# CSE 1203

## Object Oriented Programming [C++]

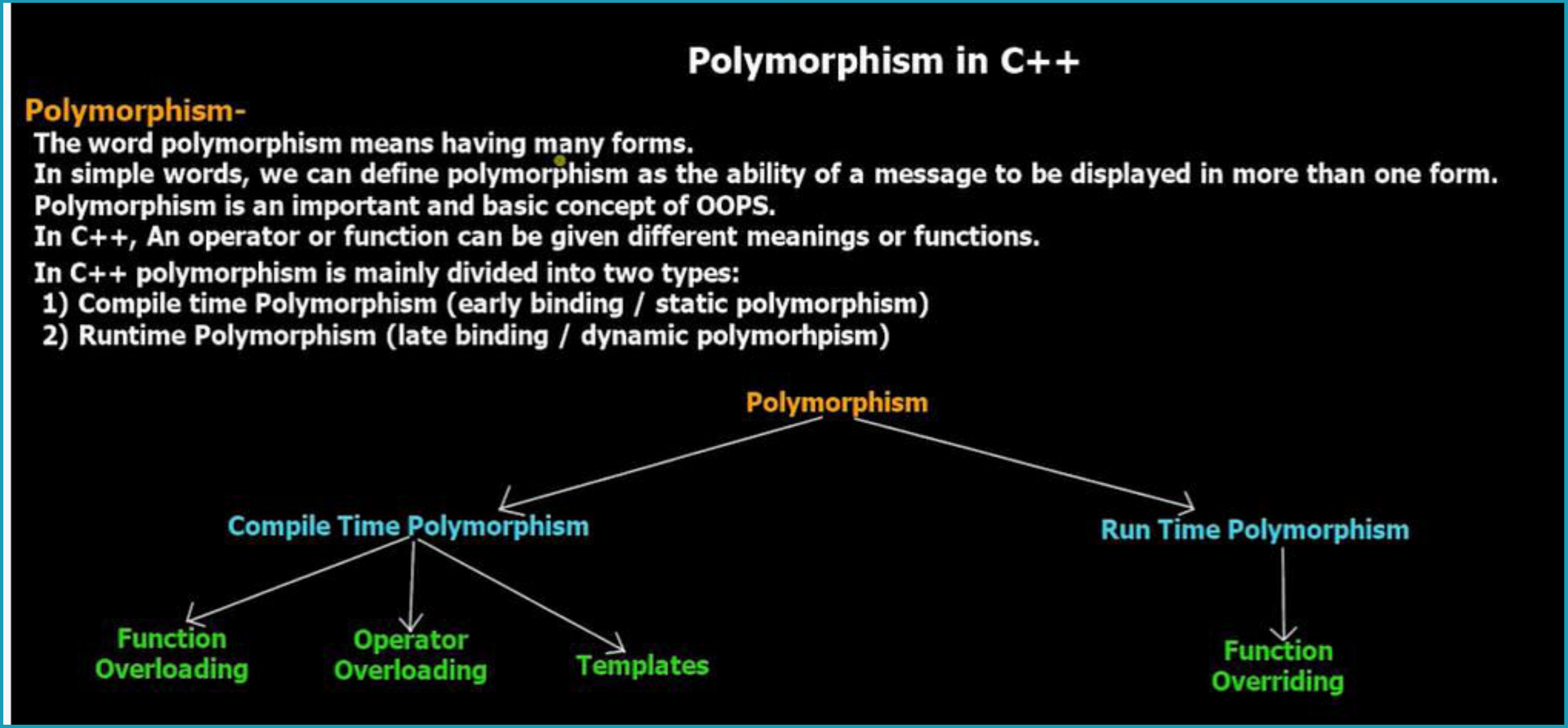
## Chapter 3: Polymorphism

# Learning Objectives

***To know about:***

- Function Overloading
- Operator Overloading
- Function Overriding
- Polymorphism

# Polymorphism



## Polymorphism in C++

**Polymorphism-**

The word polymorphism means having many forms.

In simple words, we can define polymorphism as the ability of a message to be displayed in more than one form.

Polymorphism is an important and basic concept of OOPS.

In C++, An operator or function can be given different meanings or functions.

In C++ polymorphism is mainly divided into two types:

1) Compile time Polymorphism (early binding / static polymorphism)
2) Runtime Polymorphism (late binding / dynamic polymorhpism)

Polymorphism

Compile Time Polymorphism

Run Time Polymorphism

Function Overloading

Operator Overloading

Templates

Function Overriding

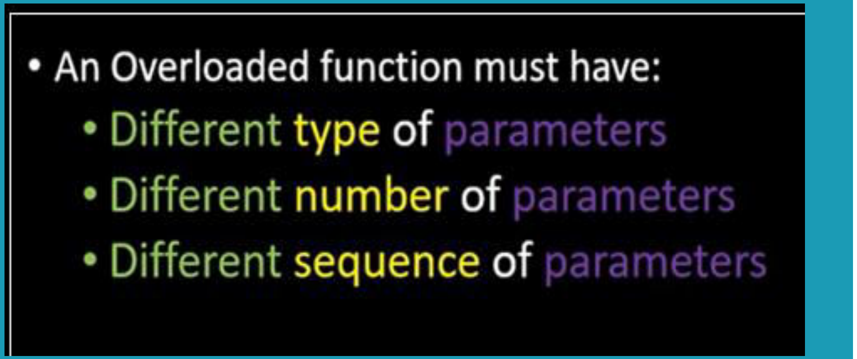
# Function Overloading

- Function overloading means to have ***more than one function*** with the ***same name*** but with ***different parameters***.
- Overloaded functions are differentiated by checking

