Object-Oriented Programming using C++

C++ Notes Day-4 Date: 12-12-2024

Class and Object in C++

- Class in C++
    - It is a blueprint of a real wolrd entity known as Object. It describe attribute and behavior of the object.
    - attribute defined using variables and behavior defined using functions / methods
    - variables defined inside the class are known data members and functions / methods defined inside the class are known as Member Functions.
    - Data Members and Members Functions can be categeroized into static and non-static.
    - We can define the following into the class:
        - Data Members
            - static
            - non-static
        - Member Functions
            - static
            - non-static
                - const
                - virtual
        - Constructor
        - Destructor
    - Class, Structure, Enum, Union: Ntested Types
    - A class for which we can create objects is known as Concrete class.
    - A class for which we can not create objects is known as Abstract class
- Object
    - variable of the class the is known as object.
    - Object is also known as instance.
    - Syntax: class ClassName ObjectName;

```
    Student S1;          //OK
    class Student S2;    //OK
```

- Message Passing
    - calling Member Function using dot/Member Selection (.) operator

```
#include <iostream>
#include <string.h>
using namespace std;

class Student
{
public:
    int RollNo;
    char Name[30];
    void AddRecord();
    void PrintRecord();
    void SetRecord(int RollNo, char Name[30])
    {
        this->RollNo=RollNo;
        //this->Name=Name;
        strcpy(this->Name, Name);
    }
};
void Student:: AddRecord(/*const Student *this*/)
    {
        cout<<"Enter Roll No:   "<<endl;
        cin>>RollNo;
        cout<<"Enter Name:  "<<endl;
        cin>>Name;
    }
    void Student:: PrintRecord()
    {
        cout<<"Roll No:     "<<RollNo<<"  Name:     "<<Name<<endl;
    }
int main()
{
    Student S1;
    Student S2;
    //Member Function call using Dot (.) Operator
    S1.AddRecord();     //S1.AddRecord(&S1); calling AddRecord Member
Function on S1
    S1.PrintRecord();   //S1.PrintRecord(&S1);

    S2.SetRecord(102, "Mahesh");
    S2.PrintRecord();
    return 0;
}
```

- calling Member Function using scope resolution (:😃 operator

```
#include <iostream>
#include <string.h>
using namespace std;

class Student
{
public:
    int RollNo;
    char Name[30];
    void AddRecord();
    void PrintRecord();
    void SetRecord(int RollNo, char Name[30])
    {
        this->RollNo=RollNo;
        //this->Name=Name;
        strcpy(this->Name, Name);
    }
};
void Student:: AddRecord(/*const Student *this*/)
    {
        cout<<"Enter Roll No:   "<<endl;
        cin>>RollNo;
        cout<<"Enter Name:  "<<endl;
        cin>>Name;
    }
    void Student:: PrintRecord()
    {
        cout<<"Roll No:     "<<RollNo<<"  Name:     "<<Name<<endl;
    }
int main()
{
    Student S1;
    Student S2;
    //Member Function call using Scope Resolution :: Operator
    S1.Student::AddRecord();
    S1.Student::PrintRecord();  //S1.PrintRecord(&S1);

    S2.SetRecord(102, "Mahesh");
    S2.PrintRecord();
    return 0;
}
```

Custom Header File and Header Guard

- #include<abc.h> versus #include"abc.h"
    - Standard directory for standard header file : C:\MicGW\include
    - If we include header file in angular bracket(< >) then preprocessor try to locate that file inside standard directory only.
    - Example: #include<stdio.h>
    - If we include header file in double quotes(" ") then preprocessor first try to locate that file inside current project directory. If not found then it will try to locate it from standard directory.
    - Example:
        - #include<stdio.h>
        - #include"stdio.h"
- Importance of Header Guard
    - If we want to expand contents of header file only once then we should use Header Guard inside header file.

```
#ifndef STUDENT_H_
#define STUDENT_H_
//Declarations
#endif /* STUDENT_H_ */
```

