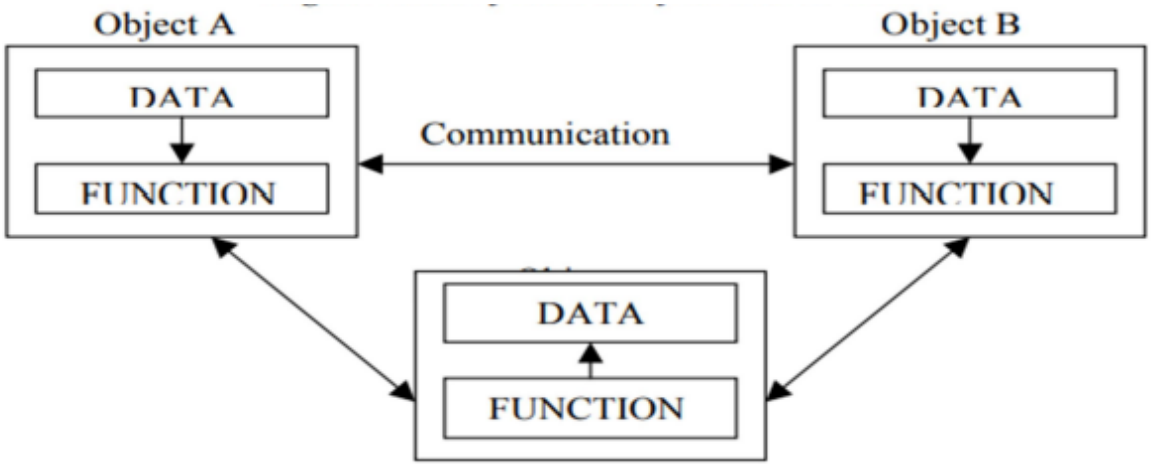
Object Oriented Programming Using C++

Unit -1

OOP Paradigm

The major motivating factor in the invention of object-oriented approach is to remove some of the flaws encountered in the procedural approach. OOP treats data as a critical element in the program development and does not allow it to flow freely around the system. It ties data more closely to the function that operates on it, and protects it from accidental modification from outside function. OOP allows decomposition of a problem into a number of entities called objects and then builds data and functions around these objects. The organization of data and function in object-oriented programs is shown in the given fig. The data of an object can be accessed only by the function associated with that object. However, the function of one object can access the function of other objects.

Organization of data and function in OOP



Some of the features of object oriented programming are:

- Emphasis is on data rather than procedure.
- Programs are divided into what are known as objects.
- Data structures are designed such that they characterize the objects.
- Functions that operate on the data of an object are ties together in the data structure.
- Data is hidden and cannot be accessed by external function.
- Objects may communicate with each other through function.
- New data and functions can be easily added whenever necessary.
- Follows bottom up approach in program design.

Object-oriented programming is the most recent concept among programming paradigms and still means different things to different people.

Benefits of object oriented programming (OOPs)

OOP offers several benefits to both the program designer and the user. Object Orientation contributes to the solution of many problems associated with the development and quality of software products. The new technology promises greater programmer productivity, better quality of software and lesser maintenance cost

Reusability: In OOPs programs functions and modules that are written by a user can be reused by other users without any modification.
Inheritance: Through this we can eliminate redundant code and extend the use of existing classes.
Data Hiding: The programmer can hide the data and functions in a class from other classes. It helps the programmer to build the secure programs.
Reduced complexity of a problem: The given problem can be viewed as a collection of different objects. Each object is responsible for a specific task. The problem is solved by interfacing the objects. This technique reduces the complexity of the program design.
Easy to Maintain and Upgrade: OOP makes it easy to maintain and modify existing code as new objects can be created with small differences to existing ones. Software complexity can be easily managed.
Message Passing: The technique of message communication between objects makes the Interface with external systems is easier.
Modifiability: it is easy to make minor changes in the data representation or the procedures in an Oops program. Changes inside a class do not affect any other part of a program, since the only public interface that the external world has to a class is through the use of methods.
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Advantages of Oops
• Through inheritance, we can eliminate redundant code extend the use of existing
• Classes.
• We can build programs from the standard working modules that communicate with one another, rather than having to start writing the code from scratch. This leads to saving of development time and higher productivity.
• The principle of data hiding helps the programmer to build secure program that can not be invaded by code in other parts of a programs.
• It is possible to have multiple instances of an object to co-exist without any interference.
• It is possible to map object in the problem domain to those in the program.
• It is easy to partition the work in a project based on objects.
• The data-centered design approach enables us to capture more detail of a model can implemental form.
• Object-oriented system can be easily upgraded from small to large system.
• Message passing techniques for communication between objects makes to interface descriptions with external systems much simpler.
• Software complexity can be easily managed. While it is possible to incorporate all these features in an object-oriented system, their importance depends on the type of the project and the preference of the programmer.

Comparison between functional Programming and Oops Approach

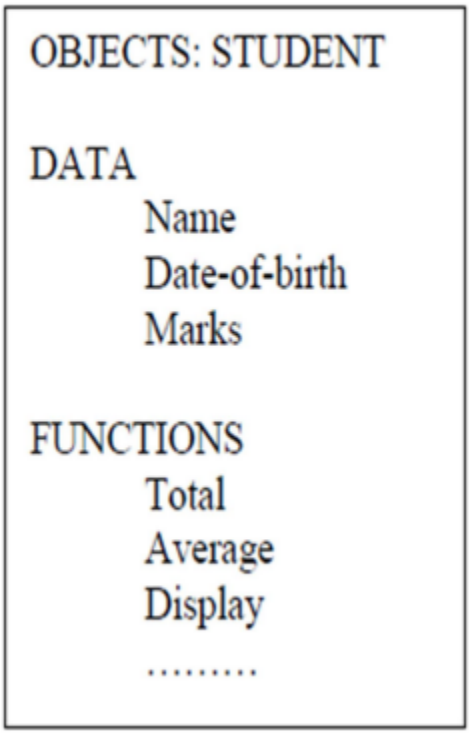
Functional Programming	Object Oriented Programming
This programming paradigm emphasizes on the use of functions where each function performs a specific task.	This programming paradigm is based on object oriented concept. Classes are uses where instance of objects are created.
Fundamental elements used are variables and functions. The data in the function are immutable (cannot be changed after creation).	Fundamental elements used are objects and methods and the data used here are mutable data.
Importance is not given to data but to functions.	Importance is given to data rather than procedures.
It uses recursion for iteration	It uses loops for iteration
It is parallel programming supported.	It does not support parallel programming.
Does not have any access specifier.	Has three access specifier namely, Public, Private and Protected.
To add new data and functions is not so easy.	Provides and easy way to add new data and functions.
No data hiding is possible. Hence, Security is not possible.	Provides data hiding. Hence, secured programs are possible.
The statements in this programming paradigm does not need to follow a particular order while execution.	The statements in this programming paradigm need to follow a order i.e., bottom up approach while execution.

Characteristics of Object Oriented Programming

It is necessary to understand some of the concepts used extensively in object-oriented programming.
These include:
• Objects
• Classes
• Data abstraction and encapsulation
• Inheritance
• Polymorphism
• Dynamic binding
• Message passing

Objects
Objects are the basic run time entities in an object-oriented system. They may represent a person, a place, a bank account, a table of data or any item that the program has to handle. They may also represent user-defined data such as vectors, time and lists. Programming problem is analyzed in terms of objects and the nature of communication between them.

Program objects should be chosen such that they match closely with the realworld objects. Objects take up space in the memory and have an associated address like a record in Pascal, or a structure in c. When a program is executed, the objects interact by sending messages to one another. For example, if “customer” and “account” are to object in a program, then the customer object may send a message to the count object requesting for the bank balance. Each object contains data, and code to manipulate data. Objects can interact without having to know details of each other’s data or code. It is sufficient to know the type of message accepted, and the type of response returned by the objects. Although different authors represent them differently fig. shows two notations that are popularly used in object oriented analysis and design.



Classes

We just mentioned that objects contain data, and code to manipulate that data. The entire set of data and code of an object can be made a user-defined data type with the help of class. In fact, objects are variables of the type class. Once a class has been defined, we can create any number of objects belonging to that class. Each object is associated with the data of the type class with which they are created. A class is thus a collection of objects of similar types.

For example, Mango, Apple and orange members of class fruit. Classes are user-defined that types and behave like the built-in types of a programming language. The syntax used to create an object is not different then the syntax used to create an integer object in C. If fruit has been defines as a class, then the statement

Fruit Mango;

Will create an object mango belonging to the class fruit.

Data Abstraction and Encapsulation

The wrapping up of data and function into a single unit (called class) is known as encapsulation. Data and encapsulation is the most striking feature of a class. The data is not accessible to the outside world, and only those functions which are wrapped in the class can access it. These functions provide the interface between the object's data and the program. This insulation of the data from direct access by the program is called data hiding or information hiding.

Abstraction refers to the act of representing essential features without including the background details or explanation. Classes use the concept of abstraction and are defined as a list of abstract attributes such as size, wait, and cost, and function operate on these attributes. They encapsulate all the essential properties of the object that are to be created. The attributes are some time called data members because they hold information. The functions that operate on these data are sometimes called methods or member function.

Inheritance

Inheritance is the process by which objects of one class acquired the properties of objects of another classes. It supports the concept of hierarchical classification. For example, the bird, 'robin' is a part of class 'flying bird' which is again a part of the class 'bird'. The principal behind this sort of division is that each derived class shares common characteristics with the class from which it is derived as illustrated in fig. In OOP, the concept of inheritance provides the idea of reusability. This means that we can add additional features to an existing class without modifying it. This is possible by deriving a new class from the existing one. The new class will have the combined feature of both the classes. The real appeal and power of the inheritance mechanism is that it allows the programmer to reuse a class i.e almost, but not exactly, what he wants, and to tailor the class in such a way that it does not introduced any undesirable side-effects into the rest of classes.

