Static Member function: The member functions of the class can also be made static which are known as static member functions. Some of the features/characteristics of such function are as follows:

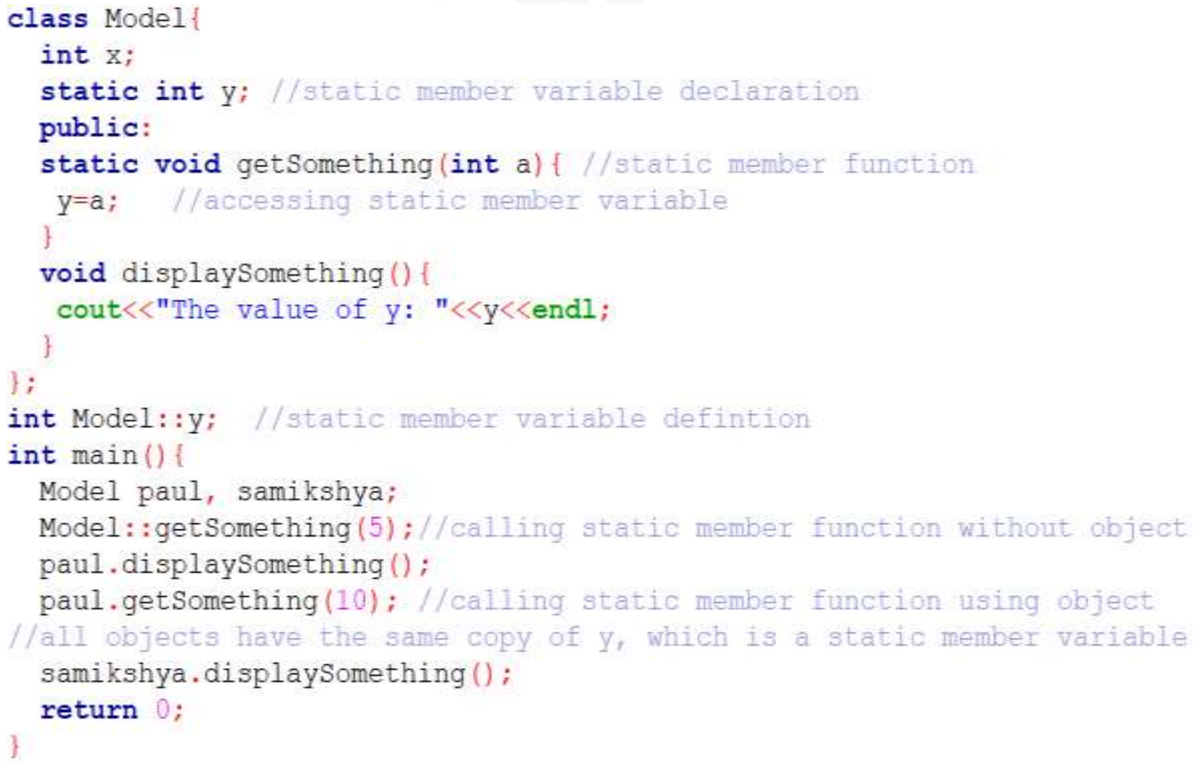
- It is declared with the keyword static.
- It is also known as class member function.
- It can be invoked(called) with or without object
- It can only access static members of the class.

Example:

```
class Student{
      int x;
      static int y;    //static member variable

      static void doSomething( ) {     //static member function
        y=y+10;   //accessing static member variable
        x=x+1;    //error //cannot access other members which are not static
      }
};
```

An example of a use of a static member function is shown below. *[Example program- 2.1]*

Example program- 2.1:



```
class Model{
  int x;
  static int y; //static member variable declaration
  public:
  static void getSomething(int a){ //static member function
   y=a;   //accessing static member variable
  }
  void displaySomething(){
   cout<<"The value of y: "<<y<<endl;
  }
};
int Model::y;  //static member variable defintion
int main(){
  Model paul, samikshya;
  Model::getSomething(5);//calling static member function without object
  paul.displaySomething();
  paul.getSomething(10); //calling static member function using object
//all objects have the same copy of y, which is a static member variable
  samikshya.displaySomething();
  return 0;
}
```

Output: The value of y: 5
The value of y: 10

Explanation: In the above program, getSomething( ) function is declared as static so that it can access only the static data member (y) and cannot access the member x. Now, when this function is called, it can be called directly using class name 'Model' without the need of objects. If this static function modifies any static data member (for e.g. y in above program), all the objects will be sharing the same copy of that data member as shown in above program.

Example program-2.2:
Q. Illustrate an example how the destructor is used to release dynamically allocated memory and avoid memory leakage.

```
class Utech{
 int *p;

 public:
 Utech(){    //Constructor
  p= new int; //Allocating memory dynamically
  cout<<"Memory allocated dynamically."<<endl;
 }

 ~Utech(){   //Destructor
   delete p;     //Releasing memory pointed by 'p'
   cout<<"Memory is released."<<endl;
  }
};

int main()
{
  Utech u1;
  return 0;
}
```

Output: Memory allocated dynamically.
Memory is released.

