Unit 4

Inheritance:

Reusability is yet another feature of OOP's. C++ strongly supports the concept of reusability. The C++ classes can be used again in several ways. Once a class has been written and tested, it can be adopted by another programmers. This is basically created by defining the new classes, reusing the properties of existing ones. The mechanism of deriving a new class from an old one is called 'INHERTTENCE'. This is often referred to as IS-A' relationship because very object of the class being defined "is" also an object of inherited class. The old class is called 'BASE' class and the new one is called 'DERIEVED' class.

Defining Derived Classes

A derived class is specified by defining its relationship with the base class in addition to its own
details. The general syntax of defining a derived class is as follows:

```
class d_classname : Access specifier baseclass name
{
__
__ // members of derived class
};
```

The colon indicates that the a-class name is derived from the base class name. The access specifier or
the visibility mode is optional and, if present, may be public, private or protected. By default it is
private. Visibility mode describes the status of derived features e.g.

```
class xyz //base class
{
members of xyz
};
class ABC : public xyz //public derivation
{
members of ABC
};
class ABC : XYZ //private derivation (by default)
{
members of ABC
};
```

In the inheritance, some of the base class data elements and member functions are inherited into the derived class. We can add our own data and member functions and thus extend the functionality of the base class. Inheritance, when used to modify and extend the capabilities of the existing classes, becomes a very powerful tool for incremental program development.

Single Inheritance

When a class inherits from a single base class, it is known as single inheritance. Following program shows the single inheritance using public derivation. #include #include class worker

```
{
int age;
char name [10];
public:
void get ( );
};
void worker : : get ( )
{
cout <<”yout name please”
cin >> name;
cout <<”your age please” ;
cin >> age;
}
void worker :: show ( )
{
cout <<”In My name is :”<<name<<”In My age is :”<<age;
}
class manager :: public worker //derived class (publicly)
{
int now;
public:
void get ( ) ;
void show ( ) ;
};
void manager : : get ( )
{
worker : : get ( ) ; //the calling of base class input fn.
cout << “number of workers under you”;
cin >> now;
cin>>name>>age;
} ( if they were public )
void manager :: show ( )
{
worker :: show ( ); //calling of base class o/p fn.
cout <<“in No. of workers under me are: “ << now;
}
main ( )
{
clrscr ( ) ;
worker W1;
manager M1;
M1 .get ( );
M1.show ( ) ;
}
```

If you input the following to this program:

```
Your name please
Aryan
Your age please
27
number of workers under you
30
```
Then the output will be as follows:
```
My name is : Aryan
My age is : 27
No. of workers under me are : 30
```
The following program shows the single inheritance by private derivation.
```
#include<iostream.h>
#include<conio.h>
class worker //Base class declaration
{
int age;
char name [10] ;
public:
void get ( ) ;
void show ( ) ;
};
void worker : : get ( )
{
cout << “your name please” ;
cin >> name;
cout << “your age please”;
cin >>age;
}
void worker : show ( )
{
cout << “in my name is: “ <<name<< “in” << “my age is : “ <<age;
}
class manager : worker //Derived class (privately by default)
{
int now;
public:
void get ( ) ;
void show ( ) ;
};
void manager : : get ( )
{
worker : : get ( ); //calling the get function of base
cout << “number of worker under you”; class which is
cin >> now;
}
void manager : : show ( )
{
```

```
worker : : show ( ) ;
cout << “in no. of worker under me are : “ <<now;
}
main ( )
{
clrscr ( ) ;
worker wl ;
manager ml;
ml.get ( ) ;
ml.show ( );
}
```
The following program shows the single inheritance using protected derivation
```
#include<conio.h>
#include<iostream.h>
class worker //Base class declaration
{ protected:
int age; char name [20];
public:
void get ( );
void show ( );
};
void worker :: get ( )
{
cout >> “your name please”;
cin >> name;
cout << “your age please”;
cin >> age;
}
void worker :: show ( )
{
cout << “in my name is: “ << name << “in my age is “ <<age;
}
class manager:: protected worker // protected inheritance
{
int now;
public:
void get ( );
void show ( ) ;
};
void manager : : get ( )
{
cout << “please enter the name In”;
cin >> name;
cout<< “please enter the age In”; //Directly inputting the data
cin >> age; members of base class
cout << “ please enter the no. of workers under you:”;
cin >> now;
```

```
}
void manager : : show ( )
{
cout « "your name is : "«name«" and age is : "«age;
cout «"In no. of workers under your are : "«now;
main ( )
{
clrscr ( ) ;
manager ml;
ml.get ( ) ;
cout « "\n \n";
ml.show ( );
}
```

Making a Private Member Inheritable

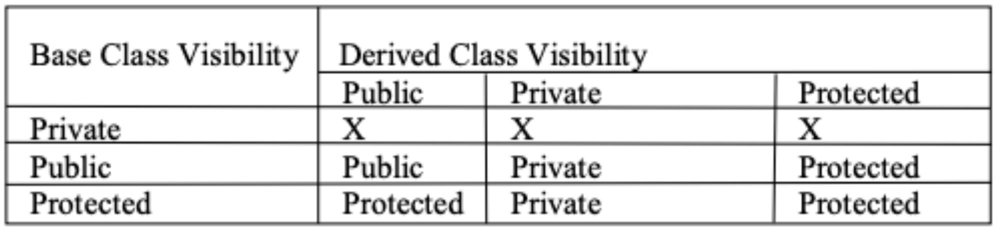
Basically we have visibility modes to specify that in which mode you are deriving the another class from the already existing base class. They are:

a. Private: when a base class is privately inherited by a derived class, 'public members' of the base class become private members of the derived class and therefore the public members of the base class can be accessed by its own objects using the dot operator. The result is that we have no member of base class that is accessible to the objects of the derived class.

b. Public: On the other hand, when the base class is publicly inherited, 'public members' of the base class become 'public members' of derived class and therefore they are accessible to the objects of the derived class.

c. Protected: C++ provides a third visibility modifier, protected, which serve a little purpose in the inheritance. A member declared as protected is accessible by the member functions within its class and any class immediately derived from it. It cannot be accessed by functions outside these two classes.

The below mentioned table summarizes how the visibility of members undergo modifications when they are inherited



Base Class Visibility	Derived Class Visibility		
	Public	Private	Protected
Private	X	X	X
Public	Public	Private	Protected
Protected	Protected	Private	Protected

The private and protected members of a class can be accessed by:

a. A function i.e. friend of a class.

b. A member function of a class that is the friend of the class.