Storage Classes C/C++

- There are four type of storage classes in C/C++
  - auto
  - extern
  - static
  - register
- storage classes describe scope and lifetime of the variable.
- non-static vs static global variable
  - We can access non static global variable inside same file where it is declared as well as inside diffrent file using extern keyword.
  - We can access static global variable inside same file where it is declared. But we can not access it inside diffrent file. We will get linker error.

```
#include <cstdio>
int main()
{
    extern int Num1;    //Here extern will look for Num1 which is declared
globally
    printf("Global Num1:    %d\n",Num1);
    //extern int Num2;  //NOT OK, static and extern can't be used together
    //printf("Static Global Num1:   %d\n",Num2);
    return 0;
}
int Num1=100;           //Non-Static Global Variable
static int Num2=200;    //Static Global Variable
```

Scope in C/C++

- There are four type of scope in C:
  - Block Scope
  - Function Scope
  - File Scope
  - Function Prototype Scope

```
#include <cstdio>
static int Num3=400;    //File Scope
int Num1=200;       //Program Scope
int Add(int X, int Y)   //Function Prototype Scope
{

}
int main()
{
    int Num2=100;   //Function Scope
    for(int i=0;i<5;i++)    //Block Scope
    {
    }
    return 0;
}
```

- Ref: https://en.cppreference.com/w/c/language/scope
- Scope in C++
  - Block Scope
  - Function Scope
  - File Scope
  - Function Prototype Scope
  - Class Scope
  - Enumuration Scope
  - Program Scope
  - Namespace Scope
- Lifetime of the variables
  - Lifetime describes time i.e how long object will be exist inside memory.
  - Lifetime in C/C++
    - Automatic Lifetime
      - All the local variables are having automatic lifetime.
    - Static Lifetime
      - All the static and global variables are having static lifetime
    - Dynamic Lifetime
      - All the dynamic objects are having dynamic lifetime.

Namespace in C++

- We can not give same name to the multiple variables inside same scope.
- We can give same name to the local variable as well as global variable.
- If name of the local variable and global variable are same then preference will be given to the local variable.
- Example:

```
int num1 = 10; //Global Variable
int main( void ){
 int num1 = 20; //Local variable
 //int num1 = 20; //error: redefinition of 'num1'
 printf("Num1 : %d\n", num1); //20
 return 0;
}
```

- Using scope resolution operator, we can use value of global variable inside program.

```
int num1 = 10; //Global Variable
int main( void ){
 int num1 = 20; //Local variable
 printf("Num1 : %d\n", ::num1); //10
 printf("Num1 : %d\n", num1); //20
 return 0;
}
```

- Example:

```
int num1 = 10; //Global Variable
int main( void ){
 int num1 = 20; //Local variable
 printf("Num1 : %d\n", ::num1); //10
 printf("Num1 : %d\n", num1); //20
 {//Start of block
 int num1 = 30;
 printf("Num1 : %d\n", ::num1); //10
 printf("Num1 : %d\n", num1); //30
 }
 return 0;
}
```

- We can use scope resolution operator with function too.

```
void Show( ){
 printf("Hello C++\n");
}
int main( void ){
 Show( ); //OK
 ::Show( ); //OK
 return 0;
}
```

- Why namespaces?
- Example:

```
int num1 = 10; //OK
int num1 = 20; //error: redefinition of 'num1'
int main( void ){
 int num2 = 30; //OK
 //int num2 = 40; //error: redefinition of 'num2'
 return 0;
}
```

- Namespace is a C++ feature which is designed:
    - to avoid name clashing / conflict / collision / ambiguity.
    - to group/organize functionally equivalent / related types together.
- namespace is a keyword in C++.

- Example 1:

```
namespace na{
 int num1 = 10;
}
int main( void ){
 printf("Num1 : %d\n", na::num1); //OK: 10
 return 0;
}
```

- Example 2:

```
namespace na{
 int num1 = 10;
}
namespace nb{
 int num1 = 20;
}
int main( void ){
 printf("Num1 : %d\n", na::num1); //OK: 10
 printf("Num1 : %d\n", nb::num1); //OK: 20
 return 0;
}
```

- Example 3:

```
namespace na{
 int num1 = 10;
}
namespace na{
 int num2 = 20;
}
int main( void ){
 printf("Num1 : %d\n", na::num1); //OK: 10
 printf("Num1 : %d\n", na::num2); //OK: 20
 return 0;
}
```