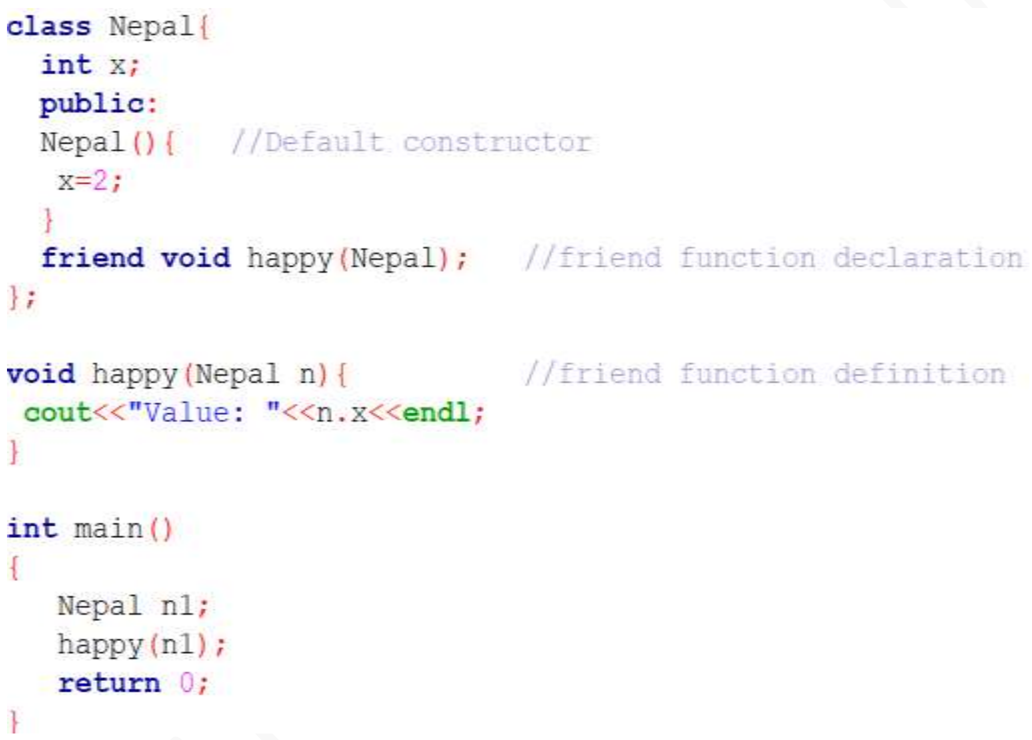
Explanation: In the above program, when an object 'u1' is created, a constructor is called automatically that allocates a memory dynamically for storing an integer. The memory address is stored in the pointer variable 'p'. And before the object goes out of scope, a destructor is called automatically that deletes the pointer 'p'. By deleting the pointer 'p', the memory pointed by it is released, and thus avoids memory leakage.

friend function: It is a special function that can access any members of the class to which it is declared as a friend.

- It is declared in the class with 'friend' keyword.
- It is not a member function of the class to which it is a friend.
- It must be defined outside the class.
- It cannot directly access the members of the class.
- It uses objects to access the members of the class.

An example of a use of a friend function is given below. *[Example program 2.3]*

Example program- 2.3:



```
class Nepal{
  int x;
  public:
  Nepal(){    //Default constructor
   x=2;
  }
  friend void happy(Nepal);   //friend function declaration
};

void happy(Nepal n){          //friend function definition
 cout<<"Value: "<<n.x<<endl;
}

int main()
{
   Nepal n1;
   happy(n1);
   return 0;
}
```

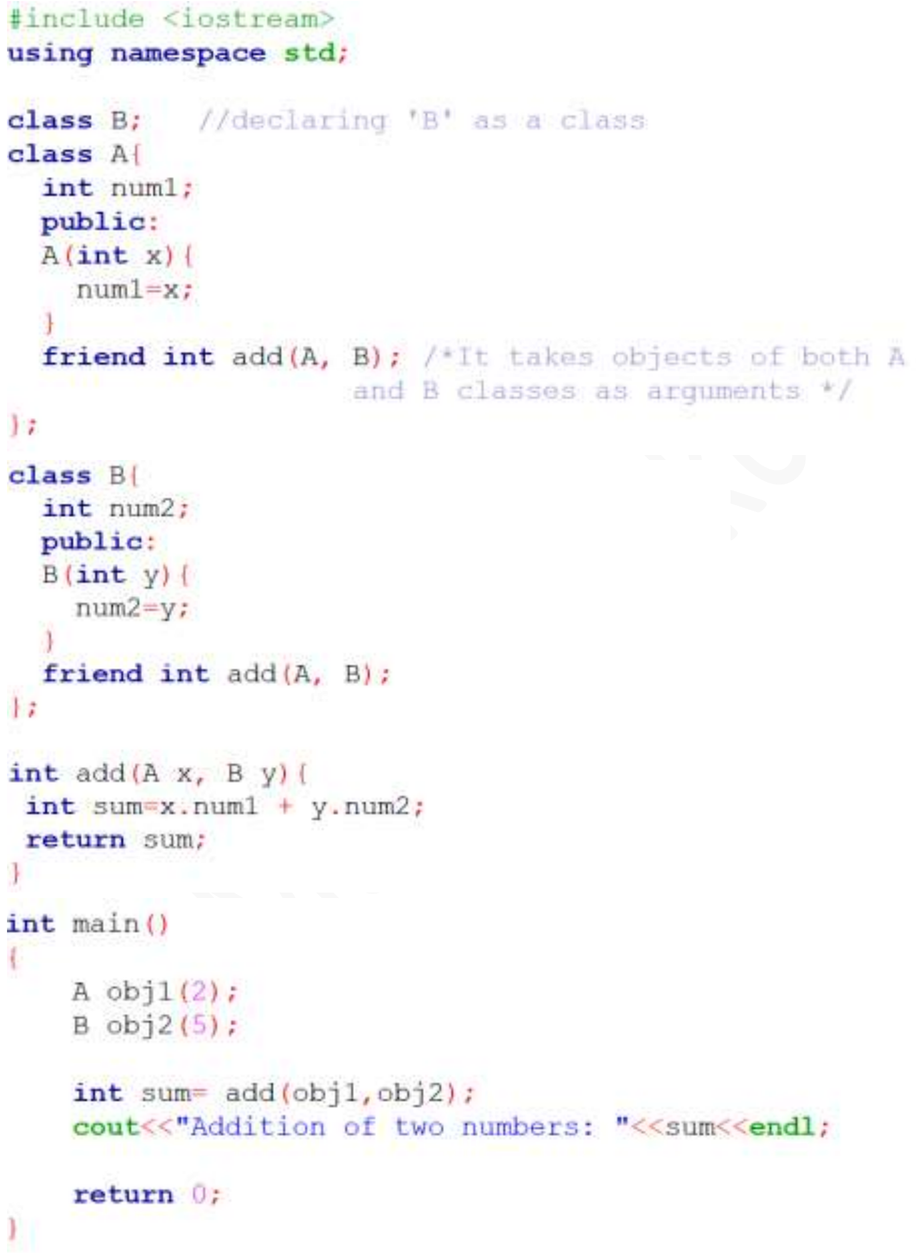
Output: Value: 2

Explanation of the program: An outsider function 'happy( )' which is not a member of the class 'Nepal' is declared as a friend inside the class 'Nepal'. So, now the 'happy( )' function can access the data member of that class (in this case x).
In the above program, object 'n1' is passed as argument in the happy( ) function. And the function uses this object to access its member 'x'.

Use cases of friend function:

- It can become friend to more than one class. So, a friend function can be used to access the data members of more than one class at the same time.
- It can be used to overload the operators.

Example program- 2.4: Write a program to add any two private numbers of two different classes using friend function.



