1.0 Introduction

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.

C++ is a superset of C, and that virtually any legal C program is a legal C++ program.

Note − A programming language is said to use static typing when type checking is performed during compile-time as opposed to run-time.

1.1 Object-Oriented Programming

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

- Encapsulation
- Data hiding
- Inheritance
- Polymorphism

1.2 Learning C++

The most important thing while learning C++ is to focus on concepts.

The purpose of learning a programming language is to become a better programmer; that is, to become more effective at designing and implementing new systems and at maintaining old ones.

C++ supports a variety of programming styles. You can write in the style of Fortran, C, Smalltalk, etc., in any language. Each style can achieve its aims effectively while maintaining runtime and space efficiency.

1.3 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++.

1.4 C++ Basic Syntax

When we consider a C++ program, it can be defined as a collection of objects that communicate via invoking each other's methods. Let us now briefly look into what a class, object, methods, and instant variables mean.

- **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.
- **Instance Variables** − Each object has its unique set of instance variables. An object's state is created by the values assigned to these instance variables.

1.4.1 C++ Program Structure

Let us look at a simple code that would print the words *Hello World*. Note this program file should be saved as .cpp file known as C++ source file.

```
#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.

1.4.2 Semicolons and Blocks in C++

In C++, the semicolon is a statement terminator. That is, each individual statement must be ended with a semicolon. It indicates the end of one logical entity.

For example, following are three different statements −

```
x = y;
y = y + 1;
add(x, y);
```

A block is a set of logically connected statements that are surrounded by opening and closing braces. For example −

```
{
   cout << "Hello World"; // prints Hello World
   return 0;
}
```

C++ does not recognize the end of the line as a terminator. For this reason, it does not matter where you put a statement in a line. For example −

```
x = y;
y = y + 1;
add(x, y);
```

is the same as

```
x = y; y = y + 1; add(x, y);
```

1.4.3 C++ Identifiers

A C++ identifier is a name used to identify a variable, function, class, module, or any other user-defined item. An identifier starts with a letter A to Z or a to z or an underscore (_) followed by zero or more letters, underscores, and digits (0 to 9).

C++ does not allow punctuation characters such as @, $, and % within identifiers. C++ is a case-sensitive programming language. Thus, **Manpower** and **manpower** are two different identifiers in C++.

Here are some examples of acceptable identifiers −

```
mohd       zara    abc   move_name  a_123
myname50   _temp   j     a23b9      retVal
```

1.4.4 C++ Keywords

The following list shows the reserved words in C++. These reserved words may not be used as constant or variable or any other identifier names.

asm	else	new	this
auto	enum	operator	throw
bool	explicit	private	true
break	export	protected	try
case	extern	public	typedef
catch	false	register	typeid
char	float	reinterpret_cast	typename
class	for	return	union
const	friend	short	unsigned
const_cast	goto	signed	using
continue	if	sizeof	virtual
default	inline	static	void
delete	int	static_cast	volatile
do	long	struct	wchar_t
double	mutable	switch	while
dynamic_cast	namespace	template	

1.4.5 Comments in C++

Program comments are explanatory statements that you can include in the C++ code. These comments help anyone reading the source code. All programming languages allow for some form of comments.

C++ supports single-line and multi-line comments. All characters available inside any comment are ignored by C++ compiler.

C++ comments start with /* and end with */ or start with //. For example −

```
Single line comment:   /* This is a comment */        or //This is a comment

Multi-line comment or block comment

/* C++ comments can also
   * span multiple lines
*/
```

A comment can also start with //, extending to the end of the line. For example −

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

```
main() {
   cout << "Hello World"; // prints Hello World

   return 0;
}
```

When the above code is compiled, it will ignore **// prints Hello World** and final executable will produce the following result −

```
Hello World
```

Within a /* and */ comment, // characters have no special meaning. Within a // comment, /* and */ have no special meaning. Thus, you can "nest" one kind of comment within the other kind. For example −

```
/* Comment out printing of Hello World:

cout << "Hello World"; // prints Hello World

*/
```

1.4.6 C++ Variable types

A variable provides us with named storage that a program can manipulate. Each variable in C++ has a specific type, which determines the size and layout of the variable's memory, that is, the range of values that can be stored within that memory; and the set of operations that can be applied to the variable.

The name of a variable can be composed of letters, digits, and the underscore character. It must begin with either a letter or an underscore. Upper and lowercase letters are distinct because C++ is case-sensitive −

Basic types of variable in C++ :

bool - Stores either value true or false.
char - Typically a single octet (one byte). This is an integer type. Example char val = ‘a’;
int - The most natural size of integer for the machine.
float - A single-precision floating point value.
double - A double-precision floating point value.
void – represents the absence of a type.
string – uses `#include <string>` in the start of the file. *Value enclosed in double quotes.*
Example string myname = “Josphat Mutethia”;

C++ also allows to define various other types of variables, which we will cover in subsequent chapters like **Enumeration, Pointer, Array, Reference, Data structures,** and **Classes**.

Following section will cover how to define, declare and use various types of variables.

Variable Definition in C++

A variable definition tells the compiler where and how much storage to create for the variable. A variable definition specifies a data type, and contains a list of one or more variables of that type as follows −

```
type variable_list;
```

Here, **type** must be a valid C++ data type including char, w_char, int, float, double, bool or any user-defined object, etc., and **variable_list** may consist of one or more identifier names separated by commas. Some valid declarations are shown here −

```
int    i, j, k;
char   c, ch;
float  f, salary;
double d;
string lname, fname;
```

The line **int i, j, k;** both declares and defines the variables i, j and k; which instructs the compiler to create variables named i, j and k of type int.

Variables can be initialized (assigned an initial value) in their declaration. The initializer consists of an equal sign followed by a constant expression as follows −