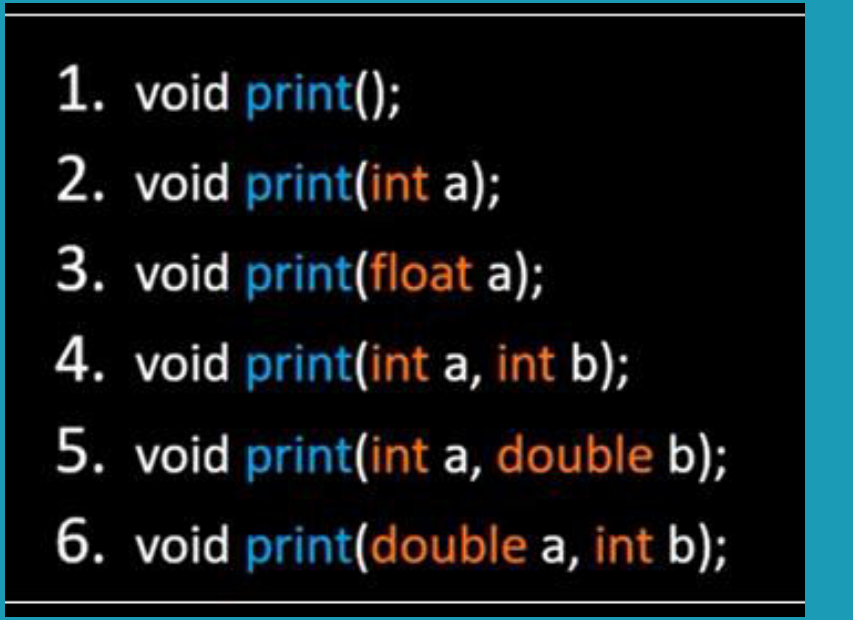
  1. ***Number*** of arguments.

  2. ***Type & sequence*** of arguments but ***not by return type*** of the function.

# Function Overloading



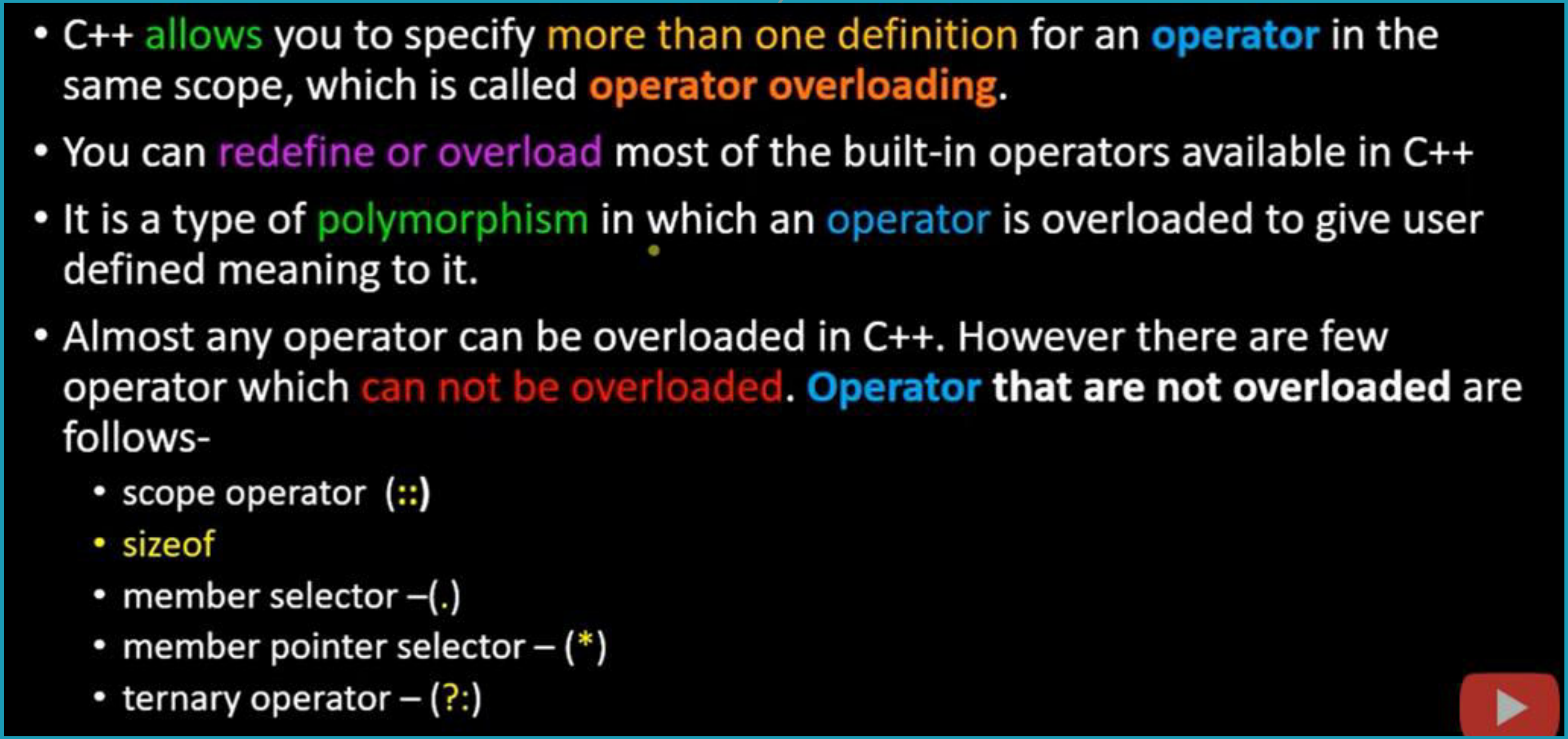
- An Overloaded function must have:
  - Different type of parameters
  - Different number of parameters
  - Different sequence of parameters



1. void print();
2. void print(int a);
3. void print(float a);
4. void print(int a, int b);
5. void print(int a, double b);
6. void print(double a, int b);

