

# Advanced Objects

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Fall 2025

last formatted: October 7, 2025

## Headers

# 1. Independent definition of function

Functions can be defined outside the class declaration:

```
1 class someclass {  
2 private:  
3     int localvar;  
4 public:  
5     // declaration:  
6     double somedo(vector);  
7 };
```

Implementation:

```
1 // definition  
2 double someclass::somedo(vector v) {  
3     .... something with v ....  
4     .... something with localvar ....  
5 };
```

## 2. C headers plusplus

You know how to use `.h` files in C.

Header files for classes in C++ need some extra syntax.

### 3. Independent definition of function

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5     // declaration:  
6     double somedo(vector);  
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```

Implementation:

```
1 // definition  
2 double someclass::somedo(vector v) {  
3     .... something with v ....  
4     .... something with localvar ....  
5 };
```

'This'

## 4. 'this' pointer to the current object

A pointer to the object itself is available as `this`. Variables of the current object can be accessed this way:

```
1 class MyClass {
2 private:
3     int myint;
4 public:
5     MyClass(int i) {
6         this->myint = i;    // option 1
7         (*this).myint = i; // option 2
8     };
9 };
```

## 5. 'this' use

You don't often need the `this` pointer. Example: you need to call a function inside a method that needs the object as argument)

```
1 /* forward definition: */ class someclass;
2 void somefunction(const someclass &c) {
3     /* ... */ }
4 class someclass {
5     // method:
6     void somemethod() {
7         somefunction(*this);
8     };
```

(Rare use of dereference star)



## Operator overloading

## 6. Operator overloading

Syntax:

```
1 <returntype> operator<op>( <argument> ) { <definition> }
```

For instance:

Code:

```
1 // geom/pointscale.cpp
2 Point operator*(float f) {
3     return Point(f*x,f*y);
4 };
5 /* ... */
6 println("p1 to origin {:.5}",
7         p1.dist_to_origin());
8 Point scale2r = p1*2.;
9 println("scaled right: {}",
10        scale2r.dist_to_origin());
11 // ILLEGAL Point scale2l = 2.*p1;
```

Output:

```
1 p1 to origin 2.2361
2 scaled right:
   ↪ 4.472136
```

# Exercise 1

Rewrite the *halfway* method of exercise ?? and replace the *add* and *scale* functions by overloaded operators.

Hint: for the *add* function you may need '`this`'.

## 7. Index overloading

If you have objects that contain an array, you may want to overload the index operator.

Code:

```
1 // array/getindex4.cpp
2 class vector10 {
3 private:
4     int array[10];
5 public:
6     /* ... */
7     int operator[](int i) {
8         return array[i];
9     };
10    /* ... */
11    vector10 v;
12    v[2] = 34; // COMPILE ERROR!!!
13    cout << v[2] << '\n';
```

Output:

```
1 getindex4.cpp:38:8:
    ↪error:
    ↪expression is
    ↪not assignable
2     38 |     v[2] = 34;
    ↪// COMPILE
    ↪ERROR!!!
3         |     ~~~~ ^
4 1 error generated.
5 make[1]: ***
    ↪[../Make.inc:118:
    ↪getindex4.o]
    ↪Error 1
```

## 8. Index overloading'

Let the index operator return a reference:

Code:

```
1 // array/getindex5.cpp
2 class vector10 {
3 private:
4     int array[10];
5 public:
6     /* ... */
7     int& operator[](int i) {
8         return array[i];
9     };
10    /* ... */
11    vector10 v;
12    v[2] = 34;
13    cout << v[2] << '\n';
```

Output:

1 34

More constructors

## 9. Constructors and contained classes

Finally, if a class contains objects of another class,

```
1 class Inner {  
2 public:  
3     Inner(int i) { /* ... */ }  
4 };  
5 class Outer {  
6 private:  
7     Inner contained;  
8 public:  
9 };
```

## 10. When are contained objects created?

```
1 Outer( int n ) {  
2     contained = Inner(n);  
3 };
```

1. This first calls the default constructor
2. then calls the *Inner(n)* constructor,
3. then copies the result over the *contained* member.

```
1 Outer( int n )  
2     : contained(Inner(n)) {  
3     /* ... */  
4 };
```

1. This creates the *Inner(n)* object,
2. placed it in the *contained* member,
3. does the rest of the constructor, if any.



