

Reference variables

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Why references?

// C version

```
void swap (int *a, int *b) {  
    int t = *a;  
    *a = *b;  
    *b = t;  
}
```

// Wrong version

```
void swap(int a, int b) {  
    int temp = a;  
    a = b;  
    b = temp;  
}  
  
int main() {  
    int x=3, y=7;  
    swap(x, y);  
    // still x == 3, y == 7 !  
}
```

// C++ version

```
void swap (int &a, int &b) {  
    int t = a;  
    a = b;  
    b = t;  
}
```

References – two definitions

- (a) A pointer that is used like an object.
- (b) Alias - alternative name to existing object.

```
int i = 10;
```

```
int& j = i; // j is a int reference  
           // initialized only  
           // once !
```

```
j += 5; // changes both i and j
```

Pointer vs. Reference *(folder 1)*

	Pointer	Reference
Initialization	Optional	Mandatory
Dynamic	Yes	No
Arithmetic	Yes	No
Always defined	No	Yes
Notation	(*p), p->x	r, r.x
Containers	Yes	No

Three ways to pass arguments

```
int * func(int *var0, int &var1, int var2);
```



By pointer

By reference

By Value

Lvalue & Rvalue

Lvalue = **Left Value** – can appear at left side of =.

= **Located Value** – has a fixed memory location.

Examples: variables, references ...

Rvalue = not Left Value. Numbers, temporaries ...

```
int a=1;
```

```
a=5; // Lvalue = Rvalue, Ok
```

```
a=a; // Lvalue = Lvalue, Ok
```

```
5=a; // Rvalue = Lvalue Comp. error
```

```
5=5; // Rvalue = Rvalue Comp. error
```

```
a+5=7; // Temporary = Rvalue - Comp. error
```

```
f(5)=7; // RIDDLE: Is this legal?
```

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```
5=5; // Rvalue = Rvalue Comp. error
```

```
a+5=7; // Temporary = Rvalue - Comp. error
```

```
f(5)=7; // .. it depends: we will see soon.
```

R/L value and references

non-const Reference – only to a non const Lvalue.

const reference – to both Lvalue and Rvalue

```
int lv=1;
```

```
const int clv=2;
```

```
int& lvr1=lv;
```

```
int& lvr2=lv+1; //error!
```

```
int& lvr3=clv; //error!
```

```
const int& cr1=clv;
```

```
const int& cr2=5+5; // This is useful for  
// Functions arguments
```


Passing arguments by const reference

// Pass by value

```
void foo (int a)
```

```
{
```

```
    ...
```

```
}
```

// Pass by pointer

```
void foo (int *pa)
```

```
{
```

```
    ...
```

```
}
```

// pass by ref

```
void foo (int &a)
```

```
{
```

```
    ...
```

```
}
```

// pass by const ref

```
void foo (const int &a)
```

```
{
```

```
    ...
```

```
}
```

- Avoid copying objects without allowing changes in their value.

Parameter passing

By value	By reference	By const reference
<code>void f (Point x) {...}</code>	<code>void f (Point& x) {...}</code>	<code>void f (const Point& x) {...}</code>
x is copied	x is not copied	x is not copied
Compiler lets f modify x, but changes have no effect outside	f can modify x	compiler does not let f modify x

```
void add(Point& a, Point b)
{
    // a is reference, b is a copy
    a._x += b._x;
    a._y += b._y;
}

int main()
{
    Point p1(2,3), p2(4,5);
    add(p1,p2); // note: we don't send pointers!
                // p1 is now (6,8)

    ...
}
```

```
void add(Point& a, const Point& b)
{
    // a is reference,
    // b is a const ref
    a._x+= b._x;
    a._y+= b._y;
}
```

- b is Reference => is not copied
- b is Const => we can't change it
- Important for large objects!

```
int main()
{
    Point p1(2,3), p2(4,5);
    add(p1,p2); // note: we dont send pointers!
               // p1 is now (6,8)
    ...
}
```

Return a reference to variable *(folder 2)*

```
class Buffer
{
    size_t _length;
    int *_buf;
public:
    Buffer (size_t l) :
        _length (l),
        _buf (new int [l])
    {
    }
    int& get(size_t i)
    {
        return _buf[i];
    }
};
```

```
int main ()
{
    Buffer buf(5);
    buf.get(0)= 3;
}
```

Return a ref. to a legal variable (e.g. not on the function stack).

Return a reference from a function *(folder 2)*

- Don't return a reference to a local variable.
- You can return a reference to a variable that will survive the function call, e.g:
 - A heap variable (allocated with new).
 - A variable from a lower part of the stack.
 - Globals.
 - Class members.
 - *this (Useful for call-chaining).

```
Point& add(Point& a, const Point& b)
{
    // a is reference, b is a const ref
    a._x+=b._x;
    a._y+=b._y;
    return a;
}
```

```
int main()
{
    Point p1(2,3), p2(4,5), p3(0,1);
    add(add(p1,p2),p3);           // now p1 is (6,9)
    cout << add(p1,p2).getX();   // note the syntax
    ...
}
```

C++ const

Const variables – like in c

```
int * const p1 = &i; // a const  
// pointer to an un-const variable
```

- p1++; // c.error
- (*p1)++; // ok

```
const int * p2 = &b; // an un-const  
// pointer to a const variable
```

- p2++; // ok
- (*p2)++; // c.error

```
const int * const p3 = &b; // a const  
// pointer to a const variable
```

Const methods *(folder 3)*

```
class A
{ int a;
public:
    void foo1() const;
    void foo2();
};
void A::foo1(int& b) const {
    a=5; //error
    cout << a; // OK
    b=5; // OK
}
void A::foo2()
{
}
```

```
int main()
{
    A a;
    const A ca;
    a.foo1();
    a.foo2();
    ca.foo1();
    ca.foo2();
    // comp. error
}
```

Const methods

```
class A
{
public:
    void foo() const;
    void foo();
};

const int A::foo() const
{
    cout << "const foo\n";
}

void A::foo()
{
    cout << "foo\n";
}
```

```
int main()
{
    A a;
    const A ca;
    a.foo () = 5;
    ca.foo();
}
```

```
// output
foo
const foo
```

Why?

Overload resolution, again:

```
A::foo(A* this)
```

```
A::foo(const A* this)
```

mutable

- **mutable** means that a variable can be changed by a const function (even if the object is const)
- QUESTION: When would you use this?

mutable: example #1

```
class X
{
public:
    ...
    X() : _fooAccessCount(0) {}

    bool foo() const
    {
        ++_fooAccessCount;
        ...
    }
    unsigned int fooAccessCount() { return _fooAccessCount; }

private:
    mutable unsigned int _fooAccessCount;
};
```

mutable: example #2

```
class Shape
{
public:
    ...
    void set...(...) { _areaNeedUpdate= true; ... }
    double area() const
    {
        if (_areaNeedUpdate) {
            _area = ...
            _areaNeedUpdate= false;
        }
        return _area;
    }
private:
    mutable bool _areaNeedUpdate= true;
    mutable double _area;
};
```