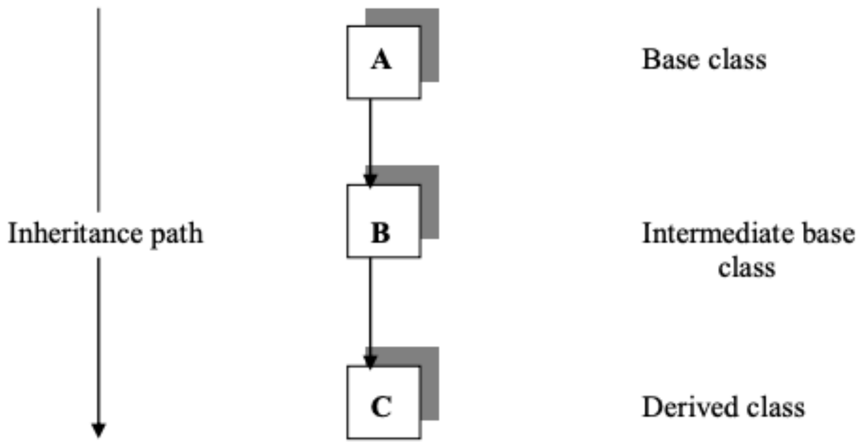
c. A member function of a derived class.

Student Activity

1. Define Inheritance. What is the inheritance mechanism in C++?
2. What are the advantage of Inheritance?
3. What should be the structure of a class when it has to be a base for other classes?

Multilevel Inheritance

When the inheritance is such that, the class A serves as a base class for a derived class B which in turn serves as a base class for the derived class C. This type of inheritance is called 'MULTILEVEL INHERITENCE'. The class B is known as the 'INTERMEDIATE BASE CLASS' since it provides a link for the inheritance between A and C. The chain ABC is called 'ITNHERITENCE*PATH' for e.g.



The declaration for the same would be:

```
Clas
s A
{
//body
}
Class B : public A
{
//body
}
Class C : public B
{
//body
}
```

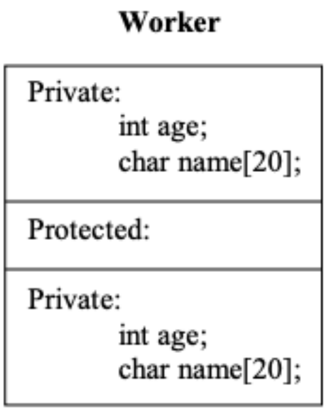
This declaration will form the different levels of inheritance.

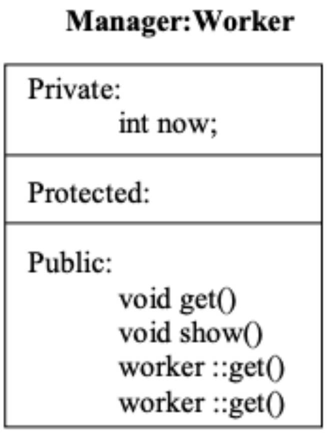
Following program exhibits the multilevel inheritance.

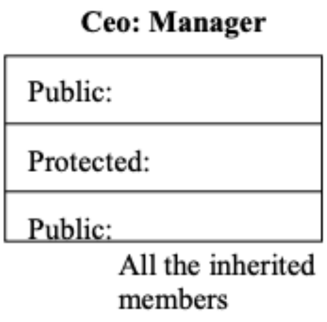
```
#include<iostream.h>
#include<conio.h>
class worker // Base class declaration
{
```

```
int age;
char name [20] ;
public;
void get( ) ;
void show( ) ;
}
void worker: get ( )
{
cout << “your name please” ;
cin >> name;
cout << “your age please” ;
}
void worker : : show ( )
{
cout << “In my name is : “ <<name<< “ In my age is : “ <<age;
}
class manager : public worker //Intermediate base class derived
{ //publicly from the base class
int now;
public:
void get ( ) ;
void show( ) ;
};
void manager :: get ( )
{
worker : :get () ; //calling get ( ) fn. of base class
cout << “no. of workers under you:”;
cin >> now;
}
void manager : : show ( )
{
worker : : show ( ) ; //calling show ( ) fn. of base class
cout << “In no. of workers under me are: “<< now;
}
class ceo: public manager //declaration of derived class
{ //publicly inherited from the
int nom; //intermediate base class
public:
void get ( ) ;
void show ( ) ;
};
void ceo : : get ( )
{
manager : : get ( ) ;
cout << “no. of managers under you are:”; cin >> nom;
}
void manager : : show ( )
```

```
{
cout << "In the no. of managers under me are: In";
cout << "nom;
}
main ( )
{
clrscr ( ) ;
ceo cl ;
cl.get ( ) ; cout << "\n\n";
cl.show ( ) ;
}
```

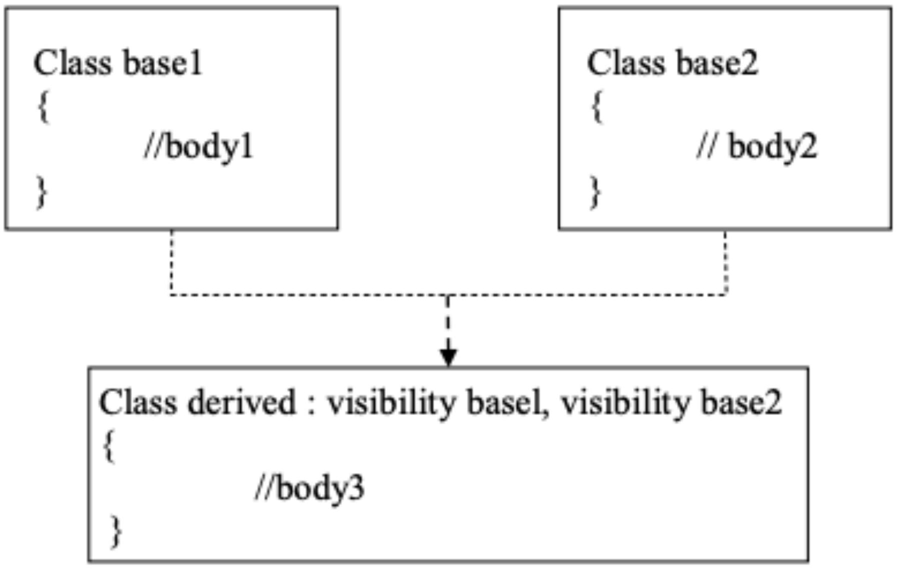






Multiple Inheritance

A class can inherit the attributes of two or more classes. This mechanism is known as 'MULTIPLE INHERITENCE'. Multiple inheritance allows us to combine the features of several existing classes as a starring point for defining new classes. It is like the child inheriting the physical feature of one parent and the intelligence of another. The syntax of the derived class is as follows:

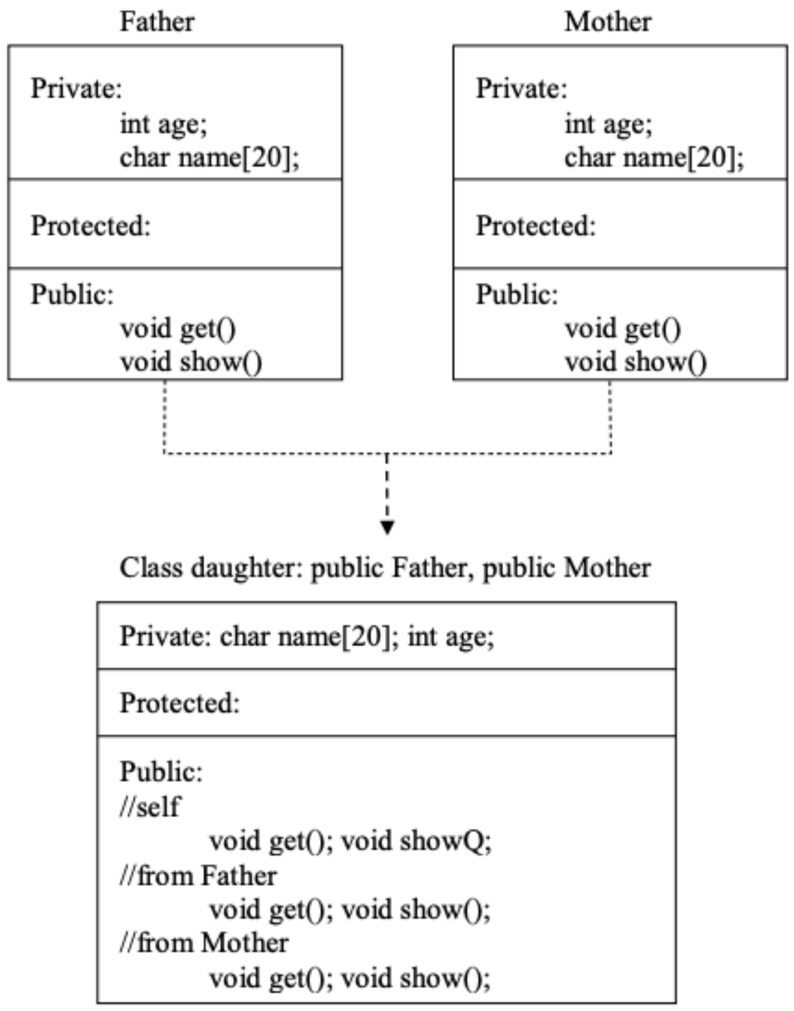


Where the visibility refers to the access specifiers i.e. public, private or protected. Following program shows the multiple inheritance.

```
#include<iostream.h>
#include<conio . h>
class father //Declaration of base classl
{
int age ;
char flame [20] ;
public:
void get ( ) ;
void show ( ) ;
};
void father : : get ( )
{
cout << “your father name please”;
cin >> name;
cout << “Enter the age”;
cin >> age;
}
void father : : show ( )
{
cout<< “In my father’s name is: ‘ <<name<< “In my father’s age is:<<age;
}
class mother //Declaration of base class 2
{
char name [20] ;
int age ;
```

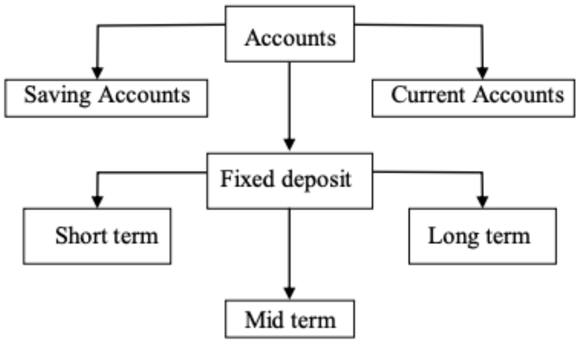
```
public:
void get ( )
{
cout << “mother’s name please” << “In”;
cin >> name;
cout << “mother’s age please” << “in”;
cin >> age;
}
void show ( )
{
cout << “In my mother’s name is: “ <<name;
cout << “In my mother’s age is: “ <<age;
}
class daughter : public father, public mother //derived class inheriting
{ //publicly
char name [20] ; //the features of both the base class
int std;
public:
void get ( ) ;
void show ( ) ;
};
void daughter :: get ( )
{
father :: get ( ) ;
mother :: get ( ) ;
cout << “child's name: “;
cin >> name;
cout << “child's standard”;
cin >> std;
}
void daughter :: show ( )
{
father :: show ( );
nfather :: show ( ) ;
cout << “In child’s name is : “ <<name;
cout << “In child's standard: “ << std;
}
main ( )
{
clrscr ( ) ;
daughter d1;
d1.get ( ) ;
d1.show ( ) ;
}
```

Diagrammatic Representation of Multiple Inheritance is as follows:

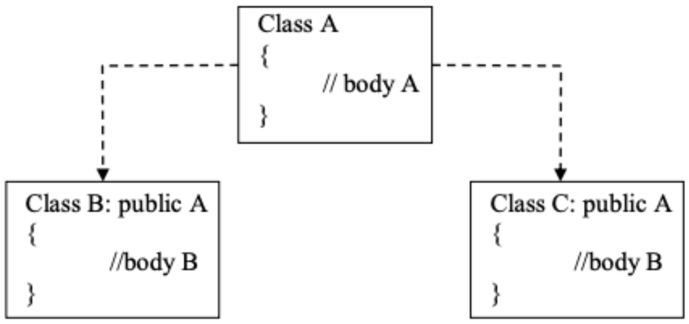


Hierarchical Inheritance

Another interesting application of inheritance is to use is as a support to a hierarchical design of a class program. Many programming problems can be cast into a hierarchy where certain features of one level are shared by many others below that level for e.g.