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

class A{
                public:
                int Sum(int a,int b){
                 return (a+b);
                }
                double Sum(double a,double b){
                 return (a+b);
                }
};

int main(void) {
  A a;
  cout<<a.Sum(3,4);
  cout<<endl;
  cout<<a.Sum(2.5,4.6);
}
```

# Operator Overloading



- C++ allows you to specify more than one definition for an operator in the same scope, which is called **operator overloading**.
- You can redefine or overload most of the built-in operators available in C++
- It is a type of polymorphism in which an operator is overloaded to give user defined meaning to it.
- Almost any operator can be overloaded in C++. However there are few operator which can not be overloaded. **Operator that are not overloaded** are follows-
  - scope operator (::)
  - sizeof
  - member selector –(.)
  - member pointer selector – (*)
  - ternary operator – (?:)

# Binary Operator Overloading

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

class Complex {
private:
   int real, imag;
public:
   Complex(int r = 0, int i = 0){
      real = r;
      imag = i;
   }

   // This is automatically called when '+'
   // is used with between two Complex objects
     Complex operator + (Complex const &obj) {
       Complex res;
       res.real = real + obj.real;
       res.imag = imag + obj.imag;
       return res;
   }
   void print() {
    cout << real << " + i" << imag << '\n';
 }
};
```

```
int main()
{
   Complex c1(10, 5), c2(2, 4);
   Complex c3;
   c3 = c1 + c2; //c3=c1.add(c2)
   c3.print();
}
```

Operator functions are the same as normal functions. The only differences are, that the name of an operator function is always the **operator** keyword followed by the symbol of the operator and operator functions are called when the corresponding operator is used.

# Unary Operator Overloading

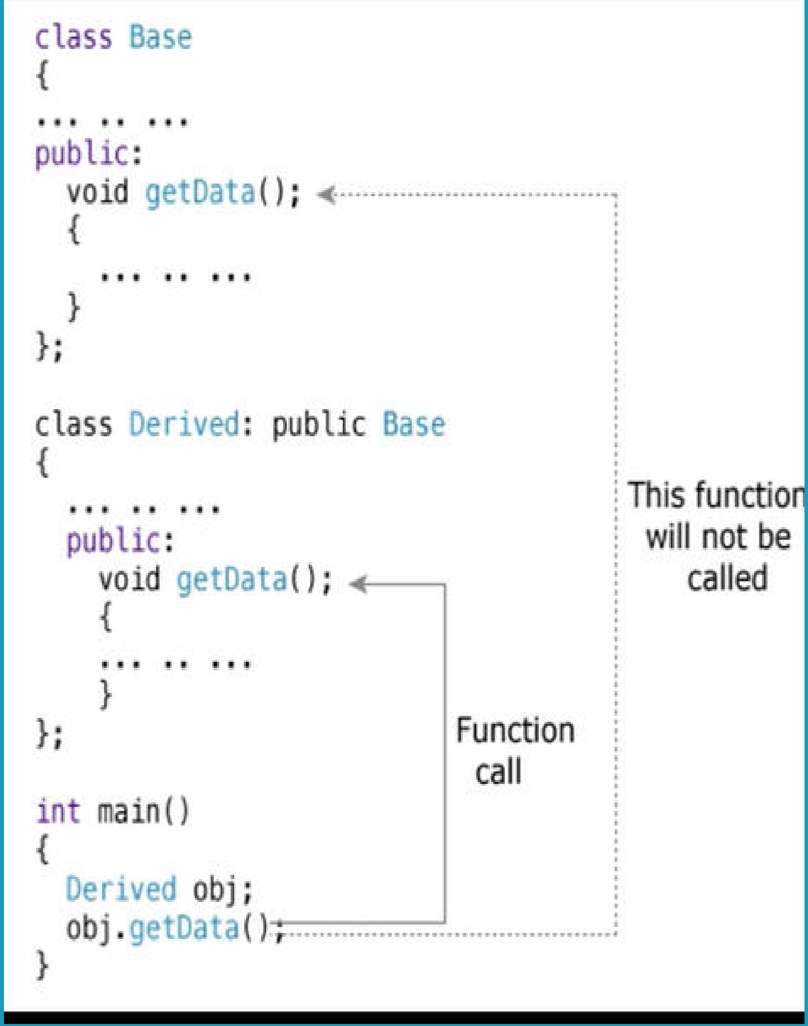
```
#include <iostream>
using namespace std;

class Counter{
private:
   int count;
public:
   Counter(){count=0;   }
   int get_count()
       {return count;}
   void operator++()
       {count++;}
};

int main(void)
{
  Counter c1, c2;
   c1++;
  cout<<"c1="<<c1.get_count();
}
```

The operator function uses unary operator. Here ++ operator is used to increment the value of private member data count.