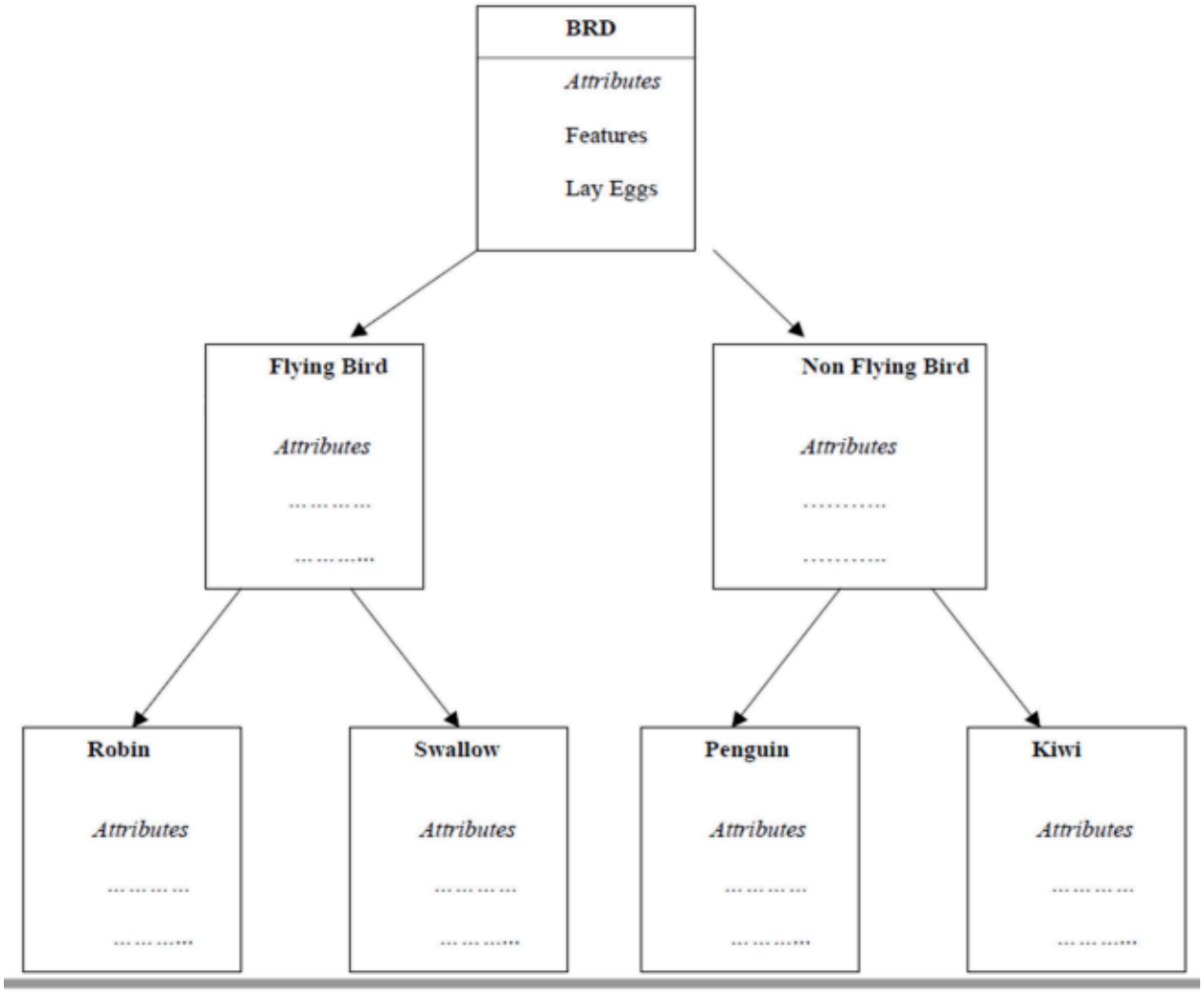
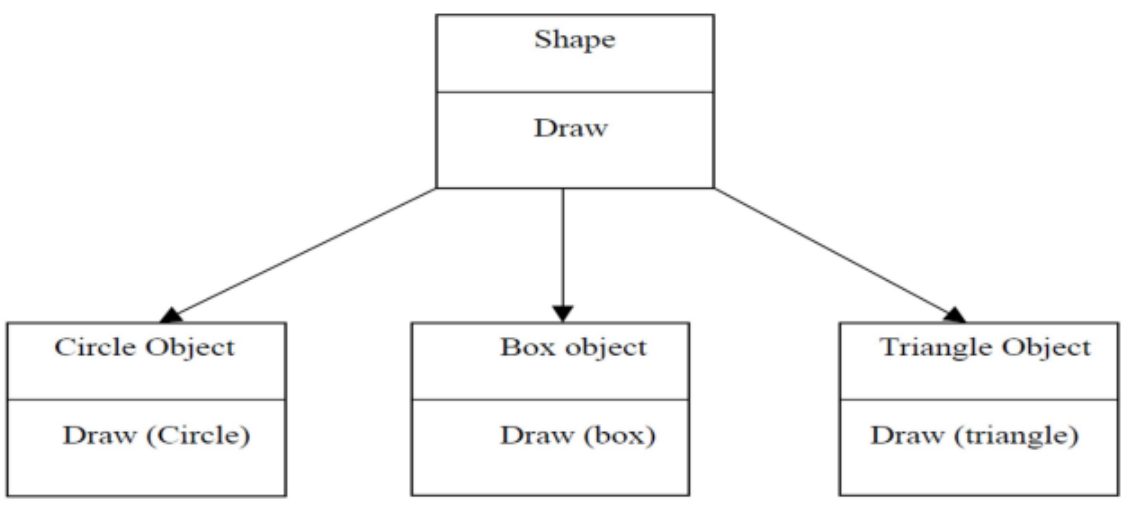


Fig. Property inheritances BIRD

Polymorphism

Polymorphism is another important OOP concept. Polymorphism, a Greek term, means the ability to take more than on form. An operation may exhibit different behavior is different instances. The behavior depends upon the types of data used in the operation. For example, consider the operation of addition. For two numbers, the operation will generate a sum. If the operands are strings, then the operation would produce a third string by concatenation. The process of making an operator to exhibit different behaviors in different instances is known as operator overloading. Fig. 1.7 illustrates that a single function name can be used to handle different number and different types of argument. This is something similar to a particular word having several different meanings depending upon the context. Using a single function name to perform different type of task is known as function overloading. Shape Draw Circle Object Draw (Circle) Box object Draw (box) Triangle Object Draw (triangle) Fig.



Polymorphism plays an important role in allowing objects having different internal structures to share the same external interface. This means that a general class of operations may be accessed in the same manner even though specific action associated with each operation may differ. Polymorphism is extensively used in implementing inheritance.

Dynamic Binding

Binding refers to the linking of a procedure call to the code to be executed in response to the call. Dynamic binding means that the code associated with a given procedure call is not known until the time of the call at run time. It is associated with polymorphism and inheritance. A function call associated with a polymorphic reference depends on the dynamic type of that reference. Consider the procedure “draw” in fig.

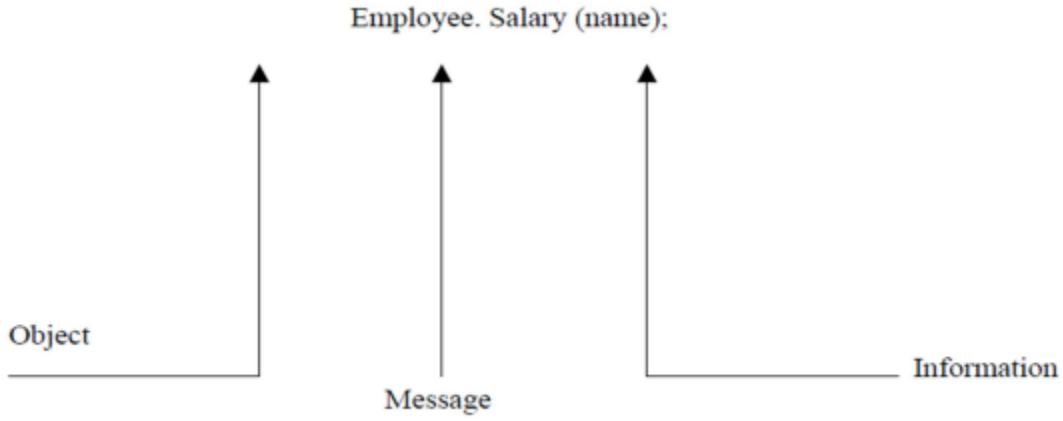
Inheritance, every object will have this procedure. Its algorithm is, however, unique to each object and so the draw procedure will be redefined in each class that defines the object. At run-time, the code matching the object under current reference will be called.

Message Passing An object-oriented program consists of a set of objects that communicate with each other.

The process of programming in an object-oriented language, involves the following basic steps:

1. Creating classes that define object and their behaviour,
2. Creating objects from class definitions, and
3. Establishing communication among objects. Objects communicate with one another by sending and receiving information much the same way as people pass messages to one another. The concept of message passing makes it easier to talk about building systems that directly model or simulate their real world counterparts. A Message for an object is a request for execution of a procedure, and therefore will invoke a function (procedure) in the receiving object that generates the desired results. Message passing involves specifying the name of object, the name of the function (message) and the information to be sent. Example: Employee. Salary (name);

Object Information Message



Object has a life cycle. They can be created and destroyed. Communication with an object is feasible as long as it is alive.
Major feature that are required for object based programming are:
• Data encapsulation
• Data hiding and access mechanisms
• Automatic initialization and clear-up of objects
• Operator overloading Languages that support programming with objects are said to the objects-based programming languages. They do not support inheritance and dynamic binding. Ada is a typical object-based programming language. Object-oriented programming language incorporates all of object-based programming features along with two additional features, namely, inheritance and dynamic binding. Object-oriented programming can therefore be characterized by the following statements: Object-based features + inheritance + dynamic binding

Application of OOP

OOP has become one of the programming buzzwords today. There appears to be a great deal of excitement and interest among software engineers in using OOP. Applications of OOP are beginning to gain importance in many areas. The most popular application of object-oriented programming, up to now, has been in the area of user interface design such as window. Hundreds of windowing systems have been developed, using the OOP techniques. Real-business system are often much more complex and contain many more objects with complicated attributes and method. OOP is useful in these types of application because it can simplify a complex problem.

