin() should run in constant time.

For example, the following code uses begin() to initialize an iterator that is used to traverse a list:

```
    // Create a list of characters
    list<char> charList;
    for( int i=0; i < 10; i++ ) {
    charList.push_front( i + 65 );
    }
    // Display the list
    list<char>::iterator theIterator;
    for( theIterator = charList.begin(); theIterator !=
    cout << *theIterator;
    }
4
```

Related Topics: end, rbegin, rend

## clear

Syntax:

> \#include <deque> void clear();

The function clear() deletes all of the elements in the deque. clear() runs in linear time.

Related Topics: erase

## Deque constructors

Syntax:

```
#include <deque>
deque();
deque( const deque& c );
deque( size_type num, const TYPE& val = TYPE() );
deque( input_iterator start, input_iterator end );
```

The default deque constructor takes no arguments, creates a new instance of that deque.

The second constructor is a default copy constructor that can be used to create a new deque that is a copy of the given deque c.

The third constructor creates a deque with space for num objects. If val is specified, each of those objects will be given that value. For example, the following code creates a deque consisting of five copies of the integer 42:

$$
\text { deque<int> dq( 5, } 42 \text { ); }
$$

The last constructor creates a deque that is initialized to contain the elements between start and end. For example:

```
    // create a deque of random integers
    cout << "original deque: ";
    deque<int> dq;
    for( int i = 0; i < 10; i++ ) {
        int num = static_cast<int>(rand() % 10);
        cout << num << " ";
        dq.push_back( num );
    }
    cout << endl;
    // find the first element of dq that is even
    deque<int>::iterator iter1 = dq.begin();
    while( iter1 != dq.end() && *iter1 % 2 != 0 ) ++iter1;
    // find the last element of dq that is even
    deque<int>::iterator iter2 = dq.end();
    do {
        --iter2;
    } while( iter2 != dq.begin() && *iter2 % 2 != 0 );
    cout << "first even number: " << *iter1 << ", last eve
    cout << "new deque: ";
    deque<int> dq2( iter1, iter2 );
for( size_t i = 0; i < dq2.size(); i++ ) {
    cout << dq2[i] << " ";
}
cout << endl;
4
```

When run, this code displays the following output:

```
original deque: 1 9 7 9 2 7 2 1 9 8
first even number: 2, last even number: 8
new deque: 2 7 2 1 9
```

In addition to containers and iterators, the STL also works with pointers and arrays. For example, the following code creates a deque using data from an array and pointer arithmetic:

```
    // create a deque from an array of integers
    const int ARR_SIZE = 4;
    int vals[ARR_SIZE] = { 13, 26, 5, 979 };
    deque<int> dq( vals, vals + sizeof(vals)/sizeof(int) );
    cout << "dq is: ";
    for( size_t i = 0; i < dq.size(); ++i ) cout << dq[i] <
    cout << '\n';
1
```

All of these constructors run in linear time except the first, which runs in constant time.

## Deque operators

## Syntax:

```
#include <deque>
TYPE& operator[]( size_type index );
const TYPE& operator[]( size_type index ) const;
deque operator=(const deque& c2);
bool operator==(const deque& c1, const deque& c2);
bool operator!=(const deque& c1, const deque& c2);
bool operator<(const deque& c1, const deque& c2);
bool operator>(const deque& c1, const deque& c2);
bool operator<=(const deque& c1, const deque& c2);
bool operator>=(const deque& c1, const deque& c2);
```

All of the C++ containers can be compared and assigned with the standard comparison operators: $==,!=, \Leftarrow,>=,<,>$, and =. Individual elements of a deque can be examined with the [] operator.

Performing a comparison or assigning one deque to another takes linear time.

The [] operator runs in constant time.
Two deques are equal if:

1. Their size is the same, and
2. Each member in location $i$ in one deque is equal to the the member in location $i$ in the other deque.

Comparisons among deques are done lexicographically.
For example, the following code uses the [] operator to access all of the elements of a deque:

```
deque<int> dq( 5, 1 );
for( size_t i = 0; i < dq.size(); i++ ) {
    cout << "Element " << i << " is " << dq[i] << '\n';
}
```

Related Topics: at

## empty

Syntax:

$$
\begin{aligned}
& \text { \#include <deque> } \\
& \text { bool empty() const; }
\end{aligned}
$$

The empty() function returns true if the deque has no elements, false otherwise.

For example, the following code uses empty() as the stopping condition on a while loop to clear a deque and display its contents in reverse order:

```
deque<int> dq;
for( int i = 0; i < 5; i++ ) {
    dq.push_back(i);
}
while( !dq.empty() ) {
    cout << dq.back() << endl;
    dq.pop_back();
}
```

Related Topics: size

## end

## Syntax:

```
#include <deque>
iterator end();
const_iterator end() const;
```

The end() function returns an iterator just past the end of the deque.
Note that before you can access the last element of the deque using an iterator that you get from a call to end(), you'll have to decrement the iterator first.

For example, the following code uses begin() and end() to iterate through all of the members of a deque:

```
deque<int> v1( 5, 789 );
deque<int>::iterator it;
for( it = dq1.begin(); it != dq1.end(); it++ ) {
    cout << *it << endl;
}
```

The iterator is initialized with a call to begin(). After the body of the loop has been executed, the iterator is incremented and tested to see if it is equal to the result of calling end(). Since end() returns an iterator pointing to an element just after the last element of the deque, the loop will only stop once all of the elements of the deque have been displayed.
end() runs in constant time.
Related Topics: begin, rbegin, rend

## erase

Syntax:

```
#include <deque>
iterator erase( iterator loc );
iterator erase( iterator start, iterator end );
```

The erase() function either deletes the element at location loc, or deletes the elements between start and end (including start but not including end). The return value is the element after the last element erased.

The first version of erase (the version that deletes a single element at location loc) runs in constant time for lists and linear time for deques, deques, and strings. The multiple-element version of erase always takes linear time.

For example:

```
// Create a deque, load it with the first ten characte
deque<char> alphaDeque;
for( int i=0; i < 10; i++ ) {
    alphaDeque.push_back( i + 65 );
}
int size = alphaDeque.size();
deque<char>::iterator startIterator;
deque<char>::iterator tempIterator;
for( int i=0; i < size; i++ ) {
    startIterator = alphaDeque.begin();
        alphaDeque.erase( startIterator );
        // Display the deque
        for( tempIterator = alphaDeque.begin(); tempIterator
            cout << *tempIterator;
        }
        cout << endl;
    }
4
```

That code would display the following output:

```
BCDEFGHIJ
CDEFGHIJ
DEFGHIJ
EFGHIJ
FGHIJ
GHIJ
HIJ
IJ
J
```

In the next example, erase() is called with two iterators to delete a range of elements from a deque:

```
// create a deque, load it with the first ten characte
deque<char> alphaDeque;
for( int i=0; i < 10; i++ ) {
    alphaDeque.push_back( i + 65 );
}
// display the complete deque
for( int i = 0; i < alphaDeque.size(); i++ ) {
    cout << alphaDeque[i];
}
cout << endl;
// use erase to remove all but the first two and last
// of the deque
alphaDeque.erase( alphaDeque.begin()+2, alphaDeque.end
// display the modified deque
for( int i = 0; i < alphaDeque.size(); i++ ) {
        cout << alphaDeque[i];
}
cout << endl;
|
```

When run, the above code displays:

## ABCDEFGHIJ

ABHIJ
Related Topics: clear, insert, pop_back, pop_front

## front

Syntax:

```
#include <deque>
TYPE& front();
const TYPE& front() const;
```

The front() function returns a reference to the first element of the deque, and runs in constant time.

Related Topics: back, pop_front, push_front

## insert

## Syntax:

```
    #include <deque>
    iterator insert( iterator loc, const TYPE& val );
    void insert( iterator loc, size_type num, const TYPE&
    template<TYPE> void insert( iterator loc, input_itera
```

1

The insert() function either:

- inserts val before loc, returning an iterator to the element inserted,
- inserts num copies of val before loc, or
- inserts the elements from start to end before loc.

For example:

```
// Create a deque, load it with the first 10 characters o
deque<char> alphaDeque;
for( int i=0; i < 10; i++ ) {
    alphaDeque.push_back( i + 65 );
}
// Insert four C's into the deque
deque<char>::iterator theIterator = alphaDeque.begin();
alphaDeque.insert( theIterator, 4, 'C' );
// Display the deque
for( theIterator = alphaDeque.begin(); theIterator != alp
    cout << *theIterator;
}
```

This code would display:

## CCCCABCDEFGHIJ

This next example uses several different methods to add data to a
deque, and then uses the copy algorithm to display the deque:

```
deque<int> dq;
dq.push_back(42);
dq.push_front(1);
dq.insert( dq.begin()+1, 2 );
dq[2] = 16;
copy( dq.begin(), dq.end(), ostream_iterator<int>(cout,"
|
```

Related Topics: assign, erase, push_back, push_front, copy

## max_size

Syntax:

```
#include <deque>
size_type max_size() const;
```

The max_size() function returns the maximum number of elements that the deque can hold. The max_size() function should not be confused with the size or capacity functions, which return the number of elements currently in the deque and the the number of elements that the deque will be able to hold before more memory will have to be allocated, respectively.

Related Topics: size

## pop_back

Syntax:

> \#include <deque> void pop_back();

The pop_back() function removes the last element of the deque.
pop_back() runs in constant time.
Related Topics: back, erase, pop_front, push_back

## pop_front

Syntax:

> \#include <deque>
> void pop_front();

The function pop_front() removes the first element of the deque.

The pop_front() function runs in constant time.

Related Topics: erase, front, pop_back, push_front

## push_back

Syntax:

```
#include <deque>
void push_back( const TYPE& val );
```

The push_back() function appends val to the end of the deque. For example, the following code puts 10 integers into a list:

```
list<int> the_list;
for( int i = 0; i < 10; i++ )
    the_list.push_back( i );
```

When displayed, the resulting list would look like this:

$$
0123456789
$$

push_back() runs in constant time.
Related Topics: assign, insert, pop_back, push_front

## push_front

Syntax:

```
#include <deque>
void push_front( const TYPE& val );
```

The push_front function inserts val at the beginning of the deque.
push_front runs in constant time.
For example, the following code uses push_front to insert several doubles into a deque, and then uses the copy algorithm to display the deque:

```
deque<double> values;
ostream_iterator<double> output( cout, " " );
values.push_front( 2.2 );
values.push_front( 3.5 );
values.push_back( 1.1 );
cout << "values contains: ";
for( size_t i = 0; i < values.size(); ++i ) cout << val
cout << '\n';
values.pop_front(); // remove first element
cout << "After pop_front, values contains: ";
copy( values.begin(), values.end(), output );
cout << '\n';
values[1] = 5.4;
cout << "Now values contains: ";
copy( values.begin(), values.end(), output );
cout << '\n';
```

Related Topics: assign, front, insert, pop_front, push_back

## rbegin

Syntax:

```
#include <deque>
reverse_iterator rbegin();
const_reverse_iterator rbegin() const;
```

The rbegin() function returns a reverse_iterator to the end of the current deque.
rbegin() runs in constant time.
Related Topics: begin, end, rend

## rend

## Syntax:

```
#include <deque>
reverse_iterator rend();
const_reverse_iterator rend() const;
```

The function rend() returns a reverse_iterator to the beginning of the current deque.
rend() runs in constant time.
Related Topics: begin, end, rbegin

## resize

Syntax:


The function resize() changes the size of the deque to size. If val is specified then any newly-created elements will be initialized to have a value of val.

This function runs in linear time.
Related Topics: size

## size

Syntax:

```
#include <deque>
size_type size() const;
```

The size function returns the number of elements in the current deque.
For example:

```
deque<int> myints;
cout << "initial size: " << myints.size() << '\n';
for( int i = 0; i < 5; ++i ) myints.push_back(i);
cout << "after five additions: " << myints.size() << '\n'
myints.insert( myints.begin(), 5, 100 );
cout << "after five insertions: " << myints.size() << '\n
myints.pop_back();
cout << "after a removal: " << myints.size() << '\n';
|
```

The above code produces the following output:

```
initial size: 0
after five additions: 5
after five insertions: 10
after a removal: 9
```

Related Topics: max_size, resize

## swap

Syntax:

```
#include <deque>
void swap( container& from );
```

The swap() function exchanges the elements of the current deque with those of from. This function operates in constant time.

For example, the following code uses the swap() function to exchange the values of two strings:

```
string first( "This comes first" );
string second( "And this is second" );
first.swap( second );
cout << first << endl;
cout << second << endl;
```

The above code displays:

```
And this is second
This comes first
```

Related Topics: insert

## bad

Syntax:

```
#include <fstream>
bool bad();
```

The bad() function returns true if a fatal error with the current stream has occurred, false otherwise.

Note: fatal errors do not normally occur. Even a failure to open a file is not a fatal error.

Related Topics: clear, eof, exceptions, fail, good, rdstate
Stream states:

- if (s): The previous operation was successful (a shorthand for !s.fail()).
- if (s.fail()): The previous operation failed.
- if (s.eof()): Reading past the end has been attempted.
- if (s.bad()): Stream state is undefined; the stream can no longer be used.
- if $(s . \operatorname{good}())$ : None of bad/eof/fail are set.
clear

Syntax:

```
#include <fstream>
void clear( iostate flags = ios::goodbit );
```

The function clear() does two things:

- it clears all io_stream_state_flags associated with the current stream,
- and sets the flags denoted by flags

The flags argument defaults to ios::goodbit, which means that by default, all flags will be cleared and ios::goodbit will be set. Example code: For example, the following code uses the clear() function to reset the flags of an output file stream, after an attempt is made to read from that output stream:

```
fstream outputFile( "output.txt", fstream::out );
// try to read from the output stream; this shouldn't
int val;
outputFile >> val;
if( outputFile.fail() ) {
    cout << "Error reading from the output stream" << en
    // reset the flags associated with the stream
    outputFile.clear();
}
|
```

```
for( int i = 0; i < 10; i++ ) {
    outputFile << i << " ";
}
outputFile << endl;
```

Related Topics: eof, fail, good, rdstate

## close

Syntax:

$$
\begin{aligned}
& \text { \#include <fstream> } \\
& \text { void close(); }
\end{aligned}
$$

The close() function closes the associated file stream.

Related Topics: O_Constructors, open

## I/O Constructors

Syntax:

```
#include <fstream>
fstream( const char *filename, openmode mode );
ifstream( const char *filename, openmode mode );
ofstream( const char *filename, openmode mode );
```

The fstream, ifstream, and ofstream objects are used to do file I/O. The optional mode defines how the file is to be opened, according to the IO stream mode flags. The optional filename specifies the file to be opened and associated with the stream.

Input and output file streams can be used in a similar manner to C++ predefined I/O streams, cin and cout.

For example, the following code reads input data and appends the result to an output file.

```
    ifstream fin( "/tmp/data.txt" );
    ofstream fout( "/tmp/results.txt", ios::app );
while( fin >> temp )
    fout << temp + 2 << endl;
    // Files are closed automatically when the variables
```

Related Topics: close, open

## eof

Syntax:

```
#include <fstream>
bool eof();
```

The function eof() returns true if the end of the associated input file has been reached, false otherwise.

A stream goes into EOF state whenever the end of stream is seen, i.e. a character past the end has been read. As operator» and getline normally keep reading characters until the end of token (until whitespace, invalid characters, line terminator or EOF) it is possible that the stream EOF flag gets set even though the token was read correctly. Conversely, the stream does not go into EOF state if there happens to be any whitespace after the last token, but trying to read another token will still fail.

Therefore, the EOF flag cannot be used as a test in a loop intended to read all stream contents until EOF.