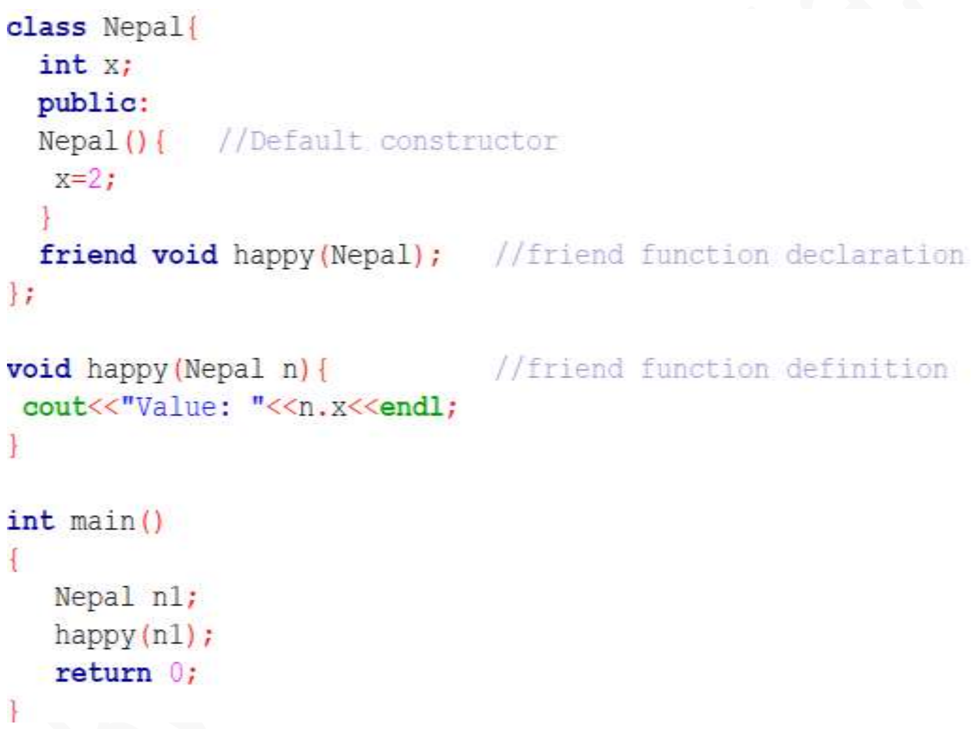
```
#include <iostream>
using namespace std;

class B;    //declaring 'B' as a class
class A{
  int num1;
  public:
  A(int x){
    num1=x;
  }
  friend int add(A, B); /*It takes objects of both A
                          and B classes as arguments */
};

class B{
  int num2;
  public:
  B(int y){
    num2=y;
  }
  friend int add(A, B);
};

int add(A x, B y){
 int sum=x.num1 + y.num2;
 return sum;
}

int main()
{
    A obj1(2);
    B obj2(5);

    int sum= add(obj1,obj2);
    cout<<"Addition of two numbers: "<<sum<<endl;

    return 0;
}
```

Output: Addition of two numbers: 7

Q. The concept of friend function is against the philosophy of OOP. Justify it.
Answer: One of the important characteristics of OOP is data encapsulation. That means, the data and functions are wrapped into a single unit. The data are kept private and are not accessible to the outside world. These data are accessed by only the member functions that are present in the same unit (i.e. in the same class). This process is also known as data hiding as the data are hidden from outside.

But, there is a special function known as friend function which violates the above principle of data hiding. If any non-member function is declared as a friend inside a class, then such function can access all the private data members of the class.

It can be demonstrated by the following program example.



```
class Nepal{
  int x;
  public:
  Nepal(){   //Default constructor
   x=2;
  }
  friend void happy(Nepal);   //friend function declaration
};

void happy(Nepal n){           //friend function definition
 cout<<"Value: "<<n.x<<endl;
}

int main()
{
   Nepal n1;
   happy(n1);
   return 0;
}
```

Output: Value: 2

In above program, 'x' is a private data member of class 'Nepal'. A non-member function happy( ) is declared as a 'friend' inside the same class. This function then accesses the private data member 'x' using the object of class 'Nepal'. Here, the principle of data hiding and encapsulation is violated. Therefore, the concept of friend function is against the philosophy of OOP.

Inheritance: It is a process of inheriting the properties and behaviors of existing class into a new class. The existing class is known as the parent class or base class or super class. The new class is known as the child class or derived class or sub class. The derived class inherits the features (data and member functions) from the base class, and can have additional features of its own.

Syntax:
```
class Base_class
{
   // data members and member functions
};
class Derived_class : visibility_mode  Base_class
{
  // data members and member functions
};
```
- ❖ The colon (:) indicates that the Derived_class is derived from the Base_class. The visibility_mode could be public, private or protected. The default visibility mode (if not stated) is private.

Example:
```
class Person
{
   // data members and member functions
};
class Student : public  Person
{
  // data members and member functions
};
```

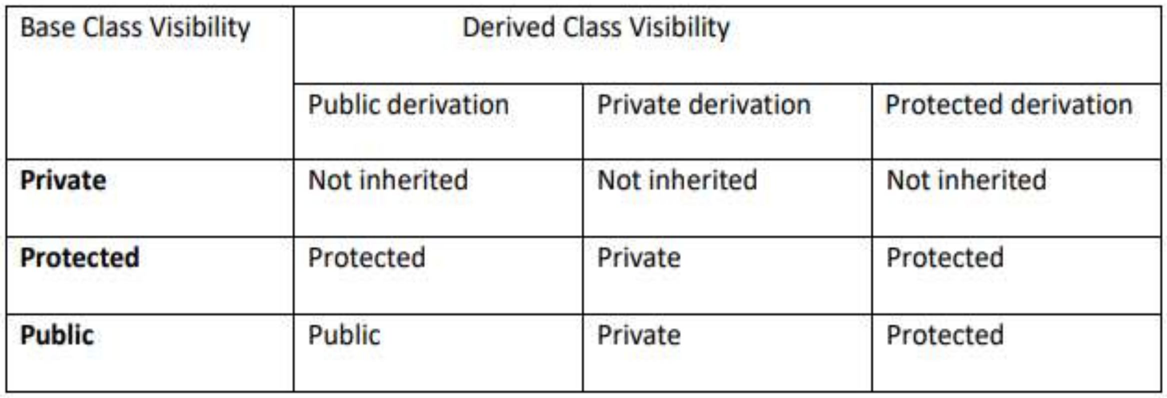
Visibility modes in inheritance: These modes specify how the features of the base class are derived to the base class. It controls the accessibility of the private, protected and public members of the base class while deriving on the base class. The visibility modes could be private, protected or public.

a) Public: If the visibility mode is public, the members in the derived class remain as it is as that of base class. That means, public members of the base class remain public in the derived class and the protected members of the base class remain protected in the derived class.
b) Protected: If the visibility mode is protected, the public and the protected members of the base class become protected in the derived class.

c) Private: If the visibility mode is private, the protected and the public members of the base class become private in the derived class.