The promising areas of application of OOP include:
• Real-time system
• Simulation and modeling
• Object-oriented data bases
• Hypertext, Hypermedia, and expertext
• AI and expert systems
• Neural networks and parallel programming
• Decision support and office automation systems

• CIM/CAM/CAD systems

The object-oriented paradigm sprang from the language, has matured into design, and has recently moved into analysis. It is believed that the richness of OOP environment will enable the software industry to improve not only the quality of software system but also its productivity. Object-oriented technology is certainly going to change the way the software engineers think, analyze, design and implement future system.

Standard Library

The C++ Standard Library provides a rich collection of functions for performing common mathematical calculations, string manipulations, character manipulations, input/output, error checking and many other useful operations. This makes the programmer's job easier, because these functions provide many of the capabilities programmers need. The C++ Standard Library functions are provided as part of the C++ programming environment. Header files contain the set of predefined standard library functions. The “#include” preprocessing directive is used to include the header files with “. Header file names ending in .h are "old-style" header files that have been superseded by the C++ Standard Library header files.

C++ Standard Library header file	Explanation
<iostream>	Contains function prototypes for the C++ standard input and standard output functions. This header file replaces header file <iostream.h>.
<iomanip>	Contains function prototypes for stream manipulators that format streams of data. This header file replaces header file <iomanip.h>.
<cmath>	Contains function prototypes for math library functions. This header file replaces header file <math.h>.
<cstdlib>	Contains function prototypes for conversions of numbers to text, text to numbers, memory allocation, random numbers and various other utility functions. This header file replaces header file <stdlib.h>.
<ctime>	Contains function prototypes and types for manipulating the time and date. This header file replaces header file <time.h>.
<cctype>	Contains function prototypes for functions that test characters for certain properties (such as whether the character is a digit or a punctuation), and function prototypes for functions that can be used to convert lowercase letters to uppercase letters and vice versa. This header file replaces header file <ctype.h>
<cstring>	Contains function prototypes for C-style string-processing functions. This header file replaces header file <string.h>.
<cstdio>	Contains function prototypes for the C-style standard input/output library functions and information used by them. This header file replaces header file <stdio.h>.

Preprocessor

Preprocessor is not a part of the compiler, but is a separate step in the compilation process. In simple terms, a C Preprocessor is just a text substitution tool and it instructs the compiler to do required pre-processing before the actual compilation.All Preprocessor commands begin with a hash symbol (#). It must be the first nonblank character, and for readability, a preprocessor directive should begin in the first column. The following section lists down all the important preprocessor directives −

Sr.No.	Directive & Description	
1	**#define**	Substitutes a preprocessor macro.
2	**#include**	Inserts a particular header from another file.
3	**#undef**	Undefines a preprocessor macro.
4	**#ifdef**	Returns true if this macro is defined.
5	**#ifndef**	Returns true if this macro is not defined.
6	**#if**	Tests if a compile time condition is true.
7	**#else**	The alternative for #if.
8	**#elif**	#else and #if in one statement.
9	**#endif**	Ends preprocessor conditional.
10	**#error**	Prints error message on stderr.

Pre-processors Examples

Analyze the following examples to understand various directives.

#define MAX_ARRAY_LENGTH 20 This directive tells the CPP to replace instances of MAX_ARRAY_LENGTH with 20. Use #define for constants to increase readability. #include #include"myheader.h" These directives tell the CPP to get stdio.h from System Libraries and add the text to the current source file. The next line tells CPP to get myheader.h from the local directory and add the content to the current source file. #undef FILE_SIZE #define FILE_SIZE 42 It tells the CPP to undefine existing FILE_SIZE and define it as 42.

Introduction of C++

C++ is an object-oriented programming language. It was developed by Bjarne Stroustrup at AT&T Bell Laboratories in Murray Hill, New Jersey, USA, in the early 1980's. wanted to combine the best of both the languages (Simula67 and C) and create a more powerful language that could support object-oriented programming features and still retain the power and elegance of C.The result was C++. Therefore, C++ is an extension of C with a major addition of the class construct feature of Simula67. C+ + is a superset of C. Almost all C programs are also C++ programs. However, there are a few minor differences that will prevent a C program to run under C++ compiler. The most important facilities that C++ adds on to C care classes, inheritance, function overloading and operator overloading.

These features enable creating of abstract data types, inherit properties from existing data types and support polymorphism, thereby making C++ a truly object-oriented language.

Application of C++

- C++ is a versatile language for handling very large programs; it is suitable for virtually any programming task including development of editors, compilers, databases, communication systems and any complex real life applications systems.
- Since C++ allow us to create hierarchy related objects, we can build special object-oriented libraries which can be used later by many programmers.
- While C++ is able to map the real-world problem properly, the C part of C++ gives the language the ability to get closed to the machine-level details.
- C++ programs are easily maintainable and expandable. When a new feature needs to be implemented, it is very easy to add to the existing structure of an object.
- It is expected that C++ will replace C as a general-purpose language in the near future.

Simple C++ Program

Let us begin with a simple example of a C++ program that prints a string on the screen.
Printing A String

#include Using namespace std; int main() { cout<<<<< is called the insertion or put to operator.

The iostream File

We have used the following #include directive in the program:
#include
The #include directive instructs the compiler to include the contents of the file enclosed within angular brackets into the source file.
The header file iostream.h should be included at the beginning of all programs that use input/output statements.

Namespace

Namespace is a new concept introduced by the ANSI C++ standards committee. This defines a scope for the identifiers that are used in a program. For using the identifier defined in the namespace scope we must include the using directive, like Using namespace std;. All ANSI C++ programs must include this directive.. Using and namespace are the new keyword of C++.

Return Type of main()

In C++, main () returns an integer value to the operating system. Therefore, every main () in C++ should end with a return (0) statement; otherwise a warning an error might occur. Since main () returns an integer type for main () is explicitly specified as int.

The following main without type and return will run with a warning:
main () { …….. ……. }

Identifiers

C++ identifiers in a program are used to refer to the name of the variables, functions, arrays, or other user-defined data types created by the programmer. They are the basic requirement of any language. Every language has its own rules for naming the identifiers. Whereas, the identifiers are the names which are defined by the programmer to the program elements such as variables, functions, arrays, objects, classes. In short, we can say that the C++ identifiers represent the essential elements in a program which are given below:

o Constants
o Variables
o Functions
o Labels
o Defined data types

Some naming rules are common in both C and C++. They are as follows:

o Only alphabetic characters, digits, and underscores are allowed.
o The identifier name cannot start with a digit, i.e., the first letter should be alphabetical. After the first letter, we can use letters, digits, or underscores.
o In C++, uppercase and lowercase letters are distinct. Therefore, we can say that C++ identifiers are case-sensitive.
o A declared keyword cannot be used as a variable name.

For example, suppose we have two identifiers, named as 'FirstName', and 'Firstname'. Both the identifiers will be different as the letter 'N' in the first case in uppercase while lowercase in second. Therefore, it proves that identifiers are case-sensitive.

Keywords

Keywords are the reserved words that have a special meaning to the compiler. They are reserved for a special purpose, which cannot be used as the identifiers. For example, 'for', 'break', 'while', 'if', 'else', etc. are the predefined words where predefined words are those words whose meaning is already known by the compiler.

C++ Keywords

Double	char	const	class	auto
Else	switch	return	short	if
int	default	do	continue	void
Typedef	goto	delete	enum	extern

Differences between Identifiers and Keywords

Identifiers	Keywords
Identifiers are the names defined by the programmer to the basic elements of a program.	Keywords are the reserved words whose meaning is known by the compiler.
It is used to identify the name of the variable.	It is used to specify the type of entity.
It can consist of letters, digits, and underscore.	It contains only letters.
It can use both lowercase and uppercase letters.	It uses only lowercase letters.
No special character can be used except the underscore.	It cannot contain any special character.
The starting letter of identifiers can be lowercase, uppercase or underscore.	It can be started only with the lowercase letter.
It can be classified as internal and external identifiers.	It cannot be further classified.
Examples are test, result, sum, power, etc.	Examples are 'for', 'if', 'else', 'break', etc.

Constants

Constants refer to values that do not change during the execution of a program.

Constants can be divided into two major categories:

Constants can be divided into two major categories:

Primary constants

Secondary constants:

1.Primary constants

a)Numeric constants

b)Integer constants.

Floating-point (real)

a)constants. b)Character constants

Single character constants

String constants

2.Secondary constants:

Enumeration constants.

Symbolic constants.

Arrays, unions, etc.