Instead, one should check for the fail condition after an attempt to read. This is done most conveniently by testing the stream itself, as follows:

```
std::ifstream file("test.txt");
std::string line;
while (std::getline(file, line)) {
    // A line was read successfully, so you can process
}
```

Line 7 of the example below illustrates the main use for checking the EOF state: after a failed read. In such a situation, it can be used to
determine whether or not the fail was caused by reaching the end of stream.

```
1: std::ifstream file("test.txt");
std::string word;
double value;
while (file >> word >> value) {
    // A word and a double value were both read succes
}
if (!file.eof()) throw std::runtime_error("Invalid (
```

The table below lists a number of different states that a stream may be in:

| Test | Description |
| :--- | :--- |
| if (s) | The previous operation was successful (a shorthand for <br> !s.fail()). |
| if (s.fail()) | The previous operation failed. |
| if (s.eof()) | Reading past the end has been attempted. |
| if (s.bad()) | Stream state is undefined; the stream can no longer be <br> used. |
| if | None of bad/eof/fail are set. |
| $(\mathrm{s.good}())$ |  |

Related Topics: bad, clear, exceptions, fail, good, rdstate

## C++ I/O Examples

Reading From Files

Assume that we have a file named data.txt that contains this text:
Fry: One Jillion dollars.
[Everyone gasps.]
Auctioneer: Sir, that's not a number.
[Everyone gasps.]
We could use this code to read data from the file, word by word:

```
ifstream fin("data.txt");
string s;
while( fin >> s ) {
    cout << "Read from file: " << s << endl;
}
```

When used in this manner, we'll get space-delimited bits of text from the file:

```
Read from file: Fry:
Read from file: One
Read from file: Jillion
Read from file: dollars.
Read from file: [Everyone
Read from file: gasps.]
Read from file: Auctioneer:
Read from file: Sir,
Read from file: that's
Read from file: not
Read from file: a
Read from file: number.
Read from file: [Everyone
Read from file: gasps.]
```

Note that in the previous example, all of the whitespace that separated
words (including newlines) was lost. If we were interested in preserving whitespace, we could read the file in line-by-line using the I/O_getline()_function.

```
ifstream fin("data.txt");
const int LINE_LENGTH = 100;
char str[LINE_LENGTH];
while( fin.getline(str,LINE_LENGTH) ) {
    cout << "Read from file: " << str << endl;
}
```

Reading line-by-line produces the following output:

```
Read from file: Fry: One Jillion dollars.
```

Read from file: [Everyone gasps.]
Read from file: Auctioneer: Sir, that's not a number.
Read from file: [Everyone gasps.]
d

If you want to avoid reading into character arrays, you can use the C++_string getline() function to read lines into strings:

```
ifstream fin("data.txt");
string s;
while( getline(fin,s) ) {
    cout << "Read from file: " << s << endl;
}
```


## Checking For Errors

Simply evaluating an I/O object in a boolean context will return false if any errors have occurred:

```
    string filename = "data.txt";
    ifstream fin( filename.c_str() );
    if( !fin ) {
        cout << "Error opening " << filename << " for input
        exit(-1);
    }
```


## exceptions

Sets the stream to throw exceptions instead of silently ignoring the error conditions specified. Without parameters returns the current setting.

The setting is composed by ORing together bits for the conditions to throw on. The following code enables all exceptions on stream s.


Related Topics: bad, clear, eof, fail, good, rdstate

## Stream states:

- if (s): The previous operation was successful (a shorthand for !s.fail()).
- if (s.fail()): The previous operation failed.
- if (s.eof()): Reading past the end has been attempted.
- if (s.bad()): Stream state is undefined; the stream can no longer be used.
- if (s.good()): None of bad/eof/fail are set.


## fail

Syntax:

```
#include <fstream>
bool fail();
```

The fail() function returns true if an error has occurred with the current stream, false otherwise. This can be used for checking whether the previous operation has failed.

Examples of failures that cause fail to be set:

- file not found (when opening for reading).
- file cannot be created (when opening for writing).
- end of file is reached before the requested data could be read.
- invalid formatting of data (e.g. letters when expecting numbers).

Once set, the fail state will make all other operations on the stream fail instantly, until the error state is cleared with the clear function.

Related Topics: bad, clear, eof, exceptions, good, rdstate

Stream states:

- if (s): The previous operation was successful (a shorthand for !s.fail()).
- if (s.fail()): The previous operation failed.
- if (s.eof()): Reading past the end has been attempted.
- if (s.bad()): Stream state is undefined; the stream can no longer be used.
- if (s.good()): None of bad/eof/fail are set.


## fill

Syntax:

```
#include <fstream>
char fill();
char fill( char ch );
```

The function fill() either returns the current fill character, or sets the current fill character to ch. The fill character is defined as the character that is used for padding when a number is smaller than the specified width(). The default fill character is the space character.

Related Topics: precision, width

## flags

Syntax:

```
#include <fstream>
fmtflags flags();
fmtflags flags( fmtflags f );
```

The flags() function either returns the io_stream_format_flags for the current stream, or sets the flags for the current stream to be f .

Related Topics: setf, unsetf

## flush

Syntax:

> \#include <fstream>
> ostream\& flush();

The flush() function causes the buffer for the current output stream to be actually written out to the attached device. This function is useful for printing out debugging information, because sometimes programs abort before they have a chance to write their output buffers to the screen. Judicious use of flush() can ensure that all of your debugging statements actually get printed.

You should use cerr for debugging, which does not buffer output by default.

Related Topics: put, write

## gcount

Syntax:

```
#include <fstream>
streamsize gcount();
```

The function gcount() is used with input streams, and returns the number of characters read by the last unformatted input operation.

Related Topics: get, getline, read

## get

## Syntax:

```
#include <fstream>
int get();
istream& get( char& ch );
istream& get( char* buffer, streamsize num );
istream& get( char* buffer, streamsize num, char deli
istream& get( streambuf& buffer );
istream& get( streambuf& buffer, char delim );
```

The get() function is used with input streams, and either:

- reads a character and returns that value,
- reads a character and stores it as ch,
- reads characters into buffer until num-1 characters have been read, or EOF, or newline encountered, or the delim character encountered (delim is not read until next time),
- or reads characters into buffer until a newline, EOF, or delim character is encountered (again, delim isn't read until the next get() ).

For example, the following code displays the contents of a file called temp.txt, character by character:

```
char ch;
ifstream fin( "temp.txt" );
while( fin.get(ch) )
        cout << ch;
fin.close();
```

Related Topics: gcount, getline, (C++ Strings) getline, ignore, peek, put, read

## getline

## Syntax:



The getline() function is used with input streams. The version without a char delim argument effectively sets the delimiter to a newline character. getline() reads characters into buffer until either:

- num - 1 characters have been read,
- an EOF is encountered,
- or, until the character delim is read. The delim character is not put into buffer.

If the delim character (newline normally) is not read, the input stream is set to a failure state.

For example, the following code uses the getline function to display the first 99 characters (one character is reserved for null-termination) or one line at a time from a text file - whichever comes first - (until EOF or a line longer than 99 characters is encountered):

```
ifstream fin("tmp.dat");
int MAX_LENGTH = 100;
char line[MAX_LENGTH];
while( fin.getline(line, MAX_LENGTH) ) {
    cout << "read line: " << line << endl;
}
```

If you'd like to read lines from a file into strings instead of character arrays, consider using the string getline function.

Those using a Microsoft compiler may find that getline reads an extra character, and should consult the documentation on the Microsoft getline bug.

Related Topics: gcount, get, string getline, ignore, read

## good

Syntax:
\#include <fstream> bool good();

The function good() returns true if no errors have occurred with the current stream, false otherwise.

Related Topics: bad, clear, eof, exceptions, fail, rdstate Stream states:

- if (s): The previous operation was successful (a shorthand for !s.fail()).
- if (s.fail()): The previous operation failed.
- if (s.eof()): Reading past the end has been attempted.
- if (s.bad()): Stream state is undefined; the stream can no longer be used.
- if (s.good()): None of bad/eof/fail are set.


## ignore

Syntax:

```
#include <fstream>
istream& ignore( streamsize num=1, int delim=EOF );
```

The ignore() function is used with input streams. It reads and throws away characters until num characters have been read (where num defaults to 1 ) or until the character delim is read (where delim defaults to EOF). The ignore() function can sometimes be useful when using the getline() function together with the » operator. For example, if you read some input that is followed by a newline using the » operator, the newline will remain in the input as the next thing to be read. Since getline() will by default stop reading input when it reaches a newline, a subsequent call to getline() will return an empty string. In this case, the ignore() function could be called before getline() to "throw away" the newline.

Related Topics: get, getline

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C++ I/O Flags

## Format flags

C++ defines some format flags for standard input and output, which can be manipulated with the flags, setf, and unsetf functions. For example,

```
cout.setf(ios_base::left);
```

turns on left justification for all output directed to cout.

| Flag | Meaning |
| :--- | :--- |
| boolalpha | Boolean values can be input/output using the words "true" <br> and "false". |
| dec | Numeric values are displayed in decimal. |
| fixed | Display floating point values using normal notation (as <br> opposed to scientific). |
| hex | Numeric values are displayed in hexidecimal. |
| internal | If a numeric value is padded to fill a field, spaces are <br> inserted between the sign and base character. |
| left | Output is left justified. |
| oct | Numeric values are displayed in octal. |
| right | Output is right justified. |
| scientific | Display floating point values using scientific notation. |
| showbase | Display the base of all numeric values. |
| showpoint | Display a decimal and extra zeros, even when not <br> needed. |
| showpos | Display a leading plus sign before positive numeric values. |
| skipws | Discard whitespace characters (spaces, tabs, newlines) <br> when reading from a stream. |
|  |  |


| unitbuf | Flush the buffer after each insertion. |
| :--- | :--- |
| uppercase | Display the "e" of scientific notation and the " $x$ " of <br> hexidecimal notation as capital letters. |

## Manipulators

You can also manipulate flags indirectly, using the following manipulators. Most programmers are familiar with the endl manipulator, which might give you an idea of how manipulators are used. For example, to set the dec flag, you might use the following command:

```
cout << dec;
```


## Manipulators defined in <iostream>

| Manipulator | Description | Input | Output |
| :--- | :--- | :---: | :---: |
| boolalpha | Turns on the boolalpha flag | X | X |
| dec | Turns on the dec flag | X | X |
| endl | Output a newline character, flush the <br> stream |  | X |
| ends | Output a null character |  | X |
| fixed | Turns on the fixed flag |  | X |
| flush | Flushes the stream |  | X |
| hex | Turns on the hex flag | X | X |
| internal | Turns on the internal flag |  | X |
| left | Turns on the left flag | X | X |
| noboolalpha | Turns off the boolalpha flag |  | X |
| noshowbase | Turns off the showbase flag |  | X |
| noshowpoint | Turns off the showpoint flag |  | X |
| noshowpos | Turns off the showpos flag |  |  |
|  |  |  |  |


| noskipws | Turns off the skipws flag | X |  |
| :--- | :--- | :---: | :---: |
| nounitbuf | Turns off the unitbuf flag |  | X |
| nouppercase | Turns off the uppercase flag |  | X |
| oct | Turns on the oct flag | X | X |
| right | Turns on the right flag |  | X |
| scientific | Turns on the scientific flag |  | X |
| showbase | Turns on the showbase flag |  | X |
| showpoint | Turns on the showpoint flag |  | X |
| showpos | Turns on the showpos flag |  | X |
| skipws | Turns on the skipws flag | X |  |
| unitbuf | Turns on the unitbuf flag |  | X |
| uppercase | Turns on the uppercase flag |  | X |
| ws | Skip any leading whitespace | X |  |

## Manipulators defined in <iomanip>

| Manipulator | Description | Input | Output |
| :--- | :--- | :---: | :---: |
| resetiosflags( long <br> f ) | Turn off the flags specified by f | X | X |
| setbase( int base ) | Sets the number base to base |  | X |
| setfill( char ch ) | Sets the fill character to ch |  | X |
| setiosflags( long f ) | Turn on the flags specified by f | X | X |
| setprecision( int p ) | Sets the number of digits of <br> precision |  | X |
| setw( int w ) | Sets the field width to w |  | X |

## State flags

The I/O stream state flags tell you the current state of an I/O stream. The flags are:

| Flag | Meaning |
| :--- | :--- |
| badbit | a fatal error has occurred |
| eofbit | EOF has been found |
| failbit | a nonfatal error has occurred |
| goodbit | no errors have occurred |

## Mode flags

The I/O stream mode flags allow you to access files in different ways. The flags are:

| Mode | Meaning |
| :--- | :--- |
| ios_base::app | append output |
| ios_base::ate | seek to EOF when opened |
| ios_base::binary | open the file in binary mode |
| ios_base::in | open the file for reading |
| ios_base:::out | open the file for writing |
| ios_base::trunc | overwrite the existing file |

## open

Syntax:
\#include <fstream>
void open( const char *filename );
void open( const char *filename, openmode mode = defa

The function open() is used with file streams. It opens filename and associates it with the current stream. The optional io_stream_mode_flag mode defaults to ios::in for ifstream, ios::out for ofstream, and ios::in|ios::out for fstream. If open() fails, the resulting stream will evaluate to false when used in a Boolean expression. For example:

```
ifstream inputStream;
inputStream.open("file.txt");
if( !inputStream ) {
    cerr << "Error opening input stream" << endl;
    return;
}
```

Related Topics: I/O Constructors, close, C++ I/O Mode Flags

## peek

## Syntax:

```
#include <fstream>
int peek();
```

The function peek() is used with input streams, and returns the next character in the stream or EOF if the end of file is read. peek() does not remove the character from the stream.

Related Topics: get, putback

## precision

Syntax:

```
#include <fstream>
streamsize precision();
streamsize precision( streamsize p );
```

The precision() function either sets or returns the current number of digits that is displayed for floating-point variables. For example, the following code sets the precision of the cout stream to 5 :
float num = 314.15926535;
cout.precision( 5 );
cout << num;
This code displays the following output:

$$
314.16
$$

Related Topics: fill, width

## put

## Syntax:

```
#include <fstream>
ostream& put( char ch );
```

The function put() is used with output streams, and writes the character ch to the stream.

Related Topics: flush, get, write

## putback

Syntax:

```
#include <fstream>
istream& putback( char ch );
```

The putback() function is used with input streams, and returns the previously- read character ch to the input stream.

Related Topics: peek, (Standard C I/O) ungetc

## rdstate

## Syntax:

```
#include <fstream>
iostate rdstate();
```

The rdstate() function returns the io_stream_state_flags of the current stream.

Related Topics: bad, clear, eof, fail, good

## read

Syntax:

```
#include <fstream>
istream& read( char* buffer, streamsize num );
```

The function read() is used with input streams, and reads num bytes from the stream before placing them in buffer. If EOF is encountered, read() stops, leaving however many bytes it put into buffer as they are. For example:

```
struct {
    int height;
    int width;
} rectangle;
input_file.read( (char *)(&rectangle), sizeof(rectan
if( input_file.bad() ) {
    cerr << "Error reading data" << endl;
    exit( 0 );
}
|
```

Related Topics: gcount, get, getline, write

## seekg

Syntax:

```
    #include <fstream>
    istream& seekg( off_type offset, ios::seekdir origin
    istream& seekg( pos_type position );
4
```

The function seekg() is used with input streams, and it repositions the "get" pointer for the current stream to offset bytes away from origin, or places the "get" pointer at position.

Related Topics: seekp, tellg, tellp

## seekp

Syntax:


The seekp() function is used with output streams, but is otherwise very similar to seekg().

Related Topics: seekg, tellg, tellp

## setf

Syntax:

```
#include <fstream>
fmtflags setf( fmtflags flags );
fmtflags setf( fmtflags flags, fmtflags needed );
```

The function setf() sets the io_stream_format_flags of the current stream to flags. The optional needed argument specifies that only the flags that are in both flags and needed should be set. The return value is the previous configuration of io_stream_format_flags. For example:

```
int number = 0x3FF;
cout.setf( ios::dec );
cout << "Decimal: " << number << endl;
cout.unsetf( ios::dec );
cout.setf( ios::hex );
cout << "Hexadecimal: " << number << endl;
```

Note that the preceding code is functionally identical to:

```
        int number = 0x3FF;
        cout << "Decimal: " << number << endl << hex << "Hex
    << dec << endl;
```

thanks to io_stream_manipulators.
Related Topics: flags, unsetf

## sync_with_stdio

Syntax:

```
    #include <fstream>
    static bool sync_with_stdio( bool sync = true );
```

The sync_with_stdio function allows you to turn on and off the ability for the C++ I/O system to work with the C I/O system.

Using this function with sync set to false can accelerate the speed of the program executing.

## tellg

Syntax:

$$
\begin{aligned}
& \text { \#include <fstream> } \\
& \text { pos_type tellg(); }
\end{aligned}
$$

The tellg() function is used with input streams, and returns the current "get" position of the pointer in the stream.

Related Topics: seekg, seekp, tellp

## tellp

Syntax:

```
#include <fstream>
pos_type tellp();
```

The tellp() function is used with output streams, and returns the current "put" position of the pointer in the stream. For example, the following code displays the file pointer as it writes to a stream:

```
string s("In Xanadu did Kubla Khan...");
ofstream fout("output.txt");
for( int i=0; i < s.length(); i++ ) {
    cout << "File pointer: " << fout.tellp();
    fout.put( s[i] );
    cout << " " << s[i] << endl;
}
fout.close();
```

Related Topics: seekg, seekp, tellg

## unsetf

## Syntax:

```
#include <fstream>
void unsetf( fmtflags flags );
```

The function unsetf() uses flags to clear the io_stream_format_flags associated with the current stream.

Related Topics: flags, setf

## width

Syntax:

```
#include <fstream>
int width();
int width( int w );
```

The function width() returns the current width, which is defined as the minimum number of characters to display with the next output. The optional argument w can be used to set the width. For example:

```
cout.width( 5 );
cout << "2";
```

displays

## 2

(that's four spaces followed by a '2')
Related Topics: fill, precision

## write

Syntax:


The write() function is used with output streams, and writes num bytes from buffer to the current output stream.

Related Topics: flush, put, read

## assign

Syntax:

```
    #include <list>
    void assign( size_type num, const TYPE& val );
    void assign( input_iterator start, input_iterator end
4
```

The assign() function either gives the current list the values from start to end, or gives it num copies of val.