In general the syntax is given as



In C++, such problems can be easily converted into hierarchies. The base class will include all the features that are common to the subclasses. A sub-class can be constructed by inheriting the features of base class and so on.

```
// Program to show the hierarchical inheritance

#include<iostream.h>
# include<conio. h>
class father //Base class declaration
{
int age;
char name [15];
public:
void get ( )
{
cout<< “father name please”; cin >> name;
cout<< “father’s age please”; cin >> age;
}
void show ( )
{
cout << “In father’s name is ‘: “<<name;
cout << “In father’s age is: “<< age;
}
};
class son : public father //derived class 1
{
char name [20] ;
int age ;
public;
void get ( ) ;
void show ( ) ;
} ;
void son : : get ( )
{
father :: get ( ) ;
cout << "your (son) name please" << "in"; cin >>name;
cout << "your age please" << "ln"; cin>>age;
}
void son :: show ( )
{
father : : show ( ) ;
cout << "In my name is : " <<name;
cout << "In my age is : " <<age;
}
class daughter : public father //derived class 2.
{
char name [15] ;
int age;
public:
void get ( )
{
father : : get ( ) ;
cout << "your (daughter's) name please In" cin>>name;
cout << "your age please In"; cin >>age;
}
void show ( )
{
father : : show ( ) ;
cout << "in my father name is: " << name << "
In and his age is : "<<age;
}
};
main ( )
{
clrscr ( ) ;
son S1;
daughter D1 ;
S1. get ( ) ;
D1. get ( ) ;
S1 .show( ) ;
D1. show ( ) ;
}
```

Hybrid Inheritance

There could be situations where we need to apply two or more types of inheritance to design a program. Basically Hybrid Inheritance is the combination of one or more types of the inheritance.

Here is one implementation of hybrid inheritance.

```
//Program to show the simple hybrid inheritance
#include<iostream. h>
#include<conio . h>
class student //base class declaration
{
protected:
int r_no;
public:
void get _n (int a)
{
r_no =a;
}
void put_n (void)
{
cout << “Roll No. : “<< r_no;
cout << “In”;
}
};
class test : public student
{ //Intermediate base class
protected : int part1, part 2;
public :
void get_m (int x, int y) {
part1= x; part 2 = y; }
void put_m (void) {
cout << “marks obtained: “ << “In”
<< “Part 1 = “ << part1 << “in”
<< “Part 2 = “ << part2 << “In”;
}
};
class sports // base for result
{
protected : int score;
public:
void get_s (int s) {
score = s }
void put_s (void) {
cout << “ sports wt. : “ << score << “\n\n”;
}
};
class result : public test, public sports //Derived from test
```

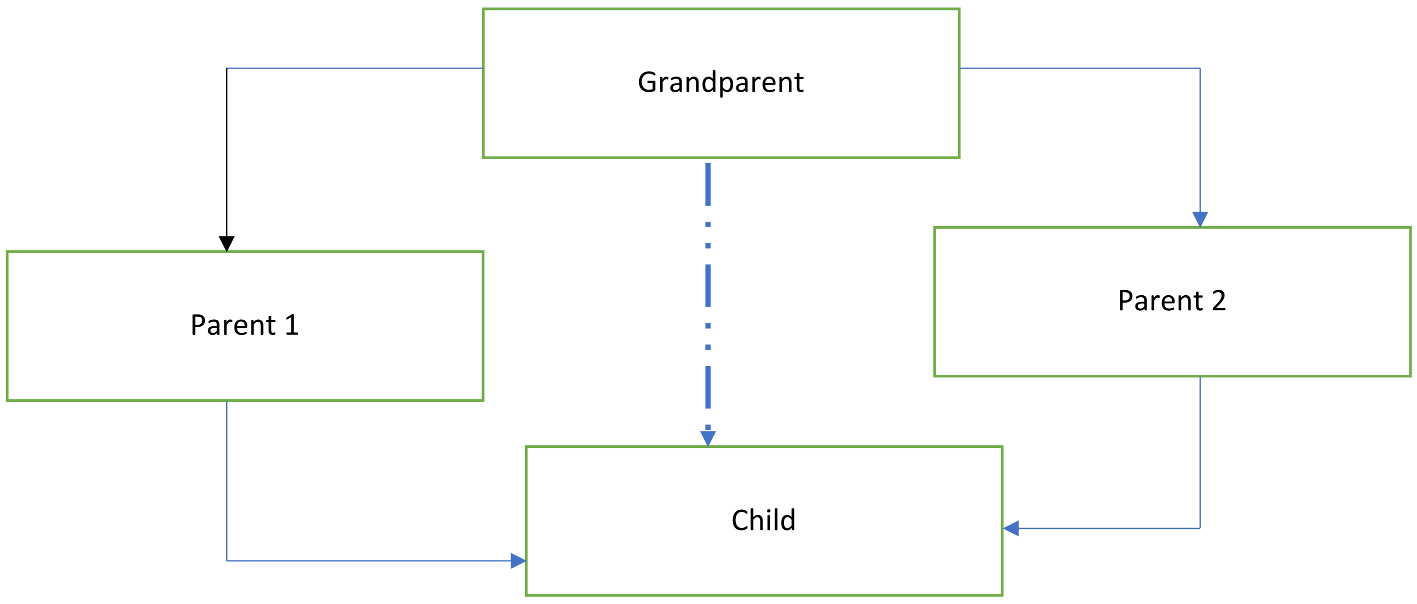
```
& sports
{
int total;
public:
void display (void);
};
void result : : display (void)
{
total = part1 + part2 + score;
put_n ( ) ;.
put_m ( );
put_S ( );
cout << “Total score: “ <<total<< “\n”
}
main ( )
{
clrscr ( ) ;
result S1;
S1.get_n (347) ;
S1.get_m (30, 35);
S1.get_s (7) ;
S1.display ( ) ;
}
```

Student Activity

1. What is the major use of multilevel Inheritance?
2. How are arguments sent to the base constructors in multiple inheritance? Whose responsibility is it.
3. What is the difference between hierarchical and hybrid Inheritance.

Virtual Base Classes

We have just discussed a situation which would require the use of both multiple and multi level inheritance. Consider a situation, where all the three kinds of inheritance, namely multi-level, multiple and hierarchical are involved. Let us say the 'child' has two direct base classes ‘parent1’ and ‘parent2’ which themselves has a common base class ‘grandparent’. The child inherits the traits of ‘grandparent’ via two separate paths. It can also be inherit directly as shown by the broken line. The grandparent is sometimes referred to as ‘INDIRECT BASE CLASS’. Now, the inheritance by the child might cause some problems. All the public and protected members of ‘grandparent’ are inherited into ‘child’ twice, first via ‘parent1’ and again via ‘parent2’. So, there occurs a duplicacy which should be avoided. The duplication of the inherited members can be avoided by making common base class as the virtual base class: for



Multipath Inheritance

e.g.