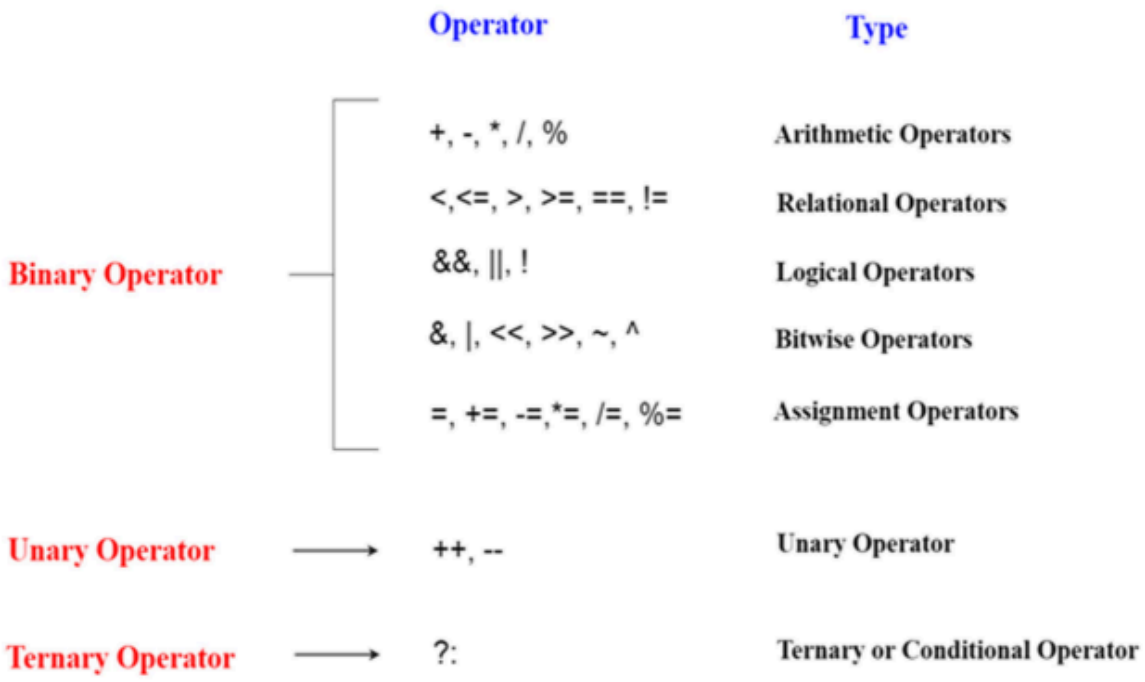
Rules for declaring constants:

1.Commas and blank spaces are not permitted within the constant.

2.The constant can be preceded by minus (-) signed if required.
3.The value of a constant must be within its minimum bounds of its specified data type.

Integer constants: An integer constant is an integer-valued number. It consists of sequence of digits. Integer constants can be written in three different number systems:
1.Decimal integer (base 10).
2.Octal integer (base 8).
3.Hexadecimal (base 16).

C++ Operators
An operator is simply a symbol that is used to perform operations. All C operators are valid in C++. There can be many types of operations like arithmetic, logical, bitwise etc. There are following types of operators to perform different types of operations in C language.
o Arithmetic Operators
o Relational Operators
o Logical Operators
o Bitwise Operators
o Assignment Operator
o Unary operator
o Ternary or Conditional Operator



1.Arithmetic Operators : All basic arithmetic operators are present in C. An arithmetic operation involving only real operands(or integer operands) is called real arithmetic(or integer arithmetic). If a combination of arithmetic and real is called mixed mode arithmetic.

operator meaning
+ add
- subtract
* multiplication
/ division
% modulo division(remainder)

2. Relational Operators : We often compare two quantities and depending on their relation take certain decisions for that comparison we use relational operators.

operator meaning
< is less than
> is greater than
<= is less than or equal to
>= is greater than or equal to
== is equal to
!= is not equal to

3.Logical Operators:
Logical Data: A piece of data is called logical if it conveys the idea of true or false. In C++ we use int data type to represent logical data. If the data value is zero, it is considered as false. If it is non -zero (1 or any integer other than 0) it is considered as true. C++ has three logical operators for combining logical values and creating new logical values:

Truth tables for AND (&&) and OR (||) operators:

X	Y	X&&Y	X||Y
0	0	0	0
0	1	0	1
1	0	0	1
1	1	1	1

Truth table for NOT (!) operator:

X	!X
0	1
1	0

4.Bit Wise Operators: C supports special operators known as bit wise operators for manipulation of data at bit level. They are not applied to float or double.operator meaning&Bitwise AND
^
<<
>>
~

Bitwise exclusive OR
left shift
right shift
one's complement

5.Assignment Operator:
The assignment expression evaluates the operand on the right side of the operator (=) and places its value in the variable on the left.
Note: The left operand in an assignment expression must be a single variable.
There are two forms of assignment:
•Simple assignment
•Compound assignment

Increment (++) And Decrement (--) Operators:
The operator ++ adds one to its operand where as the operator - - subtracts one from its operand. These operators are unary operators and take the following form:

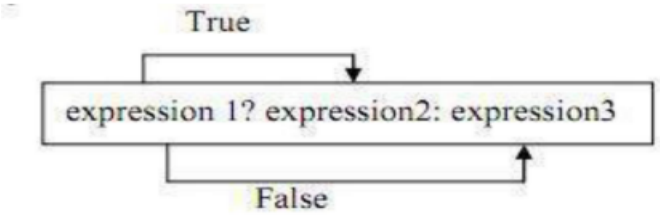
Both the increment and decrement operators may either precede or follow the operand. Postfix Increment/Decrement :(a++/a--) In postfix increment (Decrement) the value is incremented (decremented) by one. Thus the a++ has the same effect as

Operator	Description
++a	Pre-increment
a++	Post-increment
--a	Pre-decrement
a--	Post-decrement

6.Unary Operator: operator which operates on single operand is called unary operator
Operators in c++:All above operators of c language are also valid in c++.New operators introduced in c++ are

Operator Symbol
1. Scope resolution operator ::
2. Pointer to a member declarator ::*
3. Pointer to member operator ->*,->
4. Pointer to member operator .*
5. new Memory allocating operator
6. delete Memory release operator
7. endl Line feed operator
8. setw Field width operator
9. Insertion <<

7.Conditional Operator Or Ternary Operator:
A ternary operator requires two operands to operate



8.Special Operators

These operators which do not fit in any of the above classification are ,(comma), sizeof, Pointeroperators(& and *) and member selection operators (. and ->). The comma operator is used to link related expressions together.

Type conversion

The type conversion techniques present in C++.There are mainly two types of type conversion. The implicit and explicit.

Implicit type conversion

This is also known as automatic type conversion. This is done by the compiler without any external trigger from the user. This is done when one expression has more than one data type is present.

All data types are upgraded to the data type of the large variable.

bool -> char -> short int ->int -> unsigned int -> long -> unsigned -> long long -> float -> double -> long double

In the implicit conversion, it may lose some information. The sign can be lost etc.

```
include<iostream>
using namespace std;
int main() {
int a = 10;
char b = 'a';
a = b + a;
float c = a + 1.0;
cout<< "a : " << a << "\nb : " << b << "\nc : " << c;
}
```

Output

```
a : 107
b : a
c : 108
```

Explicit type conversion

This is also known as type casting. Here the user can typecast the result to make it to particular datatype. In C++ we can do this in two ways, either using expression in parentheses or using static_cast or dynamic_cast.

Example

```
#include<iostream>
usingnamespacestd;
int main()
{
double x =1.574;
intadd=(int)x +1;
cout<<"Add: "<<add;
float y =3.5;
intval=static_cast<int>(y);
cout<<"\nvalue: "<<val;
}
```

Output

```
Add: 2
value: 3
```

Variable

A variable is a name of memory location. It is used to store data. Its value can be changed and it can be reused many times. It is a way to represent memory location through symbol so that it can be easily identified.

Let's see the syntax to declare a variable:

type variable_list;

The example of declaring variable is given below:

int x;
float y;
char z;

Here, x, y, z are variables and int, float, char are data types.

Rules for defining variables

A variable can have alphabets, digits and underscore.
A variable name can start with alphabet and underscore only. It can't start with digit.
No white space is allowed within variable name.
A variable name must not be any reserved word or keyword e.g. char, float etc.

Statement

C++ statements are the program elements that control how and in what order objects are manipulated. This section includes:

Overview C ++ statements are executed sequentially, except when an expression statement, a selection statement, an iteration statement, or a jump statement specifically modifies that sequence.

Statements may be of the following types:

labeled-statement
expression-statement
compound-statement

selection-statement
iteration-statement
jump-statement
declaration-statement
try-throw-catch

o Labeled Statements
Labels are used to transfer program control directly to the specified statement.
Syntax
labeled-statement:
identifier : statement
case constant-expression : statement
default : statement
o Expression statements. These statements evaluate an expression for its side effects or for its return value.
o **Null statements.** These statements can be provided where a statement is required by the C++ syntax but where no action is to be taken.
o **Compound statements**. These statements are groups of statements enclosed in curly braces ({ }). They can be used wherever a single statement may be used.
o **Selection statements.** These statements perform a test; they then execute one section of code if the test evaluates to true (nonzero). They may execute another section of code if the test evaluates to false.
o **Iteration statements**. These statements provide for repeated execution of a block of code until a specified termination criterion is met.
o **Jump statements.** These statements either transfer control immediately to another location in the function or return control from the function.
o **Declaration statements**. Declarations introduce a name into a program.

Expressions
C++ expression consists of operators, constants, and variables which are arranged according to the rules of the language. It can also contain function calls which return values. An expression can consist of one or more operands, zero or more operators to compute a value. Every expression produces some value which is assigned to the variable with the help of an assignment operator.
Examples of C++ expression:
(a+b) - c
(x/y) -z
4a2 - 5b +c
(a+b) * (x+y)
An expression can be of following types:
o Constant expressions
o Integral expressions
o Float expressions
o Pointer expressions

o Relational expressions
o Logical expressions
o Bitwise expressions
o Special assignment expressions

Constant expressions

o A constant expression is an expression that consists of only constant values.
o It is an expression whose value is determined at the compile-time but evaluated at the run-time.
o It can be composed of integer, character, floating-point, and enumeration constants.
Constants are used in the following situations:
o It is used in the subscript declarator to describe the array bound.
o It is used after the case keyword in the switch statement.
o It is used as a numeric value in an **enum**
o It specifies a bit-field width.
o It is used in the pre-processor **#if**
The following table shows the expression containing constant value:

Expression containing constant	Constant value
x = (2/3) * 4	(2/3) * 4
extern int y = 67	67
int z = 43	43
static int a = 56	56

Expression containing constant Constant value
x = (2/3) * 4 (2/3) * 4
extern int y = 67 67
int z = 43 43
static int a = 56 56
Integral Expressions
An integer expression is an expression that produces the integer value as output after performing all the explicit and implicit conversions.
Following are the examples of integral expression:
x * y) -5
x + int(9.0)
where x and y are the integers variables.

