Notes Made By

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OOP in C++

OOP

↓

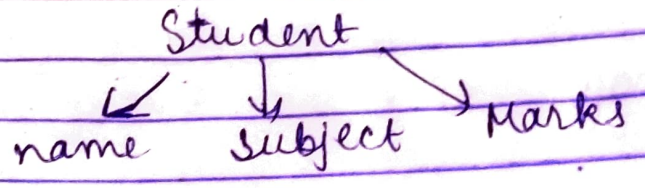
A way to build a software

↙ class

A datatype with funcn's

↘ Object

A variable of class.




```
Class Complex {
  private: int real;                    // can't be accessed outside
           int imag;                       the class
  public :
      void print()
       {
       cout << real << "+i" << imag << endl;
      }

  Complex (int r, int i)    // constructors
      real = r;
      imag = i;
   }
};

int main()
 {
  complex C1(10, 15);
   C1. print ();
   return 0;
 }.
```

Abstraction - Hiding internal details.

Encapsulation - Putting data & functions in same class.

Inheritance - Don't need to rewrite the code again & again.

Polymorphism → one function, name, diff^{n} functionalities

① Run-time (Dynamic)
② Compile time (static)

Constructors & Destructors

↓

1) Same name as class name
2) No return type
3) Called when class is created

```
Class Point {
  private:
    int x, y;
  public:
    Point() {
      x=0;
      y=0;
    }
    Point (int x1, int y1) {
      x=x1;
      y=y1;
    }
```

```
void print(){
    cout << x << "  " << y << endl;
    }
};

int main(){
    Point p1, p2(10,20);
    p1.print();
    p2.print();
    Point * ptr = new Point(5,10);
    ptr->print();
    return 0;
    }
```

We access class members using . but for pointer we use (→)

```
// initializer list
Point : x(0), y(0){

}
Point (int x1, int y1) : x(x1), y(y1) {
}
```

```
Class Test
  {
public:
 Test() {cout<< "Default"}
Test(int x) {cout << "Parameterized" \n"};
};

Class Main{
   Test t;
public:
   Main()
     {
      t= Test(10);
     }
};
```

O/p: Parameterized

Copy constructors - Special objects which are called when you create an object from existing object.

```
Class Test{
  int * ptr;
  public:
    Test(int x)
     {
      ptr = new int(x);
     }
```

Test t_2; ✗ not copy
$t_2 = t_1$

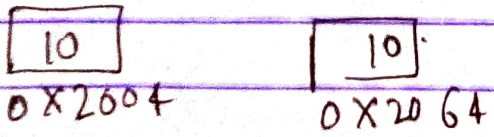
```
void set(int x) {
    *ptr = int x;
}
Test (const Test &t) {
    int val = *(t.ptr);
    ptr = new int(val);
}
void set (int x){
    *ptr = x; }
void print (){
    cout << *ptr << " "; }
};
```

```
int main(){
Test t1(10);
Test t2(t1);
t2.set(20);
t1.print();
t2.print();
}
```

O/p : 10 20

Compiler defines its own copy constructor. Dynamic memory allocation is there. Copy constructor called at this time is a shallow copy constructor. So to use dynamic memory allocation we use deep copy.

$t_1.ptr = 0x2004$ $t_2.ptr = 0x2064$



→ delete (We write own des while creating dynamic memory)

Destructor - Called when an object is destroyed (out of scope) (No parameter, no return type)

```
~Test()
{
cout<<"destructor called"<<endl;
```

```
class Test {
public:
    Test() {
    cout << "con called" << " ";}
~Test() {
    cout << " des called << " ";}
};
```

```
int main() {
{ Test t1; }
{ Test t2; }
 return 0;
```

O/P:
con called
des called
Con called
des called.

When we have multiple objects in same scope they are destructed in reverse order of their creation

Cons 10
Cons 20
Des 20
Des 10

This pointer

↓

Object to which we are calling.

```
class Point{
    int x, y;
};
public:
    point (int x, int y)
    {
        this → x = x;
        this → y = y;
    }
};
```

x, y

x = x,
y = y.

```
int main(){
    point p1(10,20);
    point p2(5,5);
}.
```

Changing of function

```
Class Point
{.
 int x; int y;
public:
    point (int x, int y){
        this.x → x;
        this.y → y;
};
```

```
Point & setX(int x)
{
  this -> x = x;
  return *this;
}

Point & setY(int y)
{
  this -> y = y;
  return *this;
}
};
```

```
int main()
{
Point p1(10,10);
[p1.setX(5)].setY(5);
  return 0;
}
```

this pointer is a constant pointer

Static Member in C++

Static variable
↓
(are shared among all objects & are created once in a class)
(defined outside the class)

```
class Player {
  public:
    static int count;
    Player () { count++; }
  ~ Player() { count--; }
  };
  int Player :: count = 0;
  int main()
  {
  Player p1;
  cout << Player :: count << " "; // 1
  { Player p2; cout << Player :: count << " "; } // 2
  cout << Player :: count << " "; // 1
}
```