```
type variable_name = value;
```

Some examples are −

```
extern int d = 3, f = 5;    // declaration of d and f.
int d = 3, f = 5;           // definition and initializing d and f.
byte z = 22;                // definition and initializes z.
char x = 'x';               // the variable x has the value 'x'.
string lname = "James";     // the variable lname has the value James.
```

For definition without an initializer: variables with static storage duration are implicitly initialized with NULL (all bytes have the value 0); the initial value of all other variables is undefined.

Variable Declaration in C++

A variable declaration provides assurance to the compiler that there is one variable existing with the given type and name so that compiler proceed for further compilation without needing complete detail about the variable. A variable declaration has its meaning at the time of compilation only, compiler needs actual variable definition at the time of linking of the program.

A variable declaration is useful when you are using multiple files and you define your variable in one of the files which will be available at the time of linking of the program. You will use **extern** keyword to declare a variable at any place. Though you can declare a variable multiple times in your C++ program, but it can be defined only once in a file, a function or a block of code.

Example

Try the following example where a variable has been declared at the top, but it has been defined inside the main function −

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

// Variable declaration:
extern int a, b;
extern int c;
extern float f;

int main () {
   // Variable definition:
   int a, b;
   int c;
   float f;

   // actual initialization
   a = 10;
   b = 20;
   c = a + b;

   cout << c << endl ;

   f = 70.0/3.0;
   cout << f << endl ;

   return 0;
}
```

When the above code is compiled and executed, it produces the following result −

```
30
23.3333
```

Same concept applies on function declaration where you provide a function name at the time of its declaration and its actual definition can be given anywhere else. For example −

```
// function declaration
int func();
int main() {
   // function call
   int i = func();
}

// function definition
```

```
int func() {
   return 0;
}
```

Lvalues and Rvalues

There are two kinds of expressions in C++ −

- **lvalue** − Expressions that refer to a memory location is called "lvalue" expression. An lvalue may appear as either the left-hand or right-hand side of an assignment.
- **rvalue** − The term rvalue refers to a data value that is stored at some address in memory. An rvalue is an expression that cannot have a value assigned to it which means an rvalue may appear on the right- but not left-hand side of an assignment.

Variables are lvalues and so may appear on the left-hand side of an assignment. Numeric literals are rvalues and so may not be assigned and cannot appear on the left-hand side. Following is a valid statement −

```
int g = 20;
```

But the following is not a valid statement and would generate compile-time error −

```
10 = 20;
```

1.4.7 C++ Basic Input/Output

The C++ standard libraries provide an extensive set of input/output capabilities which we will see in subsequent chapters. This chapter will discuss very basic and most common I/O operations required for C++ programming.

C++ I/O occurs in streams, which are sequences of bytes. If bytes flow from a device like a keyboard, a disk drive, or a network connection etc. to main memory, this is called **input operation** and if bytes flow from main memory to a device like a display screen, a printer, a disk drive, or a network connection, etc., this is called **output operation**.

I/O Library Header Files

There are following header files important to C++ programs –

<iostream>

This file defines the **cin, cout, cerr** and **clog** objects, which correspond to the standard input stream, the standard output stream, the un-buffered standard error stream and the buffered standard error stream, respectively.

<iomanip>

This file declares services useful for performing formatted I/O with so-called parameterized stream manipulators, such as **setw** and **setprecision**.

The Standard Output Stream (cout)

The predefined object **cout** is an instance of **ostream** class. The cout object is said to be "connected to" the standard output device, which usually is the display screen. The **cout** is used in conjunction with the stream insertion operator, which is written as << which are two less than signs as shown in the following example.

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

int main() {
   char str[] = "Hello C++"; //same as string str = "Hello C++";

   cout << "Value of str is : " << str << endl;
   return 0;
}
```

When the above code is compiled and executed, it produces the following result −

```
Value of str is : Hello C++
```

The C++ compiler also determines the data type of variable to be output and selects the appropriate stream insertion operator to display the value. The << operator is overloaded to output data items of built-in types integer, float, double, strings and pointer values.

The insertion operator << may be used more than once in a single statement as shown above and **endl** is used to add a new-line at the end of the line.

The Standard Input Stream (cin)

The predefined object **cin** is an instance of **istream** class. The cin object is said to be attached to the standard input device, which usually is the keyboard. The **cin** is used in conjunction with the stream extraction operator, which is written as >> which are two greater than signs as shown in the following example.

```
#include <iostream>

using namespace std;

int main() {
   char name[50];

   cout << "Please enter your name: ";
   cin >> name;
   cout << "Your name is: " << name << endl;

}
```

When the above code is compiled and executed, it will prompt you to enter a name. You enter a value and then hit enter to see the following result −

```
Please enter your name: cplusplus
Your name is: cplusplus
```

The C++ compiler also determines the data type of the entered value and selects the appropriate stream extraction operator to extract the value and store it in the given variables.

The stream extraction operator >> may be used more than once in a single statement. To request more than one datum you can use the following −

```
cin >> name >> age;
```

This will be equivalent to the following two statements −

```
cin >> name;
cin >> age;
```

The Standard Error Stream (cerr)

The predefined object **cerr** is an instance of **ostream** class. The cerr object is said to be attached to the standard error device, which is also a display screen but the object **cerr** is un-buffered and each stream insertion to cerr causes its output to appear immediately.

The **cerr** is also used in conjunction with the stream insertion operator as shown in the following example.

```
#include <iostream>

using namespace std;

int main() {
   char str[] = "Unable to read....";

   cerr << "Error message : " << str << endl;
   return 0;
}
```

When the above code is compiled and executed, it produces the following result −

```
Error message : Unable to read....
```