Note: Private members of the base class are not accessible to the derived class.

Summary Table:



Base Class Visibility	Derived Class Visibility		
	Public derivation	Private derivation	Protected derivation
Private	Not inherited	Not inherited	Not inherited
Protected	Protected	Private	Protected
Public	Public	Private	Protected

Example:

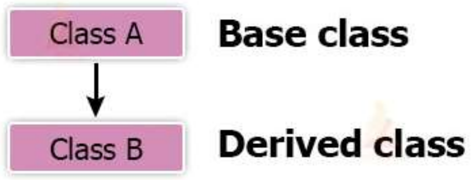
```
class Nepal {
   private:
     int a;
   protected:
     int b;
   public:
     int c;
};
class DSirCafe : private Nepal {
   //a is not accessible
   //b is private
   //c is private
};
class NS_Hospital : protected Nepal {
   //a is not accessible
   //b is protected
   //c is protected
};
class NTC : public Nepal {
   //a is not accessible
   //b is protected
   //c is public
};
```

Types of inheritance: According to the level and nature of function or data sharing, inheritance is classified into following types:

1. Single inheritance
2. Multiple inheritance
3. Multi-level inheritance
4. Hierarchical inheritance
5. Hybrid inheritance

1. Single inheritance: It is the type of inheritance in which one derived class is inherited from the only one base class.

- All the other types of inheritances are based on single inheritance.

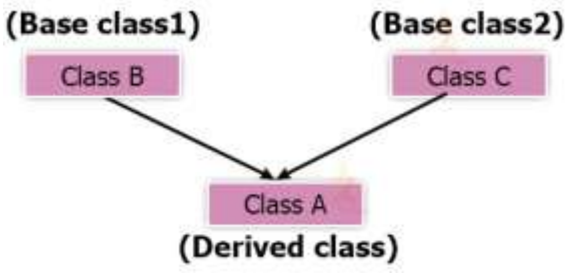


General form:

```
class Base_class
{
   // body of Base_class
};
class Derived_class : visibility_mode  Base_class
{
  // body of Derived_class
};
```

An example of a single inheritance is shown below. *[Example program: 2.5]*

2. Multiple inheritance: It is the type of inheritance in which one derived class inherits its features from two or more than two base classes. The derived class will share the features from the base classes as per its need.



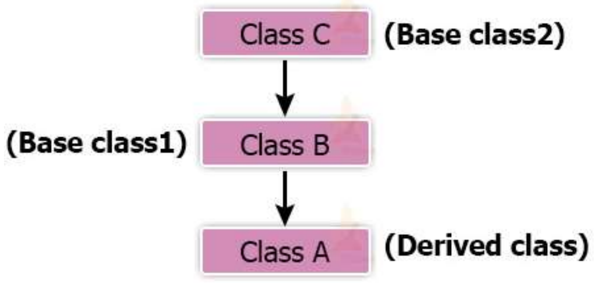
General form:

```
class Base_class1
{
   // body of Base_class1
};
```

```
class Base_class2
{
   // body of Base_class2
};
class Derived_class : visibility_mode  Base_class1, visibility_mode Base_class2
{
  // body of Derived_class
};
```

An example of a multiple inheritance is shown below. *[Example program: 2.7]*

3. Multi-level inheritance: When one class inherits another class which is further inherited by another by another class, it is called multi-level inheritance. That means, in this type of inheritance, one derived class inherits from another derived class.

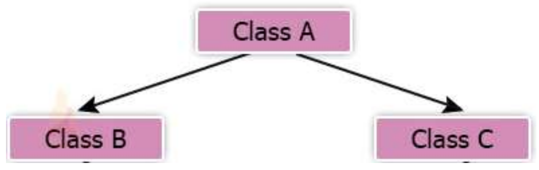


General form:

```
class Base_class2
{
   // body of Base_class2
};
class Base_class1 : visibility_mode Base_class2
{
   // body of Base_class1
};
class Derived_class : visibility_mode  Base_class1
{
  // body of Derived_class
};
```

An example of a multi-level inheritance is shown below. *[Example program: 2.8]*

4. Hierarchical inheritance: When more than one class is inherited from a single base class, it is called hierarchical inheritance. The derived classes will share the features from the base class as per their need.

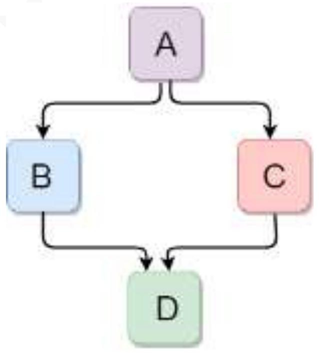


General form:

```
class A
{
   // body of class A
};
class B : visibility_mode A
{
   // body of class B
};
class C : visibility_mode A
{
  // body of class C
};
```

An example of a hierarchical inheritance is shown below.*[Example program: 2.9]*

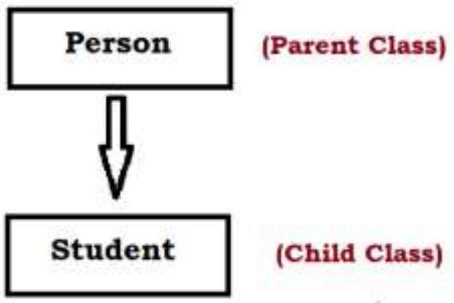
5. Hybrid inheritance: When two or more than two types of inheritances are combined, it is known as hybrid inheritance. It could be the combination of multiple and multi-level, multiple and hierarchical, multi-level and hierarchical or any other combinations of inheritance. An example of a hybrid inheritance is shown in figure, which is a combination of hierarchical & multiple inheritance.