# Function Overriding

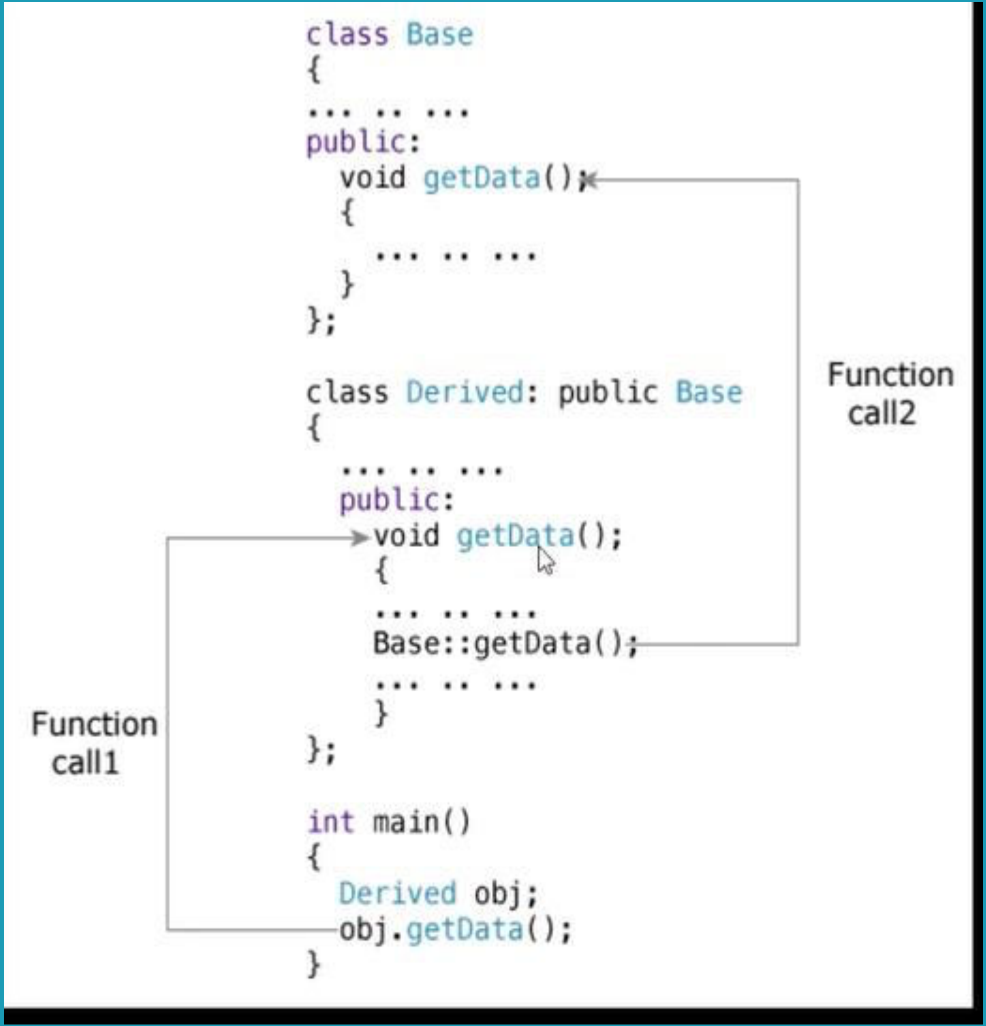
- If we inherit a class into the ***derived class*** and provide a definition for one of the base class's function again inside the ***derived class***, then that function is said to be ***overridden***, and this mechanism is called ***Function Overriding***
- Inheritance should be there. Function overriding cannot be done within a class. For this we require a derived class and a ***base class***
- Function that is redefined must have exactly the same declaration in both ***base*** and ***derived class***, that means same name, same return type and same parameter list
- If you create an object of the derived class and call the member function which is exists in both the classes then member function in the ***derived class*** is invoked and the function in the ***base class*** is ignored.

# Function Overriding



```
class Base
{
... .. ...
public:
  void getData();
  {
    ... .. ...
  }
};

class Derived: public Base
{
  ... .. ...
  public:
    void getData();
    {
    ... .. ...
    }
};

int main()
{
  Derived obj;
  obj.getData();
}
```

Parent class method is not called

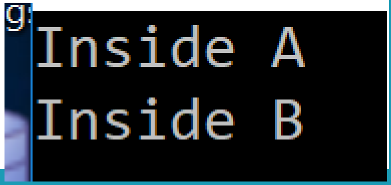


```
class Base
{
... .. ...
public:
  void getData();
  {
    ... .. ...
  }
};

class Derived: public Base
{
  ... .. ...
  public:
    void getData();
    {
    ... .. ...
    Base::getData();
    ... .. ...
    }
};

int main()
{
  Derived obj;
  obj.getData();
}
```

Parent class method is called

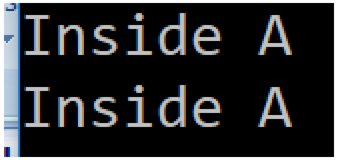
# Function Overriding

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

class A{
        public:
                void Print(){
                cout<<"Inside A"<<endl;
                }
};

class B:public A{
         public:
                void Print(){
                cout<<"Inside B"<<endl;
                                }
};
int main(void) {
  A a;
  a.Print();
  B b;
  b.Print();
}
```



```
Inside A
Inside B
```

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

class A{
        public:
                void Print(){
                cout<<"Inside A"<<endl;
                }
};

class B:public A{
         public:
    };
int main(void) {
  A a;
  a.Print();
  B b;
  b.Print();
}
```



```
Inside A
Inside A
```

If function does not exists in derived class then base class function is called

# Virtual Function & Polymorphism

- Polymorphism means **same** action but **different** reaction/reply
- In C++, polymorphism refers to the property by which **objects** belonging to **different classes** are able to **respond** to the **same** message, but in **different** forms
- Polymorphism is also known as **late** binding/**dynamic** binding/**run-time** binding
- In C++, **two** things are required to achieve polymorphism