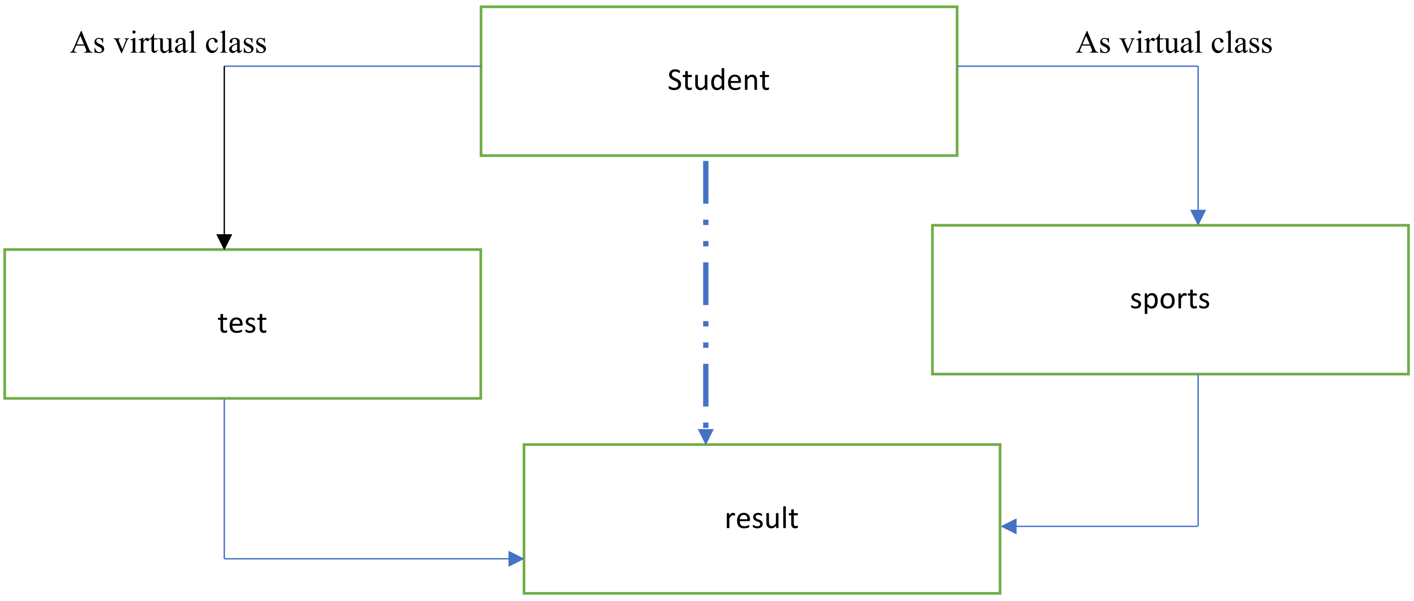
```
class g_parent
{
//Body
};
class parent1: virtual public g_parent
{
// Body
};
class parent2: public virtual g_parent
{
// Body
};
class child : public parent1, public parent2
{
// body
};
```

When a class is virtual base class, C++ takes necessary care to see that only one copy of that class is inherited, regardless of how many inheritance paths exists between virtual base class and derived class. Note that keywords ‘virtual’ and ‘public’ can be used in either order.

```
//Program to show the virtual base class
#include<iostream.h>
#include<conio . h>
class student // Base class declaration
{
```

```
protected:
int r_no;
public:
void get_n (int a)
{ r_no = a; }
void put_n (void)
{ cout << “Roll No. “ << r_no<< “ln”;}
};
class test : virtual public student // Virtually declared common
{ //base class 1
protected:
int part1;
int part2;
public:
void get_m (int x, int y)
{ part1= x; part2=y;}
void putm (void)
{
cout << “marks obtained: “ << “\n”;
cout << “part1 = “ << part1 << “\n”;
cout << “part2 = “<< part2 << “\n”;
}
};
class sports : public virtual student // virtually declared common
{ //base class 2
protected:
int score;
public:
void get_s (int a) {
score = a ;
}
void put_s (void)
{ cout << “sports wt.: “ <<score<< “\n”;}
};
class result: public test, public sports //derived class
{
private : int total ;
public:
void show (void) ;
};
void result : : show (void)
{ total = part1 + part2 + score ;
put_n ( );
put_m ( );
put_s ( ) ; cout << “\n total score= “ <<total<< “\n” ;
}
main ( )
{
clrscr ( ) ;
result S1 ;
```

```
S1.get_n (345)
S1.get_m (30, 35) ;
S1.get-S (7) ;
S1. show ( ) ;
}
```



Virtual Base Class

```
//Program to show hybrid inheritance using virtual base classes
#include<iostream.h>
#include<conio.h>
Class A
{
protected:
int x;
public:
void get (int) ;
void show (void) ;
};
void A : : get (int a)
{ x = a ; }
void A : : show (void)
{ cout << X ;}
Class A1 : Virtual Public A
{
protected:
int y ;
public:
void get (int) ;
void show (void);
};
void A1 :: get (int a)
{ y = a;}
void A1 :: show (void)
{
cout <<y ;
{
class A2 : Virtual public A
{
protected:
int z ;
public:
void get (int a)
{ z =a;}
void show (void)
{ cout << z;}
};
class A12 : public A1, public A2
{
int r, t ;
public:
void get (int a)
{ r = a;}
void show (void)
{ t = x + y + z + r ;
cout << "result =" << t ;
}
};
main ( )
{
clrscr ( ) ;
A12 r ;
r.A : : get (3) ;
r.A1 : : get (4) ;
r.A2 : : get (5) ;
r.get (6) ;
r . show ( ) ;
}
```

Polymorphism:
Polymorphism is one of the crucial features of OOP. It simply means 'one name, multiple forms'. In the functions chapter we have already seen the concept of polymorphism which is implemented using functions overloading, operator overloading. The overloaded member functions are 'selected' for invoking the matching arguments, both type and number. The information is known to the compiler at the compile time and therefore compiler is able to select the appropriate function for a particular call at the compile time. This is called early binding or static binding or static linking or compile time binding. Also known as **compile time polymorphism**. Early binding simply means that an object is bound to its function call at compile time.

Now let us consider a situation where the function name and prototype is the same in both the base and derived classes. For example:

```
class A
{
int x;
public:
 void show(){…..}
};

class B: public A
{
int y;
public:
void show() {….}
};
```

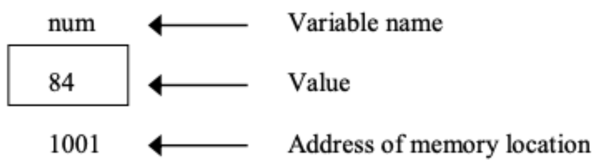
Now the question is how do we use the member function show() to print the values of objects of both the classes A and B?. Since the prototype of show() is the same in both the places, the function is not overloaded and therefore static binding does not apply.