General form:

```
class A
{
   // body of class A
};
class B : visibility_mode A
{
   // body of class B
};
class C : visibility_mode A
{
  // body of class C
};
class D: visibility_mode B, visibility_mode C
{
  // body of class D
};
```

Example program: 2.5 (Single Inheritance)



```
class Person{
  string name;
  public:
      void getData(string s){
        name=s;
      }
      void display1(){
       cout<<"Name: "<<name<<endl;
      }
};
class Student: public Person{
  int roll;
  public:
      void getInfo(string s, int i){
        getData(s);
        roll=i;
      }
      void display2(){
       display1();
       cout<<"Roll: "<<roll<<endl;
      }
};
int main(){
  Student s;
  s.getInfo("Sudeep", 15);
  s.display2();
  return 0;
}
```

Output:

```
Name: Sudeep
Roll: 15
```

Note: If the parent and the child class have the member functions with same name, then the member function of the parent class is called as follows:

Parent_class_name :: function_name( );

It can be illustrated with the following program example. *[Example Program: 2.6]*

Example Program: 2.6

```
class Person{
  string name;
  public:
      void getData(string s){
        name=s;
      }
      void display(){
       cout<<"Name: "<<name<<endl;
      }
};
class Student: public Person{
  int roll;
  public:
      void getData(string s, int i){
        Person::getData(s);
        roll=i;
      }
      void display(){
       Person::display();
       cout<<"Roll: "<<roll<<endl;
      }
};
int main(){
  Student s;
  s.getData("Sudeep", 15);
  s.display();
  return 0;
}
```

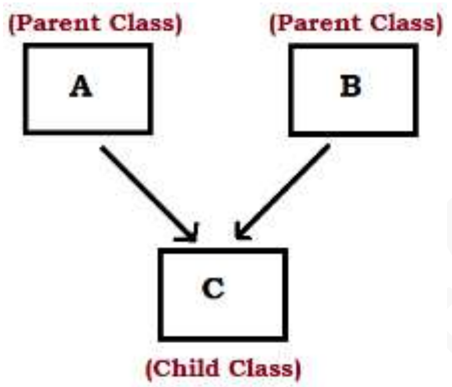
Output:

```
Name: Sudeep
Roll: 15
```

Explanation: In the above program, both the parent class 'Person' and child class 'Student' have the same member functions 'getData( )' and 'display( )'. So, when the member functions of parent class are called from child class, the name of parent class followed by the scope resolution operator (::) is needed before the function call as given below.

```
Person::getData( );
Person::display( );
```

Example program: 2.7 (Multiple Inheritance)

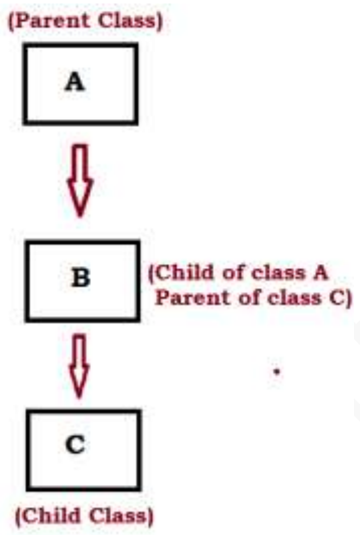


```
class A{
  int num1;
  public:
      void getData1(int n){
        num1=n;
      }
      void display1(){
       cout<<"Num1: "<<num1<<endl;
      }
};
class B{
  int num2;
  public:
      void getData2(int n){
        num2=n;
      }
      void display2(){
       cout<<"Num2: "<<num2<<endl;
      }
};
class C: public A, public B{
  int num3;
  public:
      void getData3(int n1, int n2, int n3){
        getData1(n1);
        getData2(n2);
        num3=n3;
      }
      void display3(){
        display1();
        display2();
        cout<<"Num3: "<<num3<<endl;
      }
};
int main(){
  C obj;
  obj.getData3(2,4,6);
  obj.display3();
  return 0;
}
```

Output:

```
Num1: 2
Num2: 4
Num3: 6
```

Example Program: 2.8 (Multi-level Inheritance)

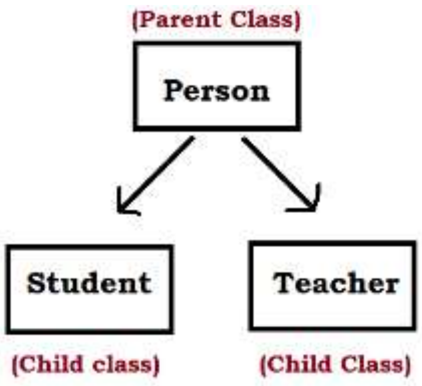


```
class A{
  int num1;
  public:
      void getData1(int n){
        num1=n;
      }
      void display1(){
       cout<<"Num1: "<<num1<<endl;
      }
};
class B: public A{
  int num2;
  public:
      void getData2(int n1, int n2){
        getData1(n1);
        num2=n2;
      }
      void display2(){
       display1();
       cout<<"Num2: "<<num2<<endl;
      }
};
class C: public B{
  int num3;
  public:
      void getData3(int n1, int n2, int n3){
        getData2(n1,n2);
        num3=n3;
      }
      void display3(){
        display2();
        cout<<"Num3: "<<num3<<endl;
      }
};
int main(){
  C obj;
  obj.getData3(2,4,6);
  obj.display3();
  return 0;
}
```

Output:

```
Num1: 2
Num2: 4
Num3: 6
```

Example Program: 2.9 (Hierarchical Inheritance)



```
class Person{
  string name;
  public:
      void getData1(){
        cout<<"Enter name: "<<endl;
        cin>>name;
      }
      void display1(){
       cout<<"Student's Name: "<<name<<endl;
      }
};
class Student: public Person{
  int roll;
  public:
      void getData2(){
        getData1();
        cout<<"Enter roll: "<<endl;
        cin>>roll;
      }
      void display2(){
       display1();
       cout<<"Roll: "<<roll<<endl;
      }
};
class Teacher: public Person{
  string subject;
  public:
      void getData3(){
         getData1();
         cout<<"Enter subject: "<<endl;
         cin>>subject;
      }
      void display3(){
        display1();
        cout<<"Subject: "<<subject<<endl;
      }
};
int main(){
  Student s;
  Teacher t;

  s.getData2();
  t.getData3();

  cout<<"Displaying Student's info"<<endl;
  s.display2();

  cout<<"Displaying Teacher's info"<<endl;
  t.display3();

  return 0;
}
```

Output:
Enter name:
Suman (entered by user)
Enter roll:
12 (entered by user)
Enter name:
Manoz (entered by user)
Enter subject:
C++ (entered by user)
Displaying Student's info..
Student's Name: Suman
Roll: 12
Displaying Teacher's info..
Student's Name: Manoz
Subject: C++

Function overriding: Functions overriding is a feature that allows us to use a function in the derived class that is already present in its base class. If a derived class has a member function with the same name and signature as in the base class, then it is known as function overriding. This feature allows us to override any functionality of the base class in the derived class.