Static members = class members

Static Member function
↓
When you have static member, use Static member fun to modify static data members.

```
Class Player {
 private:
    static int count;
 public:
    player () { count++; }
   ~player() { count--; }
  static int getCount() { return count; }.
};
int Player :: count = 0;  // It is better to initialize it outside the class
int main() {
 Player P1, P2;
 cout << Player :: getCount();
return 0;
}
```

O/P = 2.

1) Static func^{n} can access only static data members.
Non static members are not allowed

2) They don't have any this pointer as they are class members only.

Inheritance And Virtual function in C++

- protected access specifier
- Inheritance Syntax.

public : accessible anywhere outside the class.
private : not accessible outside the class.
protected : not accessible outside the class except sub class (inherited class).

```
Class Person {.
 protected :
      String name;
       int id;
 };

Class Student : public person {.
 private :
      int marks;
 public :
      void print() {
 cout << name<< id << marks;
 }
```

→ is able to access name directly.

Constructor	Destructor
Person()	Student()
Student()	Person()

	Base	Derived
private	✓	X
public	✓	Might be (public, protected, private)
protected	✓	✓

Class student : public person.

Class student : ~~public~~ private person.

public/protected member in base class become private.

Class student: protected person.

Everything except the private members becomes protected.

~~Base~~ Inheritance Access.

public → protected & public of base class remain as they are.

private → protected & public of base class become private.

protected → protected & public of base class become protected

Virtual function → At run time it is decided which func" to be called.

A base class type reference or pointer can refer to a derived class object

```
class Base { }
class Derived : public Base { };
int main()
{
Base *b = new Derived;
Derived d;
Base &b = d;
return 0;
}
```

```
Class Base{
public:
virtual void print()
{ cout << "Base"; }
};
Class Derived : public Base {
public :
void print
{
cout << " Derived"; }
};
```

function overriding

How do virtual func^n works

↓

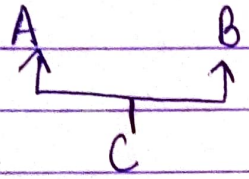
They maintain a vptr & vtable
(object) (class)

1) They reduce code complexities

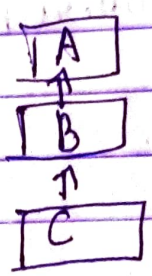
Multiple inheritance

↓

When a class inherits from 2 or more classes it's called multiple inheritance



Multiple

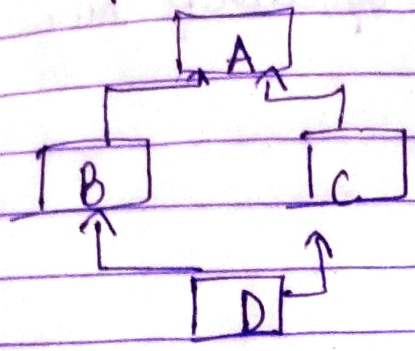


Multilevel.

```
Class A{ }
Class B{ }          order.
class C : public A, public B { };
int main () {
    Cobj;
    return 0;
}
```

// A const
B const
C const

Java doesn't allow multiple inheritance due to diamond problem.



Diamond problem

```
class A{
  public:
  int x;
};
class B:public A { };
class C: public A { };
class D: public B, public C { };
int main() {
   D d;
   cout << d.x;
   return 0;
}
```

↳ A constructor called two times

Soln: for C++ is we use virtual keyword.

```
class B : virtual public A { };
class C : virtual public A { };
class D :  public B, public C { };
```

→ Java doesn't support operator overloading

Operator overloading

↓

If we want to use operators for our own classes

```
Class Complex {
 private:
    int real, img;
public:
    Complex(int r=0, int i=0) : real(r), img(i) { }

 Complex operator+ (Complex const &obj)
      {
        Complex res;
       res.real = real + obj.real;
       res.imag =  img + obj.img;
        return res;
      }

 void print() {
    cout << real << "+i" << img << endl; }
};
 int main()
   {
   Complex c1(10, 5), c2(2, 4);
    Complex c3 = c1 + c2; // c1.operator+(c2)
   c3.print();
 return 0;
}
```

Operators which can't be overloaded.