This function will destroy the previous contents of the list.
For example, the following code uses assign() to put 10 copies of the integer 42 into a vector:

```
vector<int> v;
v.assign( 10, 42 );
for( int i = 0; i < v.size(); i++ ) {
    cout << v[i] << " ";
}
cout << endl;
```

The above code displays the following output:

$$
\begin{array}{lllllllllllll}
42 & 42 & 42 & 42 & 42 & 42 & 42 & 42 & 42 & 42
\end{array}
$$

The next example shows how assign() can be used to copy one vector to another:

```
vector<int> v1;
for( int i = 0; i < 10; i++ ) {
    v1.push_back( i );
}
vector<int> v2;
v2.assign( v1.begin(), v1.end() );
for( int i = 0; i < v2.size(); i++ ) {
    cout << v2[i] << " ";
}
cout << endl;
```

When run, the above code displays the following output:
0123456789
Related Topics: insert, push_back, push_front

## back

Syntax:

```
#include <list>
TYPE& back();
const TYPE& back() const;
```

The back() function returns a reference to the last element in the list.
For example:

```
    vector<int> v;
    for( int i = 0; i < 5; i++ ) {
        v.push_back(i);
    }
    cout << "The first element is " << v.front()
        << " and the last element is " << v.back() << end.
4
```

This code produces the following output:
The first element is 0 and the last element is 4
The back() function runs in constant time.
Related Topics: front, pop_back

## begin

Syntax:

```
#include <list>
iterator begin();
const_iterator begin() const;
```

The function begin() returns an iterator to the first element of the list. begin() should run in constant time.

For example, the following code uses begin() to initialize an iterator that is used to traverse a list:

```
    // Create a list of characters
    list<char> my_list;
    for( int i = 0; i < 10; i++ ) {
    my_list.push_front( i + 'a' );
    }
    // Display the list
    list<char>::iterator it;
    for( it = my_list.begin(); it != my_list.end(); ++it
        cout << *it;
    }
4.
```

Related Topics: end, rbegin, rend

## clear

Syntax:

```
#include <list>
void clear();
```

The function clear() deletes all of the elements in the list. clear() runs in linear time.

Related Topics: erase

## empty

Syntax:

```
#include <list>
bool empty() const;
```

The empty() function returns true if the list has no elements, false otherwise. For example, the following code uses empty() as the stopping condition on a while loop to clear a list and display its contents in reverse order:

```
vector<int> v;
for( int i = 0; i < 5; i++ ) {
    v.push_back(i);
}
while( !v.empty() ) {
    cout << v.back() << endl;
    v.pop_back();
}
```

Related Topics: size

## end

## Syntax:

```
#include <list>
iterator end();
const_iterator end() const;
```

The end() function returns an iterator just past the end of the list.
Note that before you can access the last element of the list using an iterator that you get from a call to end(), you'll have to decrement the iterator first.

For example, the following code uses begin() and end() to iterate through all of the members of a vector:

```
vector<int> v1( 5, 789 );
vector<int>::iterator it;
for( it = v1.begin(); it != v1.end(); it++ ) {
    cout << *it << endl;
}
```

The iterator is initialized with a call to begin(). After the body of the loop has been executed, the iterator is incremented and tested to see if it is equal to the result of calling end(). Since end() returns an iterator pointing to an element just after the last element of the vector, the loop will only stop once all of the elements of the vector have been displayed.
end() runs in constant time.
Related Topics: begin, rbegin, rend

## erase

Syntax:

```
#include <list>
iterator erase( iterator loc );
iterator erase( iterator start, iterator end );
```

The erase() function either deletes the element at location loc, or deletes the elements between start and end (including start but not including end). The return value is the element after the last element erased.

The first version of erase (the version that deletes a single element at location loc) runs in constant time for lists and linear time for vectors, deques, and strings. The multiple-element version of erase always takes linear time.

Lists have the important property that insertion and splicing do not invalidate iterators to list elements, and that even removal invalidates only the iterators that point to the elements that are removed.

The ordering of iterators may be changed (that is, list<T>::iterator might have a different predecessor or successor after a list operation than it did before), but the iterators themselves will not be invalidated or made to point to different elements unless that invalidation or mutation is explicit.

For example:

```
    // Create a list, load it with the first ten character
    list<char> alphaList;
    for( int i=0; i < 10; i++ ) {
        alphaList.push_back( i + 65 );
    }
    int size = alphaList.size();
    list<char>::iterator startIterator;
    list<char>::iterator tempIterator;
    for( int i=0; i < size; i++ ) {
        startIterator = alphaList.begin();
        alphaList.erase( startIterator );
        // Display the list
        copy( alphaList.begin(), alphaList.end(), ostream_it
        cout << endl;
    }

That code would display the following output:
```

BCDEFGHIJ
CDEFGHIJ
DEFGHIJ
EFGHIJ
FGHIJ
GHIJ
HIJ
I J
J

```

In the next example, erase() is called with two iterators to delete a range of elements from a list:
```

// create a list, load it with the first ten character
list<char> alphaList;
for( int i=0; i < 10; i++ ) {
alphaList.push_back( i + 65 );
}
// display the complete list
copy( alphaList.begin(), alphaList.end(), ostream_iter;
cout << endl;
// use erase to remove all but the first two and last
// of the list
alphaList.erase( advance(alphaList.begin(),2), advance
// display the modified list
copy( alphaList.begin(), alphaList.end(), ostream_iter:
cout << endl;

When run, the above code displays:

## ABCDEFGHIJ <br> ABHIJ

Related Topics: clear, insert, pop_back, pop_front, remove, remove_if

## front

Syntax:

```
#include <list>
TYPE& front();
const TYPE& front() const;
```

The front() function returns a reference to the first element of the list, and runs in constant time.

Related Topics: back, pop_front, push_front

## insert

## Syntax:

```
    #include <list>
    iterator insert( iterator loc, const TYPE& val );
    void insert( iterator loc, size_type num, const TYPE&
    template<TYPE> void insert( iterator loc, input_itera
```

4

The insert() function either:

- inserts val before loc, returning an iterator to the element inserted,
- inserts num copies of val before loc, or
- inserts the elements from start to end before loc.

For example:

```
    // Create a vector, load it with the first 10 characte
    vector<char> alphaVector;
    for( int i=0; i < 10; i++ ) {
        alphaVector.push_back( i + 65 );
    }
    // Insert four C's into the vector
    vector<char>::iterator theIterator = alphavector.begin
    alphaVector.insert( theIterator, 4, 'C' );
    // Display the vector
    for( theIterator = alphaVector.begin(); theIterator !=
    theIterator++ )
        cout << *theIterator;
    }
|
```

This code would display:

Related Topics: assign, erase, merge, push_back, push_front, splice

## List constructors

Syntax:

```
#include <list>
list();
list( const list& c );
list( size_type num, const TYPE& val = TYPE() );
list( input_iterator start, input_iterator end );
~list();
```

The default list constructor takes no arguments, creates a new instance of that list.

The second constructor is a default copy constructor that can be used to create a new list that is a copy of the given list c.

The third constructor creates a list with space for num objects. If val is specified, each of those objects will be given that value. For example, the following code creates a list consisting of five copies of the integer 42:

$$
\text { list <int> l1( 5, } 42 \text { ); }
$$

The last constructor creates a list that is initialized to contain the elements between start and end. For example:

```
        // create a vector of random integers
        cout << "original list: ";
        list<int> l;
        for( int i = 0; i < 20; i++ ) {
        int num = (int) rand() % 10;
        cout << num << " ";
    l.push_back( num );
}
cout << endl;
    // delete 5 & 7
    list<int>::iterator iter1 = l.begin();
while( iter1 != l.end() ) {
    list<int>::iterator thisone = iter1;
    iter1++;
    if ( *thisone == 5 || *thisone == 7 ) {
        cout << "erase " << *thisone << endl;
        l.erase( thisone );
    }
}
    // find the first element of l that is even
list<int>::iterator iter2 = l.begin();
while( iter2 != l.end() && *iter2 % 2 != 0 ) {
    iter2++;
}
// find the last element of l that is even
list<int>::iterator iter3 = l.end();
do
    iter3--;
} while( iter3 != l.begin() && *iter3 % 2 != 0 );
cout << "first even number: " << *iter2 << ", last ev>
```

When run, this code displays the following output:

```
original list: 7 9 3 8 0 2 4 8 3 9 0 5 2 2 7 3 7 9 0 2
erase 7
    erase 5
    erase 7
    erase 7
    first even number: 8, last even number: 2
    new list: 8 0 2 4 8 3 9 0 2 2 3 9 0
```

All of these constructors run in linear time except the first, which runs in constant time.

The default destructor calls the destructor for each object in the list with linear complexity.

## List operators

Syntax:

```
#include <list>
list operator=(const list& c2);
bool operator==(const list& c1, const list& c2);
bool operator!=(const list& c1, const list& c2);
bool operator<(const list& c1, const list& c2);
bool operator>(const list& c1, const list& c2);
bool operator<=(const list& c1, const list& c2);
bool operator>=(const list& c1, const list& c2);
```

All of the C++ containers can be compared and assigned with the standard comparison operators: ==, !=, <=, >=, <, >, and =. Performing a comparison or assigning one list to another takes linear time.

Two lists are equal if:

1. Their size is the same, and
2. Each member in location $i$ in one list is equal to the the member in location i in the other list.

Comparisons among lists are done lexicographically.
Related Topics: merge, unique

## max_size

Syntax:

```
#include <list>
size_type max_size() const;
```

The max_size() function returns the maximum number of elements that the list can hold. The max_size() function should not be confused with the size or capacity functions, which return the number of elements currently in the list and the the number of elements that the list will be able to hold before more memory will have to be allocated, respectively.

Related Topics: size

## merge

Syntax:

```
#include <list>
void merge( list &lst );
void merge( list &lst, BinPred compfunction );
```

The function merge() merges the list with Ist, producing a combined list that is ordered with respect to the < operator. If compfunction is specified, then it is used as the comparison function for the lists instead of < .
merge() runs in linear time.
Related Topics: List operators, insert, splice

## pop_back

Syntax:

$$
\begin{aligned}
& \text { \#include <list> } \\
& \text { void pop_back(); }
\end{aligned}
$$

The pop_back() function removes the last element of the list.
pop_back() runs in constant time.
Related Topics: back, erase, pop_front, push_back

## pop_front

Syntax:

```
#include <list>
void pop_front();
```

The function pop_front() removes the first element of the list.

The pop_front() function runs in constant time.

Related Topics: erase, front, pop_back, push_front

## push_back

Syntax:

```
#include <list>
void push_back( const TYPE& val );
```

The push_back() function appends val to the end of the list. For example, the following code puts 10 integers into a list:

```
list<int> the_list;
for( int i = 0; i < 10; i++ )
    the_list.push_back( i );
```

When displayed, the resulting list would look like this:

$$
0123456789
$$

push_back() runs in constant time.
Related Topics: assign, insert, pop_back, push_front

## push_front

Syntax:

```
#include <list>
void push_front( const TYPE& val );
```

The push_front() function inserts val at the beginning of list. push_front() runs in constant time.

Related Topics: assign, front, insert, pop_front, push_back

## rbegin

Syntax:

```
#include <list>
reverse_iterator rbegin();
const_reverse_iterator rbegin() const;
```

The rbegin() function returns a reverse_iterator to the end of the current list.
rbegin() runs in constant time.
Related Topics: begin, end, rend

## remove

Syntax:

```
#include <list>
void remove( const TYPE &val );
```

The function remove() removes all elements that are equal to val from the list. For example, the following code creates a list of the first 10 characters of the alphabet, then uses remove() to remove the letter ' $E$ ' from the list:

```
    // Create a list that has the first 10 letters of th
list<char> charList;
for( int i=0; i < 10; i++ )
    charList.push_front( i + 65 );
// Remove all instances of 'E'
charList.remove( 'E' );
4.
```

Remove runs in linear time.
Related Topics: erase, remove_if, unique

## remove_if

Syntax:

```
#include <list>
void remove_if( UnPred pr );
```

The remove_if() function removes all elements from the list for which the unary predicate pr is true.
remove_if() runs in linear time.
Related Topics: erase, remove, unique

## rend

## Syntax:

```
#include <list>
reverse_iterator rend();
const_reverse_iterator rend() const;
```

The function rend() returns a reverse_iterator to the beginning of the current list.
rend() runs in constant time.
Related Topics: begin, end, rbegin

## resize

Syntax:


The function resize() changes the size of the list to size. If val is specified then any newly-created elements will be initialized to have a value of val.

This function runs in linear time.
Related Topics: size

## reverse

Syntax:

$$
\begin{aligned}
& \text { \#include <list> } \\
& \text { void reverse(); }
\end{aligned}
$$

The function reverse() reverses the list, and takes linear time.
Related Topics: sort

## size

Syntax:

$$
\begin{aligned}
& \text { \#include <list> } \\
& \text { size_type size() const; }
\end{aligned}
$$

The size() function returns the number of elements in the current list.
Related Topics: empty, max_size, resize

## sort

Syntax:

```
#include <list>
void sort();
void sort( BinPred p );
```

The sort() function is used to sort lists into ascending order. Ordering is done via the < operator, unless p is specified, in which case it is used to determine if an element is less than another.

Sorting takes $\mathrm{N} \log \mathrm{N}$ time.
Related Topics: reverse

## splice

Syntax:

```
    #include <list>
    void splice( iterator pos, list& lst );
    void splice( iterator pos, list& lst, iterator del );
    void splice( iterator pos, list& lst, iterator start,
4
```

The splice function moves one or more items from lst right before location pos. The first overloading moves all items to lst, the second moves just the item at del, and the third moves all items in the range inclusive of start to just before end.
splice simply moves elements from one list to another, and doesn't actually do any copying or deleting. Because of this, splice runs in constant time except for the third overloading which needs no more than linear time in the case that lst is not the same as this. However, if size is linear complexity then splice is constant time for all three.

Related Topics: insert, merge, swap

## swap

Syntax:

```
#include <list>
void swap( container& from );
```

The swap() function exchanges the elements of the current list with those of from. This function operates in constant time.

For example, the following code uses the swap() function to exchange the values of two strings:

```
string first( "This comes first" );
string second( "And this is second" );
first.swap( second );
cout << first << endl;
cout << second << endl;
```

The above code displays:

```
And this is second
This comes first
```

Related Topics: splice

## unique

Syntax:

```
#include <list>
void unique();
void unique( BinPred pr );
```

The function unique() removes all consecutive duplicate elements from the list.

Note that only consecutive duplicates are removed, which may require that you sort() the list first.

Equality is tested using the == operator, unless pr is specified as a replacement. The ordering of the elements in a list should not change after a call to unique().
unique() runs in linear time.
Related Topics: List operators, remove, remove_if

## begin

Syntax:

```
#include <map>
iterator begin();
const_iterator begin() const;
```

The begin() function returns an iterator to the first element of the map. If the map doesn't contain any element, then begin() returns the same as end().
begin() should run in constant time.
For example, the following code uses begin() to initialize an iterator that is used to traverse a list:

```
map<string,int> stringCounts;
string str;
while( cin >> str ) ++stringCounts[str];
map<string,int>::iterator iter;
for( iter = stringCounts.begin(); iter != stringCount
        cout << "word: " << iter->first << ", count: " << i
}
4.
```

When given this input:
here are some words and here are some more words
...the above code generates this output:
word: and, count: 1
word: are, count: 2
word: here, count: 2
word: more, count: 1
word: some, count: 2
word: words, count: 2
Related Topics: end, rbegin, rend

## clear

Syntax:

> \#include <map> void clear();

The function clear() deletes all of the elements in the map. clear() runs in linear time.

Related Topics: erase

## count

Syntax:

```
#include <map>
size_type map::count(const key_type& key);
```

The method count() returns the number of occurrences of key in the map. count() should run in logarithmic time.

## empty

Syntax:

```
#include <map>
bool empty() const;
```

The empty() function returns true if the map has no elements, false otherwise.

For example, the following code uses empty() as the stopping condition on a while loop to clear a map and display its contents in order:

```
struct strcmp {
    bool operator()( const char* s1, const char* s2 ) c
        return strcmp( s1, s2 ) < 0;
    }
};
...
map<const char*, int, strCmp> ages;
ages["Homer"] = 38;
ages["Marge"] = 37;
ages["Lisa"] = 8;
ages["Maggie"] = 1;
ages["Bart"] = 11;
while( !ages.empty() ) {
    cout << "Erasing: " << (*ages.begin()).first << ",
    ages.erase( ages.begin() );
}
```

When run, the above code displays:

```
Erasing: Bart, 11
Erasing: Homer, 38
Erasing: Lisa, 8
Erasing: Maggie, 1
Erasing: Marge, 37
```

Related Topics: begin, erase, size

## end

Syntax:

```
#include <map>
iterator end();
const_iterator end() const;
```

The end() function returns an iterator just past the end of the map.
Note that before you can access the last element of the map using an iterator that you get from a call to end(), you'll have to decrement the iterator first.

