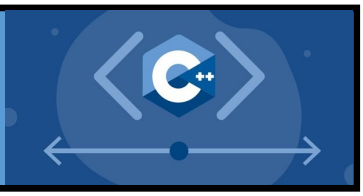
C++ 20

Reference Guide
version 0.2.5



Classes

class classname: defines a class
: public classname: inherits a class leaving scope of members intact
: private classname: inherits a class making all members private
: protected classname: inherits a class making public members protected
: virtual public classname: inherits a virtual base class. Classes share one copy of the base class
{
private:: member access inside class only
type variable: define private members
type functionname **(**arguments**){**statements**;}**
public:: member access outside the class
type variable: define public members
classname**(**type variable**=**value**,**...**)**: constructor
classname**()=default**: specify default constructor
classname**(const** classname**&)**: copy constructor
classname**(**classname**&&)**: move constructor
classname**(const** classname**&)=delete**: no default copy constructor
classname**& operator= (const** classname**&)**: assignment operator for a class
classname**& operator= (const** classname**&)=delete**: no default assignment constructor
~classname**()**: destructor, always to be used when working with dynamic memory
classname**(**type variable**,**...**):**privatevariable **{**variable**}**: constructor assigning value from variable to private member variable
explicit classname**(**type variable**=**value**,**...**)**: constructor where type has to be explicit correct
friend class classname: classname has access to the private members of the class
friend classname **operator**operator **(**arguments**)** **{**statements**; return** value**;}**: friend operator

```
friend Stock operator*(int d,const Stock& s) {
  return Stock(d*s.small, d*s.big); } // d * s
```

operator stdtype**() const {return** value**}**: converts a class to a standard type

```
operator int() const {return s.small;}
```

type functionname **(**arguments**){**statements**;}**
type functionname **(**arguments**) const** **{**statements**;}**: function does not change private members of the class
type functionname **(**arguments**) {**statements**;}**
override: overrides a virtual function in baseclass
type classname**::operator**operator**(**arguments**)** **{**statements**; return** value**;}**: operator overload
virtual type functionname **(**arguments**)** **{**statements**;}**: in baseclass for pointers or references, will call appropriate function in derived classes with overriden functions

```
Person *p, *s, *e; //pointers to base class
s = new Student; //Student is a derived class Person
s -> to_string(); //call to_string from Student class
```

virtual type functionname **(void)=0**: abstract fction
protected:: member access for inherited classes
type variable: define protected members
type functionname **(**arguments**){**statements**;}**
}
module: the compilation defines a module
export module name: define module with name
export class classname: exports class in module
export function: exports function in the module
namespace name **{**class definition**}**: put the class definition in a namespace
struct classname: class with default public members, used mainly for small classes
union classname **{**type variable**;** type variable**;...}**: a struct where only one member variable is used

Directives

#define name: conditional compilation name
#ifdef name statements; **#endif**: conditional block
#include <name**>**: includes header file
#include "name**"**: includes header file
// comment: includes single line comment
/* comment ***/**: includes multi line comment
assert(condition**)**: break in debug mode when false
import module: imports a module name
using namespace**::**class: default scope resolution

Exceptions

#include <exception>
exception.**what()**: returns a readable error string
functiondefinition **noexcept**: no exception thrown
throw: re-throws an exception in nested functions
throw int: throws an exception with type int
throw classname**(**arguments**)**: throws class type
try { statements**;} catch(**exception**) {**statements**;}**
catch(exception**){**statements**;}**: try statements, if an exception of any type is raised execute statements. Common exception examples:

```
std::bad_alloc //memory full
classname variable //can use variable in statements
std::string s // with throw std::string{"error"}
std::exception& exc //can use exc.what()
… //catch all other exceptions
```

Functions

type functionname **()**: function that returns a type
type**&** functionname **()**: function that returns a reference to a type, if an lvalue is needed
type* functionname **()**: function that returns an address to a type
void functionname **()**: function without arguments
void functionname **(**type variable**,...)**: function with variadic (...) arguments as value (no intention to change the value of the arguments)
void functionname **(**type variable**[][**int**])**: argument is a 2 dimensional array, needs dimensions after the first dimension since memory is a flat model
void functionname **(**type**&** variable**)**: function with arguments as reference (use if you want to change the argument in the function)
void functionname **(const** type**&** variable**)**: argument as a const reference acting as a value argument, saves stack memory
void functionname **(**type variable**=**value**)**: sets a default value for arguments
void (*functionname**)(**type**)**: a pointer to a function with one argument of type type

```
int sum(int x,int y);
int product(int x, int y);
int calc(int a,int b, int(*f)(int,int));
calc(1,2,product); //function pointer as argument
```