., ::, ?:) and size of

* While operator overloading there is no change in precedence, associativity

$C4 = C1 + C2 * C3;$

first

second

* If we don't called an assignment operator, compiler calls itself. → (by default created)

Friend function → Java doesn't support

A classA can specify other classB a friend of it (then classB can access private & protected member of class A)

1) It is against Encapsulation.

```
class A {
  int x=4;
friend class B; // friend class.
};

class B {.
public :
   void display(A &a)
      {
      cout <<"value of x:" <<a.x ;
      }
   };
int main()
 {
 A a;
 B b;
 b.display(a);
 return 0;
 }.
```

O/p : value of x is:4

```
class BOX{
   int L;
public :
     Box(): L(0) { }.
   friend int printlength(Box x); // friend func^n.
};
```

```
int printlength (Box b)
    {
    b.length += 10;
    return b.length;
}

int main()
    {
    Box b;
    cout << printlength(b);
    }
```

O/p 10.

Granted, Not Mutual, Not Transitive & Not Inherited

Advanced

Exception Handling in C++

```
int average (int arr[], int n)
    {
    int sum = 0;
for(int i = 0; i<n; i++)
        sum = sum + arr[i];,        // When n = 0 then
        sum = sum/n;                  ! ! !
        return res;
}
```

we can't use if (n = 0) because there might be a condn that the avg is -1.

Cases of Exception Handling

1) Divide by zero
2) No heap memory Available.
3) Accessing array elements outside the allowed index range
4) Pop from an Empty stack.

Try, catch & throw in C++

- try: before the block of code
- catch: used before a block after try
- throw: used to throw an exception

```
try {
    // The code that may
    // throw exception
}
```

throw: used to throw an exception

Catch: One or more catch blocks are used to handle exception

Example code:

```
int main()
  {
   int x, y;
   cin >> x >> y;
  try {
       if (y == 0)
          throw 0;
       cout << "Result is" << x/y;
  }
  catch (int x)
    {
     cout << "Divisor is zero";
  }
  return 0;
}
```

I/P

x = 10
y = 2

O/P

Result is 5.

x = 10
y = 0

O/P.

Divisor is 0.

```
int main() {
  double x, y;
  cin >> x >> y;

  try {
    (if x == 0.0)
       throw 0;
    if (y == 0.0)
       throw string ("y is zero");

    if (x+y < 0.0)
          throw (x+y);
  }

catch(int e1)    { cout << e1; }
Catch(String &e2) { cout << e2; }
catch(...)  { cout << "x+y is less than 0"; }
      ↓
   catchall (it catches all the datatype exception
             not present in catch like for double)

cout << "\n Bye ... ";
return 0;
}
```

I/p 0.0 1.0
O/p 0
Bye ...

I/p 1.0 0.0
y is zero
Bye ...

I/p -1.0 -2.0
x+y is less than zero
Bye ...

Ex

```
int avg (int arr[], int n)
  {
  if (n == 0)
     throw string ("Array size is zero");

int sum = 0;
for (int i = 0; i<n; i++)
     sum += arr[i];
return sum/n;
}

int main()
 { int arr[] = {4,5,2}
   int n = 0;
 try {
    int res = avg(arr, n);
     cout<<res;
    }
 Catch (string &e) {
     cout << e; }
cout << "Bye....";
return 0;
}
```

O/P: Array size is zero
Bye...

int average (int arr[], int n) throw (string)

↓

It is used to specify what all exceptions can be thrown by the function.

Stack Unwinding in C++

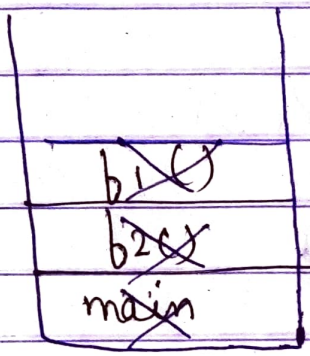
↓

If a func^n throws an exception & doesn't handle this exception then control goes to the caller & if it doesn't handle then goes to the handler.

```
void f1 throw (int)
{
 cout << "f1 Begins \n";
  throw 100;
  cout << "f1 ends \n";
}

void f2 throw (int)
{
 cout << "f2 begins \n";
  f1();
  cout << "f2 ends \n";
}
```

```
int main()
  {
  try {
      f2();
    }
    catch (int i)
      {
       cout << "Caught exception \n";
      }
    cout << "Bye ....!";
}.
```



O/p : f2 Begins
f1 begins
Caught Exception
Bye ...