Float Expressions

A float expression is an expression that produces floating-point value as output after performing all the explicit and implicit conversions.
The following are the examples of float expressions:
x+y
(x/10) + y

34.5
x+float(10)

Pointer Expressions
A pointer expression is an expression that produces address value as an output.

The following are the examples of pointer expression:
&x
ptr
ptr++
Ptr

Relational Expressions
A relational expression is an expression that produces a value of type bool, which can be either true or false. It is also known as a boolean expression. When arithmetic expressions are used on both sides of the relational operator, arithmetic expressions are evaluated first, and then their results are compared.
The following are the examples of the relational expression:
a>b
a+b == x+y
a+b>80

Logical Expressions
A logical expression is an expression that combines two or more relational expressions and produces a bool type value. The logical operators are '&&' and '||' that combines two or more relational expressions.
The following are some examples of logical expressions:
a>b && x>y
a>10 || b==5

Bitwise Expressions
A bitwise expression is an expression which is used to manipulate the data at a bit level. They are basically used to shift the bits.
For example:
```
 x=3
 x>>3
```
// This statement means that we are shifting the three-bit position to the right.
In the above example, the value of 'x' is 3 and its binary value is 0011. We are shifting the value of 'x' by three-bit position to the right.

Special Assignment Expressions
Special assignment expressions are the expressions which can be further classified depending upon the value assigned to the variable.
1.Chained Assignment: Chained assignment expression is an expression in which the same value is assigned to more than one variable by using single statement.

2.Embedded Assignment Expression: An embedded assignment expression is an assignment expression in which assignment expression is enclosed within another assignment expression.
3. Compound Assignment:A compound assignment expression is an expression which is a combination of an assignment operator and binary operator.

User Defined Data types

User Defined Data type in c++ is a type by which the data can be represented. The type of data will inform the interpreter how the programmer will use the data. A data type can be pre-defined or user-defined. Examples of pre-defined data types are char, int, float, etc. As the programming languages allow the user to create their own data types according to their needs. Hence, the data types that are defined by the user are known as user-defined data types. For example; arrays, class, structure, union, Enumeration, pointer, etc. These data types hold more complexity than pre-defined data types.

Types of User-Defined Data in C++

Here are the types mentioned below:

1. Structure

A structure is defined as a collection of various types of related information under one name. The declaration of structure forms a template and the variables of structures are known as members. All the members of the structure are generally related. The keyword used for the structure is “struct”.
For example; a structure for student identity having ‘name’, ‘class’, ‘roll_number’, ‘address’ as a member can be created as follows:

```
 structstud_id
{
char name[20];
int class;
introll_number;
char address[30];
};
```

This is called the declaration of the structure and it is terminated by a semicolon (;). The memory is not allocated while the structure declaration is delegated when specifying the same. The structure definition creates structure variables and allocates storage space for them.
2. Array
An Array is defined as a collection of homogeneous data. It should be defined before using it for the storage of information. The array can be defined as follows:

```
 <datatype><array_name><[size of array]>
 int marks[10]
```

The above statement defined an integer type array named marks that can store marks of 10 students. After the array is created, one can access any element of an array by writing the name an array followed by its index. For example; to access 5th element from marks, the syntax is as follows:

```
marks[5]
```

It will give the marks stored at the 5th location of an array. An array can be one-dimensional, two-dimensional or multi-dimensional depending upon the specification of elements.

3. Union

Just like structures, the union also contain members of different data types. The main difference between the two is that union saves memory as members of a union share the same storage area whereas members of the structure are assigned their own unique storage area. Unions are declared with keyword “union” as follows:

```
union employee
{
int id;
double salary;
char name[20];
}
```

The variable of the union can be defined as:

```
union employee E;
```

To access the members of the union, the dot operator can be used as follows:

```
E.salary;
```

4. Class

A class is an important feature of object-oriented programming language just like C++. A class is defined as a group of objects with the same operations and attributes. It is declared using a keyword “class”. The syntax is as follows:

```
class<classname>
{
private:
Data_members;
Member_functions;
public:
Data_members;
Member_functions;
};
```

In this, the names of data members should be different from member functions. There are two access specifiers for classes that define the scope of the members of a class. These are private and public. The member specified as private can be only accessed by the member functions of that particular class only. The members with no specifier are private by default. The objects belonging to a class are called instances of the class.

The syntax for creating an object of a class is as follows:

```
<classname><objectname>
```

5. Enumeration

Enumeration is specified by using a keyword “enum”. It is defined as a set of named integer constants that specify all the possible values a variable of that type can have. For example, enumeration of the week can have names of all the seven days of the week as shown below:

Example:

```
enumweek_days{sun, mon, tues, wed, thur, fri, sat};
int main()
{
enumweek_days d;
d = mon;
cout<< d;
return 0;
}
```

6. Pointer

A Pointer is that kind of user-defined data type that creates variables for holding the memory address of other variables. If one variable carries the address of another variable, the the first variable is said to be the pointer of another. The syntax for the same is:

```
type *ptr_name;
```

Here type is any data type of the pointer and ptr_name is the pointer’s name.

7. Typedef

Using the keyword “typedef”, you can define new data type names to the existing ones. Its syntax is:

```
typedef<type><newname>;
typedef float balance;
```

Where a new name is created for float i.e. using balance, we can declare any variable of float type.

Conditional Expression

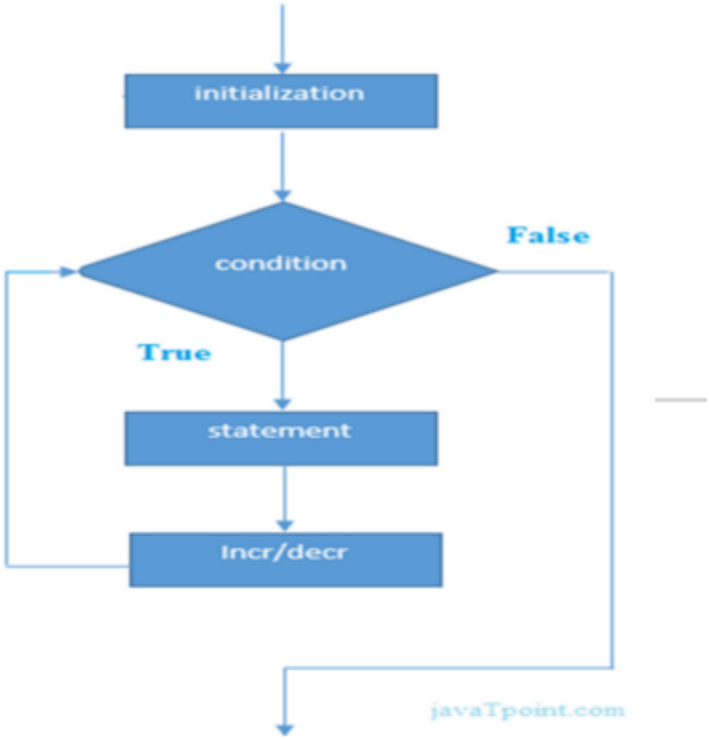
C++ For Loop

The C++ for loop is used to iterate a part of the program several times. If the number of iteration is fixed, it is recommended to use for loop than while or do-while loops. The C++ for loopis same as C/C#.

We can initialize variable, check condition and increment/decrement value.

```
for(initialization; condition; incr/decr){
//code to be executed
}
```

Flowchart:



C++ For Loop Example

```
#include <iostream>
using namespace std;
int main() {
 for(int i=1;i<=10;i++){
 cout<<i <<"\n";
 }
 }
```

Output

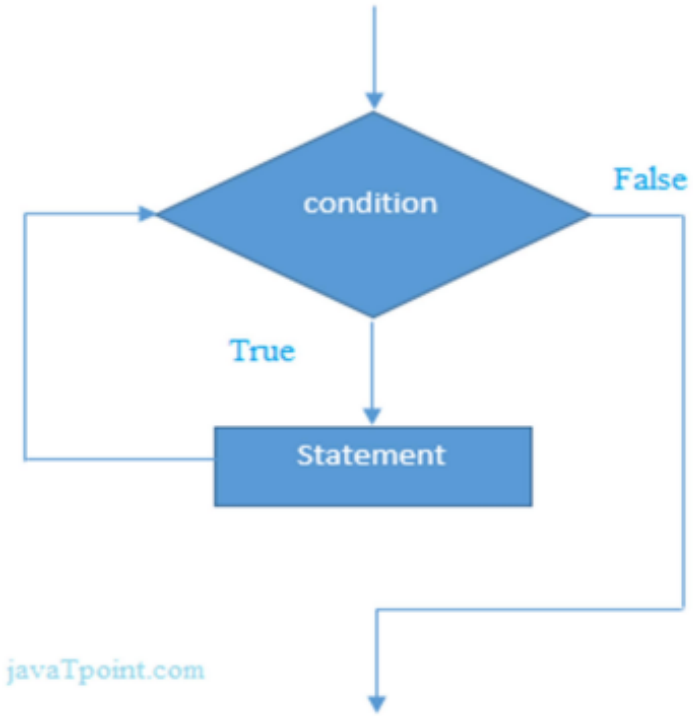
```
1
2
3
4
5
6
7
8
9
10
```

C++ While loop

In C++, while loop is used to iterate a part of the program several times. If the number of iteration is not fixed, it is recommended to use while loop rather than for loop.

```
while(condition)
{
//code to be executed
}
```