- Example 4:

```
namespace na{
 int num1 = 10;
 int num2 = 20;
}
namespace nb{
 int num1 = 30;
 int num3 = 40;
}
int main( void ){
 printf("Num1 : %d\n", na::num1); //OK: 10
 printf("Num2 : %d\n", na::num2); //OK: 20
 printf("Num1 : %d\n", nb::num1); //OK: 30
 printf("Num3 : %d\n", nb::num3); //OK: 40
 return 0;
}
```

- Example 5:

```
namespace na{
 int num1 = 10;
 int num2 = 20;
}
namespace na{
 //int num1 = 30; //error: redefinition of 'num1'
 int num3 = 30;
}
int main( void ){
 printf("Num1 : %d\n", na::num1); //OK: 10
 printf("Num2 : %d\n", na::num2); //OK: 20
 printf("Num3 : %d\n", na::num3); //OK: 30
 return 0;
}
```

- We can not define namespace inside block scope / function scope or class scope. Namespace definition must appear in either namespace scope or file/program scope.

```
int main( void ){
 namespace na{ //error: namespaces can only be defined in global or
namespace scope
 int num1 = 10;
 }
 return 0;
}
```

- Example 6:

```
int num1 = 10;
//File Scope
namespace na{
 int num2 = 20;
 //Namespace scope
 namespace nb{ //Nested namespace
 int num3 = 30;
```

```
  }
}
int main( void ){
 printf("Num1 : %d\n", ::num1); //10
 printf("Num2 : %d\n", na::num2); //20
 printf("Num3 : %d\n", na::nb::num3); //30
 return 0;
}
```

- If we define variable/function/class without namespace globally then it is considered as a member of global namespace.
- If we dont want to use namespace name and :: operator every time then we should use using directive.
- Example 7:

```
namespace na{
 int num1 = 10;
}
int main( void ){
 using namespace na;
 printf("Num1 : %d\n", num1 );
 return 0;
}
```

- Example 8:

```
namespace na{
 int num1 = 10;
}
int main( void ){
 int num1 = 20;
 using namespace na;
 printf("Num1 : %d\n", num1 ); //20
 printf("Num1 : %d\n", na::num1 ); //10
 return 0;
}
```

- Example 9:

```
namespace na{
 int num1 = 10;
}
namespace nb{
 int num1 = 20;
}
int main( void ){
 using namespace na;
 printf("Num1 : %d\n", num1 ); //10
 using namespace nb;
 //printf("Num1 : %d\n", num1 ); //error: reference to 'num1' is ambiguous
 printf("Num1 : %d\n", nb::num1 ); //10
 return 0;
}
```

- xample 10:

```
namespace na{
 int num1 = 10;
}
void show_record( ){
 printf("Num1 : %d\n", na::num1);
}
void print_record( ){
 printf("Num1 : %d\n", na::num1);
}
void display_record( ){
 printf("Num1 : %d\n", na::num1);
}
int main( void ){
 ::show_record( );
 ::print_record( );
 ::display_record( );
 return 0;
}
```

- Example 11:

```
namespace na{
 int num1 = 10;
}
using namespace na;
void show_record( ){
 printf("Num1 : %d\n", num1);
}
void print_record( ){
 printf("Num1 : %d\n", num1);
}
void display_record( ){
 printf("Num1 : %d\n", num1);
}
int main( void ){
 ::show_record( );
 ::print_record( );
 ::display_record( );
 return 0;
}
```

- Except main function, we can declare any member inside namespace.
- Example 12:

```
namespace na{
int num1 = 10;
}
using namespace na;
namespace nb{
 void show_record( ){
 printf("Num1 : %d\n", num1);
 }
 void print_record( ){
 printf("Num1 : %d\n", num1);
 }
 void display_record( ){
 printf("Num1 : %d\n", num1);
 }
}
int main( void ){
 nb::show_record( );
 nb::print_record( );
 nb::display_record( );
 return 0;
}
```

- Example 13:

```
namespace na{
 int num1 = 10;
}
int main( void ){
 printf("Num1 : %d\n", na::num1);
 namespace nb = na; //Alias
 printf("Num1 : %d\n", nb::num1);
 return 0;
}
```

Stream concept

- Variable is a container which is used to store data in RAM.
- File is a container which is used to store data in HDD.
- Stream is an abstraction(object), which either produce(write) or consume(read) inform from source to destination.
- Console is also called as terminal = Keyboard + Monitor / Printer.
- Standered stream objects in C
    - stdin
        - standerd input stream associated with keyboard to read the data from keyboard.

```
scanf("%d",&Num1);
//fscanf(stdin,"%d",&Num1);
```

- stdout
  - standerd output stream associated with monitor to write the data.

  ```
  printf("%d",Num1);
  //fprintf(stdout,"%d",Num1);
  ```

- stderr
  - standerd output stream associated with monitor to write the error.