User Defined Exceptions

```
int avg (int arr[], int n)
  {
  if (n == 0)  throw ArraySizeZero()
  if (n < 0)   throw ArraySizeNegative()
for (int i = 0; i < n; i++) {
            sum += arr[i]
        return sum/n;
}
```

```
int main(){
    int n;
    cin >>n;
    int * arr = new int[n];
  for(int i = 0; i<n; i++)
        cin >>arr[i];

  try {
        int res = avg(arr,n);
        cout<<res;
    }
  catch (ArraySizeZeroException &e1)
    {
    cout <<"Array size is zero" ;}
  Catch (ArraySizeNegativeException &e2)
    {
    cout <<"Array size is negative"; }
  return 0;
  }
```

* It is not allowed in java to throw primitive type as exception.

Exception class in C++

→ from new operator

All standard library exceptions like bad_alloc, bad_cast etc inherit from exception class directly or indirectly.

Exception class has an what function.

```
class MyException: public exception
{
   virtual const char* what() const throw();
     { return "Exception occured\n";
     }
};

int main(){
    try {
       throw MyException();
       }
   catch (exception &e) {
       cout << e.what();
     }
}.
```

Function pointers

Stack	→ for func^n calls (local data of a func^n)
Heap	→ for dynamically allocated memory
Data	→ to store static, global variables
Text	→ instructions or executable code (a func^n pointer stays here)

Q. Why do we need function pointer?

→ Stores address of a function (set of instructions)
→ Like normal pointers, we can pass a func^n. pointer to other functions
→ Used in qsort(), sort(), forEach() or any other place where we wish to provide functionality as a parameter.
→ Used to implement virtual function.

Example 1:

```
void fun(){
cout<<"GFG";
}

int main(){
void (*fun_ptr)() = &fun;
fun_ptr();   // (*fun_ptr)();
return 0;
}
```

it is optional as function name gives the address of func^n.

O/P
GFG

```
auto fun_ptr = fun;
```

```
int fun (int x, int y) {
    return (x+y); }.

int main() {.
  auto fun_ptr = fun;
  Cout << fun_ptr (10,20); // int (*fun_ptr)(int, int) = fun;
  return 0;
  }
```

Passing functions as parameters

```
int add ( int x, int y) { return (x+y) ; }.
int multiply (int x, int y) { return x * y; }.
int compute (int x, int y , int (* fun-ptr) (int, int))
  { return fun-ptr (x, y) ;
  }
int main()
   {
   cout << compute (10, 20, add) << "\n" ;
   cout << compute (10, 20, multiply);
   return 0;
   }
```

O/p
30
200

Sort func^n in array.

```
bool compare (int x, int y) {
    return abs(x) < abs(y); }

int main(){
    int arr[] = {2, 4, -1, 8, -9};
    int n = sizeof(arr)/ sizeof(arr[0]);

    sort (arr, arr+n, compare);

    for(int i=0 ; i<n; i++) {
        cout << arr[i] << " ";
    return 0;
}
```

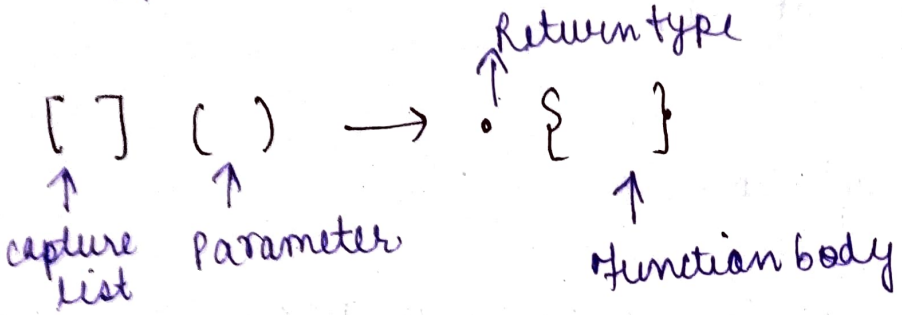
O/p: -1 2 4 8 -9

(anonymous)
Lambda Expression
↓
You don't have to create a separate function

```
int main() {
    int arr = {-20, 10, -30, 5};
sort (arr, arr+n, [](int a, int b) {return abs(a) < abs(b);})
```

```
for (auto x: arr)
    cout << x << " ";
return 0;
}
```

O/p 5 10 -20 -30



OR.

```
auto mycmp = [] (int a, int b) { return abs(a) < abs(b); };
sort (arr, arr+n, mycmp);
```

Example 1: for_each( )

↓

between 2 operators we can do a provided functionality.

```
int main() {
    vector<int> v {10, 20, 30};
for_each (v.begin(), v.end(), [] (int &x) {x = x*2;});
for_each(v.begin(), v.end(), [] (int &x) {cout << x << " ";});
return 0;
}
```

O/p: 3.

