UNIT I

C++ Basics

OVERVIEW OF C++:

C++ is a statically typed, compiled, general-purpose, case-sensitive, free-form programming language that supports procedural, object-oriented, and generic programming.

C++ is regarded as a **middle-level** language, as it comprises a combination of both high-level and low-level language features.

C++ was developed by Bjarne Stroustrup starting in 1979 at Bell Labs in Murray Hill, New Jersey, as an enhancement to the C language and originally named C with Classes but later it was renamed C++ in 1983.

Object-Oriented Programming

C++ fully supports object-oriented programming, including the four pillars of object-oriented development −

- **Encapsulation**
- **Data hiding**
- **Inheritance**
- **Polymorphism**

Use of C++

C++ is used by hundreds of thousands of programmers in essentially every application domain.

C++ is being highly used to write device drivers and other software that rely on direct manipulation of hardware under realtime constraints.

C++ is widely used for teaching and research because it is clean enough for successful teaching of basic concepts.

Anyone who has used either an Apple Macintosh or a PC running Windows has indirectly used C++ because the primary user interfaces of these systems are written in C++.

- **Object** − Objects have states and behaviors. Example: A dog has states - color, name, breed as well as behaviors - wagging, barking, eating. An object is an instance of a class.
- **Class** − A class can be defined as a template/blueprint that describes the behaviors/states that object of its type support.
- **Methods** − A method is basically a behavior. A class can contain many methods. It is in methods where the logics are written, data is manipulated and all the actions are executed.

C++ Program Structure

Let us look at a simple code that would print the words *Hello World*.

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

// main() is where program execution begins.
int main() {
   cout << "Hello World"; // prints Hello World
   return 0;
}
```

Let us look at the various parts of the above program −

- The C++ language defines several headers, which contain information that is either necessary or useful to your program. For this program, the header **<iostream>** is needed.
- The line **using namespace std;** tells the compiler to use the std namespace. Namespaces are a relatively recent addition to C++.
- The next line '**// main() is where program execution begins.**' is a single-line comment available in C++. Single-line comments begin with // and stop at the end of the line.
- The line **int main()** is the main function where program execution begins.
- The next line **cout << "Hello World";** causes the message "Hello World" to be displayed on the screen.
- The next line **return 0;** terminates main( )function and causes it to return the value 0 to the calling process.

C++ Functions:

A function is a group of statements that together perform a task. Every C++ program has at least one function, which is **main()**, and all the most trivial programs can define additional functions.

- You can divide up your code into separate functions. How you divide up your code among different functions is up to you, but logically the division usually is such that each function performs a specific task.
- A function **declaration** tells the compiler about a function's name, return type, and parameters. A function **definition** provides the actual body of the function.

- The C++ standard library provides numerous built-in functions that your program can call. For example, function **strcat()** to concatenate two strings, function **memcpy()** to copy one memory location to another location and many more functions.
- A function is known with various names like a method or a sub-routine or a procedure etc.

Defining a Function

The general form of a C++ function definition is as follows –

Syntax:

```
return_type function_name( parameter list )
 {
   body of the function
 }
```

A C++ function definition consists of a function header and a function body. Here are all the parts of a function −

- **Return Type** − A function may return a value. The **return_type** is the data type of the value the function returns. Some functions perform the desired operations without returning a value. In this case, the return_type is the keyword **void**.
- **Function Name** − This is the actual name of the function. The function name and the parameter list together constitute the function signature.
- **Parameters** − A parameter is like a placeholder. When a function is invoked, you pass a value to the parameter. This value is referred to as actual parameter or argument. The parameter list refers to the type, order, and number of the parameters of a function. Parameters are optional; that is, a function may contain no parameters.
- **Function Body** − The function body contains a collection of statements that define what the function does.

Example

Following is the source code for a function called **max()**. This function takes two parameters num1 and num2 and return the biggest of both −

// function returning the max between two numbers

```
int max(int num1, int num2) {
  // local variable declaration
  int result;

  if (num1 > num2)
    result = num1;
  else
     result = num2;

   return result;
}
```

Function Declarations

A function **declaration** tells the compiler about a function name and how to call the function. The actual body of the function can be defined separately.

A function declaration has the following parts −

```
return_type function_name( parameter list );
```

For the above defined function max(), following is the function declaration −

```
int max(int num1, int num2);
```

Parameter names are not important in function declaration only their type is required, so following is also valid declaration −