Related Topics: begin, rbegin, rend

## equal_range

Syntax:


The function equal_range() returns two iterators - one to the first element that contains key, another to a point just after the last element that contains key.

## erase

Syntax:

```
#include <map>
void erase( iterator pos );
void erase( iterator start, iterator end );
size_type erase( const key_type& key );
```

The erase function() either erases the element at pos, erases the elements from start to end (but not including end), or erases all elements that have the value of key. Note that the first example invalidates the iterator pos.

For example, the following code uses erase() in a while loop to incrementally clear a map and display its contents in order:

```
struct strCmp {
    bool operator()( const char* s1, const char* s2 ) c
            return strcmp( s1, s2 ) < 0;
    }
};
...
map<const char*, int, strCmp> ages;
ages["Homer"] = 38;
ages["Marge"] = 37;
ages["Lisa"] = 8;
ages["Maggie"] = 1;
ages["Bart"] = 11;
while( !ages.empty() ) {
    cout << "Erasing: " << ages.begin()->first << ", "
    ages.erase( ages.begin() );
}
```

When run, the above code displays:

```
Erasing: Bart, 11
Erasing: Homer, 38
Erasing: Lisa, 8
Erasing: Maggie, 1
Erasing: Marge, 37
```

Related Topics: begin, clear, empty, size

## find

## Syntax:

```
#include <map>
iterator find( const key_type& key );
```

The find() function returns an iterator to key, or an iterator to the end of the map if key is not found.
find() runs in logarithmic time.
For example, the following code uses the find() function to determine how many times a user entered a certain word:

```
map<string,int> stringCounts;
string str;
while( cin >> str ) ++stringCounts[str];
map<string,int>::iterator iter = stringCounts.find("s
if( iter != stringCounts.end() ) {
    cout << "You typed '" << iter->first << "' " << ite
}
4
```

When run with this input:
my spoon is too big. my spoon is TOO big! my SPOON is d
...the above code produces this output:

```
You typed 'spoon' 2 time(s)
```


## insert

## Syntax:

```
#include <map>
iterator insert( iterator pos, const TYPE& pair );
void insert( input_iterator start, input_iterator end );
pair<iterator,bool> insert( const TYPE& pair );
```

The function insert() either:

- inserts pair after the element at pos (where pos is really just a suggestion as to where pair should go, since sets and maps are ordered), and returns an iterator to that element.
- inserts a range of elements from start to end.
- inserts pair<key, val>, but only if no element with key key already exists. The return value is an iterator to the element inserted (or an existing pair with key key), and a boolean which is true if an insertion took place.

For example, the following code uses insert function (along with make_pair) to insert some data into a map, and then displays that data:

```
map<string,int> theMap;
theMap.insert( make_pair( "Key 1", -1 ) );
theMap.insert( make_pair( "Another key!", 32 ) );
theMap.insert( make_pair( "Key the Three", 66667 ) );
map<string,int>::iterator iter;
for( iter = theMap.begin(); iter != theMap.end(); ++iter
    cout << "Key: '" << iter->first << "', Value: " << iter
}
```

When run, the above code displays this output:

Key: 'Another key!', Value: 32
Key: 'Key 1', Value: -1
Key: 'Key the Three', Value: 66667
Note that because maps are sorted containers, the output is sorted by the key value. In this case, since the map key data type is string, the map is sorted alphabetically by key.

Related Topics: [] operator

## key_comp

Syntax:

```
    #include <map>
    key_compare key_comp() const;
```

The function key_comp() returns the function that compares keys.
key_comp() runs in constant time.

Related Topics: value_comp

## lower_bound

Syntax:

```
#include <map>
iterator lower_bound( const key_type& key );
```

The lower_bound() function returns an iterator to the first element which has a value greater than or equal to key.
lower_bound() runs in logarithmic time.
Related Topics: upper_bound

## Map Constructors \& Destructors

Syntax:

```
#include <map>
map();
map( const map& m );
map( iterator start, iterator end );
map( iterator start, iterator end, const key_compare&
map( const key_compare& cmp );
~map();
```

1

The default constructor takes no arguments, creates a new instance of that map, and runs in constant time. The default copy constructor runs in linear time and can be used to create a new map that is a copy of the given map $m$.

You can also create a map that will contain a copy of the elements between start and end, or specify a comparison function cmp.

The default destructor is called when the map should be destroyed.

For example, the following code creates a map that associates a string with an integer:

```
    struct strCmp {
        bool operator()( const char* s1, const char* s2 ) c
            return strcmp( s1, s2 ) < 0;
        }
    };
    ...
    map<const char*, int, strCmp> ages;
    ages["Homer"] = 38;
    ages["Marge"] = 37;
    ages["Lisa"] = 8;
    ages["Maggie"] = 1;
    ages["Bart"] = 11;
    cout << "Bart is " << ages["Bart"] << " years old" <<
4
```

Related Topics: Map operators

## Map operators

Syntax:

```
#include <map>
TYPE& operator[]( const key_type& key );
map operator=(const map& c2);
bool operator==(const map& c1, const map& c2);
bool operator!=(const map& c1, const map& c2);
bool operator<(const map& c1, const map& c2);
bool operator>(const map& c1, const map& c2);
bool operator<=(const map& c1, const map& c2);
bool operator>=(const map& c1, const map& c2);
```

Maps can be compared and assigned with the standard comparison operators: $==,!=, \Leftarrow,>=,<,>$, and $=$. Individual elements of a map can be examined with the [] operator.

Performing a comparison or assigning one map to another takes linear time.

Two maps are equal if:

1. Their size is the same, and
2. Each member in location $i$ in one map is equal to the the member in location in the other map.

Comparisons among maps are done lexicographically.
For example, the following code defines a map between strings and integers and loads values into the map using the [ operator:

```
    struct strCmp {
        bool operator()( const char* s1, const char* s2 ) c
            return strcmp( s1, s2 ) < 0;
        }
};
map<const char*, int, strCmp> ages;
ages["Homer"] = 38;
ages["Marge"] = 37;
ages["Lisa"] = 8;
ages["Maggie"] = 1;
ages["Bart"] = 11;
cout << "Bart is " << ages["Bart"] << " years old" <<
cout << "In alphabetical order: " << endl;
for( map<const char*, int, strCmp>::iterator iter = a
    cout << (*iter).first << " is " << (*iter).second <'
}
|
```

When run, the above code displays this output:

```
Bart is 11 years old
In alphabetical order:
Bart is 11 years old
Homer is 38 years old
Lisa is 8 years old
Maggie is 1 years old
Marge is 37 years old
```

Related Topics: insert, Map Constructors \& Destructors

## Map typedefs

Syntax:

```
#include <map>
typedef ... key_type;
typedef ... value_type;
typedef ... allocator_type;
typedef ... size_type;
```


## max_size

Syntax:

```
#include <map>
size_type max_size() const;
```

The max_size() function returns the maximum number of elements that the map can hold.

Related Topics: size

## rbegin

Syntax:

```
#include <map>
reverse_iterator rbegin();
const_reverse_iterator rbegin() const;
```

The rbegin() function returns a reverse_iterator to the end of the current map.
rbegin() runs in constant time.
Related Topics: begin, end, rend

## rend

## Syntax:

```
#include <map>
reverse_iterator rend();
const_reverse_iterator rend() const;
```

The function rend() returns a reverse_iterator to the beginning of the current map.
rend() runs in constant time.
Related Topics: begin, end, rbegin

## size

Syntax:

> \#include <map> size_type size() const;

The size() function returns the number of elements in the current map.
Related Topics: empty, max_size

## swap

Syntax:

```
#include <map>
void swap( container& from );
```

The swap() function exchanges the elements of the current map with those of from. This function operates in constant time.

## upper_bound

Syntax:
\#include <map>
iterator upper_bound( const key_type\& key );
The function upper_bound() returns an iterator to the first element in the map with a key greater than key.

Related Topics: lower_bound

## value_comp

Syntax:

```
#include <map>
value_compare value_comp() const;
```

The value_comp() function returns the function that compares values. value_comp() runs in constant time.

Related Topics: key_comp

## auto_ptr

Syntax:

```
#include <memory>
auto_ptr<class TYPE> name
```

The auto_ptr class allows the programmer to create pointers that point to other objects. When auto_ptr pointers are destroyed, the objects to which they point are also destroyed.

The auto_ptr class supports normal pointer operations like $=$, *, and ->, as well as two functions TYPE* get() and TYPE* release(). The get() function returns a pointer to the object that the auto_ptr points to. The release() function acts similarily to the get() function, but also relieves the auto_ptr of its memory destruction duties. When an auto_ptr that has been released goes out of scope, it will not call the destructor of the object that it points to.

Warning: It is generally a bad idea to put auto_ptr objects inside C++ STL containers. C++ containers can do funny things with the data inside them, including frequent reallocation (when being copied, for instance). Since calling the destructor of an auto_ptr object will free up the memory associated with that object, any C++ container reallocation will cause any auto_ptr objects to become invalid.

```
#include <memory>
using namespace std;
class MyClass {
public:
    MyClass() {} // nothing
    ~MyClass() {} // nothing
    void myFunc() {} // nothing
};
int main() {
    auto_ptr<MyClass> ptr1(new MyClass), ptr2;
    ptr2 = ptr1;
    ptr2->myFunc();
    MyClass* ptr = ptr2.get();
    ptr->myFunc();
    return 0;
}
```


## begin

Syntax:

```
#include <map>
iterator begin();
const_iterator begin() const;
```

The function begin() returns an iterator to the first element of the multimap.
begin() should run in constant time.
Related Topics: end, rbegin, rend

## clear

Syntax:

> \#include <map>
> void clear();

The function clear() deletes all of the elements in the multimap. clear() runs in linear time.

Related Topics: erase

## count

Syntax:

```
#include <map>
size_type count( const key_type& key );
```

The function count() returns the number of occurrences of key in the multimap. count() should run in logarithmic time.

## empty

Syntax:

$$
\begin{aligned}
& \text { \#include <map> } \\
& \text { bool empty() const; }
\end{aligned}
$$

The empty() function returns true if the multimap has no elements, false otherwise.

Related Topics: size

## end

Syntax:

```
#include <map>
iterator end();
const_iterator end() const;
```

The end() function returns an iterator just past the end of the multimap. Note that before you can access the last element of the multimap using an iterator that you get from a call to end(), you'll have to decrement the iterator first.
end() runs in constant time.
Related Topics: begin, rbegin, rend

## equal_range

## Syntax:



The function equal_range() returns two iterators - one to the first element that contains key, another to a point just after the last element that contains key.

For example, here is a hypothetical input-configuration loader using multimaps, strings and equal_range():

```
    multimap<string,pair<int,int> > input_config;
    // read configuration from file "input.conf" to input_c
readConfigFile( input_config, "input.conf" );
pair<multimap<string,pair<int,int> >: :iterator,multimap
multimap<string,pair<int,int> >: :iterator i;
    ii = input_config.equal_range("key"); // keyboa
    // we can iterate over a range just like with begin() a
    for( i = ii.first; i != ii.second; ++i ) {
    // add a key binding with this key and output
    bindkey(i->second.first, i->second.second);
}
    ii = input_config.equal_range("joyb"); // joysti
    for( i = ii.first; i != ii.second; ++i ) {
        // add a key binding with this joystick button and ou
        bindjoyb(i->second.first, i->second.second);
    }
4
```


## erase

Syntax:

```
#include <map>
void erase( iterator pos );
void erase( iterator start, iterator end );
size_type erase( const key_type& key );
```

The erase function() either erases the element at pos, erases the elements between start and end, or erases all elements that have the value of key.

## find

Syntax:
\#include <map>
iterator find( const key_type\& key );
The find() function returns an iterator to key, or an iterator to the end of the multimap if key is not found.
find() runs in logarithmic time.

## insert

Syntax:

```
    #include <map>
    iterator insert( iterator pos, const TYPE& val );
    iterator insert( const TYPE& val );
    void insert( input_iterator start, input_iterator end
```

4

The function insert() either:

- inserts val after the element at pos (where pos is really just a suggestion as to where val should go, since multimaps are ordered), and returns an iterator to that element.
- inserts val into the multimap, returning an iterator to the element inserted.
- inserts a range of elements from start to end.

For example, the following code uses the insert() function to add several <name,ID> pairs to a employee multimap:

```
    multimap<string,int> m;
    int employeeID = 0;
    m.insert( pair<string,int>("Bob Smith",employeeID++)
    m.insert( pair<string,int>("Bob Thompson",employeeID+
    m.insert( pair<string,int>("Bob Smithey",employeeID++
    m.insert( pair<string,int>("Bob Smith",employeeID++)
    cout << "Number of employees named 'Bob Smith': " << ।
    cout << "Number of employees named 'Bob Thompson': " .
    cout << "Number of employees named 'Bob Smithey': " <
    cout << "Employee list: " << endl;
    for( multimap<string, int>::iterator iter = m.begin()
        cout << " Name: " << iter->first << ", ID #" << ite
    }
4
```

When run, the above code produces the following output:

```
Number of employees named 'Bob Smith': 2
Number of employees named 'Bob Thompson': 1
Number of employees named 'Bob Smithey': 1
Employee list:
    Name: Bob Smith, ID #0
    Name: Bob Smith, ID #3
    Name: Bob Smithey, ID #2
    Name: Bob Thompson, ID #1
```


## key_comp

Syntax:

```
    #include <map>
    key_compare key_comp() const;
```

The function key_comp() returns the function that compares keys.
key_comp() runs in constant time.

Related Topics: value_comp

## lower_bound

Syntax:

```
#include <map>
iterator lower_bound( const key_type& key );
```

The lower_bound() function returns an iterator to the first element which has a value greater than or equal to key.
lower_bound() runs in logarithmic time.
Related Topics: upper_bound

## max_size

Syntax:

```
#include <map>
size_type max_size() const;
```

The max_size() function returns the maximum number of elements that the multimap can hold.

Related Topics: size

## Multimap constructors \& destructors

Syntax:

```
#include <map>
multimap();
multimap( const multimap& c );
multimap( iterator begin, iterator end,
    const key_compare& cmp = Compare(), const a
~multimap();
```

4

Multimaps have several constructors:

- The default constructor takes no arguments, creates a new instance of that multimap, and runs in constant time.
- The default copy constructor runs in linear time and can be used to create a new multimap that is a copy of the given multimap c.
- Multimaps can also be created from a range of elements defined by begin and end. When using this constructor, an optional comparison function cmp and allocator alloc can also be provided.

The default destructor is called when the multimap should be destroyed.
The template definition of multimaps requires that both a key type and value type be supplied. For example, you can instantiate a multimap that maps strings to integers with this statement:

```
multimap<string,int> m;
```

You can also supply a comparison function and an allocator in the template:

```
multimap<string,int,myComp,myAlloc> m;
```

For example, the following code uses a multimap to associate a series of employee names with numerical IDs:

```
    multimap<string,int> m;
    int employeeID = 0;
m.insert( pair<string,int>("Bob Smith",employeeID++)
m.insert( pair<string,int>("Bob Thompson",employeeID+
m.insert( pair<string,int>("Bob Smithey",employeeID++
m.insert( pair<string,int>("Bob Smith",employeeID++)
cout << "Number of employees named 'Bob Smith': " << ।
cout << "Number of employees named 'Bob Thompson': " .
cout << "Number of employees named 'Bob Smithey': " <
cout << "Employee list: " << endl;
for( multimap<string, int>::iterator iter = m.begin()
    cout << " Name: " << iter->first << ", ID #" << ite
}
4]
```

When run, the above code produces the following output. Note that the employee list is displayed in alphabetical order, because multimaps are sorted associative containers:

```
Number of employees named 'Bob Smith': 2
Number of employees named 'Bob Thompson': 1
Number of employees named 'Bob Smithey': 1
Employee list:
    Name: Bob Smith, ID #0
    Name: Bob Smith, ID #3
    Name: Bob Smithey, ID #2
    Name: Bob Thompson, ID #1
```

Related Topics: count, insert

## Multimap operators

Syntax:

```
    #include <map>
    multimap operator=(const multimap& c2);
    bool operator==(const multimap& c1, const multimap& c
    bool operator!=(const multimap& c1, const multimap& c.
    bool operator<(const multimap& c1, const multimap& c2
    bool operator>(const multimap& c1, const multimap& c2
    bool operator<=(const multimap& c1, const multimap& c
    bool operator>=(const multimap& c1, const multimap& c.
|
```

All of the C++ containers can be compared and assigned with the standard comparison operators: $==,!=, \Leftarrow,>=,<,>$, and $=$. Performing a comparison or assigning one multimap to another takes linear time.

Two multimaps are equal if:

1. Their size is the same, and
2. Each member in location $i$ in one multimap is equal to the the member in location $i$ in the other multimap.