Example 2: count_if → (count no. greater than a no)

```
int main() {
  vector<int> v {10, 5, 3, 20, 100};
int res = count_if (v.begin(), v.end(),
                    [](int x) {return x >= 10;});
  cout << res << "\n";
  return 0;
}
```

Example 3: find_if() → iterator to the first element that satisfies the condn.

```
int main() {
vector <int> v {100, 20, 4, 200, 1};
auto it = find_if (v.begin(), v.end(),
                   [](int x){return x < 10;});
cout << *it;
return 0;
}
```

O/p : 4

Example 4: accumulate()

accumulate by default does sum of elements.

```
int main() {
  vector<int> v{10, 2, 4, 20, 1};
int res = accumulate (v.begin(), v.end(), 0);
 cout << res << "\n";
res = accumulate (v.begin(), v.end(), 1,
                  [](int x, int y){return x*y;});

 cout<<res;
 return 0;
}
```

O/p : 35 0+10+2+4+20+1 = 35

1600 1*10*2*4*20*1 = 1600

Capture list in lambda expression

[ ] : Nothing

[=] : Everything by value

[&] : Everything by reference

[=, &x] : Everything by value & x by reference

[&, x] : Everything by reference & x by value

Static & global variables are always captured.

```
int main() {
  int x=5, y=10;
  auto lambda_expr = [&] (int a) {

      x = x+a;
      y = y+a;

  };

  lambda_expr(20);
  cout << x << "  " << y << "\n";
  return 0;
}
```

o/p = 25, 30

Some exception

```
auto lambda_expr = [=] (int a) mutable {
      x = x+a;
      y = y+a;
  };
```

o/p : 5, 10

without the use of mutable these values can't be modified

Smart pointer in C++
(wrap a pointer to a class object)

In normal pointers there is a memory leak.

```
void fun()
{
  int * ptr = new int[10];
}

int main()
{
  while (true) {
    fun();
  }
}
```

crashed.

```
class SP {
   int * ptr;          // wraps an integer to pointer
public:
   SP (int * p = NULL) { ptr = p; }.
~SP{ delete ptr; }

int & operator * () { return * ptr; } *
};

int main()
{
  SP sp( new int() );
  * sp = 20;
  cout << * sp;
  return 0;
}
```

O/p = 20

Here, in the example we don't get the value as destructor called.

```
class Test {
public : int x, y;
Test (int a=0, int b=0)
      {
       x= a;
       y= b;
       cout << " constructor called \n";
      }
~Test ( )
  {
  cout << " Destructor called \n";
  }
};

int main() {
 cout <<"main begins \n";
  {
  Test *p = new Test (10,20);
  }
 cout <<"Main ends";
 return 0;
}
```

Op: Main begins
constructor called
Main ends

So we would overload & → and * operators.

```
class SP {
    Test * ptr;
public:
    SP(Test *p = NULL) { ptr = p; }

    ~SP() { delete ptr; }

    Test & operator * () { return *ptr; }
    Test * operator -> () { return ptr; }
};

int main()
  {
  cout << "main begin";
    {
     SP sp(new Test(10, 20));
    }
  cout << "Main Ends";
  return 0;
}
```

O/P
Main begins
Constructor called
Destructor called
Main Ends.

Objects of SP goes out of scope it is called.

Template Smart Pointer

```
template <class T>
class SP
{
 T* ptr;
public:
 SP(T* p = NULL) { ptr = p; }
 ~SP()  { delete ptr; }

 T& operator*() { return *ptr; }
 T* operator->() { return ptr; }
};

int main()
{
 SP<int> sp(new int());
 *sp = 20;
 cout << *sp;
 return 0;
}
```

O/p: 20

Since it deallocates the memory sometimes pointers which are deallocated is called which may lead to compiler error.

Smart pointers

unique_ptr (by using make_unique)

shared_ptr (multiple shared pointers can own same objects)

weak_ptr (used with shared ! No ownership) doesn't increase refrence count

include <memory>

Errors in C++

1) Syntax Error → like puting semicolon

2) Semantic Error → statement doesn't makes a sense (16 = x)

3) Linker Error → If func^n. definition is not present which is called.

4) Runtime Error → when program is running (x/y, y=0)

5) Logical error → x = a + b/2 (forgot to put brackets)

Compilation process

preprocess directives → compiled → binary code → linking of the func^n → an executable file → O/P