- Standard stream objects in C++ associated with console (Keyboard + Monitor).
  - cin,
  - cout,
  - cerr
  - clog objects
  - Above listed stream objects are decalred in std namesapces in iostream header file.
    - cin (Character Input): Keyboard
    - cout (Character Output): Monitor
    - cerr + clog (Character Error + Chracter Log): Monitor
  - cin, cout, cerr and clog are external objects declared in std namespace. Hence to use it we should use std::cin, std::cout, std::cerr, std::clog.

Character Output(cout)

```
    typedef basic_ostream<char> ostream;
```

- As shown above, ostream is alias / another name given to the basic_ostream class.
- cout is object of ostream class. It is external object declared in std namespace.
- It represents monitor which is used to write data on monitor.
- Example 1:

```
#include<cstdio>
#include<iostream>
int main( void ){
 printf("Hello World\n");
 std::cout << "Hello World\n";
 return 0;
}
```

- "<<" operator is called as insertion operator.
- In C language, escape sequence is a character which is used to format the output.

    - Example: '\n', '\t', '\r' etc.
- In C++ language, manipulator is a function which is used to format the output.
    - Example: endl, setw, fixed,scientific, dec, oct, hex etc.
- Example 2:

```
#include<iostream>
int main( void ){
 std::cout << "Hello World" << std::endl;
 //or
 using namespace std;
 cout << "Hello World" <<endl;
 return 0;
}
```

- Example 3:

```
#include<iostream>
int main( void ){
int num1 = 10;
int num2 = 20;
using namespace std;
cout << num1 << num2 << endl;
return 0;
}
```

- Example 4:

```
#include<iostream>
int main( void ){
 int num1 = 10;
 int num2 = 20;
 using namespace std;
 cout << num1 << endl;
 cout << num2 << endl;
 return 0;
}
```

- Example 5:

```
#include<iostream>
int main( void ){
 int num1 = 10;
 int num2 = 20;
 using namespace std;
 cout << "Num1 : " << num1 << endl;
 cout << "Num2 : " << num2 << endl;
 return 0;
}
```

Character Input(cin)

```
    typedef basic_istream<char> istream;
```

- As shown above, istream is another name given to the basic_istream class.
- cin is object of istream class. It is external object declared in std namespace.
- It represents keyboard which is used to read data from keyboard.
- Example 1:

```
#include<cstdio>
#include<iostream>
int main( void ){
 int num1;
 //In C programming language
 printf("Num1 : ");
 scanf("%d", &num1 );
 //In C++ programming language
 std::cout << "Num1 : ";
 std::cin >> num1;
 return 0;
}
```

- ">>" operator is called as extraction operator.
- Example 2:

```
#include<iostream>
int main( void ){
 int num1;
 std::cout << "Num1 : ";
 std::cin >> num1;
 //or
 using namespace std;
 cout << "Num1 : ";
 cin >> num1;
 return 0;
}
```

- Example 3:

```
#include<iostream>
int main( void ){
 int num1, num2;
 using namespace std;
 cin >> num1 >> num2;
 cout << num1 << num2 << endl;
 return 0;
}
```

- Example 4:

```
#include<iostream>
int main( void ){
 using namespace std;
 int num1;
 cout << "Num1 : ";
 cin >> num1;
 int num2;
 cout << "Num2 : ";
 cin >> num2;
 cout << "Num1 : " << num1 << endl;
 cout << "Num2 : " << num2 << endl;
 return 0;
}
```

Character Error(cerr) and Character Log(clog)