Flowchart:



C++ While Loop Example

Let's see a simple example of while loop.

```
#include <iostream>
using namespace std;
int main() {
int i=1;
while(i<=10)
{
cout<<i <<"\n";
i++;
}
}
```

Output:

```
1
2
```

3
4
5
6
7
8
9

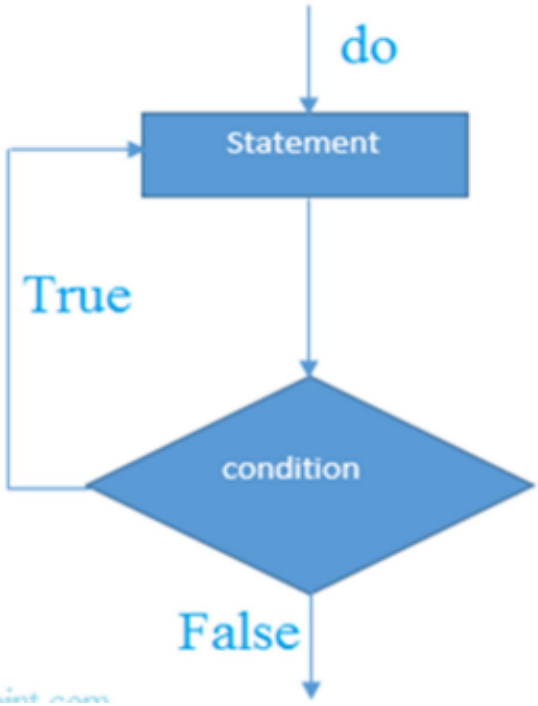
C++ Do-While Loop

The C++ do-while loop is used to iterate a part of the program several times. If the number of iteration is not fixed and you must have to execute the loop at least once, it is recommended to use do-while loop.

The C++ do-while loop is executed at least once because condition is checked after loop body.

```
Do
{
//code to be executed
}
while(condition);
```

Flowchart:



C++ do-while Loop Example

Let's see a simple example of C++ do-while loop to print the table of 1.

```
#include <iostream>
using namespace std;
int main() {
 int i = 1;
```

```
 do
{
 cout<<i<<"\n";
 i++;
 } while (i <= 10) ;
}
```

Output:

```
1
2
3
4
5
6
7
8
9
10
```

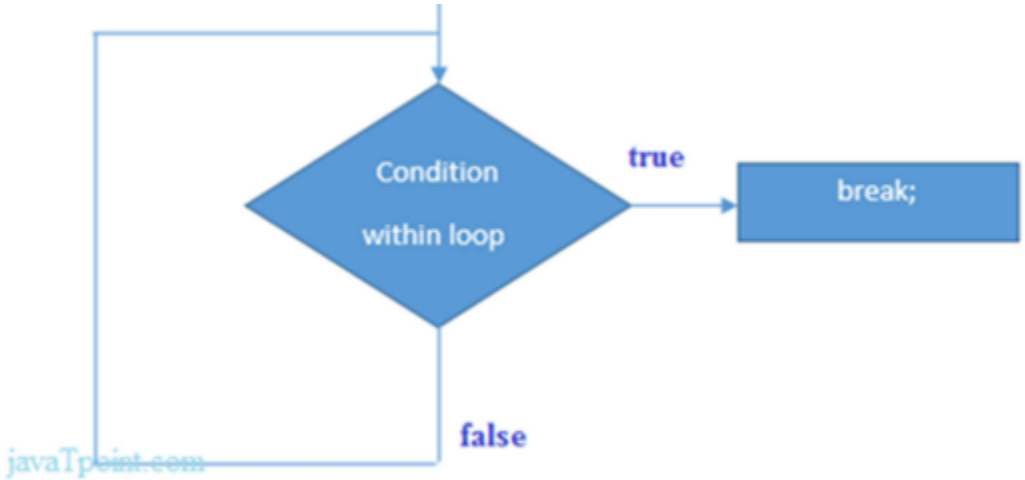
Breaking control statement

Break Statement

The C++ break is used to break loop or switch statement. It breaks the current flow of the program at the given condition. In case of inner loop, it breaks only inner loop.

```
 jump-statement;
break;
```

Flowchart:



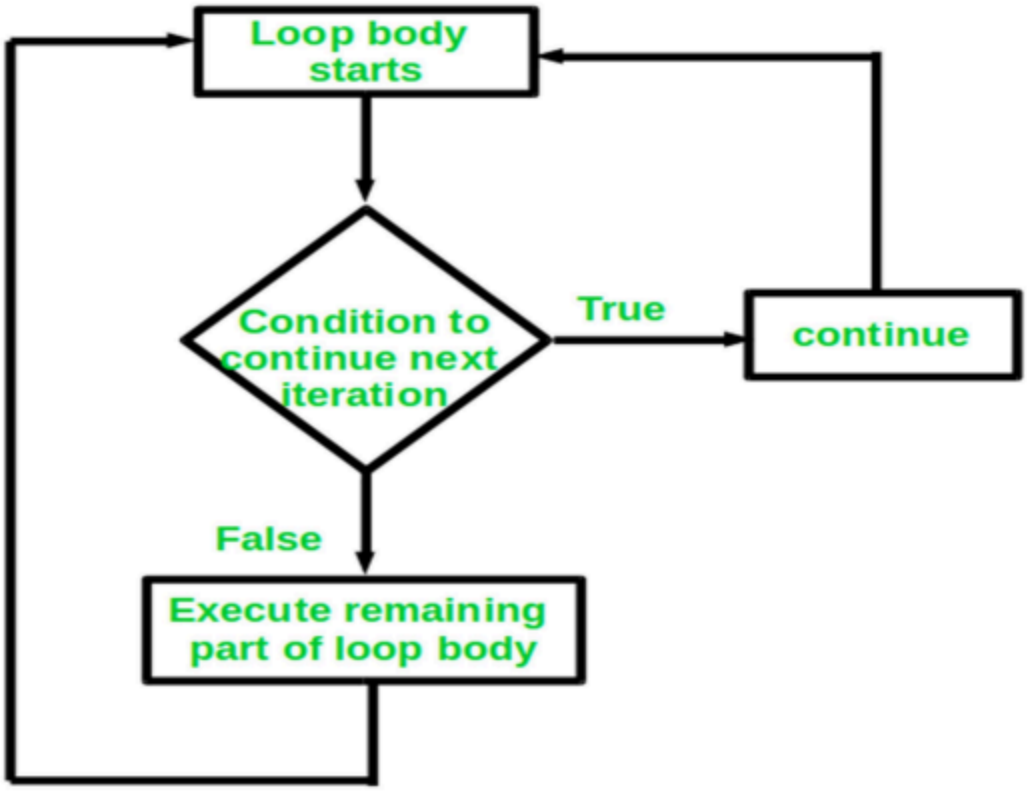
Continue Statement in C/C++

Continue is also a loop control statement just like the break statement. continue statement is opposite to that of break statement, instead of terminating the loop, it forces to execute the next iteration of the loop.

As the name suggest the continue statement forces the loop to continue or execute the next iteration. When the continue statement is executed in the loop, the code inside the loop following the continue statement will be skipped and next iteration of the loop will begin.

Syntax: Continue

```
/*c program to find sum of n positive numbers read from keyboard*/
 #include<stdio.h>
 int main()
 {
 int i ,sum = 0,n,number;
 cout<<Enter N";
 cin>>n;
 for(i=1;i<=n;i++)
 {
 cout<<“Enter a number:”;
 cin>>number;
 if(number<0) continue;
 sum = sum + number;
 }
 cout<<“Sum of”<<n<<” numbers is:”<<sum;
 return 0;
 }
```



Break Statement in C/C++

The break in C or C++ is a loop control statement which is used to terminate the loop. As soon as the break statement is encountered from within a loop, the loop iterations stops there and control returns from the loop immediately to the first statement after the loop.

Syntax:

```
break;
```

C++ Break Statement Example

Let's see a simple example of C++ break statement which is used inside the loop.

```
#include <iostream>
using namespace std;
int main() {
for (int i = 1; i <= 10; i++)
 {
if (i == 5)
 {
 break;
 }
 cout<<i<<"\n";
 }
 }
```

Output:
1
2
3
4

Continue Statement

The C++ continue statement is used to continue the loop. It continues the current flow of the program and skips the remaining code at specified condition. In the case of the inner loop, it continues only in the inner loop.

jump-statement;
continue;

C++ Continue Statement Example

```
#include <iostream>
using namespace std;
int main()
{
 for(int i=1;i<=10;i++){
 if(i==5){
 continue;
 }
 cout<<i<<"\n";
 }
}
```

Output:
1
2
3
4
6
7
8
9
10

We will see here the usage of break statement with three different types of loops:

1. Simple loops
2. Nested loops
3. Infinite loops

Let us now look at the examples for each of the above three types of loops using break statement.

1.Simple loops: Consider the situation where we want to search an element in an array. To do this, use a loop to traverse the array starting from the first index and compare the array elements with the given key.

2.Nested Loops: We can also use break statement while working with nested loops. If the

break statement is used in the innermost loop. The control will come out only from the innermost loop.
3.Infinite Loops: break statement can be included in an infinite loop with a condition in order to terminate the execution of the infinite loop.