Comparisons among multimaps are done lexicographically.
Related Topics: Multimap constructors \& destructors

## rbegin

Syntax:

```
#include <map>
reverse_iterator rbegin();
const_reverse_iterator rbegin() const;
```

The rbegin() function returns a reverse_iterator to the end of the current multimap.
rbegin() runs in constant time.
Related Topics: begin, end, rend

## rend

## Syntax:

```
#include <map>
reverse_iterator rend();
const_reverse_iterator rend() const;
```

The function rend() returns a reverse_iterator to the beginning of the current multimap.
rend() runs in constant time.
Related Topics: begin, end, rbegin

## size

Syntax:

> \#include <map> size_type size() const;

The size() function returns the number of elements in the current multimap.

Related Topics: empty

## swap

Syntax:

```
#include <map>
void swap( container& from );
```

The swap() function exchanges the elements of the current multimap with those of from. This function operates in constant time.

## upper_bound

Syntax:
\#include <map>
iterator upper_bound( const key_type\& key );
The function upper_bound() returns an iterator to the first element in the multimap with a key greater than key.

Related Topics: lower_bound

## value_comp

Syntax:

```
#include <map>
value_compare value_comp() const;
```

The value_comp() function returns the function that compares values.
value_comp() runs in constant time.

Related Topics: key_comp

## begin

Syntax:

```
#include <set>
iterator begin();
const_iterator begin() const;
```

The function begin() returns an iterator to the first element of the multiset. begin() should run in constant time.

Related Topics: end, rbegin, rend

## clear

Syntax:

$$
\begin{aligned}
& \text { \#include <set> } \\
& \text { void clear(); }
\end{aligned}
$$

The function clear() deletes all of the elements in the multiset. clear() runs in linear time.

Related Topics: (C++ Lists) erase

## count

Syntax:

```
#include <set>
size_type count( const key_type& key );
```

The function count() returns the number of occurrences of key in the multiset. count() should run in logarithmic time.

## empty

Syntax:

$$
\begin{aligned}
& \text { \#include <set> } \\
& \text { bool empty() const; }
\end{aligned}
$$

The empty() function returns true if the multiset has no elements, false otherwise.

Related Topics: size

## end

Syntax:

```
#include <set>
iterator end();
const_iterator end() const;
```

The end() function returns an iterator just past the end of the multiset.
Note that before you can access the last element of the multiset using an iterator that you get from a call to end(), you'll have to decrement the iterator first.
end() runs in constant time.
Related Topics: begin, rbegin, rend

## equal_range

Syntax:


The function equal_range() returns two iterators - one to the first element that contains key, another to a point just after the last element that contains key.

## erase

Syntax:

```
#include <set>
void erase( iterator pos );
void erase( iterator start, iterator end );
size_type erase( const key_type& key );
```

The erase function() either erases the element at pos, erases the elements between start and end, or erases all elements that have the value of key.

## find

Syntax:

```
    #include <set>
    iterator find( const key_type& key );
```

The find() function returns an iterator to key, or an iterator to the end of the multiset if key is not found.
find() runs in logarithmic time.

## insert

Syntax:

```
    #include <set>
    iterator insert( iterator pos, const TYPE& val );
    iterator insert( const TYPE& val );
    void insert( input_iterator start, input_iterator end
```

4

The function insert() either:

- inserts val after the element at pos (where pos is really just a suggestion as to where val should go, since multisets and multimaps are ordered), and returns an iterator to that element.
- inserts val into the multiset, returning an iterator to the element inserted.
- inserts a range of elements from start to end.


## key_comp

Syntax:

```
    #include <set>
    key_compare key_comp() const;
```

The function key_comp() returns the function that compares keys.
key_comp() runs in constant time.

Related Topics: value_comp

## lower_bound

Syntax:

```
#include <set>
iterator lower_bound( const key_type& key );
```

The lower_bound() function returns an iterator to the first element which has a value greater than or equal to key.
lower_bound() runs in logarithmic time.
Related Topics: upper_bound

## max_size

Syntax:

```
#include <set>
size_type max_size() const;
```

The max_size() function returns the maximum number of elements that the multiset can hold.

Related Topics: size

## Multiset Constructors

Syntax:

```
#include <set>
multiset();
multiset( const multiset& c );
~multiset();
```

Every multiset has a default constructor, copy constructor, and destructor.

The default constructor takes no arguments, creates a new instance of that multiset, and runs in constant time. The default copy constructor runs in linear time and can be used to create a new multiset that is a copy of the given multiset c.

The default destructor is called when the multiset should be destroyed.

## Multiset Operators

Syntax:

```
    #include <set>
    multiset operator=(const multiset& c2);
    bool operator==(const multiset& c1, const multiset& c
    bool operator!=(const multiset& c1, const multiset& c.
    bool operator<(const multiset& c1, const multiset& c2
    bool operator>(const multiset& c1, const multiset& c2
    bool operator<=(const multiset& c1, const multiset& c
    bool operator>=(const multiset& c1, const multiset& c.
|
```

All of the C++ containers can be compared and assigned with the standard comparison operators: $==,!=, \Leftarrow,>=,<,>$, and $=$. Performing a comparison or assigning one multiset to another takes linear time.

Two multisets are equal if:

1. Their size is the same, and
2. Each member in location $i$ in one multiset is equal to the the member in location $i$ in the other multiset.

Comparisons among multisets are done lexicographically.

## rbegin

Syntax:

```
#include <set>
reverse_iterator rbegin();
const_reverse_iterator rbegin() const;
```

The rbegin() function returns a reverse_iterator to the end of the current multiset.
rbegin() runs in constant time.
Related Topics: begin, end, rend

## rend

## Syntax:

```
#include <set>
reverse_iterator rend();
const_reverse_iterator rend() const;
```

The function rend() returns a reverse_iterator to the beginning of the current multiset.
rend() runs in constant time.
Related Topics: begin, end, rbegin

## size

Syntax:

```
#include <set>
size_type size() const;
```

The size() function returns the number of elements in the current multiset.

Related Topics: empty

## swap

Syntax:

```
#include <set>
void swap( container& from );
```

The swap() function exchanges the elements of the current multiset with those of from. This function operates in constant time.

## upper_bound

Syntax:
\#include <set>
iterator upper_bound( const key_type\& key );
The function upper_bound() returns an iterator to the first element in the multiset with a key greater than key.

Related Topics: lower_bound

## value_comp

Syntax:

```
#include <set>
value_compare value_comp() const;
```

The value_comp() function returns the function that compares values. value_comp() runs in constant time.

Related Topics: key_comp

## sleep

Sleep is a C++ function that suspends the thread execution for integer value seconds.

It accepts only integer values.
If someone wants to suspend a thread execution for a float value seconds i.e. nnn,nnn he must use a combination of sleep and usleep.

## Non-standard Functions

C++ is officially defined by an ISO standard (most recently, ISO/IEC 14882:2003). However, some compilers support extra functions that are not included in the standard. These non-standard functions are not guaranteed to work across different platforms.
sleep wait for N seconds
usleep wait for N microseconds

## usleep

usleep is a C++ function that suspends the thread execution for integer value microseconds.

It accepts only integer values.

If some one wants to suspend the thread execution for something like 4.536 seconds, he set usleep as follows:

```
usleep(4536000); // (in microseconds)
```

He can alternatively use the combination of sleep and usleep as follows:

```
sleep(4); // (in seconds)
usleep(536000); // (in microseconds)
```


## empty

Syntax:

> \#include <queue> bool empty() const;

The empty() function returns true if the priority queue has no elements, false otherwise.

Related Topics: size

## pop

## Syntax:

\#include <queue>
void pop();
The function pop() removes the top element of the priority queue and discards it.

Related Topics: push, top

## Priority queue constructors

Syntax:

```
#include <queue>
priority_queue( const Compare& cmp = Compare(),
    const Container& c = Container() );
priority_queue( input_iterator start,
    input_iterator end,
    const Compare& comp = Compare(),
    const Container& c = Container() );
```

Priority queues can be constructed with an optional compare function cmp and an optional container c. If start and end are specified, the priority queue will be constructed with the elements between start and end.

## push

## Syntax:

```
#include <queue>
void push( const TYPE& val );
```

The function push() adds val to the end of the current priority queue.

## size

Syntax:

> \#include <queue> size_type size() const;

The size() function returns the number of elements in the current priority queue.

Related Topics: empty

## top

Syntax:

```
#include <queue>
TYPE& top();
```

The function top() returns a reference to the top element of the priority queue.

For example, the following code removes all of the elements from a stack and uses top() to display them:

```
while( !s.empty() ) {
    cout << s.top() << " ";
    s.pop();
}
```

Related Topics: pop

## back

Syntax:

```
#include <queue>
TYPE& back();
const TYPE& back() const;
```

The back() function returns a reference to the last element in the queue. For example:

```
    queue<int> q;
    for( int i = 0; i < 5; i++ ) {
        q.push(i);
    }
    cout << "The first element is " << q.front()
        << " and the last element is " << q.back() << end
|
```

This code produces the following output:
The first element is 0 and the last element is 4
The back() function runs in constant time.
Related Topics: front

## empty

Syntax:

$$
\begin{aligned}
& \text { \#include <queue> } \\
& \text { bool empty() const; }
\end{aligned}
$$

The empty() function returns true if the queue has no elements, false otherwise.

For example, the following code uses empty() as the stopping condition on a while loop to clear a queue while displaying its contents:

```
queue<int> q;
for( int i = 0; i < 5; i++ ) {
    q.push(i);
}
while( !q.empty() ) {
    cout << q.front() << endl;
    q.pop();
}
```

Related Topics: size

## front

Syntax:

```
#include <queue>
TYPE& front();
const TYPE& front() const;
```

The front() function returns a reference to the first element of the queue, and runs in constant time.

Related Topics: back

## pop

## Syntax:

\#include <queue>
void pop();
The function pop() removes the first element of the queue and discards it.

Related Topics: push

## push

Syntax:

```
#include <queue>
void push( const TYPE& val );
```

The function push() adds val to the end of the current queue.
For example, the following code uses the push() function to add ten integers to the end of a queue:

```
queue<int> q;
for( int i=0; i < 10; i++ ) {
        q.push(i);
}
```

Related Topics: pop

## Queue constructor

Syntax:

```
#include <queue>
queue();
queue( const queue& other );
```

Queues have a default constructor as well as a copy constructor that will create a new queue out of the container con.

For example, the following code creates a queue of strings, populates it with input from the user, and then displays it back to the user:

```
queue<string> waiting_line;
while( waiting_line.size() < 5 ) {
    cout << "Welcome to the line, please enter your nam
    string s;
    getline( cin, s );
    waiting_line.push(s);
}
while( !waiting_line.empty() ) {
    cout << "Now serving: " << waiting_line.front() << ,
    waiting_line.pop();
}
4)
```

When run, the above code might produce this output:

```
Welcome to the line, please enter your name: Bart
Welcome to the line, please enter your name: Milhouse
Welcome to the line, please enter your name: Ralph
Welcome to the line, please enter your name: Lisa
Welcome to the line, please enter your name: Lunchlady Do
Now serving: Bart
Now serving: Milhouse
Now serving: Ralph
Now serving: Lisa
Now serving: Lunchlady Doris
```


## size

Syntax:

> \#include <queue>
> size_type size() const;

The size() function returns the number of elements in the current queue.
Related Topics: empty

## begin

Syntax:

```
#include <set>
iterator begin();
const_iterator begin() const;
```

The function begin() returns an iterator to the first element of the set. begin () should run in constant time.

For example, the following code uses begin() to initialize an iterator that is used to enumerate a set:

```
// Create a set of characters
set<char> charSet;
const char* s = "Hello There";
for( int i=0; i < strlen(s); i++ ) {
    charSet.insert( s[i] );
}
// Display the set
set<char>::iterator theIterator;
for( theIterator = charSet.begin(); theIterator != c
    cout << *theIterator;
}
// output is " HTehlor"
4
```

Related Topics: end, rbegin, rend

## clear

Syntax:

```
#include <set>
void clear();
```

The function clear() deletes all of the elements in the set. clear() runs in linear time.

For example, the following code uses clear() to reinitialize a set:

```
// Create a set of characters
set<char> charSet;
charSet.insert( 'A' );
charSet.insert( 'B' );
charSet.insert( 'C' );
charSet.clear();
charSet.insert( 'A' );
charSet.insert( 'D' );
charSet.insert( 'E' );
// Display the set
set<char>::iterator theIterator;
for( theIterator = charSet.begin(); theIterator != c
    cout << *theIterator;
    }
// output is "ADE"
|

Related Topics: erase

\section*{count}

Syntax:
```

\#include <set>
size_type count( const key_type\& key );

```

The function count() returns the number of occurrences of key in the set, which is always 0 or 1 . count() should run in logarithmic time.

For example, the following code uses count() to determine if elements are contained in the set:
```

    // create a set of characters
    set<char> charSet;
    const char* s = "Hello There";
    for( int i=0; i < strlen(s); i++ ) {
        charSet.insert( s[i] );
    }
    // Display the set
cout << charSet.count('A');
cout << charSet.count('T');
// output is "01" (the characters in the set are " H
4.

```

\section*{empty}

Syntax:
```

\#include <set>
bool empty() const;

```

The empty() function returns true if the set has no elements, false otherwise.

For example, the following code uses empty() to determine if a set is empty:
```

// Create a set of characters
set<char> charSet;
cout << (charSet.empty() ? "EMPTY " : "NON-EMPTY ");
charSet.insert( 'A' );
charSet.insert( 'B' );
charSet.insert( 'C' );
cout << (charSet.empty() ? "EMPTY " : "NON-EMPTY ");
charSet.clear();
cout << (charSet.empty() ? "EMPTY " : "NON-EMPTY ");
// output is "EMPTY NON-EMPTY EMPTY '
4.

```

Related Topics: size

\section*{end}

Syntax:
```

\#include <set>
iterator end();
const_iterator end() const;

```

The end() function returns an iterator just past the end of the set. Note that before you can access the last element of the set using an iterator that you get from a call to end(), you'll have to decrement the iterator first.

For example, the following code uses end() to display the set in reverse order:
```

// Create a set of characters
set<char> charSet;
const char* s = "Hello There";
for( int i=0; i < strlen(s); i++ ) {
charSet.insert( s[i] );
}
// Display the last element of the set
set<char>::iterator theIterator = charSet.end();
for( theIterator = charSet.end(); theIterator != cha
theIterator--;
cout << *theIterator;
}
// output is "rolheTH "

```
1

Related Topics: begin, rbegin, rend

\section*{equal_range}

Syntax:


The function equal_range() returns two iterators - one to the first element that contains key, another to a point just after the last element that contains key.

\section*{erase}

Syntax:
```

    #include <set>
    void erase( iterator pos );
    void erase( iterator start, iterator end );
    size_type erase( const key_type& key ); // returns nul
    ```
1

The erase function() either erases the element at pos, erases the elements between start and end, or erases all elements that have the value of key.

\section*{With all container types you have to be careful when inserting or erasing elements, since it may lead to invalid iterators.}

Especially, set::erase() only invalidates the iterators (and pointers) referencing the element to be erased.

The example erases some elements depending on a condition (it will erase the letters B and D):
```

\#include <iostream>
\#include <set>
\#include <iterator>
using namespace std;
int main()
{
// Create a set, load it with the first ten character
set<char> alphas;
for( int i=0; i < 10; i++ )
alphas.insert( alphas.end(), i + 65 );
// display content before
copy(alphas.begin(), alphas.end(), ostream_iterator<c
cout << endl;
set<char>::iterator iter = alphas.begin();
while( iter != alphas.end() )
{
if (*iter == 'B' || *iter == 'D')
// A copy of iter is passed into erase(), ++ is e
// Thus iter remains valid
alphas.erase( iter++ );
else
++iter;
}
// display content after
copy(alphas.begin(), alphas.end(), ostream_iterator<c
cout << endl;
}

```

When run, the above code displays:

\section*{ABCDEFGHIJ}

ACEFGHIJ
Related Topics: clear

\section*{find}

Syntax:
\#include <set>
iterator find( const key_type\& key );
The find() function returns an iterator to key, or an iterator to the end of the set if key is not found.
find() runs in logarithmic time.

\section*{insert}

\section*{Syntax:}
```

\#include <set>
iterator set::insert(iterator pos, const TYPE\& val);
void set::insert(input_iterator start, input_iterator
pair<iterator, bool> set::insert(const TYPE\& val);

```

The method insert() either:
- inserts val before the element at pos (where pos is really just a suggestion as to where val should go, since sets and maps are ordered), and returns an iterator to that element.
- inserts a range of elements from start to end.
- inserts val, but only if val doesn't already exist. The return value is an iterator to the element inserted, and a boolean describing whether an insertion took place.