Initialization

delete[] variable: deletes a dynamic array
this: pointer to current object in a class
***this**: current object in a class
type* variable**=new** type**[**int**]**: makes a dynamic (at runtime) array of int elements
type* variable**=nullptr**: pointer to address 0
type variable **{**value**}**: uniform initialization
static type variable=value: the (class) variable initializes once to value and keeps its changing value when entering the process block it was defined, for a class it becomes a singleton var

Iterators

class class**Iterator {**: make a custom iterator class
private: node* pointer;
public:
class**Iterator(**node* **init=nullptr):**pointer**{init}**
int& operator*() {return pointer->element**();}**
class**Iterator& operator++() {return** nextpointer**}**
bool operator!=(class**Iterator** iter**) {return** pointer **!=** iter.pointer**;} }**
std::string::iterator variable: pointer to chars

```
std::string s {"abcd"};
std::string::iterator pos;
for(pos=s.begin();pos!=s.end();++pos) {};
```

std::vector<type**>::iterator** variable: vector pointer

Lambda functions

[capture list**]**: variables to capture for the function

```
[a] //captures variable a by copy
[&b] //captures variable b by reference
[=] //captures all variables by copy
[&] //captures all variables by reference
[] //don't capture any variable
[this] //capture this pointer of current object
```

(parameter list**)**: parameters for the function
mutable: optional keyword in order to change captured variables by copy in the function
->return type: define a return type for the function
{statements;}

```
[factor](double x)->double {return x*factor;}
[factor](int&x)mutable{x*=factor;factor++;}
```

Manipulators

#include <iomanip>
std::dec: sets decimal value of integer
std::fixed: fixed notation of floating point
std::hex: sets hexadecimal value of integer
std::left: aligns the text left
std::oct: sets octal value of integer
std::right: aligns the text right
std::scientific: e-notation of floating point
std::setfill(char**)**: sets fill character
std::setprecision(int**)**: sets number of decimals
std::setw(int**)**: sets width
std::showpoint: shows the decimal point

Modifiers

type* **const** variable: the pointer is constant
const: makes a value constant for the compiler
const type* variable: a const pointer to a constant
const type* **const** variable: const pointer to const
constexpr: makes an expression constant
extern type variable: global var in different sources
mutable type variable: change of var in const struct
volatile type variable: var can be changed by I/O

Operators

&: bitwise AND
&&: logical AND
&variable: returns the address of the variable
|: bitwise OR
||: logical OR
!: logical NOT
!=: does not equal to
==: is equal to
=: assignment operator
^: bitwise XOR
+: sums the operands
++: increment by 1

```
int i=10;
int n=++i; //prefix n gets the value 11
```

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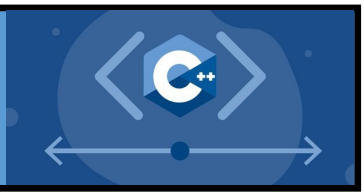

```
int m=i++; //postfix m gets the value 10
int* j;
j++; //moves the pointer sizeof(int) bytes
```

-: subtracts the operands, bitwise complement
--: decrements by 1
->: call member function of a pointer
*: multiply the operands
/: divides the operands
%: modulo by division of the operands
<: smaller then
<=: smaller then or equal
<<: sends characters to the stream object
>: bigger then
>=: bigger then or equal
<=>: spaceship operator compares all attributes of objects for find or sort algorithms
>>: gets characters from the stream object
[]: collection index operator
(): function call operator
dynamic_cast<type**>(**variable**)**: casts at runtime
reinterpret_cast<type**>(**variable**)**: forces conversion to a specific type via binary format
sizeof(type**)**: returns the size in bytes of the type
static_cast<type**>(**variable**)**: typecasting at compiler time