```
int max(int, int);
```

Function declaration is required when you define a function in one source file and you call that function in another file. In such case, you should declare the function at the top of the file calling the function.

Calling a Function

While creating a C++ function, you give a definition of what the function has to do. To use a function, you will have to call or invoke that function.

When a program calls a function, program control is transferred to the called function. A called function performs defined task and when it’s return statement is executed or when its function-ending closing brace is reached, it returns program control back to the main program.

To call a function, you simply need to pass the required parameters along with function name, and if function returns a value, then you can store returned value. For example −

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

// function declaration
int max(int num1, int num2);

int main () {
   // local variable declaration:
   int a = 100;
   int b = 200;
   int ret;
   // calling a function to get max value.
   ret = max(a, b);
   cout << "Max value is : " << ret << endl;

   return 0;
}

// function returning the max between two numbers
int max(int num1, int num2) {
   // local variable declaration
   int result;

   if (num1 > num2)
      result = num1;
   else
      result = num2;

   return result;
}
```

I kept max() function along with main() function and compiled the source code. While running final executable, it would produce the following result −

```
Max value is : 200
```

Function Arguments

If a function is to use arguments, it must declare variables that accept the values of the arguments. These variables are called the **formal parameters** of the function.

The formal parameters behave like other local variables inside the function and are created upon entry into the function and destroyed upon exit.

While calling a function, there are two ways that arguments can be passed to a function −

Sr.No	Call Type & Description
1	Call by Value This method copies the actual value of an argument into the formal parameter of the function. In this case, changes made to the parameter inside the function have no effect on the argument.
2	Call by Pointer This method copies the address of an argument into the formal parameter. Inside the function, the address is used to access the actual argument used in the call. This means that changes made to the parameter affect the argument.
3	Call by Reference

	This method copies the reference of an argument into the formal parameter. Inside the function, the reference is used to access the actual argument used in the call. This means that changes made to the parameter affect the argument.

By default, C++ uses **call by value** to pass arguments. In general, this means that code within a function cannot alter the arguments used to call the function and above mentioned example while calling max() function used the same method.

CALL BY REFERENCE IN C++

In call by reference, original value is modified because we pass reference (address).Here, address of the value is passed in the function, so actual and formal arguments share the same address space. Hence, value changed inside the function, is reflected inside as well as outside the function.

Example:

```
#include<iostream>
using namespace std;
void swap(int *x, int *y)
{
 int swap;
 swap=*x;
 *x=*y;
 *y=swap;
}
int main()
{
 int x=500, y=100;
 swap(&x, &y);  // passing value to function
 cout<<"Value of x is: "<<x<<endl;
 cout<<"Value of y is: "<<y<<endl;
 return 0;
}
```

Output:

```
Value of x is: 100
Value of y is: 500
```

INLINE FUNCTION:

If make a function as inline, then the compiler replaces the function calling location with the definition of the inline function at compile time.

Any changes made to an inline function will require the inline function to be recompiled again because the compiler would need to replace all the code with a new code; otherwise, it will execute the old functionality.

Syntax for an inline function:

```
inline return_type function_name(parameters)
{
  // function code?
}
```

Example:

```
#include <iostream>
using namespace std;
inline int add(int a, int b)
{
 return(a+b);
 }
 int main()
{
cout<<"Addition of 'a' and 'b' is:"<<add(2,3);A
return 0;
}
```

Why do we need an inline function in C++?

The main use of the inline function in C++ is to save memory space. Whenever the function is called, then it takes a lot of time to execute the tasks, such as moving to the calling function.

If the length of the function is small, then the substantial amount of execution time is spent in such overheads, and sometimes time taken required for moving to the calling function will be greater than the time taken required to execute that function.

The solution to this problem is to use macro definitions known as macros. The preprocessor macros are widely used in C, but the major drawback with the macros is that these are not normal functions which means the error checking process will not be done during the compilation.

C++ has provided one solution to this problem. In the case of function calling, the time for calling such small functions is huge, so to overcome such a problem, a new concept was introduced known as an inline function. When the function is encountered inside the main() method, it is expanded with its definition thus saving time.

We cannot provide the inlining to the functions in the following circumstances:

- If a function is recursive.
- If a function contains a loop like for, while, do-while loop.
- If a function contains static variables.
- If a function contains a switch or go to statement

Advantages of inline function

- In the inline function, we do not need to call a function, so it does not cause any overhead.
- It also saves the overhead of the return statement from a function.
- It does not require any stack on which we can push or pop the variables as it does not perform any function calling.
- An inline function is mainly beneficial for the embedded systems as it yields less code than a normal function.