  1. A **virtual** function in the **base class**
  2. A **pointer** of the **base class**

# Virtual Function & Polymorphism

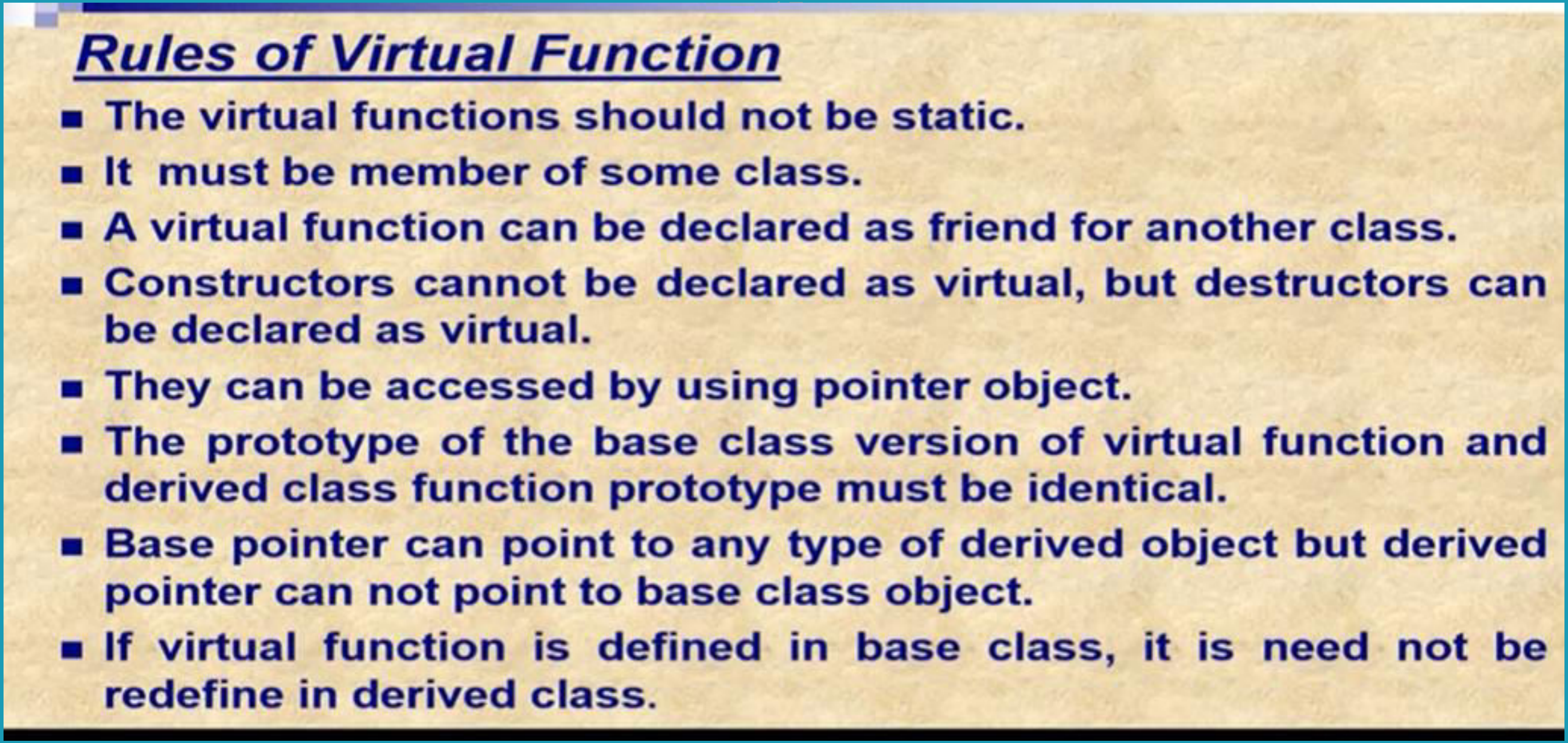
- The function in the base class is declared as **virtual** by using the keyword virtual preceding its normal declaration
- When a function is made virtual, C++ determines which function to use at runtime **based** on the **type of the object** pointed to by the base pointer.

# Virtual Function & Polymorphism

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

class A{
            public:
            virtual void Print(){
            cout<<"Inside A"<<endl;
            }
};
class B:public A{
            public:
            void Print(){
            cout<<"Inside B"<<endl;
            }
};

int main(void) {
 A *pa;
 A a;
 pa=&a;
 pa->Print();
 B b;
 pa=&b;
 pa->Print();
}
```

Here pa is the pointer to base class.
First it points to base class object a.
So pa->Print() calls base class method
After that pa is assigned to B class object b. So pa->Print() calls derived class method
As the address generates at runtime the statement pa=&b will be executed at runtime which ultimate creates run-time calling (dynamic binding)
So a base class pointer can point to any derived class objects at run-time.

# Virtual Function



## Rules of Virtual Function

- The virtual functions should not be static.
- It must be member of some class.
- A virtual function can be declared as friend for another class.
- Constructors cannot be declared as virtual, but destructors can be declared as virtual.
- They can be accessed by using pointer object.
- The prototype of the base class version of virtual function and derived class function prototype must be identical.
- Base pointer can point to any type of derived object but derived pointer can not point to base class object.
- If virtual function is defined in base class, it is need not be redefine in derived class.

# Virtual Function