Access Modifiers in C++

Access modifiers are used to implement an important aspect of Object-Oriented Programming known as **Data Hiding**. Consider a real-life example:
The Research and Analysis Wing (R&AW), having 10 core members, has come into possession of sensitive confidential information regarding national security. Now we can correlate these core members to data members or member functions of a class, which in turn can be correlated to the R&A Wing. These 10 members can directly access the confidential information from their wing (the class), but anyone apart from these 10 members can't access this information directly, i.e., outside functions other than those prevalent in the class itself can't access the information (that is not entitled to them) without having either assigned privileges (such as those possessed by a friend class or an inherited class, as will be seen in this article ahead) or access to one of these 10 members who is allowed direct access to the confidential information (similar to how private members of a class can be accessed in the outside world through public member functions of the class that have direct access to private members). This is what data hiding is in practice.
Access Modifiers or Access Specifiers in a class are used to assign the accessibility to the class members, i.e., they set some restrictions on the class members so that they can't be directly accessed by the outside functions.
There are 3 types of access modifiers available in C++:

1. **Public**
2. **Private**
3. **Protected**

Note: If we do not specify any access modifiers for the members inside the class, then by default the access modifier for the members will be Private.

Let us now look at each one of these access modifiers in detail:
1. Public: All the class members declared under the public specifier will be available to everyone. The data members and member functions declared as public can be accessed by other classes and functions too. The public members of a class can be accessed from anywhere in the program using the direct member access operator (.) with the object of that class.

// C++ program to demonstrate public

// access modifier

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

// class definition
class Circle
{
	public:
		double radius;

		double compute_area()
		{
			return 3.14*radius*radius;
		}

};

// main function
int main()
{
	Circle obj;

	// accessing public data member outside class
	obj.radius = 5.5;

	cout << "Radius is: " << obj.radius << "\n";
	cout << "Area is: " << obj.compute_area();
	return 0;
}
```

Output:

Radius is: 5.5

Area is: 94.985

In the above program, the data member radius is declared as public so it could be accessed outside the class and thus was allowed access from inside main().

2. Private: The class members declared as private can be accessed only by the member functions inside the class. They are not allowed to be accessed directly by any object or function outside the class. Only the member functions or the friend functions are allowed to access the private data members of the class.

Example:

```
// C++ program to demonstrate private
// access modifier

#include<iostream>
using namespace std;

class Circle
{
    // private data member
    private:
        double radius;

    // public member function
    public:
        double compute_area()
        { // member function can access private
            // data member radius
            return 3.14*radius*radius;
        }
```

```
};

// main function
int main()
{
        // creating object of the class
        Circle obj;

        // trying to access private data member
        // directly outside the class
        obj.radius = 1.5;

        cout << "Area is:" << obj.compute_area();
        return 0;
}
```

Output:

```
In function 'int main()':
11:16: error: 'double Circle::radius' is private
      double radius;
             ^
31:9: error: within this context
    obj.radius = 1.5;
```

The output of the above program is a compile time error because we are not allowed to access the private data members of a class directly from outside the class. Yet an access to obj.radius is attempted, but radius being a private data member, we obtained the above compilation error.

However, we can access the private data members of a class indirectly using the public member functions of the class.

```
// C++ program to demonstrate private
// access modifier
```

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

class Circle
{
	// private data member
	private:
		double radius;

	// public member function
	public:
		void compute_area(double r)
		{ // member function can access private
			// data member radius
			radius = r;

			double area = 3.14*radius*radius;

			cout << "Radius is: " << radius << endl;
			cout << "Area is: " << area;
		}

};

// main function
int main()
{
	// creating object of the class
```

```
    Circle obj;

    // trying to access private data member
    // directly outside the class
    obj.compute_area(1.5);

    return 0;
}
```

Output:

Radius is: 1.5

Area is: 7.065

3. Protected: The protected access modifier is similar to the private access modifier in the sense that it can't be accessed outside of its class unless with the help of a friend class. The difference is that the class members declared as Protected can be accessed by any subclass (derived class) of that class as well.

Note: This access through inheritance can alter the access modifier of the elements of base class in derived class depending on the mode of Inheritance.

Example:

```
// C++ program to demonstrate
// protected access modifier
#include <bits/stdc++.h>
using namespace std;

// base class
class Parent
{
    // protected data members
    protected:
```

```
        int id_protected;

};

// sub class or derived class from public base class
class Child : public Parent
{
        public:
        void setId(int id)
        {

                // Child class is able to access the inherited
                // protected data members of base class

                id_protected = id;

        }

        void displayId()
        {
                cout << "id_protected is: " << id_protected << endl;
        }
};

// main function
int main() {

        Child obj1;
```

```
        // member function of the derived class can
        // access the protected data members of the base class

        obj1.setId(81);
        obj1.displayId();
        return 0;
}
```

Output:

id_protected is: 81

****

Unit 2 Constructors in a class

Function

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. Functions are used to minimize the repetition of code, as a function allows you to write the code inside the block. And you can call that block whenever you need that code segment, rather than writing the code repeatedly. It also helps in dividing the program into well-organized segments. Now, have a look at the syntax of C++ functions.

Function Syntax

The syntax for creating a function is as follows:

Here, the return type is the data type of the value that the function will return. Then there is the function name, followed by the parameters which are not mandatory, which means a function may or may not contain parameters.

Example:

Declaration: A function can be declared by writing its return type, the name of the function, and the arguments inside brackets. It informs the compiler that this particular function is present. In C++, if you want to define the function after the main function, then you have to declare that function first. Function declaration is required when you define a function in one source file and you call that function in another file.

Definition:

A function definition specifies the body of the function. The declaration and definition of a function can be made together, but it should be done before calling it. A function definition in C programming 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 an 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.

Calling:

When you define a function, you tell the function what to do and to use that function; you have to call or invoke the function. When a function is called from the main function, then the control of the function is transferred to the function that is called. And then that function performs its task. When the task is finished, it returns the control to the main function.

Types of Functions

There are two types of functions in C++

- Built-in functions
- User-defined functions

Built-in Functions:

These are functions that are already present in C++; their definitions are already provided in the header files. The compiler picks the definition from header files and uses them in the program.

User-defined Functions:

These are functions that a user creates by themselves, wherein the user gives their own definition.

You can put them down as the following types:

No argument and no return value

No argument but the return value

Argument but no return value

Argument and return value

-No argument and no return value: In this type, as the name suggests, it passes no arguments to the function, and you print the output within the function. So, there is no return value.

-No argument but return value: In this type, it passes no arguments to the function, but there is a return value.

-Argument but no return value: In this type of function, it passes arguments, but there is no return value. And it prints the output within the function.

-Argument and return value: In this type of function, it passes arguments, and there is also a return value.

Now, move on to the calling methods of C++ functions.

:

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 that function to perform the defined task. When a

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

In C++ programs, functions with arguments can be invoked by :

(a) Value (b) Reference

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 In this method the values of the actual parameters (appearing in the function call) are copied into the formal parameters (appearing in the function definition), i.e., the function creates its own copy of argument values and operates on them.

The following program illustrates this concept :

```
//calculation of compound interest using a function
#include<iostream.h>
#include<conio.h>
#include<math.h> //for pow()function
Void main()
{
Float principal, rate, time; //local variables
Void calculate (float, float, float); //function prototype clrscr();
Cout<<"\nEnter the following values:\n";
Cout<<"\nPrincipal:";
Cin>>principal;
Cout<<"\nRate of interest:";
Cin>>rate;
Cout<<"\nTime period (in yeaers) :";
Cin>>time;
Calculate (principal, rate, time); //function call
Getch ();
}
//function definition calculate()
Void calculate (float p, float r, float t)
{
Float interest; //local variable
Interest = p* (pow((1+r/100.0),t))-p;
Cout<<"\nCompound interest is : "<<interest;
}
```

Call by Reference: - 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. A reference provides– an alternate name – for the variable, i.e., the same variable's value can be used by two different names : the original name and the alias name. So the called function does not create its own copy of original value(s) but works with the original value(s) with different name. Any change in the original data in the called function gets reflected back to the calling

function. It is useful when you want to change the original variables in the calling function by the called function.

```
//Swapping of two numbers using function call by reference
#include<iostream.h>
#include<conio.h>
void main()
{
clrscr();
int num1,num2;
void swap (int&, int&); //function prototype
cin>>num1>>num2;
cout<<"\nBefore swapping:\nNum1: "<<num1;
cout<<endl<<"num2: "<<num2;
swap(num1,num2); //function call
cout<<"\n\nAfter swapping : \Num1: "<<num1;
cout<<endl<<"num2: "<<num2;
getch();
}
//function fefinitionswap()
void swap (int& a, int& b)
{
Int temp=a;
 a=b;
 b=temp;
}
```

Inline Functions

These are the functions designed to speed up program execution. An inline function is expanded (i.e. the function code is replaced when a call to the inline function is made) in the line where it is invoked. You are familiar with the fact that in case of normal functions, the compiler have to jump to another location for the execution of the function and then the control is returned back to the instruction immediately after the function call statement. So execution time taken is more in case of normal functions. There is a memory penalty in the case of an inline function.

The system of inline function is as follows :

```
inlinefunction_header
 { body of the function
 }
```

For example,

```
//function definition min()
inline void min (int x, int y)
cout<< (x < Y? x : y);
 }
 Void main()
```

```
 {
int num1, num2;
cout<<"\Enter the two intergers\n";
cin>>num1>>num2;
min (num1,num2; //function code inserted here
 ----------
 ----------
 }
```

An inline function definition must be defined before being invoked as shown in the above example.

The inlining does not work for the following situations :

1. For functions returning values and having a loop or a switch or a goto statement.
2. For functions that do not return value and having a return statement.
3. For functions having static variable(s).
4. If the inline functions are recursive (i.e. a function defined in terms of itself).

The benefits of inline functions are as follows :

1. Better than a macro.
2. Function call overheads are eliminated.
3. Program becomes more readable.
4. Program executes more efficiently.

Member functions

Member functions are operators and functions that are declared as members of a class. Member functions do not include operators and functions declared with the friend specifier. These are called friends of a class. You can declare a member function as static; this is called a static member function. A member function that is not declared as static is called a nonstatic member function.