For example, the following code uses insert to populate a set of integers:
```

    const int max_nums = 10;
    int nums[max_nums] = {3,1,4,1,5,9,2,6,5,8};
    set<int> digits;
    for( int i = 0; i < max_nums; ++i ) digits.insert(nums[
    cout << "Unique digits are: ";
    for( set<int>::const_iterator iter = digits.begin();
        iter != digits.end();
        ++iter ) {
    cout << *iter << ' ';
    }
cout << '\n';

When run, this code displays:
Unique digits are: 12345689
Related Topics: begin, end

## key_comp

Syntax:

```
    #include <set>
    key_compare key_comp() const;
```

The function key_comp() returns the function that compares keys.
key_comp() runs in constant time.

Related Topics: value_comp

## lower_bound

Syntax:

```
#include <set>
iterator lower_bound( const key_type& key );
```

The lower_bound() function returns an iterator to the first element which has a value greater than or equal to key.
lower_bound() runs in logarithmic time.
Related Topics: upper_bound

## max_size

Syntax:

```
#include <set>
size_type max_size() const;
```

The max_size() function returns the maximum number of elements that the set can hold.

Related Topics: size

## rbegin

Syntax:

```
#include <set>
reverse_iterator rbegin();
const_reverse_iterator rbegin() const;
```

The rbegin() function returns a reverse_iterator to the end of the current set.
rbegin() runs in constant time.
Related Topics: begin, end, rend

## rend

## Syntax:

```
#include <set>
reverse_iterator rend();
const_reverse_iterator rend() const;
```

The function rend() returns a reverse_iterator to the beginning of the current set.
rend() runs in constant time.

Related Topics: begin, end, rbegin

## Set constructors \& destructors

Syntax:

```
#include <set>
set();
set( const set& c );
~set();
```

Every set has a default constructor, copy constructor, and destructor.
The default constructor takes no arguments, creates a new instance of that set, and runs in constant time. The default copy constructor runs in linear time and can be used to create a new set that is a copy of the given set c.

The default destructor is called when the set should be destroyed.

For example, the following code creates and displays a set of integers:

```
    const int max_nums = 10;
    int nums[max_nums] \(=\{3,1,4,1,5,9,2,6,5,8\}\);
    set<int> digits;
    for( int i = 0; i < max_nums; ++i ) digits.insert(nums[
    cout << "Unique digits are: ";
    for( set<int>::const_iterator iter = digits.begin();
        iter != digits.end();
        ++iter ) \{
    cout << *iter << ' ';
\}
cout << '\n';
1
```

When run, this code displays:

Unique digits are: 12345689

## Set operators

Syntax:

```
#include <set>
set operator=(const set& c2);
bool operator==(const set& c1, const set& c2);
bool operator!=(const set& c1, const set& c2);
bool operator<(const set& c1, const set& c2);
bool operator>(const set& c1, const set& c2);
bool operator<=(const set& c1, const set& c2);
bool operator>=(const set& c1, const set& c2);
```

All of the C++ containers can be compared and assigned with the standard comparison operators: ==, !=, <=, >=, <, >, and =. Performing a comparison or assigning one set to another takes linear time.

Two sets are equal if:

1. Their size is the same, and
2. Each member in location $i$ in one set is equal to the the member in location $i$ in the other set.

Comparisons among sets are done lexicographically.

## size

Syntax:

```
#include <set>
size_type size() const;
```

The size() function returns the number of elements in the current set.
For example, the following code uses size() to determine the number of elements in a set:

```
    // Create a set of characters
set<char> charSet;
const char* s = "Hello There";
for( int i=0; i < strlen(s); i++ ) {
    charSet.insert( s[i] );
    }
    // Display the size of the set
cout << charSet.size();
// output is "8" (the characters in the set are " HT
```

Related Topics: empty

## swap

Syntax:

```
#include <set>
void swap( container& from );
```

The swap() function exchanges the elements of the current set with those of from. This function operates in constant time.

## upper_bound

Syntax:
\#include <set>
iterator upper_bound( const key_type\& key );
The function upper_bound() returns an iterator to the first element in the set with a value greater than key.

Related Topics: lower_bound

## value_comp

Syntax:

```
#include <set>
value_compare value_comp() const;
```

The value_comp() function returns the function that compares values. value_comp() runs in constant time.

Related Topics: key_comp

## String Stream Constructors

## Syntax:

```
#include <sstream>
stringstream()
stringstream( openmode mode )
stringstream( string s, openmode mode )
ostringstream()
ostringstream( openmode mode )
ostringstream( string s, openmode mode )
istringstream()
istringstream( openmode mode )
istringstream( string s, openmode mode )
```

The stringstream, ostringstream, and istringstream objects are used for input and output to a string. They behave in a manner similar to fstream, ofstream and ifstream objects. The optional mode parameter defines how the file is to be opened, according to the io_stream_mode_flags. An ostringstream object can be used to write to a string. This is similar to the $C$ sprintf() function. For example:

```
ostringstream s1;
int i = 22;
s1 << "Hello " << i << endl;
string s2 = s1.str();
cout << s2;
```

An istringstream object can be used to read from a string. This is similar to the $C \operatorname{sscanf}()$ function. For example:

```
istringstream stream1;
string string1 = "25";
stream1.str(string1);
int i;
stream1 >> i;
cout << i << endl; // displays 25
```

You can also specify the input string in the istringstream constructor as in this example:

```
string string1 = "25";
istringstream stream1(string1);
int i;
stream1 >> i;
cout << i << endl; // displays 25
```

A stringstream object can be used for both input and output to a string like an fstream object.

Related Topics: C++ I/O streams

## String Stream Operators

Syntax:

```
#include <sstream>
operator<<
operator>>
```

Like C++_I/O_Streams, the simplest way to use string streams is to take advantage of the overloaded « and » operators. The « operator inserts data into the stream. For example:

```
stream1 << "hello" << i;
```

This example inserts the string "hello" and the variable i into stream1. In contrast, the » operator extracts data out of a string stream:

```
stream1 >> i;
```

This code reads a value from stream1 and assigns the variable it that value.

Related Topics: C++ I/O Streams

## rdbuf

Syntax:

$$
\begin{aligned}
& \text { \#include <sstream> } \\
& \text { stringbuf* rdbuf(); }
\end{aligned}
$$

The rdbuf() function returns a pointer to the string buffer for the current string stream.

Related Topics: str, C++ I/O Streams

## str

Syntax:

```
#include <sstream>
void str( string s );
string str();
```

The function $\operatorname{str}()$ can be used in two ways. First, it can be used to get a copy of the string that is being manipulated by the current stream string. This is most useful with output strings. For example:

```
ostringstream stream1;
stream1 << "Testing!" << endl;
cout << stream1.str();
```

Second, $\operatorname{str}()$ can be used to copy a string into the stream. This is most useful with input strings. For example:

```
istringstream stream1;
string string1 = "25";
stream1.str(string1);
```

$\operatorname{str}()$, along with clear(), is also handy when you need to clear the stream so that it can be reused:

```
    istringstream stream1;
    float num;
    // use it once
    string string1 = "25 1 3.235\n1111111\n222222";
    stream1.str(string1);
    while( stream1 >> num ) cout << "num: " << num << end
    // use the same string stream again with clear() and
    string string2 = "1 2 3 4 5 6 7 8 9 10";
    stream1.clear();
    stream1.str(string2);
    while( stream1 >> num ) cout << "num: " << num << end
|
```

Related Topics: rdbuf, C++ I/O Streams

## empty

Syntax:

```
#include <stack>
bool empty() const;
```

The empty() function returns true if the stack has no elements, false otherwise.

For example, the following code uses empty() as the stopping condition on a while loop to clear a stack and display its contents in reverse order:

```
stack<int> s;
for( int i = 0; i < 5; i++ ) {
    s.push(i);
}
while( !s.empty() ) {
    cout << s.top() << endl;
    s.pop();
}
```

Related Topics: size

## pop

## Syntax:

> \#include <stack>
> void pop();

The function pop() removes the top element of the stack and discards it.
Related Topics: push, top

## push

Syntax:

```
#include <stack>
void push( const TYPE& val );
```

The function push() adds val to the top of the current stack.
For example, the following code uses the push() function to add ten integers to the top of a stack:

```
stack<int> s;
for( int i=0; i < 10; i++ ) s.push(i);
```

Related Topics: pop

## size

Syntax:

$$
\begin{aligned}
& \text { \#include <stack> } \\
& \text { size_type size() const; }
\end{aligned}
$$

The size() function returns the number of elements in the current stack.
Related Topics: empty

## Stack constructors

Syntax:

```
#include <stack>
stack();
stack( const Container& con );
```

Stacks have an empty constructor and a constructor that can be used to specify a container type.

## top

Syntax:

```
#include <stack>
TYPE& top();
```

The function top() returns a reference to the top element of the stack.
For example, the following code removes all of the elements from a stack and uses top() to display them:

```
while( !s.empty() ) {
        cout << s.top() << " ";
        s.pop();
}
```

Related Topics: pop

## append

## Syntax:

```
#include <string>
string& append( const string& str );
string& append( const char* str );
string& append( const string& str, size_type index, s.
string& append( const char* str, size_type num );
string& append( size_type num, char ch );
string& append( input_iterator start, input_iterator 
```

1

The append function either:

- (1\&2)appends str on to the end of the current string,
- (3)appends a substring of str starting at index that is len characters long on to the end of the current string,
- (4)appends first num characters from str on to string
- (5)appends num repetitions of ch on to the end of the current string,
- (6)appends the sequence denoted by start and end on to the end of the current string.

For example, the following code uses append to add 10 copies of the '!' character to a string:

```
string str = "Hello World";
str.append( 10, '!' );
cout << str << endl;
```

That code displays:

## Hello World!!!!!!!!!!

In the next example, append() is used to concatenate a substring of one string onto another string:

```
    string str1 = "Eventually I stopped caring... ";
string str2 = "but that was the '80s so nobody noticed
str1.append( str2, 25, 15 );
cout << "str1 is " << str1 << endl;
4.
```

When run, the above code displays:
str1 is Eventually I stopped caring... nobody noticed.

## assign

Syntax:

```
#include <string>
void assign( size_type num, const char& val );
void assign( input_iterator start, input_iterator end
string& assign( const string& str );
string& assign( const char* str );
string& assign( const char* str, size_type num );
string& assign( const string& str, size_type index, s.
string& assign( size_type num, const char& ch );
```

1

The default assign() function gives the current string the values from start to end, or gives it num copies of val. In addition to the normal assign functionality that all C++ containers have, strings possess an assign() function that also allows them to:

- assign str to the current string,
- assign the first num characters of str to the current string,
- assign a substring of str starting at index that is len characters long to the current string,

For example, the following code:

```
string str1, str2 = "War and Peace";
str1.assign( str2, 4, 3 );
cout << str1 << endl;
```

displays
and
This function will destroy the previous contents of the string.

Related Topics: [] operator

## at

Syntax:

```
#include <string>
char& at( size_type loc );
const char& at( size_type loc ) const;
```

The at() function returns the character in the string at index loc. The at() function is safer than the [] operator, because it won't let you reference items passed the end of the string.

For example, consider the following code:

```
string s("abcdef");
for( int i = 0; i < 10; i++ ) {
    cout << "Element " << i << " is " << s[i] << endl;
}
```

This code overruns the end of the string, producing potentially dangerous results. The following code would be much safer:

```
    string s("abcdef");
    for( int i = 0; i < 10; i++ ) {
        cout << "Element " << i << " is " << s.at(i) << endl
    }
```

Instead of attempting to read garbage values from memory, the at() function will realize that it is about to overrun the string and will throw an exception.

Related Topics: [] operator

## begin

Syntax:

```
#include <string>
iterator begin();
const_iterator begin() const;
```

The function begin() returns an iterator to the first element of the string. begin() should run in constant time. For example, the following code uses begin() to initialize an iterator that is used to traverse a list:

```
    // Create a list of characters
    list<char> charList;
    for( int i=0; i < 10; i++ ) {
        charList.push_front( i + 65 );
        }
        // Display the list
        list<char>::iterator theIterator;
        for( theIterator = charList.begin(); theIterator !=
    theIterator++ ) {
        cout << *theIterator;
    }
4.
```

Related Topics: end, rbegin, rend

## capacity

Syntax:

```
#include <string>
size_type capacity() const;
```

The capacity() function returns the number of elements that the string can hold before it will need to allocate more space. For example, the following code uses two different methods to set the capacity of two vectors. One method passes an argument to the constructor that suggests an initial size, the other method calls the reserve function to achieve a similar goal:

```
    vector<int> v1(10);
    cout << "The capacity of v1 is " << v1.capacity() << e
    vector<int> v2;
    v2.reserve(20);
    cout << "The capacity of v2 is " << v2.capacity() << e
|
```

When run, the above code produces the following output:

```
The capacity of v1 is 10
The capacity of v2 is 20
```

C++ containers are designed to grow in size dynamically. This frees the programmer from having to worry about storing an arbitrary number of elements in a container. However, sometimes the programmer can improve the performance of her program by giving hints to the compiler about the size of the containers that the program will use. These hints come in the form of the reserve() function and the constructor used in the above example, which tell the compiler how large the container is expected to get. The capacity() function runs in constant time.

Related Topics: reserve, resize, size

## clear

Syntax:

> \#include <string> void clear();

The function clear() deletes all of the elements in the string. clear() runs in linear time.

Related Topics: (C++ Lists) erase

## compare

Syntax:

```
#include <string>
int compare( const string& str );
int compare( const char* str );
int compare( size_type index, size_type length, const
int compare( size_type index, size_type length, const
int compare( size_type index, size_type length, const
```

The compare() function either compares str to the current string in a variety of ways, returning

| Return Value | Case |
| :--- | :--- |
| less than zero | this $<$ str |
| zero | this $==$ str |
| greater than zero | this $>$ str |

The various functions either:

- compare str to the current string,
- compare str to a substring of the current string, starting at index for length characters,
- compare a substring of str to a substring of the current string, where index2 and length2 refer to str and index and length refer to the current string,
- or compare a substring of str to a substring of the current string, where the substring of str begins at zero and is length2 characters long, and the substring of the current string begins at index and is length characters long.

For example, the following code uses compare() to compare four strings
with eachother:

```
    string names[] = {"Homer", "Marge", "3-eyed fish", "in
    for( int i = 0; i < 4; i++ ) {
        for( int j = 0; j < 4; j++ ) {
            cout << names[i].compare( names[j] ) << " ";
        }
        cout << endl;
    }
|
```

Data from the above code was used to generate this table, which shows how the various strings compare to eachother:

|  | Homer Marge | 3-eyed <br> fish | inanimate <br> carbon rod |  |
| :--- | :--- | :--- | :--- | :--- |
| "Homer".compare $(x)$ | 0 | -1 | 1 | -1 |
| "Marge".compare $(x)$ | 1 | 0 | 1 | -1 |
| "3-eyed fish".compare $(x)$ | -1 | -1 | 0 | -1 |
| "inanimate carbon <br> rod".compare $(x)$ | 1 | 1 | 1 | 0 |

Related Topics: String operators

## copy

Syntax:


The copy() function copies num characters of the current string (starting at index if it's specified, 0 otherwise) into str. The return value of copy() is the number of characters copied. For example, the following code uses copy() to extract a substring of a string into an array of characters:

```
        char buf[30];
memset( buf, '\0', 30 );
string str = "Trying is the first step towards success
str.copy( buf, 24 );
cout << buf << endl;
|
```

When run, this code displays:

## Trying is the first step

Note that before calling copy(), we first call (Standard C String and Character) memset() to fill the destination array with copies of the NULL character. This step is included to make sure that the resulting array of characters is NULL-terminated.

Related Topics: substr

## C_str

Syntax:

```
#include <string>
const char* c_str();
```

The function c_str() returns a const pointer to a regular C string, identical to the current string. The returned string is null-terminated.

Note that since the returned pointer is of type const, the character data that c_str() returns cannot be modified. Furthermore, you do not need to call free or delete on this pointer.

Related Topics: String operators, data

## data

Syntax:

```
#include <string>
const char *data();
```

The function data() returns a pointer to the first character in the current string.

Related Topics: String operators, c_str

## empty

Syntax:

```
#include <string>
bool empty() const;
```

The empty() function returns true if the string has no elements, false otherwise. For example:

```
string s1;
string s2("");
string s3("This is a string");
cout.setf(ios::boolalpha);
cout << s1.empty() << endl;
cout << s2.empty() << endl;
cout << s3.empty() << endl;
```

When run, this code produces the following output:

```
true
true
false
```

Related Topics: size

## end

Syntax:

```
#include <string>
iterator end();
const_iterator end() const;
```

The end() function returns an iterator just past the end of the string. Note that before you can access the last element of the string using an iterator that you get from a call to end(), you'll have to decrement the iterator first. For example, the following code uses begin() and end() to iterate through all of the members of a vector:

```
vector<int> v1( 5, 789 );
vector<int>::iterator it;
for( it = v1.begin(); it != v1.end(); it++ ) {
    cout << *it << endl;
}
```

The iterator is initialized with a call to begin(). After the body of the loop has been executed, the iterator is incremented and tested to see if it is equal to the result of calling end(). Since end() returns an iterator pointing to an element just after the last element of the vector, the loop will only stop once all of the elements of the vector have been displayed. end() runs in constant time.

Related Topics: begin, rbegin, rend

## erase

Syntax:

```
#include <string>
    iterator erase( iterator loc );
    iterator erase( iterator start, iterator end );
    string& erase( size_type index = 0, size_type num = n
```

The erase() function either:

- removes the character pointed to by loc, returning an iterator to the character after the last character removed
- removes all characters between start and end, returning an iterator to the next character (not the one at end)
- removes num characters starting from index, returning the modified string. The parameters index and num have default values, which means that erase() can be called with just index to erase all characters after index or with no arguments to erase all characters.


## For example:

string s("So, you like donuts, eh? Well, have all the d cout << "The original string is '" << s << "'" << endl;
s.erase( 50, 13 );
cout << "Now the string is '" << s << "'" << endl; s.erase( 24 );
cout << "Now the string is '" << s << "'" << endl;
s.erase();
cout << "Now the string is '" << s << "'" << endl;
will display

```
The original string is 'So, you like donuts, eh? Well, Now the string is 'So, you like donuts, eh? Well, have Now the string is 'So, you like donuts, eh?' Now the string is ''
erase() runs in linear time.