Function overriding allows us to create a newer version of the base class function in the derived class. If we call the overridden function using the object of the derived class, the function of the derived class is executed.

An example of a use of function overriding is shown below. *[Example program: 2.10]*

Example program: 2.10
```
class A{
   public:
     void fun(){
       cout<<"Fun from class A."<<endl;
     }
};

class B : public A{
   public:
     void fun(){ //function overriding
       cout<<"Fun from class B."<<endl;
     }
};

int main()
{
  B obj;
  obj.fun(); //calls fun() from class B due to function overriding
  return 0;
}
```
Output: Fun from class B.

Explanation: In the above program, the base class A and the derived class B have the same function fun( ) with same name and signature. Now, when this function is called from the derived object, the fun( ) in the derived class is executed as it overrides the same in base class.

Ambiguity in multiple inheritance: One of the common errors that might occur during multiple inheritance is the ambiguity error. It arises during function overriding in multiple inheritance. For example, two base classes have a same function which is not overridden in derived class. And if we try to call the function using the object of the derived class, the compiler won't be able to know which function to call and shows error due to ambiguity.

An example that shows ambiguity in multiple inheritance is given below. *[Example program: 2.11]*

Example program: 2.11

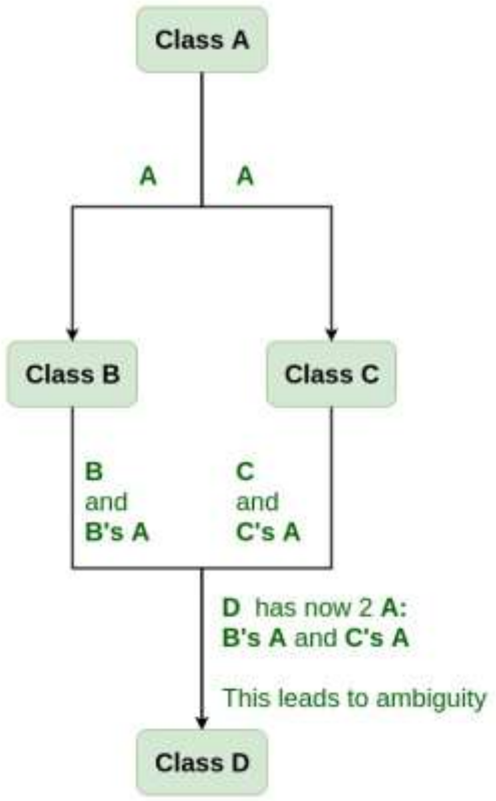
```
class Russia{
  public:
    void acceptWar(){
     cout<<"Hey! you can't join alliance with NATO."<<endl;
    }
};
class Ukraine{
  public:
   void acceptWar(){
    cout<<"Sorry! I don't like you. I prefer to join them."<<endl;
   }
};
class World: public Russia, public Ukraine{
  public:
    void stopWar(){
     cout<<"Hey please! Stop war."<<endl;
    }
};
int main(){
  World w;
  w.acceptWar();     //Error due to ambiguity
  return 0;
}
```

Explanation: In the above program, the two base classes 'Russia' and 'Ukraine' have same function acceptWar( ), and is absent (is not overridden) in derived class 'World'. If this function is called by creating an object of derived class 'World', then the compiler gets confused which function of the base class to call. This is the ambiguity problem.

Solution to the ambiguity problem:
The problem can be solved by using the scope resolution operator to specify which function of the base class is being called. In the above example, ambiguity problem can be solved by writing the following code.

```
int main(){
  World w;
  w.Russia::acceptWar();   //solves the problem of ambiguity
  w.Ukraine::acceptWar();  //solves the problem of ambiguity
  return 0;
}
```

Ambiguity in hybrid inheritance: Let us consider a following situation in hybrid inheritance.



Here, both the class B and class C are inheriting the features from class A. They both have the single copy of class A. Both these classes are inherited further into another class D. So, the features from class A are inherited twice to class D. The class D will have two copies of A, one from class B and another from class C. Now, if any member of class A is accessed by an object of class D, the compiler gets confused which path should it follow either from B, or from C and hence displays error. This is the ambiguity problem resulting in hybrid inheritance.

An example of hybrid inheritance that results into ambiguity error is given below. *[Example program: 2.12]*

Example program: 2.12

```
class A{
   public:
     void fun(){
       cout<<"Fun from class A."<<endl;
     }
};
class B : public A{

};
class C : public A{

};
class D: public B, public C{

};
int main()
{
  D obj;
  obj.fun(); /** It results ambiguity error **/
  return 0;
}
```

Solution to the ambiguity problem:
The problem can be solved by using a **virtual base class**. Virtual base class prevents multiple copies of a given class appearing in an inheritance hierarchy when using multiple inheritances. That means, only one copy of the base class is inherited to its derived classes.

This is obtained by declaring the base class as a virtual class during inheritance. It is specified by placing a 'virtual' keyword in the base class. In the above example, a base class could be declared as virtual as shown below.

```
class A {

};
class B: virtual public A {

};
class C: virtual public A {

};
class D: public B, public C {

};
```

A use of virtual base class that solves the ambiguity problem occurred in program 2.12 is shown below.

```
class A{
   public:
     void fun(){
       cout<<"Fun from class A."<<endl;
     }
};
//Making base class virtual solves the ambiguity problem
class B : virtual public A{

};
class C : virtual public A{

};
class D: public B, public C{

};
int main()
{
  D obj;
  obj.fun();
  return 0;
}
```

Output: Fun from class A.

Constructors in inheritance: When an object of a derived class is created, the default constructor of the derived class will be invoked. But before the execution of the constructor of the derived class, the default constructor of all the base classes will be invoked and executed implicitly (automatically). Therefore in this process, the order of execution is the constructor of the base class at first and then the derived class.