Smart pointers

#include <memory>: header for smart pointers
std::shared_ptr<type**>** variable: reference counted pointer, when pointers that reference a memory block go out of scope memory block is released
std::unique_ptr<type**>** variable: defines a unique pointer, when pointer goes out of scope memory block is released
std::weak_ptr<type**>** variable: only to be used when you have a circular list of pointers, connect the last pointer with a weak_ptr to the first one

Standard library

#include <algorithm>: uses algorithms
std::find(start, end, value**)**: iterator to position
std::find_if(container,predicatefn**)**: predicate fn

```
bool pair(const int& n){return n%2==0;}
pos=std::ranges::find_if(v,pair);
```

std::iota(start, end, value**)**: fill container with range

```
std::iota(v.begin(),v.end(),3);//v={3,4,5,6,…}
```

#include <chrono>: use processor ticks

```
auto t0=std::chrono::high_resolution_clock::now();
auto t1=std::chrono::high_resolution_clock::now();
cout<<std::chrono::duration_cast<milliseconds>(t1-
t0).count()<<" msec\n";
```

#include<cmath>: mathematical library

```
abs(x);sqrt(x),cos(x);acos(x);sinh(x);exp(x);log(x);
```

#include <deque>: a double ended queue
#include <list>: linked list with two pointers

```
std::list<std::string> animals;
animals.push_back("Cat"); //pop_back
animals.push_front("Dog"); //pop_front
animals.unique(); //preserves unique values
animals.merge(humans); //merges two lists
```

#include <map>: associative array of dictionary

```
std::map<string,int> phone_book;
phone_book.insert("David",123456); //inserts entry
int i=phone_book.find("David"); //finds value for key
```

#include <ranges>: uses ranges functions
std::ranges::copy(range, start**)**: copies containers

```
std::ranges::copy(original, destination.begin());
```

std::ranges::copy(range, inserter**)**: uses inserters

```
std::ranges::copy(org,std::back_inserter(dest));
std::ranges::copy(org,std::front_inserter(dest));
std::ranges::copy(org.begin(),org.begin()+5,
std::inserter(dest,dest.begin()));
```

std::ranges::for_each(start,end,function**)**: applies function from start to end iterators
std::ranges::for_each(container,function**)**

```
std::vector<int> v{1,2,3,4,5,6,7,8,9,10};
void print(int x) {std::cout<<x<<' ';}
std::ranges::for_each(v,print);
```

std::ranges::for_each(container, function, projection**)**: projection is a object attribute

```
std::ranges::for_each(v,print,&Person::name);
```

std::ranges::sort(container**)**: sorts a collection
std::ranges::sort(container, comparator**)**: compare

```
bool compnr(const Person& p1,const Person& p2)
   {return p1.getnr() < p2.getnr()}
std::ranges::sort(v,compnr);
```

std::ranges::sort(container, comparator, projection**)**: see comparator and projection
std::views::drop(int**)**: drops first int elements
std::views::iota(start, end**)**: generates int range
std::views::filter(predicatefn**)**: filter using predicate
std::views::take(int**)**: take first int elements
std::views::transform(function**)**: applies function

```
auto square=[](auto x){return x*x;};
auto v_square=std::views::transform(v,square);
auto v2_square=v | std::views:transform(square); use|
```

#include <regex>: regular expression

```
regex pat{R"(\w{2}\s*\d{5}(-\d{4})?)"}; //pattern
smatch matches; //a vector of strings of matches
regex_search(text,matches,pat); //search pat in text
```

#include <stack>: a LIFO stack list

```
std::stack<int> s;
s.push(123);
std::cout << s.top();
s.pop();
```

#include<thread>: concurrency library

```
std::thread t1{f};//starts f() in a new thread
t1.join();//wait for thread to be finished
mutex m;//mutual exclusion object
scoped_lock lck(m);//locks mutex until end of block
shared_mutex mx;//mutex for readers and a writer
shared_lock lck(mx);//shared access with readers
unique_lock lck(mx);//exclusive writer access
async(f,arg1,arg2);//async execution on threads
```

#include <queue>: a FIFO stack list

Statements (structures)

condition **?** truestatement:falsestatement
break: breaks a loop statement block
continue: exits body, but continuous loop itself
do {statements;} **while** (condition)
for (type variable: container) {statements;}: a range based for
for (type**&** variable: container) {statements;}: a range based for for referencing the variable
for (initialization; condition; raise) {statements;}
if (condition) {statements;}
if (condition) {statements;} **else** {statements;}
switch (variable) {**case** value**:** statements; **break**; **default:** statements;}
typedef type name: gives type another name
while (condition) {statements;}