Related Topics: insert

\section*{find}

\section*{Syntax:}
```

    #include <string>
    size_type find( const string& str, size_type index = '
    size_type find( const char* str, size_type index = 0
    size_type find( const char* str, size_type index, siz
    size_type find( char ch, size_type index = 0 ) const;
    |

```

The function find() returns either:
- the first occurrence of str within the current string, starting at index, or string::npos if nothing is found
- the first length characters of str within the current string, starting at index, or string::npos if nothing is found.

For example:
```

string str1( "Alpha Beta Gamma Delta" );
string::size_type loc = str1.find( "Omega", 0 );
if( loc != string::npos ) {
cout << "Found Omega at " << loc << endl;
} else {
cout << "Didn't find Omega" << endl;
}

```

Related Topics: find_first_not_of, find_first_of, find_last_not_of, find_last_of, rfind

\section*{find_first_not_of}

\section*{Syntax:}
\#include <string>
size_type find_first_not_of( const string\& str, size_-
size_type find_first_not_of( const char* str, size_ty
size_type find_first_not_of( const char* str, size_ty
size_type find_first_not_of( char ch, size_type index

The find_first_not_of() function either:
- returns the index of the first character within the current string that does not match any character in str, beginning the search at index, string::npos if nothing is found,
- searches the current string, beginning at index, for any character that does not match the first num characters in str, returning the index in the current string of the first character found that meets this criteria, otherwise returning string::npos,
- or returns the index of the first occurrence of a character that does not match ch in the current string, starting the search at index, string::npos if nothing is found.

For example, the following code searches a string of text for the first character that is not a lower-case character, space, comma, or hypen:


When run, find_first_not_of() finds the first upper-case letter in str at index 29 and displays this output:

\section*{first non-lower-case letter in str at: 29}

Related Topics: find, find_first_not_of, find_first_of, find_last_not_of, find_last_of, rfind

\section*{find_first_of}

\section*{Syntax:}
\#include <string>
size_type find_first_of( const string \&str, size_type
size_type find_first_of( const char* str, size_type i
size_type find_first_of( const char* str, size_type i
size_type find_first_of( char ch, size_type index = 0

The find_first_of function either:
- returns the index of the first character within the current string that matches any character in str, beginning the search at index, string::npos if nothing is found,
- searches the current string, beginning at index, for any of the first num characters in str, returning the index in the current string of the first character found, or string::npos if no characters match,
- or returns the index of the first occurrence of ch in the current string, starting the search at index, string::npos if nothing is found.

For example, the following code uses find_first_of to replace all the vowels in a string with asterisks:
```

    string str = "In this house, we obey the laws of thermo
    size_type found = str.find_first_of("aeiouAEIOU");
    while( found != string::npos ) {
    str[found] = '*';
    found = str.find_first_of("aeiouAEIUO",found+1);
    }
cout << str << '\n'; // displays "*n th*s h**s*, w* *b

```

Related Topics: find, find_first_not_of, find_last_not_of, find_last_of, rfind

\section*{find_last_not_of}

\section*{Syntax:}
\#include <string>
size_type find_last_not_of( const string\& str, size_t
size_type find_last_not_of ( const char* str, size_typ
size_type find_last_not_of const char* str, size_typ
size_type find_last_not_of (char ch, size_type index

The find_last_not_of() function either:
- returns the index of the last character within the current string that does not match any character in str, doing a reverse search from index, string::npos if nothing is found,
- returns the index of the last character within the current string that does not match any character in str, doing a reverse search from index, string::npos if nothing is found,
- returns the index of the last character within the current string that does not match any of the first num characters in str, doing a reverse search from index, string::npos if nothing is found,
- returns the index of the last character within the current string that does not match ch in the current string, doing a reverse search from index, string::npos if nothing is found.

For example, the following code searches for the last non-lower-case character in a mixed string of characters:
```

    string lower_case = "abcdefghijklmnopqrstuvwxyz";
    string str = "abcdefgABCDEFGhijklmnop";
    cout << "last non-lower-case letter in str at: " << s
4

```

This code displays the following output:
last non-lower-case letter in str at: 13
Related Topics: find, find_first_not_of, find_first_of, find_last_of, rfind

\section*{find_last_of}

Syntax:
```

    #include <string>
    size_type find_last_of( const string& str, size_type
    size_type find_last_of( const char* str, size_type in
    size_type find_last_of( const char* str, size_type in
    size_type find_last_of( char ch, size_type index = np
    |

The find_last_of() function either:

- does a reverse search from index, returning the index of the first character within the current string that matches any character in str, or string::npos if nothing is found,
- does a reverse search in the current string, beginning at index, for any of the first num characters in str, returning the index in the current string of the first character found, or string::npos if no characters match,
- or does a reverse search from index, returning the index of the first occurrence of ch in the current string, string::npos if nothing is found.

Related Topics: find, find_first_not_of, find_first_of, find_last_not_of, rfind

## getline

Syntax:


The C++ string header defines the global function getline() to read strings from an I/O stream. The getline() function, which is not part of the string class, reads a line from is and stores it into s. If a character delimiter is specified, then getline() will use delimiter to decide when to stop reading data.

For example, the following code reads a line of text from stdin and displays it to stdout:

```
string s;
getline( cin, s );
cout << "You entered " << s << endl;
```

After getting a line of data in a string, you may find that stringstreams are useful in extracting data from that string. For example, the following code reads numbers from standard input, ignoring any "commented" lines that begin with double slashes:

```
    // expects either space-delimited numbers or lines th
    // two forward slashes (//)
    string s;
    while( getline(cin,s) ) {
        if( s.size() >= 2 && s[0] == '/' && s[1] == '/' ) {
        cout << " ignoring comment: " << s << endl;
        } else {
        istringstream ss(s);
        double d;
        while( ss >> d ) {
            cout << " got a number: " << d << endl;
        }
    }
    }
4
```

When run with a user supplying input, the above code might produce this output:

```
// test
    ignoring comment: // test
23.3 -1 3.14159
    got a number: 23.3
    got a number: -1
    got a number: 3.14159
// next batch
    ignoring comment: // next batch
12345
    got a number: 1
    got a number: 2
    got a number: 3
    got a number: 4
    got a number: 5
5 0
    got a number: 50
```

Related Topics: get, getline, stringstream

## insert

Syntax:

```
#include <string>
iterator insert( iterator i, const char& ch );
string& insert( size_type index, const string& str );
string& insert( size_type index, const char* str );
string& insert( size_type index1, const string& str,
string& insert( size_type index, const char* str, siz
string& insert( size_type index, size_type num, char 
void insert( iterator i, size_type num, const char& c
void insert( iterator i, input_iterator start, input_
```

1

The very multi-purpose insert() function either:

- inserts ch before the character denoted by $i$,
- inserts str into the current string, at location index,
- inserts a substring of str (starting at index2 and num characters long) into the current string, at location index1,
- inserts num copies of ch into the current string, at location index,
- inserts num copies of ch into the current string, before the character denoted by $i$, before the character specified by $i$.

Related Topics: erase, replace

## length

Syntax:

$$
\begin{aligned}
& \text { \#include <string> } \\
& \text { size_type length() const; }
\end{aligned}
$$

The length() function returns the number of elements in the current string, performing the same role as the size() function.

If testing whether a string is empty or not, use empty() since it doesn't need to count beyond the first character in the string.

Related Topics: capacity, empty, max_size, resize, size

## max_size

Syntax:

```
#include <string>
size_type max_size() const;
```

The max_size() function returns the maximum number of elements that the string can hold. The max_size() function should not be confused with the size() or capacity() functions, which return the number of elements currently in the string and the the number of elements that the string will be able to hold before more memory will have to be allocated, respectively.

Related Topics: size

## push_back

Syntax:

```
#include <string>
void push_back( char c );
```

The push_back() function appends c to the end of the string. For example, the following code adds 10 characters to a string:

```
string the_string;
for( int i = 0; i < 10; i++ )
    the_string.push_back( i+'a' );
```

When displayed, the resulting string would look like this:

## abcdefghij

push_back() runs in constant time.
Related Topics: assign, insert

## rbegin

Syntax:

```
#include <string>
reverse_iterator rbegin();
const_reverse_iterator rbegin() const;
```

The rbegin() function returns a reverse_iterator to the end of the current string. rbegin() runs in constant time.

Related Topics: begin, end, rend

## rend

## Syntax:

```
#include <string>
reverse_iterator rend();
const_reverse_iterator rend() const;
```

The function rend() returns a reverse_iterator to the beginning of the current string. rend() runs in constant time.

Related Topics: begin, end, rbegin

## replace

## Syntax:

```
#include <string>
string& replace( size_type index, size_type num, cons
string& replace( size_type index1, size_type num1, co
string& replace( size_type index, size_type num, cons
string& replace( size_type index, size_type num1, con
string& replace( size_type index, size_type num1, siz
string& replace( iterator start, iterator end, const
string& replace( iterator start, iterator end, const
string& replace( iterator start, iterator end, const
string& replace( iterator start, iterator end, size_t)
```

1

The function replace() either:

* replaces characters of the current string with up to num characters from str,

```
    beginning at index,
    with up to num2 characters from str beginning at index2
    beginning at index in str,
    with num2 characters from str beginning at index2,
    with num2 copies of ch,
```

1

* replaces characters in the current string from start to end with num

```
characters from str,
copies of ch.
```

For example, the following code displays the string "They say he carved it himself...find your soul-mate, Homer."

```
    string s = "They say he carved it himself...from a B
    string s2 = "find your soul-mate, Homer.";
    s.replace( 32, s2.length(), s2 );
    cout << s << endl;
|
```

Related Topics: insert

## reserve

Syntax:

```
#include <string>
void reserve( size_type size );
```

The reserve() function sets the capacity of the string to at least size. reserve() runs in linear time.

Related Topics: capacity

## resize

Syntax:


The function resize() changes the size of the string to size. If val is specified then any newly-created elements will be initialized to have a value of val. This function runs in linear time.

Related Topics: (C++ Multimaps) Multimap_constructors_\&_destructors, capacity, size

## rfind

## Syntax:

```
#include <string>
size_type rfind( const string& str, size_type index )
size_type rfind( const char* str, size_type index );
size_type rfind( const char* str, size_type index, si:
size_type rfind( char ch, size_type index );
```

4

The rfind() function either:

* returns the location of the first occurrence of str in the current string,
doing a reverse search from index, string::npos if noth
doing a reverse search from index, searching at most nu npos if nothing is found,
doing a reverse search from index, string::npos if noth -

For example, in the following code, the first call to rfind() returns string:: npos, because the target word is not within the first 8 characters of the string. However, the second call returns 9, because the target word is within 20 characters of the beginning of the string.


Related Topics: find, find_first_not_of, find_first_of, find_last_not_of, find_last_of

## size

Syntax:

> \#include <string> size_type size() const;

The size function returns the number of elements in the current string.
If testing whether a string is empty or not, use empty since it doesn't need to count beyond the first character in the string.

Related Topics: capacity, empty, length, max_size, resize

## String constructors

## Syntax:

```
#include <string>
string();
string( const string& s );
string( size_type length, const char& ch );
string( const char* str );
string( const char* str, size_type length );
string( const string& str, size_type index, size_type
string( input_iterator start, input_iterator end );
~string();
```

The string constructors create a new string containing:

- nothing; an empty string,
- a copy of the given string s,
- length copies of ch,
- a duplicate of str (optionally up to length characters long),
- a substring of str starting at index and length characters long
- a string of characters denoted by the start and end iterators

For example,

```
string str1( 5, 'c' );
string str2( "Now is the time..." );
string str3( str2, 11, 4 );
cout << str1 << endl;
cout << str2 << endl;
cout << str3 << endl;
```

displays

```
ccccc
Now is the time...
time
```

The string constructors usually run in linear time, except the empty constructor, which runs in constant time.

## String operators

## Syntax:

```
#include <string>
bool operator==(const string& c1, const string& c2);
bool operator!=(const string& c1, const string& c2);
bool operator<(const string& c1, const string& c2);
bool operator>(const string& c1, const string& c2);
bool operator<=(const string& c1, const string& c2);
bool operator>=(const string& c1, const string& c2);
string operator+(const string& s1, const string& s2 )
string operator+(const char* s, const string& s2 );
string operator+( char c, const string& s2 );
string operator+( const string& s1, const char* s );
string operator+( const string& s1, char c );
basic_string& operator+=(const basic_string& append);
basic_string& operator+=(const char* append);
basic_string& operator+=(const char append);
ostream& operator<<( ostream& os, const string& s );
istream& operator>>( istream& is, string& s );
string& operator=( const string& s );
string& operator=( const char* s );
string& operator=( char ch );
char& operator[]( size_type index );
```

C++ strings can be compared and assigned with the standard comparison operators: ==, !=, <=, >=, <, >, and =. Performing a comparison or assigning one string to another takes linear time.

Two strings are equal if:

1. Their size is the same, and
2. Each member in location $i$ in one string is equal to the the member in location $i$ in the other string.

Comparisons among strings are done lexicographically.

In addition to the normal container operators, strings can also be concatenated with the + operator and fed to the C++ I/O stream classes with the << and >> operators.

For example, the following code concatenates two strings and displays the result:

```
string s1 = "Now is the time...";
string s2 = "for all good men...";
string s3 = s1 + s2;
cout << "s3 is " << s3 << endl;
```

Futhermore, strings can be assigned values that are other strings, character arrays, or even single characters. The following code is perfectly valid:

```
char ch = 'N';
string s;
s = ch;
```

Individual characters of a string can be examined with the [] operator, which runs in constant time.

Related Topics: c_str, compare, data

## substr

Syntax:


The substr() method returns a substring of the current string, starting at index, and length characters long.

If index + length is past the end of the string, then only the remainder of the string starting at index will be returned.

If length is omitted, it will default to string::npos, and the substr() function will simply return the remainder of the string starting at index.

For example:

displays
The original string is What we have here is a failur The substring is a failure to communicate

Related Topics: copy

## swap

Syntax:

```
#include <string>
void swap( container& from );
```

The swap() function exchanges the elements of the current string with those of from. This function operates in constant time. For example, the following code uses the swap() function to exchange the values of two strings:

```
string first( "This comes first" );
string second( "And this is second" );
first.swap( second );
cout << first << endl;
cout << second << endl;
```

The above code displays:

```
And this is second
This comes first
```

Related Topics: (C++ Lists) splice

## make_pair

## Syntax:

pair<TYPE1,TYPE2> make_pair( const TYPE1 \&a, const TYPE -

The make_pair function returns a single object that contains the two items a and b. make_pair is a quick way of creating an instance of the pair class.

For example:

```
#include <string>
using std::string;
#include <iostream>
using std::cout;
#include <utility>
using std::pair;
using std::make_pair;
int main () {
    pair<int,string> tuple = make_pair( 42, "The answer" );
    cout << "tuple.first: " << tuple.first
        << ", tuple.second: " << tuple.second << '\n';
    return 0;
}
|
```


## pair

Syntax:

```
pair();
pair( const T1 &a, const T2 &b );
```

The pair struct is a way to store two pieces of heterogeneous data.
These data may be accessed using the first and second fields of a pair.

Pairs may be tested for equality with the == operator. The < operator is also defined for pairs; given two pairs $x$ and $y$, the < operator returns:


The make_pair function can be used as a shortcut when creating pairs to avoid explicitly specifying the types for the two pieces of data.

Related: make_pair

## assign

Syntax:

```
    #include <vector>
    void assign( size_type num, const TYPE& val );
    void assign( input_iterator start, input_iterator end
4
```

The assign() function either gives the current vector the values from start to end, or gives it num copies of val.

This function will destroy the previous contents of the vector.
For example, the following code uses assign() to put 10 copies of the integer 42 into a vector:

```
vector<int> v;
v.assign( 10, 42 );
for( int i = 0; i < v.size(); i++ ) {
    cout << v[i] << " ";
}
cout << endl;
```

The above code displays the following output:

$$
\begin{array}{lllllllllllll}
42 & 42 & 42 & 42 & 42 & 42 & 42 & 42 & 42 & 42
\end{array}
$$

The next example shows how assign() can be used to copy one vector to another:

```
vector<int> v1;
for( int i = 0; i < 10; i++ ) {
    v1.push_back( i );
}
vector<int> v2;
v2.assign( v1.begin(), v1.end() );
for( int i = 0; i < v2.size(); i++ ) {
    cout << v2[i] << " ";
}
cout << endl;
```

When run, the above code displays the following output:
0123456789
Related Topics: insert, push_back, [] operator

## at

## Syntax:

```
#include <vector>
TYPE& at( size_type loc );
const TYPE& at( size_type loc ) const;
```

The at() function returns a reference to the element in the vector at index loc. The at() function is safer than the ] operator, because it won't let you reference items outside the bounds of the vector.

For example, consider the following code:

```
vector<int> v( 5, 1 );
for( int i = 0; i < 10; i++ ) {
    cout << "Element " << i << " is " << v[i] << endl;
}
```

This code overruns the end of the vector, producing potentially dangerous results. The following code would be much safer:

```
    vector<int> v( 5, 1 );
    for( int i = 0; i < 10; i++ ) {
        cout << "Element " << i << " is " << v.at(i) << endl
    }
|
```

Instead of attempting to read garbage values from memory, the at() function will realize that it is about to overrun the vector and will throw an exception.

Related Topics: [] operator

## back

Syntax:

```
#include <vector>
TYPE& back();
const TYPE& back() const;
```

The back() function returns a reference to the last element in the vector. For example:

```
    vector<int> v;
    for( int i = 0; i < 5; i++ ) {
        v.push_back(i);
    }
    cout << "The first element is " << v.front()
        << " and the last element is " << v.back() << end.
|
```

This code produces the following output:
The first element is 0 and the last element is 4
The back() function runs in constant time.
Related Topics: front, pop_back

## begin

Syntax:

```
#include <vector>
iterator begin();
const_iterator begin() const;
```

The function begin() returns an iterator to the first element of the vector, and runs in constant time.

For example, the following code uses begin() to initialize an iterator that is used to traverse the elements of a vector:

```
vector<string> words;
string str;
while( cin >> str ) words.push_back(str);
vector<string>::iterator iter;
for( iter = words.begin(); iter != words.end(); iter+
    cout << *iter << endl;
}
```

When given this input:

```
hey mickey you're so fine
```

...the above code produces the following output:

```
hey
mickey
you're
so
fine
```

Related Topics: [] operator, at, end, rbegin, rend

## capacity

Syntax:

```
#include <vector>
size_type capacity() const;
```

The capacity() function returns the number of elements that the vector can hold before it will need to allocate more space.

For example, the following code uses two different methods to set the capacity of two vectors. One method passes an argument to the constructor that initializes the vector with 10 elements of value 0 , the other method calls the reserve function. However, the actual size of the vector remains zero.

```
vector<int> v1(10);
cout << "The capacity of v1 is " << v1.capacity() << e
cout << "The size of v1 is " << v1.size() << endl;
vector<int> v2;
v2.reserve(20);
cout << "The capacity of v2 is " << v2.capacity() << e
cout << "The size of v2 is " << v2.size() << endl;
```

When run, the above code produces the following output:

```
The capacity of v1 is 10
The size of v1 is 10
The capacity of v2 is 20
The size of v2 is 0
```

C++ containers are designed to grow in size dynamically. This frees the programmer from having to worry about storing an arbitrary number of elements in a container. However, sometimes the programmer can improve the performance of her program by giving hints to the compiler
about the size of the containers that the program will use. These hints come in the form of the reserve function and the constructor used in the above example, which tell the compiler how large the container is expected to get.

The capacity() function runs in constant time.
Related Topics: reserve, resize, size

## clear

Syntax:

> \#include <vector> void clear();

The function clear() deletes all of the elements in the vector. clear() runs in linear time.

Related Topics: erase

## empty

Syntax:

$$
\begin{aligned}
& \text { \#include <vector> } \\
& \text { bool empty() const; }
\end{aligned}
$$

The empty() function returns true if the vector has no elements, false otherwise.

For example, the following code uses empty() as the stopping condition on a while loop to clear a vector and display its contents in reverse order:

```
vector<int> v;
for( int i = 0; i < 5; i++ ) {
    v.push_back(i);
}
while( !v.empty() ) {
    cout << v.back() << endl;
    v.pop_back();
}
```

Related Topics: size

## end

Syntax:

```
#include <vector>
iterator end();
const_iterator end() const;
```

The end() function returns an iterator just past the end of the vector. Note that before you can access the last element of the vector using an iterator that you get from a call to end(), you'll have to decrement the iterator first. This is because end() doesn't point to the end of the vector; it points just past the end of the vector.

For example, in the following code, the first "cout" statement will display garbage, whereas the second statement will actually display the last element of the vector:

```
vector<int> v1;
v1.push_back( 0 );
v1.push_back( 1 );
v1.push_back( 2 );
v1.push_back( 3 );
int bad_val = *(v1.end());
cout << "bad_val is " << bad_val << endl;
int good_val = *(v1.end() - 1);
cout << "good_val is " << good_val << endl;
```

The next example shows how begin() and end() can be used to iterate through all of the members of a vector.

```
vector<int> v1( 3, 5 );
vector<int>::iterator it;
for( it = v1.begin(); it != v1.end(); it++ ) {
    cout << *it << endl;
}
```

The iterator is initialized with a call to begin(). After the body of the loop has been executed, the iterator is incremented and tested to see if it is equal to the result of calling end(). Since end() returns an iterator pointing to an element just after the last element of the vector, the loop will only stop once all of the elements of the vector have been displayed.
end() runs in constant time.
Related Topics: begin, rbegin, rend

## erase

Syntax:

```
#include <vector>
iterator erase( iterator loc );
iterator erase( iterator start, iterator end );
```

The erase() function either deletes the element at location loc, or deletes the elements between start and end (including start but not including end). The return value is the element after the last element erased.

The first version of erase (the version that deletes a single element at location loc) runs in constant time for lists and linear time for vectors, dequeues, and strings. The multiple-element version of erase always takes linear time.

For example:

```
    // Create a vector, load it with the first ten charac
    vector<char> alphas;
    for( int i=0; i < 10; i++ ) {
        alphas.push_back( i + 65 );
    }
int size = alphas.size();
vector<char>::iterator startIterator;
vector<char>::iterator tempIterator;
for( int i=0; i < size; i++ ) {
    startIterator = alphas.begin();
    alphas.erase( startIterator );
    // Display the vector
    for( tempIterator = alphas.begin(); tempIterator !=
        cout << *tempIterator;
    }
    cout << endl;
}
4.
```

That code would display the following output:

```
BCDEFGHIJ
CDEFGHIJ
DEFGHIJ
EFGHIJ
FGHIJ
GHIJ
HIJ
I J
J
```

In the next example, erase() is called with two iterators to delete a range of elements from a vector:

```
// create a vector, load it with the first ten charac
vector<char> alphas;
for( int i=0; i < 10; i++ ) {
    alphas.push_back( i + 65 );
}
// display the complete vector
for( int i = 0; i < alphas.size(); i++ ) {
    cout << alphas[i];
    }
    cout << endl;
    // use erase to remove all but the first two and last
    // of the vector
    alphas.erase( alphas.begin()+2, alphas.end()-3 );
    // display the modified vector
    for( int i = 0; i < alphas.size(); i++ ) {
        cout << alphas[i];
    }
    cout << endl;
1
```

When run, the above code displays:

## ABCDEFGHIJ

ABHIJ

## With all container types you have to be careful when inserting or erasing elements, since it may lead to invalid iterators.

Here is an example that works for std::vector. Especially, vector::erase() invalidates all iterators (and pointers) following the element to be erased. The example erases some elements depending on a condition (it will erase the letters B and D).

```
#include <iostream>
#include <vector>
#include <iterator>
using namespace std;
int main()
{
    vector<char> alphas;
    for( int i=0; i < 10; i++ ) {
        alphas.push_back( i + 65 );
    }
    vector<char>::iterator iter = alphas.begin();
    while( iter != alphas.end() )
    {
        if (*iter == 'B' || *iter == 'D')
            iter = alphas.erase( iter );
        else
            ++iter;
    }
        copy(alphas.begin(), alphas.end(), ostream_iterator<c
        cout << endl;
}
|

When run, the above code displays:

\section*{ACEFGHIJ}

Related Topics: clear, insert, pop_back

\section*{front}

Syntax:
```

\#include <vector>
TYPE\& front();
const TYPE\& front() const;

```

The front() function returns a reference to the first element of the vector, and runs in constant time.

For example, the following code uses a vector and the sort()_algorithm to display the first word (in alphabetical order) entered by a user:


When provided with this input:

...the above code displays:
In alphabetical order, the first word is 'aid'.
Related Topics: back

\section*{insert}

Syntax:
```

\#include <vector>
iterator insert( iterator loc, const TYPE\& val );
void insert( iterator loc, size_type num, const TYPE\&
void insert( iterator loc, input_iterator start, inpu

```
4.

The insert() function either:
- inserts val before loc, returning an iterator to the element inserted,
- inserts num copies of val before loc, or
- inserts the elements from start to end before loc.

Note that inserting elements into a vector can be relatively timeintensive, since the underlying data structure for a vector is an array. In order to insert data into an array, you might need to displace a lot of the elements of that array, and this can take linear time. If you are planning on doing a lot of insertions into your vector and you care about speed, you might be better off using a container that has a linked list as its underlying data structure (such as a C++ Lists or a C++ Double-ended Queues).

For example, the following code uses the insert() function to splice four copies of the character 'C' into a vector of characters:
```

    // Create a vector, load it with the first 10 characte
    vector<char> alphaVector;
    for( int i=0; i < 10; i++ ) {
        alphaVector.push_back( i + 'A' );
    }
    // Insert four C's into the vector
    vector<char>::iterator theIterator = alphaVector.begin
    alphaVector.insert( theIterator, 4, 'C' );
    // Display the vector
    for( theIterator = alphaVector.begin(); theIterator !=
    theIterator++ ) {
        cout << *theIterator;
    }
    This code would display:

## CCCCABCDEFGHIJ

Here is another example of the insert() function. In this code, insert() is used to append the contents of one vector into the end of another:

```
vector<int> v1;
v1.push_back( 0 );
v1.push_back( 1 );
v1.push_back( 2 );
v1.push_back( 3 );
vector<int> v2;
v2.push_back( 5 );
v2.push_back( 6 );
v2.push_back( 7 );
v2.push_back( 8 );
cout << "Before, v2 is: ";
for( int i = 0; i < v2.size(); i++ ) {
        cout << v2[i] << " ";
}
cout << endl;
v2.insert( v2.end(), v1.begin(), v1.end() );
cout << "After, v2 is: ";
for( int i = 0; i < v2.size(); i++ ) {
        cout << v2[i] << " ";
}
cout << endl;
```

When run, this code displays:
Before, v2 is: 5678
After, v2 is: 56780123
Related Topics: assign, erase, push_back

## max_size

Syntax:

```
#include <vector>
size_type max_size() const;
```

The max_size() function returns the maximum number of elements that the vector can hold. The max_size() function should not be confused with the size or capacity functions, which return the number of elements currently in the vector and the the number of elements that the vector will be able to hold before more memory will have to be allocated, respectively.

Related Topics: size, capacity

## pop_back

Syntax:

> \#include <vector> void pop_back();

The pop_back() function removes the last element of the vector. pop_back() runs in constant time.

Related Topics: back, erase, push_back

## push_back

Syntax:

```
#include <vector>
void push_back( const TYPE& val );
```

The push_back() function appends val to the end of the vector. For example, the following code puts 10 integers into a vector:

```
vector<int> the_vector;
for( int i = 0; i < 10; i++ ) {
    the_vector.push_back( i );
}
```

When displayed, the resulting vector would look like this:

$$
0123456789
$$

push_back() runs in constant time.

Related Topics: assign, insert, pop_back

## rbegin

Syntax:

```
#include <vector>
reverse_iterator rbegin();
const_reverse_iterator rbegin() const;
```

The rbegin() function returns a reverse_iterator to the end of the current vector.
rbegin() runs in constant time.
Related Topics: begin, end, rend

## rend

## Syntax:

```
#include <vector>
reverse_iterator rend();
const_reverse_iterator rend() const;
```

The function rend() returns a reverse_iterator to the beginning of the current vector.
rend() runs in constant time.
Related Topics: begin, end, rbegin

## reserve

Syntax:

```
\#include <vector>
void reserve( size_type size );
```

The reserve() function sets the capacity of the vector to at least size.
reserve() runs in linear time.
Related Topics: capacity

## resize

Syntax:


The function resize() changes the size of the vector to num. If val is specified then any newly-created elements will be initialized to have a value of val. The contents of the vector up to num will remain unchanged.

## Example:



This function runs in linear time.
Related Topics: Vector constructors, capacity, size

## size

Syntax:
\#include <vector>
size_type size() const;
The size() function returns the number of elements in the current vector.
Related Topics: capacity, empty, max_size, resize

## swap

Syntax:

```
#include <vector>
void swap( container& from );
```

The swap() function exchanges the elements of the current vector with those of from. This function operates in constant time.

For example, the following code uses the swap() function to exchange the contents of two vectors:

```
    vector<string> v1;
    v1.push_back("I'm in v1!");
    vector<string> v2;
    v2.push_back("And I'm in v2!");
    v1.swap(v2);
    cout << "The first element in v1 is " << v1.front() <
    cout << "The first element in v2 is " << v2.front() <
4
```

The above code displays:

```
The first element in v1 is And I'm in v2!
The first element in v2 is I'm in v1!
```

Related Topics: = operator

## Vector constructors

## Syntax:

```
#include <vector>
vector();
vector( const vector& c );
vector( size_type num, const TYPE& val = TYPE() );
vector( input_iterator start, input_iterator end );
~vector();
```

The default vector constructor takes no arguments, creates a new instance of that vector.

The second constructor is a default copy constructor that can be used to create a new vector that is a copy of the given vector c.

The third constructor creates a vector with space for num objects. If val is specified, each of those objects will be given that value. For example, the following code creates a vector consisting of five copies of the integer 42:

$$
\text { vector<int> v1( 5, } 42 \text { ); }
$$

The last constructor creates a vector that is initialized to contain the elements between start and end. For example:

```
    // create a vector of random integers
    cout << "original vector: ";
    vector<int> v;
    for( int i = 0; i < 10; ++i ) {
        int num = (int) rand() % 10;
        cout << num << " ";
        v.push_back( num );
    }
    cout << endl;
    // find the first element of v that is even
vector<int>::iterator iter1 = v.begin();
while( iter1 != v.end() && *iter1 % 2 != 0 ) {
    ++iter1;
}
// find the last element of v that is even
vector<int>::iterator iter2 = v.end();
do {
    --iter2;
    } while( iter2 != v.begin() && *iter2 % 2 != 0 );
    // only proceed if we find both numbers
if( iter1 != v.end() && iter2 != v.begin() ) {
    cout << "first even number: " << *iter1 << ", last e
        cout << "new vector: ";
        vector<int> v2( iter1, iter2 );
        for( int i = 0; i < v2.size(); ++i ) {
            cout << v2[i] << " ";
    }
    cout << endl;
}
|
```

When run, this code displays the following output:

```
original vector: 1 9 7 9 2 7 2 1 9 8
first even number: 2, last even number: 8
new vector: 2 7 2 1 9
```

All of these constructors run in linear time except the first, which runs in
constant time.

The default destructor is called when the vector should be destroyed.

## Vector operators

## Syntax:

```
#include <vector>
TYPE& operator[]( size_type index );
const TYPE& operator[]( size_type index ) const;
vector operator=(const vector& c2);
bool operator==(const vector& c1, const vector& c2);
bool operator!=(const vector& c1, const vector& c2);
bool operator<(const vector& c1, const vector& c2);
bool operator>(const vector& c1, const vector& c2);
bool operator<=(const vector& c1, const vector& c2);
bool operator>=(const vector& c1, const vector& c2);
```

All of the C++ containers can be compared and assigned with the standard comparison operators: ==, !=, <=, >=, <, >, and =. Individual elements of a vector can be examined with the [] operator.

Performing a comparison or assigning one vector to another takes linear time.

The [] operator runs in constant time.

Two vectors are equal if:

1. Their size is the same, and
2. Each member in location i in one vector is equal to the the member in location in the other vector.

Comparisons among vectors are done lexicographically.
For example, the following code uses the [] operator to access all of the elements of a vector:

```
vector<int> v( 5, 1 );
for( int i = 0; i < v.size(); i++ ) {
    cout << "Element " << i << " is " << v[i] << endl;
}
```

Related Topics: at

The <functional> header file

TODO: fill this out.

## The <limits> header file

| numeric_limits | a templated class that defines various properties of <br> built-in types |
| :--- | :--- |

## numeric_limits

This templated class provides various information about the built-in types.