It would be nice if the appropriate member function could be selected while the program is running. This is known as **run time polymorphism. This can be done with a mechanism known as virtual function.**

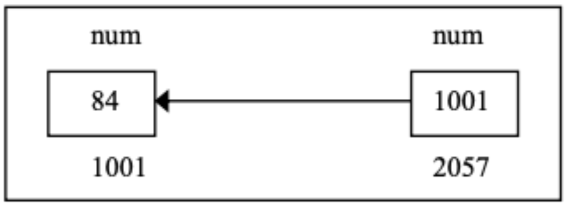
At run time, when it is known what class objects are under consideration, the appropriate version of the function is invoked. Since the function is linked with a particular class much later after compilation, this process is termed as **late binding**. **It is also known as dynamic binding because the selection of the appropriate function is done dynamically at run time.**

Dynamic binding requires the use of pointers to objects.

When an object is created from its class, the member variables and member functions are allocated memory spaces. The memory spaces have unique addresses. Pointer is a mechanism to access these memory locations using their address rather than the name assigned to them. Pointer is a variable which can hold the address of a memory location rather than the value at the location. Consider the following statement int num =84; This statement instructs the compiler to reserve a 2-byte of memory location and puts the value 84 in that location. Assume that the compiler allocates memory location 1001 to num. Diagrammatically, the allocation can be shown as:



As the memory addresses are themselves numbers, they can be assigned to some other variable For example, ptr be the variable to hold the address of variable num. Thus, we can access the value of num by the variable ptr. We can say "ptr points to num" as shown in the figure below.



Pointers to Objects
An object of a class behaves identically as any other variable. Just as pointers can be defined in case of base C++ variables so also pointers can be defined for an object type. To create a pointer variable for the following class

```
class employee {
 int code;
 char name [20] ;
public:
 inline void getdata ( )= 0 ;
 inline void display ( )= 0 ;
};
```

The following codes is written employee *abc; This declaration creates a pointer variable abc that can point to any object of employee type.

this Pointer
C++ uses a unique keyword called "this" to represent an object that invokes a member function. 'this' is a pointer that points to the object for which this function was called. This unique pointer is called and it passes to the member function automatically. The pointer this acts as an implicit argument to all the member function, for e.g.

```
class ABC
{
 int a ;
-----
-----
};
```

The private variable 'a' can be used directly inside a member function, like

```
a=123;
```

We can also use the following statement to do the same job.

```
this → a = 123
```

e.g.

```
class stud
{
int a;
public:
void set (int a)
{
this → a = a; //here this point is used to assign a class level
} 'a' with the argument 'a'
void show ( )
{
cout << a;
}
};
main ( )
{
stud S1, S2;
S1.bet (5) ;
S2.show ( );
}
o/p = 5
```

Pointers to Derived Classes

Polymorphism is also accomplished using pointers in C++. It allows a pointer in a base class to point to either a base class object or to any derived class object. We can have the following Program segment show how we can assign a pointer to point to the object of the derived class.

```
class base
{
//Data Members
//Member Functions
};
class derived : public base
{
//Data Members
//Member functions
};
void main ( ) {
base *ptr; //pointer to class base
derived obj ;
ptr = &obj ; //indirect reference obj to the pointer
//Other Program statements
}
```

The pointer ptr points to an object of the derived class obj. But, a pointer to a derived class object
may not point to a base class object without explicit casting.
For example, the following assignment statements are not valid

```
void main ( )
{
base obja;
derived *ptr;
ptr = &obja; //invalid.... .explicit casting required
//Other Program statements
}
```

A derived class pointer cannot point to base class objects. But, it is possible by using explicit casting.

```
void main ( )
{
base obj ;
derived *ptr; // pointer of the derived class
ptr = (derived *) & obj; //correct reference
//Other Program statements
}
```

Student Activity

1. Define Pointers.
2. What are the various operators of pointer? Describe their usage.
3. How will you declare a pointer in C++?

Virtual Functions

Virtual functions, one of advanced features of OOP is one that does not really exist but it« appears real in some parts of a program. This section deals with the polymorphic features which are incorporated using the virtual functions. The general syntax of the virtual function declaration is:

```
class use_detined_name{
private:
public:
virtual return_type function_name1 (arguments);
virtual return_type function_name2(arguments);
virtual return_type function_name3( arguments);
-----------------
};
```

To make a member function virtual, the keyword virtual is used in the methods while it is declared in
the class definition but not in the member function definition. The keyword virtual precedes the
return type of the function name. The compiler gets information from the keyword virtual that it is a
virtual function and not a conventional function declaration.
For. example, the following declararion of the virtual function is valid.

```
class point {
intx;
inty;
public:
virtual int length ( );
virtual void display ( );
};
```

Remember that the keyword virtual should not be repeated in the definition if the definition occurs
outside the class declaration. The use of a function specifier virtual in the function definition is
invalid.
For example

```
class point {
intx ;
inty ;
public:
virtual void display ( );
};
virtual void point: : display ( ) //error
{
Function Body
}
```
A virtual function cannot be a static member since a virtual member is always a member of a particular object in a class rather than a member of the class as a whole.
```
class point {
int x ;
int y ;
public:
virtual static int length ( ); //error
};
int point: : length ( )
{
Function body
}
```
A virtual function cannot have a constructor member function but it can have the destructor member
function.
```
class point {
int x ;
int y ;
public:
virtual point (int xx, int yy) ; // constructors, error
void display ( ) ;
int length ( ) ;
};
```
A destructor member function does not take any argument and no return type can be specified for it
not even void.
```
class point {
int x ;
int y ;
public:
virtual point (int xx, int yy) ; //invalid
void display ( ) ;
int length ( ) ;
```
It is an error to redefine a virtual method with a change of return data type in the derived class with
the same parameter types as those of a virtuall method in the base class.
```
class base {
int x,y ;
public:
virtual int sum (int xx, int yy ) ; //error
} ;
class derived: public base {
intz ;
```

public:
virtual float sum (int xx, int yy) ;
};
The above declarations of two virtual functions are invalid. Even though these functions take identical arguments note that the return data types are different.
virtual int sum (int xx, int IT) ; //base class
virtual float sum (int xx, int IT) ; //derived class
Both the above functions can be written with int data types in the base class as well as in the derived
class as
virtual int sum (int xx, int yy) ; //base class
virtual int sum (int xx, int yy) ; //derived class
Only a member function of a class can be declared as virtual. A non member function (nonmethod)
of a class cannot be declared virtual.
virtual void display ( ) //error, nonmember function
{
Function body
}

Student Activity

1. What are virtual functions
2. What are pure virtual functions
3. Define Virtual destructors.

Late Binding/Run Time Binding/Dynamic Binding

As we studied in the earlier unit, late binding means selecting functions during the execution
.
Though late binding requires some overhead it provides increased power and flexibility. The late binding is implemented through virtual functions as a result we have to declare an object of a class either as a pointer to a class or a reference to a class.
For example the following shows how a late binding or run time binding can be carried out with the help of a virtual function.

```
class base {
private :
int x;
float y;
public:
virtual void display ( ) ;
int sum ( ) ;
};
class derivedD : public baseA
{
private :
int x ;
float y;
public:
void display ( ); //virtual
int sum ( ) ;
};
void main ( )
{
baseA *ptr ;
derivedD objd ;
ptr = &objd ;
Other Program statements
ptr- >di splay ( ) ; //run time binding
ptr->sum ( ) ; //compile time binding
}
```