```
class A{
            public:
            void Print(){
            cout<<"Inside Print A"<<endl;
            }
            void Show(){
            cout<<"Inside Show A"<<endl;
            }
};
class B:public A{
            public:
            void Print(){
            cout<<"Inside Print B"<<endl;
            }
            void Show(){
            cout<<"Inside Show B"<<endl;
            }
};
int main(void) {
 A *pa;
 B b;
 pa=&b;
 pa->Print();
 pa->Show();
}
```

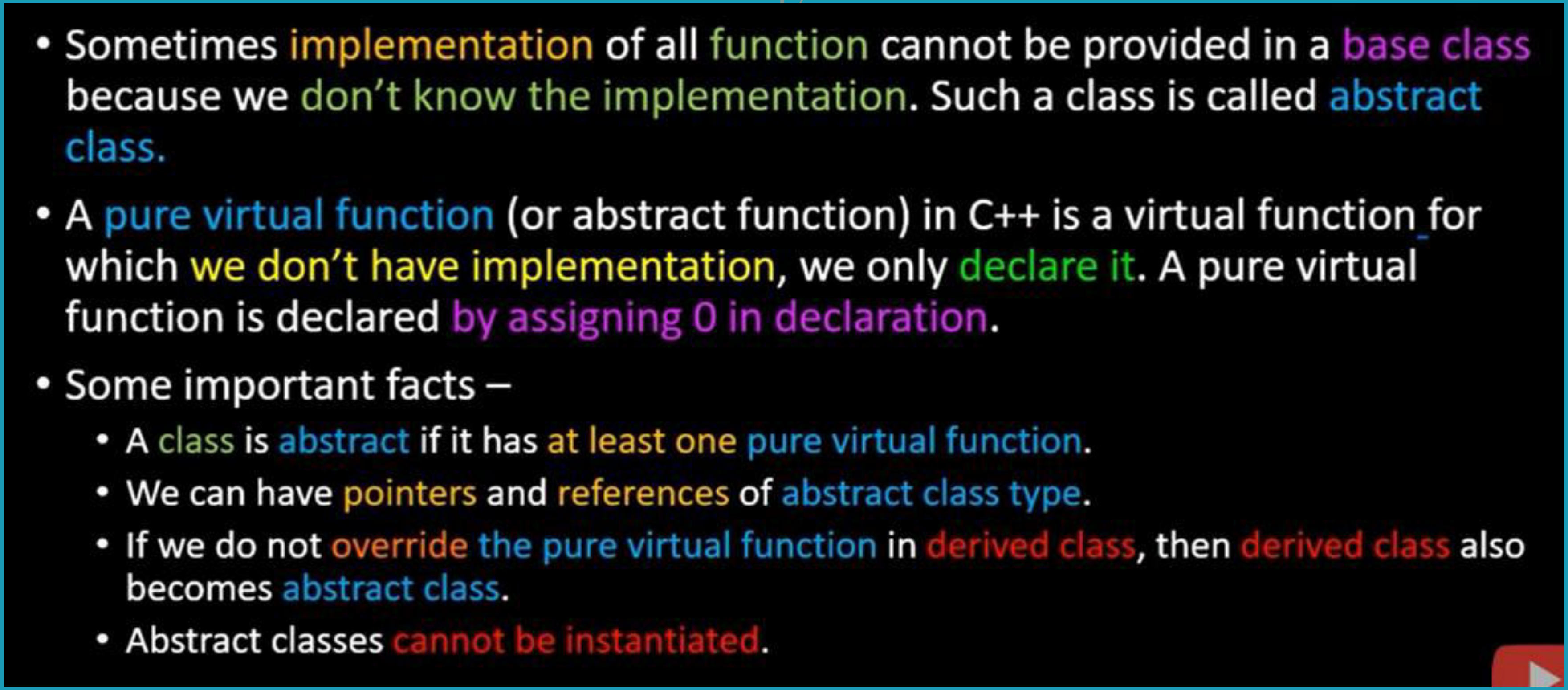
```
Inside Print A
Inside Show A
```

```
class A{
            public:
            virtual void Print(){
            cout<<"Inside Print A"<<endl;
            }
            void Show(){
            cout<<"Inside Show A"<<endl;
            }
};
class B:public A{
            public:
            void Print(){
            cout<<"Inside Print B"<<endl;
            }
            void Show(){
            cout<<"Inside Show B"<<endl;
            }
};
int main(void) {
 A *pa;
 B b;
 pa=&b;
 pa->Print();
 pa->Show();
}
```