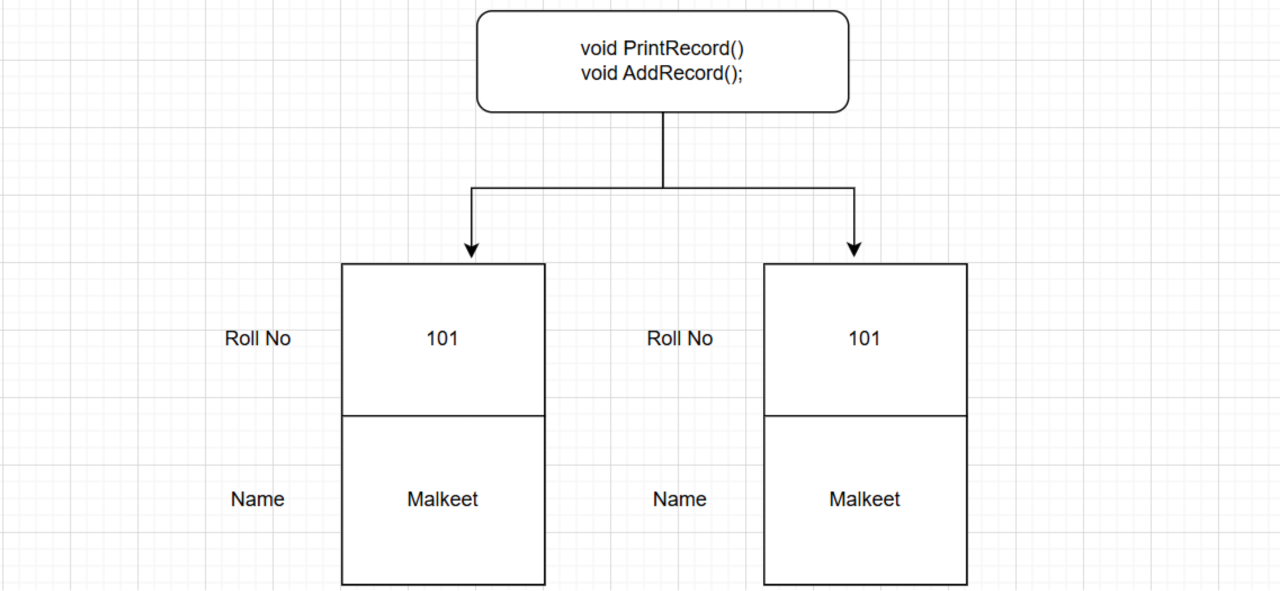
- Consider below program:

```
#include<iostream>
#include<iomanip>
int main( void ){
using namespace std;
int num1;
cout << "Num1 : ";
cin >> num1;
clog << "Numerator is accepted" <<endl;
int num2;
cout << "Num1 : ";
cin >> num2;
clog << "Denominator is accepted" <<endl;
if( num2 == 0 ){
cerr << "Value of denominator is 0" <<endl;
clog << "Can not calculate Result because value of denominator is
0." <<endl;
}else{
int result = num1 / num2;
clog << "Result is calculated" <<endl;
cout<< "Result : "<< result << endl;
clog << "Result is printed" <<endl;
}
```

```
    return 0;
    }
```

Object oriented concepts

- Only data members get space inside object. Member function do not get space inside object.
- Data members of the class get space once per object according their order of declaration inside class.
- Member function do not get space inside object, rather all the objects of same class share single copy of it.



- Size of object depdends on size of all the data members declared inside class.
- Characteristics of Object
    - State:
        - Value stored inside object is called as state of the object.
        - Value of the data member represents state of the object.
    - Behavior
        - Set of operations which are allowed to perform on object is called behavior of the object.
        - Member function defined inside class represents behavior of the object.
    - Idenitity
        - Value of any data member, which is used to identify object uniquely, is called as identity of the object.
        - When state of objects are same then its address can be considered as its identity.
- Lets revise Class & Object
    - Class Definition:
        - Class is collection of data members and member function.
        - Structure and behaviour of the object depends on class. Hence class is considered as a template / model / blueprint for object.
        - Class represents, group of objects which is having common structure and common behavior.
        - Class is an imaginary / logical entity.
        - Example: Book, Laptop, Mobile Phone, Car.
    - Object Definition:
        - Object is instance/variable of a class.

        - An entity which is having physical existance is called as object.
        - An entity, which is having state, behavior and identity is called as object.
        - Object is real time / physical entity.
        - Example: "More Effective C++", "MacBook Air", "iPhone 15", "Skoda Kushaq".