# 11. Copy constructor

- Default defined copy and 'copy assignment' constructors:

```
1 some_object x(data);  
2 some_object y = x;  
3 some_object z(x);
```

- They copy an object:
  - simple data, including pointers
  - included objects recursively.
- You can redefine them as needed.

```
1 // object/copyscalar.cpp  
2 class has_int {  
3 private:  
4     int mine{1};  
5 public:  
6     has_int(int v) {  
7         cout << "set: " << v  
8             << '\n';  
9         mine = v; }  
10    has_int( has_int &h ) {  
11        auto v = h.mine;  
12        cout << "copy: " << v  
13            << '\n';  
14        mine = v; }  
15    void printme() {  
16        cout << "I have: " << mine  
17            << '\n'; }  
18 };
```

## 12. Copy constructor in action

### Code:

```
1 // object/copyscalar.cpp
2 has_int an_int(5);
3 has_int other_int(an_int);
4 an_int.printme();
5 other_int.printme();
6 has_int yet_other = other_int;
7 yet_other.printme();
```

### Output:

```
1 set: 5
2 copy: 5
3 I have: 5
4 I have: 5
5 copy: 5
6 I have: 5
```

# 13. Copying is recursive

Class with a vector:

```
1 // object/copyvector.cpp
2 class has_vector {
3 private:
4     vector<int> myvector;
5 public:
6     has_vector(int v) { myvector.push_back(v); };
7     void set(int v) { myvector.at(0) = v; };
8     void printme() { cout
9         << "I have: " << myvector.at(0) << '\n'; };
10 };
```

Copying is recursive, so the copy has its own vector:

Code:

```
1 // object/copyvector.cpp
2 has_vector a_vector(5);
3 has_vector other_vector(a_vector);
4 a_vector.set(3);
5 a_vector.printme();
6 other_vector.printme();
```

Output:

```
1 I have: 3
2 I have: 5
```

## 14. Destructor

- Every class *myclass* has a *destructor* *~myclass* defined by default.
- The default destructor does nothing:

```
1 ~myclass() {};
```

- A destructor is called when the object goes out of scope.  
Great way to prevent memory leaks: dynamic data can be released in the destructor. Also: closing files.

## 15. Destructor example

Just for tracing, constructor and destructor do `cout`:

```
1 // object/destructor.cpp
2 class SomeObject {
3 public:
4     SomeObject() {
5         cout << "calling the constructor"
6             << '\n';
7     };
8     ~SomeObject() {
9         cout << "calling the destructor"
10            << '\n';
11     };
12 };
```

## 16. Destructor example

Destructor called implicitly:

Code:

```
1 // object/destructor.cpp
2 cout << "Before the nested scope"
3     << '\n';
4 {
5     SomeObject obj;
6     cout << "Inside the nested scope"
7         << '\n';
8 }
9 cout << "After the nested scope"
10    << '\n';
```

Output:

```
1 Before the nested
   ↪scope
2 calling the
   ↪constructor
3 Inside the nested
   ↪scope
4 calling the
   ↪destructor
5 After the nested
   ↪scope
```

References and such

## 17. Direct alteration of internals

Return a reference to a private member:

```
1 class Point {  
2 private:  
3     double x,y;  
4 public:  
5     double &x_component() { return x; };  
6 };  
7 int main() {  
8     Point v;  
9     v.x_component() = 3.1;  
10 }
```

Only define this if you need to be able to alter the internal entity.



## 18. Reference to internals

Returning a reference saves you on copying.

Prevent unwanted changes by using a 'const reference'.

```
1 class Grid {
2 private:
3     vector<Point> thepoints;
4 public:
5     const vector<Point> &points() const {
6         return thepoints; };
7 };
8 int main() {
9     Grid grid;
10    cout << grid.points()[0];
11    // grid.points()[0] = whatever ILLEGAL
12 }
```

## 19. Access gone wrong

We make a class for points on the unit circle

```
1 // object/unit.cpp
2 class UnitCirclePoint {
3 private:
4     float x,y;
5 public:
6     UnitCirclePoint(float x) {
7         setx(x); };
8     void setx(float newx) {
9         x = newx; y = sqrt(1-x*x);
10    };
```

You don't want to be able to change just one of  $x,y$ !

In general: enforce invariants on the members.

## 20. Const functions

A function can be marked as const:  
it does not alter class data,  
only changes are through return and parameters

## Static variables

## 21. Static class members

A static member acts as if it's shared between all objects.

(Note: C++17 syntax)

Code:

```
1 // link/static17.cpp
2 class myclass {
3 private:
4     static inline int count=0;
5 public:
6     myclass() { ++count; };
7     int create_count() {
8         return count; };
9 };
10     /* ... */
11     myclass obj1,obj2;
12     cout << "I have defined "
13         << obj1.create_count()
14         << " objects" << '\n';
```

Output:

```
1 I have defined 2
   ↪objects
```

## 22. Static class members, C++11 syntax

```
1 // link/static.cpp
2 class myclass {
3 private:
4     static int count;
5 public:
6     myclass() { ++count; };
7     int create_count() { return count; };
8 };
9     /* ... */
10 // in main program
11 int myclass::count=0;
```