If the base class has parameterized constructors, then they should be explicitly called from the constructor of the derived class using the following syntax:
 Derived_class_constructor : Base_class_constructor(arguments)

An example that demonstrates the order of execution of constructors in base and derived class is as follows: *[Example program: 2.13]*

Example program: 2.13

```
class Russia{
  public:
    Russia(){
     cout<<"I am constructor of Russia."<<endl;
    }
};
class Ukraine: public Russia{
  public:
   Ukraine(){
    cout<<"I am constructor of Ukraine"<<endl;
   }
};
int main(){
  Ukraine u;
  return 0;
}
```

Output: I am constructor of Russia.

```
I am constructor of Russia.
I am constructor of Ukraine.
```

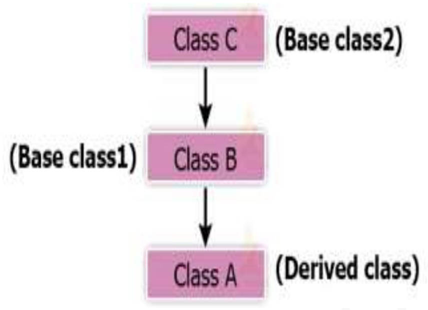
Explanation: When an object of derived class Ukraine is created, both the constructors of the base class and the derived class are executed automatically. At first, the constructor of the base class Russia is executed and then the constructor of the derived class Ukraine. An example that demonstrates the case of base class having parameterized constructor is shown below. *[Example program: 2.14]*

Example program: 2.14

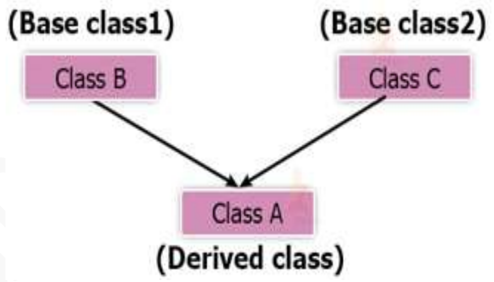
```
class Russia{
  int a;
  public:
  Russia(int y){
   a=y;
   cout<<"Russian constructor, Value: "<<a<<endl;
  }
};
class Ukraine: public Russia{
  int b;
  public:
  Ukraine(int x, int y): Russia(y){
   b=x;
   cout<<"Ukrainian constructor, Value: "<<b<<endl;
  }
};
int main(){
  Ukraine u(20,70);
  return 0;
}
```

```
Output: Russian constructor, Value:  70
        Ukrainian constructor, Value:  20
```

Order of execution of constructors in inheritance: For the multi-level inheritance as shown below, the constructor of class C is executed first, then the constructor of class B and finally of the class A. The order of execution is from the highest level base class to the other subsequent classes.



For the multiple-inheritance, the constructors of the base class are executed in the order of inheritance in which they are coded. That means, for the inheritance as coded below, the constructor of the class B is executed at first, then the constructor of class C, and finally of the derived class A.



Order of Inheritance:

```
Class A: public B, public C
{
   //body of class A
};
```

Destructors in inheritance:

Destructors are executed in the opposite order of that of constructors. That means, the constructor of the derived class is executed at first and then the constructors of its base classes in order.

An example that demonstrates the order of execution of destructors in base and derived class is as follows: [Example program: 2.15]

Example program: 2.15
```
class Russia{
   public:
  ~Russia(){
    cout<<"I am destructor from Russia."<<endl;
   }
};
class Ukraine: public Russia{
   public:
  ~Ukraine(){
    cout<<"I am destructor from Ukraine."<<endl;
   }
};
```
Output: I am destructor from Ukraine.
I am destructor from Russia.

Few Program Tasks:

Example program: 2.16 Create a class called Person with suitable data members to represent their name and age. Use member functions to initialize and display this information. Derive Student and Employee from the Person class with their unique features. Initialize objects of these classes using constructor and display the information.

Solution:
```
#include <iostream>
using namespace std;

class Person
{
    string name;
    int age;
    public:
    void getData(string n, int a){
        name=n;
        age=a;
    }
    void displayData(){
        cout<<"Name: "<<name<<endl;
        cout<<"Age: "<<age<<endl;
    }
};
```

```
class Student: public Person
{
    int rollNos;
    public:
    Student(){  //default constructor

    }
    Student(string name, int age, int r){  //Parameterized constructor
        Person::getData(name,age); //calling member function of base class
        rollNos=r;
    }
    displayData(){
        Person::displayData();
        cout<<"RollNos: "<<rollNos<<endl;
    }
};
class Employee: public Person
{
    int id;
    public:
    Employee( ){     //default constructor

    }
    Employee(string name, int age, int i){   //Parameterized constructor
        Person::getData(name,age); //calling member function of base class
        id =i;
    }
    void displayData(){
        Person::displayData();
        cout<<"ID: "<<id<<endl;
    }
};
int main()
{
     Student s1("Neha", 20, 15);
     Employee e1("Aashish", 25, 101);

     cout<<"Displaying student info.."<<endl;
     s1.displayData();

     cout<<"Displaying employee info.."<<endl;
     e1.displayData();

     return 0;
}
```

Output:

```
Displaying student info..
Name: Neha
Age: 20
RollNos: 15
Displaying employee info..
Name: Aashish
Age: 25
ID: 101
```

Example program: 2.17 Create a class Person with data members Name, Age and Address. Create another class Teacher with data members Qualification and Department. Also create another class Student with data members Program and Semester. Both classes are inherited from the class Person. Every class has at least one constructor which uses base class constructor. Create a member function showData( ) in each to display the information of the class member. Create objects of the derived classes and display the information.

Solution:

```
class Person
{
    string name;
    int age;
    string address;

    public:
    Person(){  //Default constructor

    }

    Person(string n, int a, string b){
      name=n;
      age=a;
      address=b;
    }

    void showData(){
        cout<<"Name: "<<name<<endl;
        cout<<"Age: "<<age<<endl;
        cout<<"Address: "<<address<<endl;
    }
};
```