```
Inside Print B
Inside Show A
```

AS Print() declared as virtual so pa->Print() call derived class method

# Pure Virtual Function & Abstract Class

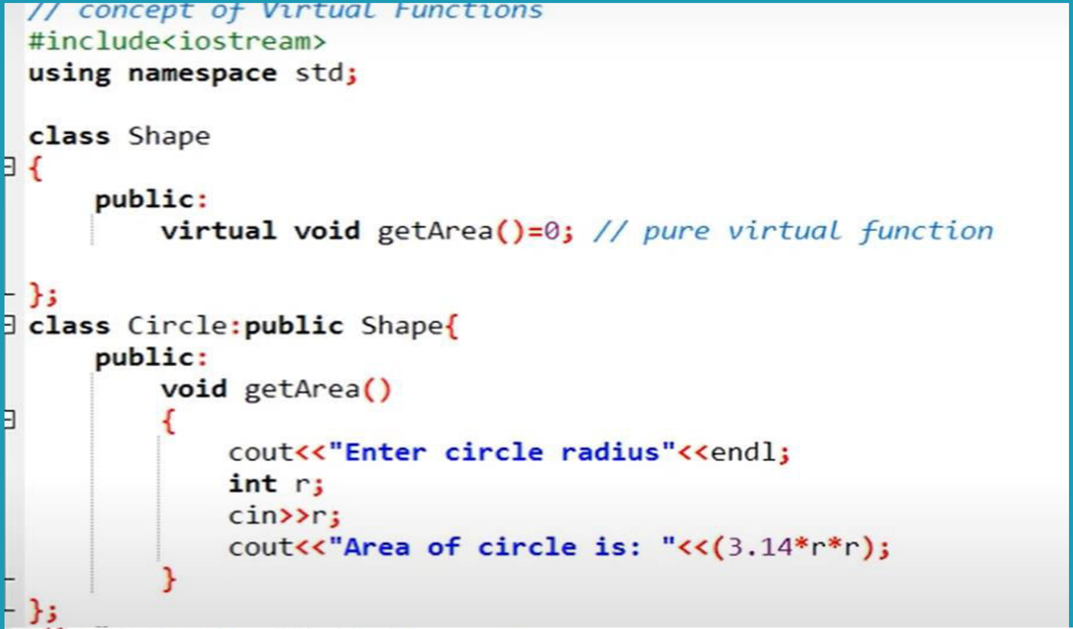


- Sometimes implementation of all function cannot be provided in a base class because we don’t know the implementation. Such a class is called abstract class.
- A pure virtual function (or abstract function) in C++ is a virtual function for which we don’t have implementation, we only declare it. A pure virtual function is declared by assigning 0 in declaration.
- Some important facts –
  - A class is abstract if it has at least one pure virtual function.
  - We can have pointers and references of abstract class type.
  - If we do not override the pure virtual function in derived class, then derived class also becomes abstract class.
  - Abstract classes cannot be instantiated.

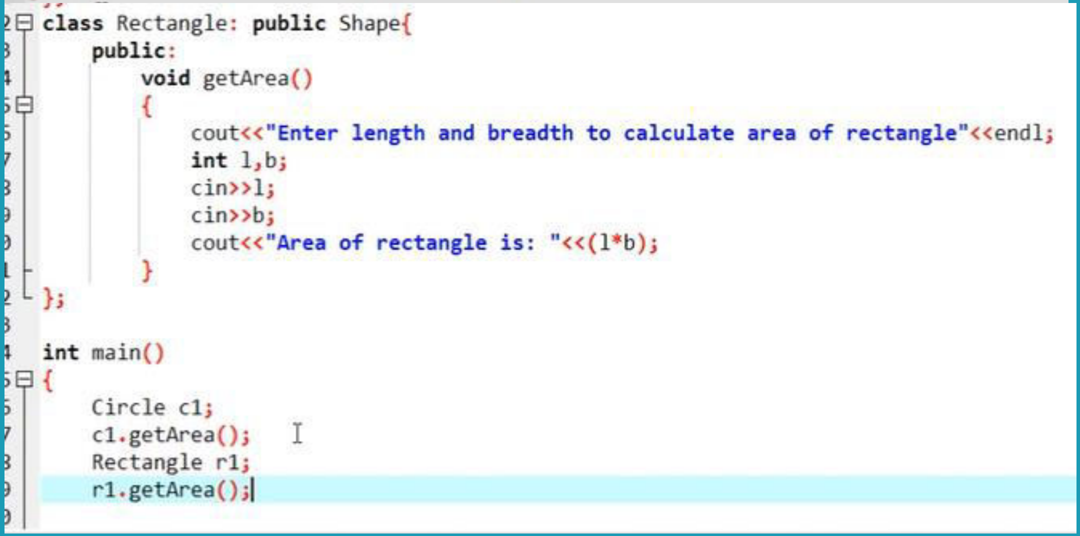
# Pure Virtual Function & Abstract Class

- A pure virtual function is used to make a class **abstract**
- An abstract class is such a class whose **objects** cannot be created
- A virtual function is made **‘pure virtual’** by assigning **zero(0)** to the function name. Such a function is also known as ‘do-nothing’ function
- virtual void show() = 0;

# Pure Virtual Function & Abstract Class



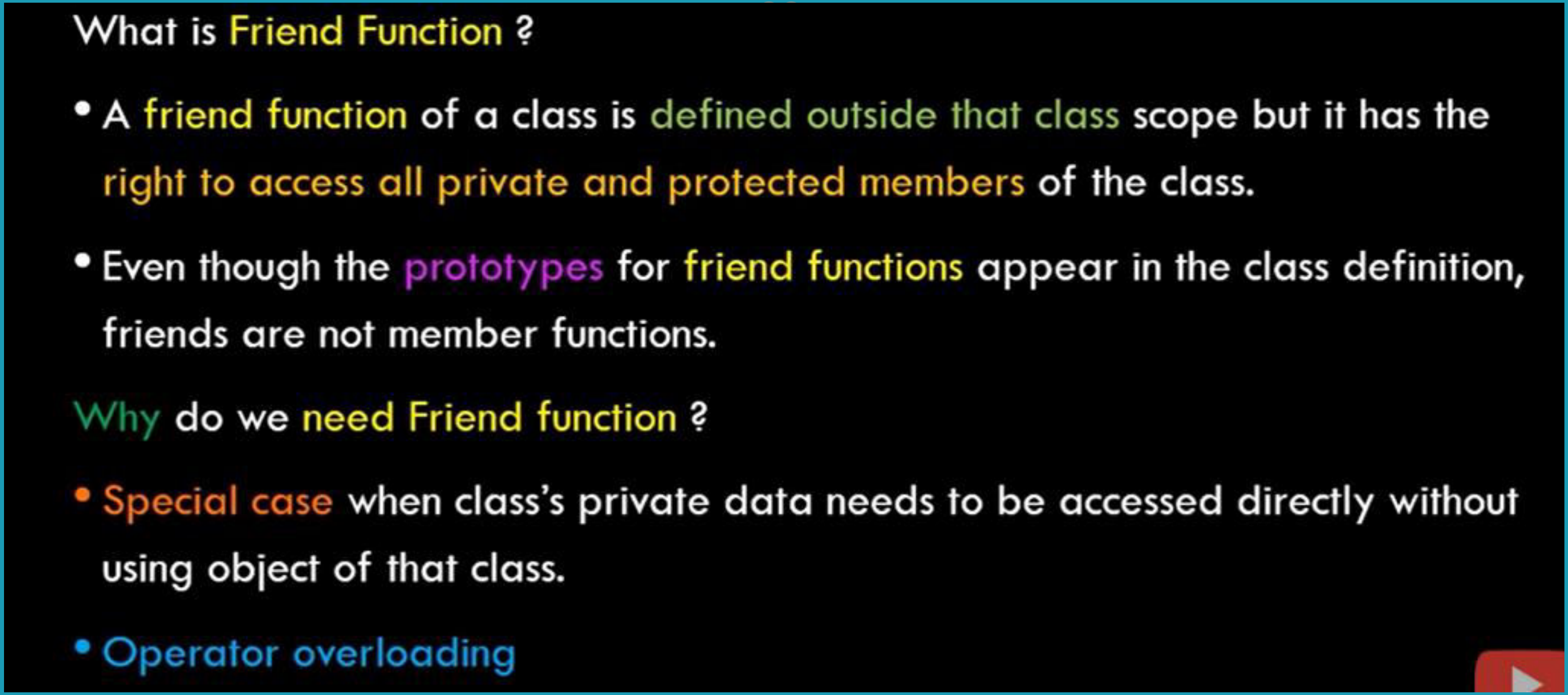
```
// concept of Virtual Functions
#include<iostream>
using namespace std;

class Shape
{
    public:
        virtual void getArea()=0; // pure virtual function