OVERLOADING OF FUNCTIONS:

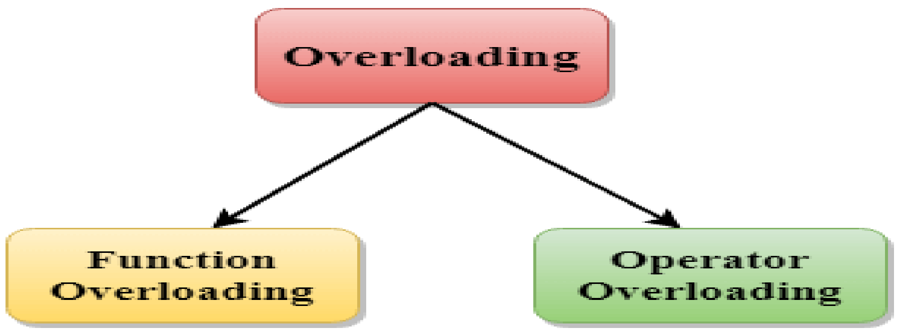
If we create two or more members having the same name but different in number or type of parameter, it is known as C++ overloading. In C++, we can overload:

- methods,
- constructors, and
- indexed properties

It is because these members have parameters only.

Types of overloading in C++ are:

- Function overloading
- Operator overloading



FUNCTION OVERLOADING:

Function Overloading is defined as the process of having two or more function with the same name, but different in parameters is known as function overloading in C++.

In function overloading, the function is redefined by using either different types of arguments or a different number of arguments. It is only through these differences compiler can differentiate between the functions.

The **advantage** of Function overloading is that it increases the readability of the program because you don't need to use different names for the same action.

The easiest way to remember this rule is that the parameters should qualify any one or more than one of the following conditions:

- they should have a different type
- they should have a different number
- they should have a different sequence of parameters.

Rules of Function Overloading in C++
Different parameters or three different conditions :

1. These functions have different parameter type

sum(int a, int b)

sum(double a, double b)

2. **These functions have a different number of parameters**

    sum(int a, int b)

    sum(int a, int b, int c)

3. **These functions have a different sequence of parameters**

    sum(int a, double b)

    sum(double a, int b)

The above three cases are valid cases of overloading. We can have any number of functions,

EXAMPLE

```
#include <iostream>
using namespace std;
class Cal {
   public:
static int add(int a,int b){
       return a + b;
   }
static int add(int a, int b, int c)
   {
       return a + b + c;
   }
};
int main(void) {
   Cal C;                                  //    class object declaration.
   cout<<C.add(10, 20)<<endl;
   cout<<C.add(12, 20, 23);
  return 0;
}
```

Output:

```
30
55
```

C++ Operators Overloading

Operator overloading is a compile-time polymorphism in which the operator is overloaded to provide the special meaning to the user-defined data type. Operator overloading is used to overload or redefines most of the operators available in C++. It is used to perform the operation on the user-defined data type. For example, C++ provides the ability to add the variables of the user-defined data type that is applied to the built-in data types.

The advantage of Operators overloading is to perform different operations on the same operand.

Operator that cannot be overloaded are as follows:

- Scope operator (::)
- Sizeof
- member selector(.)
- member pointer selector(*)
- ternary operator(?:)

Syntax of Operator Overloading

```
return_type class_name  : : operator op(argument_list)
{
    // body of the function.
}
```

Where the **return type** is the type of value returned by the function.

class_name is the name of the class.

operator op is an operator function where op is the operator being overloaded, and the operator is the keyword.

DEFAULT ARGUMENTS IN C++

In a function, arguments are defined as the values passed when a function is called. Values passed are the source, and the receiving function is the destination.

Definition

A default argument is a value in the function declaration automatically assigned by the compiler if the calling function does not pass any value to that argument.

Characteristics for defining the default arguments

Following are the rules of declaring default arguments -

- The values passed in the default arguments are not constant. These values can be overwritten if the value is passed to the function. If not, the previously declared value retains.
- During the calling of function, the values are copied from left to right.
- All the values that will be given default value will be on the right.

Example

- Void function(int x, int y, int z = 0)
  Explanation - The above function is valid. Here z is the value that is predefined as a part of the default argument.
- Void function(int x, int z = 0, int y)
  Explanation - The above function is invalid. Here z is the value defined in between, and it is not accepted.