Empty class

- A class which do not contain any member is called as empty class.

```
Consider example:
class Student{
};
```

- Size of the object depends on data members declared inside class.
- According to above definition, size of object of empty class should be zero.
- According to oops concept, class is imaginary/logica term/entity and object is real time / physical term/entity. It means that object must get some space inside memory.
- According to Bjarne Stroustrup, size of object of empty class should be non zero.
- Due to compiler optimization, object of empty class get one byte space.

Function Overloading

- In C programming language, we can not give same name to the multiple functions in same project.
- In C++, we can give same name to the multiple functions.
- If implementation of functions are logically same / equivalent then we should give same name to the function.
- If we want to give same name to the function then we must follow some rules:
- Rule 1:
    - If we want to give same name to the function and if type of all the parameters are same then number of parameters passed to the function must be different.

    ```
    void sum( int num1, int num2 ){
    int result = num1 + num2;
    cout<<"Result : "<<result<<endl;
    }
    void sum( int num1, int num2, int num3 ){
    int result = num1 + num2 + num3;
    cout<<"Result : "<<result<<endl;
    }
    int main( void ){
    sum( 10, 20 );
    sum( 10, 20, 30 );
    return 0;
    }
    ```

- Rule 2:

- If we want to give same name to the function and if number of parameters are same then type of at least one parameter must be different.

```
void sum( int num1, int num2 ){
int result = num1 + num2;
cout<<"Result : "<<result<<endl;
}
void sum( int num1, double num2 ){
double result = num1 + num2 ;
cout<<"Result : "<<result<<endl;
}
int main( void ){
sum( 10, 20 );
sum( 10, 20.5 );
return 0;
}
```

- Rule 3:
  - If we want to give same name to the function and if number of parameters are same then order of type of parameters must be different.

```
void sum( int num1, float num2 ){
float result = num1 + num2;
cout<<"Result : "<<result<<endl;
}
void sum( float num1, int num2 ){
float result = num1 + num2 ;
cout<<"Result : "<<result<<endl;
}
int main( void ){
sum( 10, 20.2f );
sum( 10.1f, 20 );
return 0;
}
```

- Rule 4
  - Only on the basis of different return type, we can not give same name to the function.

```
int sum( int num1, int num2 ){
int result = num1 + num2;
return result;
}
void sum( int num1, int num2 ){ //Error: Function definition is
not allowed
int result = num1 + num2;
}
int main( void ){
```

```
return 0;
}
```

- Definition of Function Overloading
  - When we define multiple functions with the help of above 4 rules then process is called as function overloading.
  - Process of defining functions with same name and different signature is called as function overloading.
  - Functions which take part into overloading are called as overloaded functions.
  - If implementation of functions are logically same / equivalent then we should overload function.
  - In C++ we can overload:
    - global function
    - member function
    - constructor
    - static member function
    - constant member function
    - virtual member function
  - In C++ we can not overload:
    - main function
    - destructor
  - Per project, we can define only one main function. Hence we can not overload main function in C++.
  - Since destructor do not take any parameter, we can not overload destructor.

Why retrun type is not considered in function overloading?

- Since catching value from function is optional, return type is not considered in function overloading.

Name mangling and Mangled name

- nm is a tool which is used to print symbol table. We can used it to see mangled name.
- if we define function in C++, then compiler generate unique name for each function by looking toward name of the function and type of parameter passed to the function. Such name is called as mangled name.

```
void Add(int num1)      //_Z3Addi, Mangled Name
{
    cout<<"Am Sum";
}
void Add(int num1, int num2)    //_Z3Addii
{
    cout<<"Am Sum";
}
void Add(float num1, int num2)  //_Z3Addfi
{
    cout<<"Am Sum";
}
```

```
void Add(int num1, float num2)  //_Z3Addif
{
    cout<<"Am Sum";
}
int main()
{
    return 0;
}
```

- Process or algorithm which generates mangled name is called as name mangling.
- ISO has not defined any specification on mangled name hence it may vary from compiler to compiler

To be discussed tomorrow (13-12-2024)

- default argument
- extern "C"
- enum demo
- Getter and Setter function
- Constructor and its type
- Constructor member initializer list
- Aggregate Type and aggregate initialization
- Array of objects
- Constant variable, data member and member function
- mutable data member.
- Reference
- Call by value vs call by address vs call by reference
- Difference between pointer and reference
- Exception handling in C++