Note that the keyword virtual is be followed by the return type of a member function if a run time is to be bound. Otherwise, the compile time binding will be effected as usual. In the above program segment, only the display ( ) function has been declared as virtual in the base class, whereas the sum ( ) is nonvirtual. Even though the message is given from the pointer of the base class to the objects of the derived class, it will not access the sum ( ) function of the derived class as it has been declared as nonvirtual. The sum ( ) function compiles only the static binding. The following program demonstrates the run time binding of the member functions of a class. The same message is given to access the derived class member functions from the array of pointers. As function are declared as virtual, the C++ compiler invokes the dynamic binding.

```
#include <iostream.h>
#include <conio.h>
class baseA {
public :
virtual void display () {
cout<< “One \n”;
}
};
class derivedB : public baseA
{
public:
virtual void display(){
cout<< “Two\n”; }
};
class derivedC: public derivedB
{
public:
virtual void display ( ) {
cout<< “Three \n”; }
};
void main ( ) {
//define three objects
baseA obja;
derivedB objb;
derivedC objc;
base A *ptr [3]; //define an array of pointers to baseA
ptr [0] = &obja;
ptr [1] = &objb;
ptr [2] = &objc;
for ( int i = 0; i <=2; i ++ )
ptr [i]->display ( ); //same message for all objects
getche ( ) ;
}
```

Output

```
One
Two
Three
```

The program listed below illustrates the static binding of the member functions of a class. In program there are two classes student and academic. The class academic is derived from class student. The two member function getdata and display are defined for both the classes. *obj is defined for class student, the address of which is stored in the object of the class academic. The functions getdata ( ) and display ( ) of student class are invoked by the pointer to the class.

```
#include<iostream.h>
#include<conio.h>
class student {
private:
int rollno;
char name [20];
public:
void getdata ( );
void display ( );
};
class academic: public student {
private:
char stream;
public:
void getdata ( );
void display ( ) ;
};
void student:: getdata ( )
{
cout<< “enterrollno\n”;
cin>>rollno;
cout<< “enter name \n”;
cin>>name;
}
void student:: display ( )
```

```
{
cout<< “the student’s roll number is “<<rollno<< “and name is”<<name ;
cout<< endl;
}
void academic :: getdata ( )
{
cout<< “enter stream of a student? \n”;
cin >>stream;
}
void academic :: display ( ) {
cout<< “students stream \n”;
cout <<stream<< endl;
}
void main ( )
{
student *ptr ;
academic obj ;
ptr=&obj;
ptr->getdata ( ) ;
ptr->display ( ) ;
getche ( );
}
```

output

```
enter rollno
25
enter name
raghu
the student’s roll number is 25 and name is raghu
```

The program listed below illustrates the dynamic binding of member functions of a class. In this program there are two classes student and academic. The class academic is derived from student. Student function has two virtual functions getdata ( ) and display (). The pointer for student class is defined and object . for academic class is created. The pointer is assigned the address of the object and function of derived class are invoked by pointer to student.

```
#include <iostream.h>
#include <conio.h>
class student {
private:
introllno;
char name [20];
public:
virtual void getdata ( );
virtual void display ( );
};
class academic: public student {
private :
```

```
char stream[10];
public:
void getdata { };
void display ( ) ;
};
void student: : getdata ( )
{
cout<< “enter rollno\n”;
cin >> rollno;
cout<< “enter name \n”;
cin >>name;
}
void student:: display ( )
{
cout<< “the student’s roll number is”<<rollno<< “and name is”<<name;
cout<< end1;
}
void academic: : getdata ( )
{
cout << “enter stream of a student? \n”;
cin>> stream;
}
void academic:: display ( )
{
cout<< “students stream \n”;
cout<< stream << endl;
}
void main ( )
{
student *ptr ;
academic obj ;
ptr = &obj ;
ptr->getdata ( );
ptr->dlsplay ( );
getch ( );
}
```

output

```
enter stream of a student?
Btech
students stream
Btech
```

Pure Virtual Functions

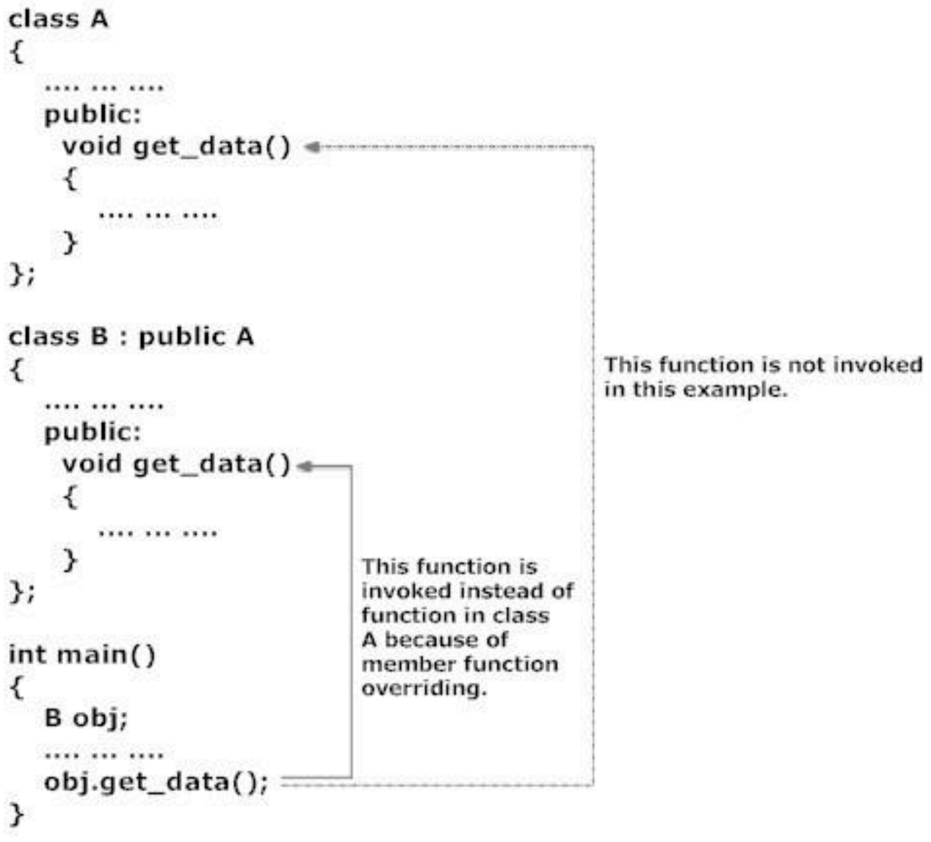
Generally a function is declared virtual inside a base class and we redefine it the derived classes. The function declared in the base class seldom performs any task. The following program demonstrates how a pure virtual function is defined, declared and invoked from the object of a derived class through the pointer of the base class. In the example there are two classes employee and grade. The class employee is base class and the grade is derived class. The functions getdata ( ) and display ( ) are declared for both the classes. For the class employee the functions are defined with empty body or no code inside the function. The code is written for the grade class. The methods of the derived class are invoked by the pointer to the base class.

```
#include<iostream.h>
#include<conio.h>
class employee {
int code
char name [20] ;
public:
virtual void getdata ( ) ;
virtual void display ( ) ;
};
class grade: public employee
{
char grd [90] ;
float salary ;
public :
void getdata ( ) ;
void display ( );
};
void employee :: getdata ( )
{
}
void employee:: display ( )
{
}
void grade : : getdata ( )
{
cout<< " enter employee's grade ";
cin> > grd ;
cout<< "\n enter the salary " ;
cin>> salary;
}
void grade : : display ( )
{
cout«" Grade salary \n";
cout« grd« " "« salary« endl;
}
void main ( )
{
employee *ptr ;
grade obj ;
ptr = &obj ;
ptr->getdata ( ) ;
ptr->display ( ) ;
getche ( ) ;
```