EXAMPLE:

```
#include<iostream>
using namespace std;
int sum(int x, int y, int z=0, int w=0) // Here there are two values in the default arguments
{ // Both z and w are initialised to zero
   return (x + y + z + w); // return sum of all parameter values
}
int main()
{
   cout << sum(10, 15) << endl; // x = 10, y = 15, z = 0, w = 0
   cout << sum(10, 15, 25) << endl; // x = 10, y = 15, z = 25, w = 0
   cout << sum(10, 15, 25, 30) << endl; // x = 10, y = 15, z = 25, w = 30
   return 0;
}
```

Output

```
25
50
80
```

Explanation

In the above program, we have called the sum function three times.

- Sum(10,15)

  When this function is called, it reaches the definition of the sum. There it initializes x to 10 y to 15, and the rest values are zero by default as no value is passed. And all the values after sum give 25 as output.

- Sum(10, 15, 25)

  When this function is called, x remains 10, y remains 15, the third parameter z that is passed is initialized to 25 instead of zero. And the last value remains 0. The sum of x, y, z, w, is 50 which is returned as output.

- Sum(10, 15, 25, 30)

  In this function call, there are four parameter values passed into the function with x as 10, y as 15, z is 25, and w as 30. All the values are then summed up to give 80 as the output.

C++ FRIEND FUNCTION

If a function is defined as a friend function in C++, then the protected and private data of a class can be accessed using the function.

By using the keyword friend compiler knows the given function is a friend function.

For accessing the data, the declaration of a friend function should be done inside the body of a class starting with the keyword friend.

Declaration of friend function in C++

```
class class_name
{
    friend data_type function_name(argument/s);            // syntax of friend function.
};
```

In the above declaration, the friend function is preceded by the keyword friend. The function can be defined anywhere in the program like a normal C++ function. The function definition does not use either the keyword **friend or scope resolution operator**.

Characteristics of a Friend function:

- The function is not in the scope of the class to which it has been declared as a friend.
- It cannot be called using the object as it is not in the scope of that class.
- It can be invoked like a normal function without using the object.
- It cannot access the member names directly and has to use an object name and dot membership operator with the member name.
- It can be declared either in the private or the public part.

C++ friend function Example

Example of C++ friend function used to print the length of a box.

```
#include <iostream>
using namespace std;
class Box
{
    private:
        int length;
    public:
        Box(): length(0) { }
        friend int printLength(Box); //friend function
};
int printLength(Box b)
{
   b.length += 10;
    return b.length;
}
int main()
{
    Box b;
    cout<<"Length of box: "<< printLength(b)<<endl;
    return 0;
}
```

Output:

```
Length of box: 10
```

C++ VIRTUAL FUNCTION

- A C++ virtual function is a member function in the base class that you redefine in a derived class. It is declared using the virtual keyword.
- It is used to tell the compiler to perform dynamic linkage or late binding on the function.
- There is a necessity to use the single pointer to refer to all the objects of the different classes. So, we create the pointer to the base class that refers to all the derived objects. But, when base class pointer contains the address of the derived class object, always executes the base class function. This issue can only be resolved by using the 'virtual' function.
- A 'virtual' is a keyword preceding the normal declaration of a function.
- When the function is made virtual, C++ determines which function is to be invoked at the runtime based on the type of the object pointed by the base class pointer.

Late binding or Dynamic linkage

In late binding function call is resolved during runtime. Therefore compiler determines the type of object at runtime, and then binds the function call.

Rules of Virtual Function

- Virtual functions must be members of some class.
- Virtual functions cannot be static members.
- They are accessed through object pointers.
- They can be a friend of another class.
- A virtual function must be defined in the base class, even though it is not used.
- The prototypes of a virtual function of the base class and all the derived classes must be identical. If the two functions with the same name but different prototypes, C++ will consider them as the overloaded functions.
- We cannot have a virtual constructor, but we can have a virtual destructor

EXAMPLE:

```
#include <iostream>
{
 public:
 virtual void display()
 {
  cout << "Base class is invoked"<<endl;
 }
};
class B:public A
{
 public:
 void display()
 {
  cout << "Derived Class is invoked"<<endl;
 }
};
int main()
{
 A* a;    //pointer of base class
 B b;     //object of derived class
 a = &b;
 a->display();   //Late Binding occurs
}
```

Output:

```
Derived Class is invoked
```