};
class Circle:public Shape{
    public:
        void getArea()
        {
            cout<<"Enter circle radius"<<endl;
            int r;
            cin>>r;
            cout<<"Area of circle is: "<<(3.14*r*r);
        }
};
```



```
class Rectangle: public Shape{
    public:
        void getArea()
        {
            cout<<"Enter length and breadth to calculate area of rectangle"<<endl;
            int l,b;
            cin>>l;
            cin>>b;
            cout<<"Area of rectangle is: "<<(l*b);
        }
};

int main()
{
    Circle c1;
    c1.getArea();
    Rectangle r1;
    r1.getArea();
```

Here getArea() is pure virtual function makes Shape as abstract class.
The getArea() method needs to be defined in derived class.

# Friend Function



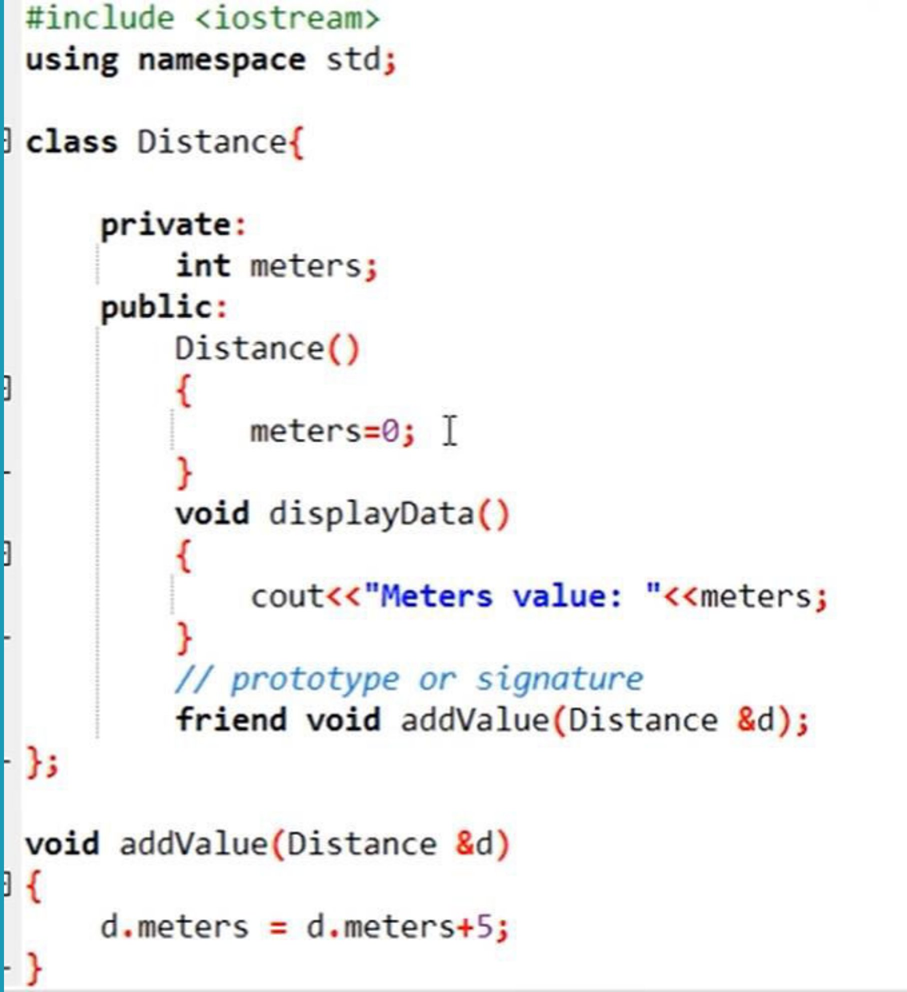
What is Friend Function ?

- A friend function of a class is defined outside that class scope but it has the right to access all private and protected members of the class.
- Even though the prototypes for friend functions appear in the class definition, friends are not member functions.

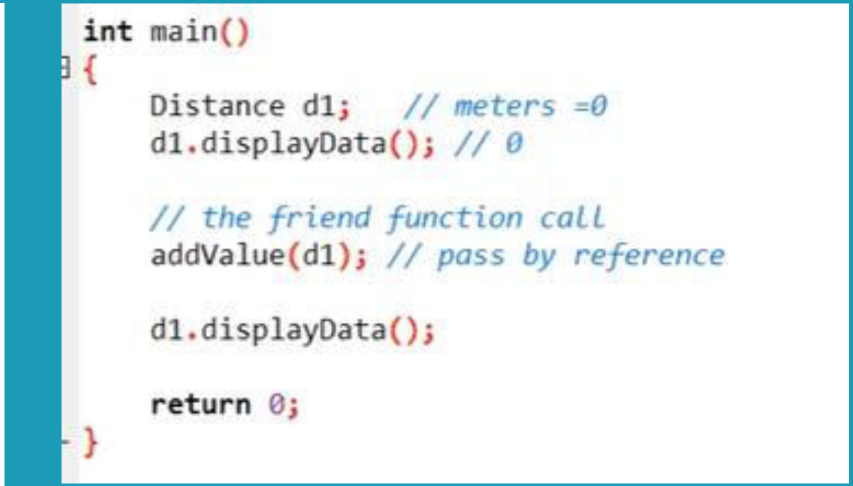
Why do we need Friend function ?

- Special case when class's private data needs to be accessed directly without using object of that class.
- Operator overloading

# Friend Function



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

class Distance{

    private:
        int meters;
    public:
        Distance()
        {
            meters=0;
        }
        void displayData()
        {
            cout<<"Meters value: "<<meters;
        }
        // prototype or signature
        friend void addValue(Distance &d);
};

void addValue(Distance &d)
{
    d.meters = d.meters+5;
}
```



```cpp
int main()
{
    Distance d1;    // meters =0
    d1.displayData(); // 0

    // the friend function call
    addValue(d1); // pass by reference

    d1.displayData();

    return 0;
}
```

# THANK YOU