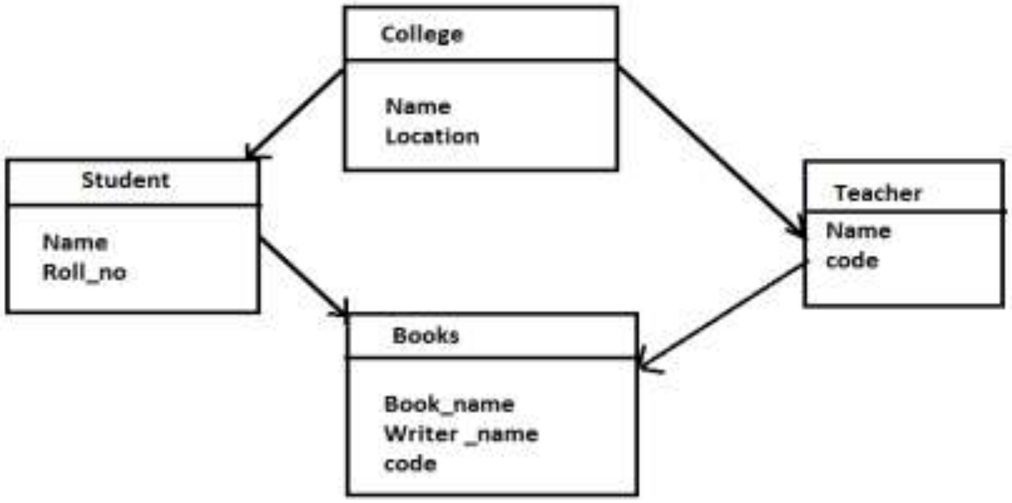
```
class Teacher: public Person
{
    string qualification;
    string department;

    public:
    Teacher( ){      //default constructor

    }

    Teacher(string name, int age, string add, string q, string d): Person(name, age, add)
    {
        qualification=q;
        department=d;
    }
    void displayData(){
        Person::showData();
        cout<<"Qualification: "<<qualification<<endl;
        cout<<"Department: "<<department<<endl;
    }
};
class Student: public Person
{
    string program;
    int semester;
    public:
    Student(){  //default constructor

    }
    Student(string name, int age, string add, string p, int s): Person(name, age, add)
    {
        program=p;
        semester=s;
    }
    displayData(){
        Person::showData();
        cout<<"Program: "<<program<<endl;
        cout<<"Semester: "<<semester<<endl;
    }
};
```

```
int main()
{
    Teacher t1("Manoz", 30, "Bharatpur", "Masters", "Computer Science");
    Student s1("Kiran", 20, "Bharatpur", "BE", 2);


    cout<<"Displaying Teacher info.."<<endl;
    t1.displayData();

    cout<<endl;
    cout<<"Displaying Student info.."<<endl;
    s1.displayData();

    return 0;
}
```

Output:

```
Displaying Teacher info..
Name: Manoz
Age: 30
Address: Bharatpur
Qualification: Masters

Department: Computer Science
Displaying Student info..
Name: Kiran
Age: 20
Address: Bharatpur
Program: BE
Semester: 2
```

Example program: 2.18 The following figure shows the minimum information required for each class. Write a program by realizing the necessary member functions to read and display information of individual object. Every class should contain at least one constructor and should be inherited to other classes as well.



Solution:

```
#include <iostream>
using namespace std;

class College
{
    string name;
    string location;

public:
    College(string a, string b)
    {
        name=a;
        location=b;
    }

    void displayCollegeInfo()
    {
        cout<<"College Name: "<<name<<endl;
        cout<<"Location: "<<location<<endl;
    }

};

class Student: virtual public College
{
    string name;
    int roll_no;

public:
    Student(string a, string b, string c, int d): College(a,b)
    {
        name=c;
        roll_no=d;
    }

    void displayStudentInfo()
    {
        cout<<"Student Name: "<<name<<endl;
        cout<<"Roll no: "<<roll_no<<endl;
    }

};
```

```
class Teacher: virtual public College
{
     string name;
     int code;

public:
     Teacher(string a, string b, string e, int f): College(a,b)
     {
          name=e;
          code=f;
     }
     void displayTeacherInfo()
     {
          cout<<"Teacher Name: "<<name<<endl;
          cout<<"Code: "<<code<<endl;
     }

};
class Books: public Student, public Teacher
{
    string book_name;
    string writer_name;
    int code;
public:
    Books(string a, string b, string c, int d, string e, int f, string g, string h, int i):
        College(a,b), Student(a,b,c,d), Teacher(a,b,e,f)
    {
        book_name=g;
        writer_name=h;
        code=i;
    }

    void displayInfo(){
        displayCollegeInfo();
        displayStudentInfo();
        displayTeacherInfo();
        cout<<"Book Name: "<<book_name<<endl;
        cout<<"Write Name: "<<writer_name<<endl;
        cout<<"Code: "<<code<<endl;
    }
};
int main()
{
    Books b1("Utech", "Bharatpur", "Kiran", 12, "Manoz", 105, "C++", "Robert", 1010);
    b1.displayInfo();

    return 0;
}
```

Output:

```
College Name: Utech
Location: Bharatpur
Student Name: Kiran
Roll no: 12
Teacher Name: Manoz
Code: 105
Book Name: C++
Write Name: Robert
Code: 1010
```

Example program: 2.19 Create a class Account with data members acc_no, balance, and min_balance (static).

- Include methods for reading and displaying values of objects
- Define static member function to display min_balance
- Create array of objects to store data of 5 accounts and read and display values of each object.

Solution:

```
class Account{
  int acc_no;
  float balance;
  static float min_balance;

  public:
  void getData(){
   cout<<"Enter account number: "<<endl;
   cin>>acc_no;
   cout<<"Enter balance: "<<endl;
   cin>>balance;
  }

  void displayInfo(){
   cout<<"The account number: "<<acc_no<<endl;
   cout<<"The balance: "<<balance<<endl;
  }

  static void display_min_balance(){
   cout<<"The minimum balance: "<<min_balance<<endl;
  }
};
```

```
float Account::min_balance=500.0;

int main()
{
   Account a[5];

   for(int i=0; i<5; i++){
     cout<<"The Account: "<<i+1<<endl;
     a[i].getData();
   }

   cout<<endl;
   for(int i=0; i<5; i++){
     cout<<"The Account: "<<i+1<<endl;
     Account::display_min_balance();
     a[i].displayInfo();
   }

   return 0;
}
```

Output:

```
The Account: 1
Enter account number:
10203040 (entered by user)
Enter balance:
10000 (entered by user)
The Account: 2
Enter account number:
10203041 (entered by user)
Enter balance:
15000 (entered by user)
The Account: 3
Enter account number:
10203042 (entered by user)
Enter balance:
20000 (entered by user)
The Account: 4
Enter account number:
10203043 (entered by user)
Enter balance:
25000 (entered by user)
The Account: 5
Enter account number:
10203044 (entered by user)
Enter balance:
30000 (entered by user)
```

```
The Account: 1
The minimum balance: 500
The account number: 10203040
The balance: 10000
The Account: 2
The minimum balance: 500
The account number: 10203041
The balance: 15000
The Account: 3
The minimum balance: 500
The account number: 10203042
The balance: 20000
The Account: 4
The minimum balance: 500
The account number: 10203043
The balance: 25000
The Account: 5
The minimum balance: 500
The account number: 10203044
The balance: 30000
```