}
Output
enter employee’s grade A
enter the salary 250000
Grade salary
A 250000

C++ Function Overriding

If base class and derived class have member functions with same name and arguments. If you create an object of derived class and write code to access that member function then, the member function in derived class is only invoked, i.e., the member function of derived class overrides the member function of base class. This feature in C++ programming is known as function overriding as shown below:



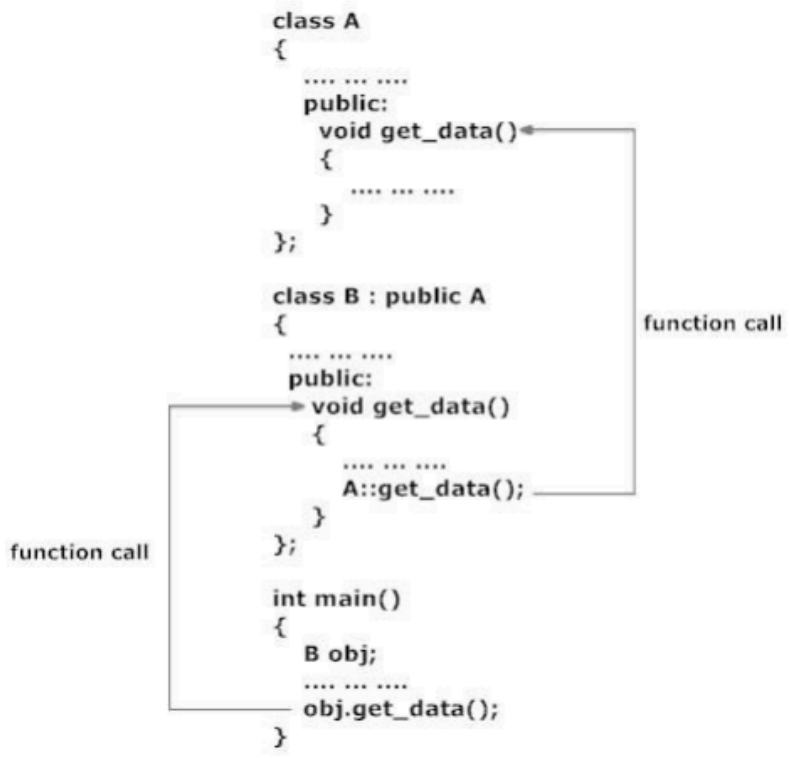
```
class A
{
  .... ... ....
  public:
   void get_data()
   {
     .... ... ....
   }
};

class B : public A
{
  .... ... ....
  public:
   void get_data()
   {
     .... ... ....
   }
};

int main()
{
  B obj;
  .... ... ....
  obj.get_data();
}
```

This function is not invoked in this example.

This function is invoked instead of function in class A because of member function overriding.

Accessing the Overridden Function in Base Class From Derived Class

To access the overridden function of base class from derived class, scope resolution operator ::. For example: If you want to access get_data() function of base class from derived class in above example then, the following statement is used in derived class.
A::get_data; // Calling get_data() of class A.
It is because, if the name of class is not specified, the compiler thinks get_data() function is calling itself.



```
class A
{
   .... ... ....
   public:
     void get_data()
     {
        .... ... ....
     }
};

class B : public A
{
  .... ... ....
  public:
    void get_data()
    {
       .... ... ....
       A::get_data();
    }
};

int main()
{
   B obj;
   .... ... ....
   obj.get_data();
}
```

Abstract Class
Abstract Class is a class which contains atleast one Pure Virtual function in it. Abstract classes are used to provide an Interface for its sub classes. Classes inheriting an Abstract Class must provide definition to the pure virtual function, otherwise they will also become abstract class.
Characteristics of Abstract Class
1. Abstract class cannot be instantiated, but pointers and refrences of Abstract class type can be created.
2. Abstract class can have normal functions and variables along with a pure virtual function.
3. Abstract classes are mainly used for Upcasting, so that its derived classes can use its interface.
4. Classes inheriting an Abstract Class must implement all pure virtual functions, or else they will become Abstract too.

Pure Virtual Functions
Pure virtual Functions are virtual functions with no definition. They start with virtual keyword and ends with = 0. Here is the syntax for a pure virtual function,

virtual void f() = 0;

Example of Abstract Class
class Base //Abstract base class

{

```
public:
virtual void show() = 0; //Pure Virtual Function
};
class Derived:public Base
{
public:
void show()
{ cout << "Implementation of Virtual Function in Derived class"; }
};
int main()
{
Base obj; //Compile Time Error
Base *b;
Derived d;
b = &d;
b->show();
}
```

```
Output : Implementation of Virtual Function in Derived class
```

In the above example Base class is abstract, with pure virtual show() function, hence we cannot create object of base class.

Why can't we create Object of Abstract Class ?

When we create a pure virtual function in Abstract class, we reserve a slot for a function in the VTABLE(studied in last topic), but doesn't put any address in that slot. Hence the VTABLE will be incomplete. As the VTABLE for Abstract class is incomplete, hence the compiler will not let the creation of object for such class and will display an errror message whenever you try to do so.