Streams

#include <iostream>: header for standard streams

```
std::cin >> c; //standard input
std::cout << c; //standard output
std::cerr << c; std::clog << c; //error logs
```

#include <fstream>: header for file streams

```
//write to a file
std::ofstream out{"output.txt"};
std::ofstream output{"output.txt",ios::app};//append
std::ofstream output{"output.txt",ios::trunc};//clear
std::ofstream out{"out.txt",ios::noreplace};//newfile

//read from a file
std::ifstream in{"input.txt"};
std::ifstream input; input.open("input.txt");

//read and write to a file
std::fstream file{"readwrite.txt",ios::in|ios::out};

//check for errors
if(!in||!out){//error};

//using std::ranges::copy
std::vector<int> v {1,2,3,4,5,6,7,8,9};
std::ranges::copy(v,std::ostream_iterator<int>{out});
std::ranges::copy(std::istream_iterator<int>{in},
std::istream_iterator<int>{}, back_inserter(v));

//using operators
out << "string test" + '\n';
std::string s;
while (in) { // while (!in.eof()) {
std::getline(in,s);} //getline for strings, not >>!
if(in.fail()){//wrong information in file};

//random access
out.seekp(0);//put-pointer to position 0
in.seekg(0); //get-pointer to position 0

//binary files
std::ofstream bin{"binary.txt",ios::binary};
bin.put("a"); //saves one byte
bin.write(reinterpret_cast<char*>(&Cclass), sizeof
(Cclass); //writes block, not for dynamic memory
std::ifstream bin{"binary.txt",ios::binary};
bin.get(c); //reads one byte
bin.read(reinterpret_cast<char*>(&Cclass), sizeof
(Cclass); //reads block, not for dynamic memory
std::cout << bin.rdbuf();//pointer to buffer file

//close file handles
out.close(); in.close();
```

#include <sstream>: header for string streams

```
std::ostringstream os;
os << "test" << i << " integer, double: " << d;
std::string s = os.str();
```

Strings

#include <string>: header for std::string class
string variable **{}**: defines a string variable
.find(string**)**: returns position of string
.length(): returns the number of chars in a string
.replace(int,int,string**)**: replaces int chars with string from position int
.substr(int,int**)**: returns int chars from position int
string variable**(**int,char**)**: initializes int times char

Templates

template<typename T,…>: template prefix with template argument T, the yet unknown type

```
template<Sequence S> //type S must support iterators
template<Number N> //type N must be a number
template<Sequence S, Number N> requires Arithmetic
<Value_type<S>,N> //type S,N must support calculus
```

template<typename T, typename … Tail>: variadic, use Tail… to get values of types in Tail
template<typename T, arguments**>**: include args
template<typename T=type**>**: define a default type
T functionname**(T** arguments**)**: function template
classname**<T>::**classname**(T** arguments**)**: a class template of type T with a constructor using T
classname**<T>::**function**()**: define class T function

Types

type variable**[**int**]**: defines an array of int positions
type variable**[**int**][**int**]**: a int * int array (2 dim)
type***** variable: defines a pointer to a type
auto: compiler auto defines type when possible
bool: Boolean value
char: one ASCII character
decltype(variable**)** variable: type variable=variable
double: value between +- 1.7e-308
enum class variable **{**value**,** value**,** …**}**: enumerations class, use with variable::value
float: value between +-3.4e-38 (eg 3.14159F)
int: value between +-2147483648 (eg 0x1A)
int:bits: define integer of bits bitfield
long: value +- 9223372036854775808 (eg 32L)
long double: value between +-3.4e-4932
long long: value +-9223372036854775808 (eg 32LL)
short: value between +-32768
unsigned type: only positive numeric values (eg 2U)

Vector

#include <vector>: header for std::vector class
std::vector<type**> {}** variable: a vector collection
.capacity(): returns the capacity of the vector
.insert(int,value**)**: inserts value at position int
.pop_back(): removes last element
.push_back(value**)**: add element to the back
.reserve(int**)**: reserves capacity
.resize(int**)**: resizes the vector (grow only)
.size(): returns the size of the vector