The definition of a member function is within the scope of its enclosing class. The body of a member function is analyzed after the class declaration so that members of that class can be used in the member function body, even if the member function definition appears before the declaration of that member in the class member list. When the function add() is called in the following example, the data variables a, b, and c can be used in the body of add().

```
class x
{
public:
int add() // inline member function add
 {returna+b+c;};
private:
inta,b,c;
};
```

Objects

When a class is defined, only the specification for the object is defined; no memory or storage is allocated.To use the data and access functions defined in the class, we need to create objects.

Syntax to Define Object in C++

classNameobjectVariableName;

We can create objects of Room class (defined in the above example) as follows:

```
// sample function
voidsampleFunction(){
// create objects
 Room room1, room2;
}
intmain(){
// create objects
 Room room3, room4;
}
```

Here, two objects room1 and room2 of the Room class are created in sampleFunction(). Similarly, the objects room3 and room4 are created in main().

As we can see, we can create objects of a class in any function of the program. We can also create objects of a class within the class itself, or in other classes.

Also, we can create as many objects as we want from a single class.

Access Data Members and Member Functions

We can access the data members and member functions of a class by using a . (dot) operator. For example,

room2.calculateArea();

This will call the calculateArea() function inside the Room class for object room2.Similarly, the data members can be accessed as:

room1.length = 5.5;

In this case, it initializes the length variable of room1 to 5.5.

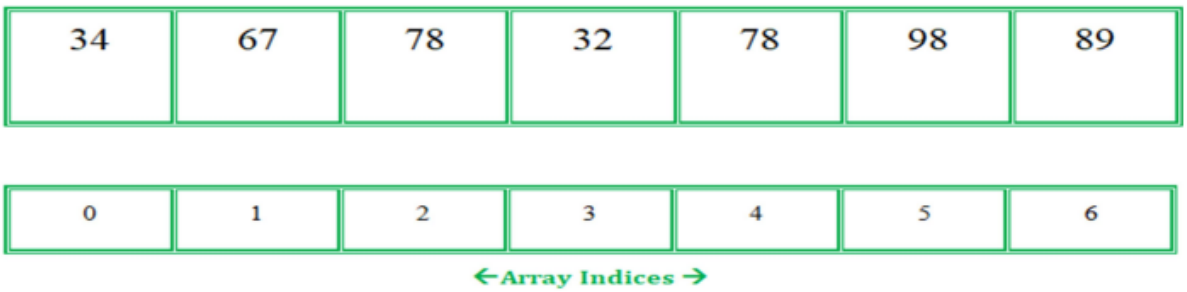
Output

Area of Room = 1309

Volume of Room = 25132.8

Array of Objects

An array in C/C++ or be it in any programming language is a collection of similar data items stored at contiguous memory locations and elements can be accessed randomly using indices of an array. They can be used to store the collection of primitive data types such as int, float, double, char, etc of any particular type. To add to it, an array in C/C++ can store derived data types such as structures, pointers, etc. Given below is the picture representation of an array.



Example:
Let’s consider an example of taking random integers from the user.

Array of Objects

When a class is defined, only the specification for the object is defined; no memory or storage is allocated. To use the data and access functions defined in the class, you need to create objects.
Syntax:
ClassNameObjectName[number of objects];

The Array of Objects stores objects. An array of a class type is also known as an array of objects.

Example#1:

Storing more than one Employee data. Let’s assume there is an array of objects for storing employee data emp[50].

Below is the C++ program for storing data of one Employee:

```
// C++ program to implement
// the above approach
#include<iostream>
usingnamespacestd;

classEmployee
{
 intid;
 charname[30];
 public:
 voidgetdata();//Declaration of
function
 voidputdata();//Declaration of
function
};
voidEmployee::getdata(){//Defining of
function
 cout<<"Enter Id : ";
 cin>>id;
 cout<<"Enter Name : ";
```

```
 cin>>name;
}
voidEmployee::putdata(){//Defining of
function
  cout<<id<<" ";
 cout<<name<<" ";
 cout<<endl;
}
intmain(){
 Employee emp; //One member
 emp.getdata();//Accessing the
function
 emp.putdata();//Accessing the
function
 return0;
}
```

Let's understand the above example –

In the above example, a class named Employee with id and name is being considered.

The two functions are declared-

getdata(): Taking user input for id and name.

putdata(): Showing the data on the console screen.

This program can take the data of only one Employee. What if there is a requirement to add data of more than one Employee. Here comes the answer: Array of Objects. An array of objects can be used if there is a need to store data of more than one employee. Below is the C++ program to implement the above approachExplanation:

In this example, more than one Employee's details with an Employee id and name can be stored.

Employee emp[30] – This is an array of objects having a maximum limit of 30 Employees.

Two for loops are being used-

First one to take the input from user by calling emp[i].getdata() function.

Second one to print the data of Employee by calling the function emp[i].putdata() function.

Advantages of Array of Objects:

1. The array of objects represent storing multiple objects in a single name.
2. In an array of objects, the data can be accessed randomly by using the index number.
3. Reduce the time and memory by storing the data in a single variable.

Nested Classes in C++

A nested class is a class which is declared in another enclosing class. A nested class is a member and as such has the same access rights as any other member. The members of an enclosing class have no special access to members of a nested class; the usual access rules shall be obeyed.

For example, program 1 compiles without any error and program 2 fails in compilation.

Program

```
#include<iostream>
usingnamespacestd;
 /* start of Enclosing class declaration */
classEnclosing {
 private:
 intx;
 /* start of Nested class declaration */
 classNested {
 inty;
 voidNestedFun(Enclosing *e) {
 cout<<e->x; // works fine: nested
class can access
 // private members of
Enclosing class
 }
 }; // declaration Nested class ends here
}; // declaration Enclosing class ends here

intmain()
{
}
```

Constructors

Constructor in C++ is a special method that is invoked automatically at the time of object creation. It is used to initialize the data members of new objects generally. The constructor in C++ has the same name as the class or structure. It constructs the values i.e. provides data for the object which is why it is known as constructor.

• Constructor is a member function of a class, whose name is same as the class name.
• Constructor is a special type of member function that is used to initialize the data members for an object of a class automatically, when an object of the same class is created.
• Constructor is invoked at the time of object creation. It constructs the values i.e. provides data for the object that is why it is known as constructor.
• Constructor do not return value, hence they do not have a return type.

The prototype of the constructor looks like
<class-name> (list-of-parameters);

Constructor can be defined inside the class declaration or outside the class declaration

a. Syntax for defining the constructor within the class

```
<class-name>(list-of-parameters)
{
        //constructor definition
}
```

b. Syntax for defining the constructor outside the class

```
    <class-name>: :<class-name>(list-of-parameters)
    {
        //constructor definition
    }
```

// Example: defining the constructor within the class

```
#include<iostream>
using namespace std;
class student
{
        int rno;
        char name[50];
        double fee;
        public:
        student()
        {
                cout<<"Enter the RollNo:";
                cin>>rno;
                cout<<"Enter the Name:";
                cin>>name;
                cout<<"Enter the Fee:";
                cin>>fee;
        }



        void display()
        {
                cout<<endl<<rno<<"\t"<<name<<"\t"<<fee;
        }
};

int main()
{
        student s; //constructor gets called automatically when we create the object of the class
        s.display();
        return 0;

}
```

// Example: defining the constructor outside the class

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

```
class student
{
	int rno;
	char name[50];
	double fee;
	public:
	student();
	void display();

};

	student::student()
	{
		cout<<"Enter the RollNo:";
		cin>>rno;
		cout<<"Enter the Name:";
		cin>>name;
		cout<<"Enter the Fee:";
		cin>>fee;
	}

void student::display()
	{
		cout<<endl<<rno<<"\t"<<name<<"\t"<<fee;
	}

int main()
{
	student s;
	s.display();
	return 0;
}
```

Characteristics of constructor

The name of the constructor is the same as its class name.

- Constructors are mostly declared in the public section of the class though it can be declared in the private section of the class.
- Constructors do not return values; hence they do not have a return type.
- A constructor gets called automatically when we create the object of the class.
- Constructors can be overloaded.
- Constructor can not be declared virtual.

Types of constructor

- Default constructor

- Parameterized constructo
- Overloaded constructor
- Constructor with default value
- Copy constructor
- inline constructor

Constructor does not have a return value, hence they do not have a return type.

The prototype of Constructors is as follows:

<class-name> (list-of-parameters);

Constructors can be defined inside or outside the class declaration:-

The syntax for defining the constructor within the class:

<class-name> (list-of-parameters) { // constructor definition }

The syntax for defining the constructor outside the class:

<class-name>: :<class-name> (list-of-parameters){ // constructor definition}

// defining the constructor within the class

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

class student {
        int rno;
        char name[10];
        double fee;

public:
        student()
        {
                cout << "Enter the RollNo:";
                cin >> rno;
                cout << "Enter the Name:";
                cin >> name;
                cout << "Enter the Fee:";
                cin >> fee;
        }

        void display()
        {
                cout << endl << rno << "\t" << name << "\t" << fee;
        }
```

```
};

int main()
{
	student s; // constructor gets called automatically when
				// we create the object of the class
	s.display();

	return 0;
}

Enter the RollNo:Enter the Name:Enter the Fee:
0	6.95303e-310

// defining the constructor outside the class

#include <iostream>
using namespace std;
class student {
	int rno;
	char name[50];
	double fee;

public:
	student();
	void display();
};

student::student()
{
	cout << "Enter the RollNo:";
	cin >> rno;

	cout << "Enter the Name:";
	cin >> name;

	cout << "Enter the Fee:";
	cin >> fee;
}

void student::display()
{
	cout << endl << rno << "\t" << name << "\t" << fee;
}
```

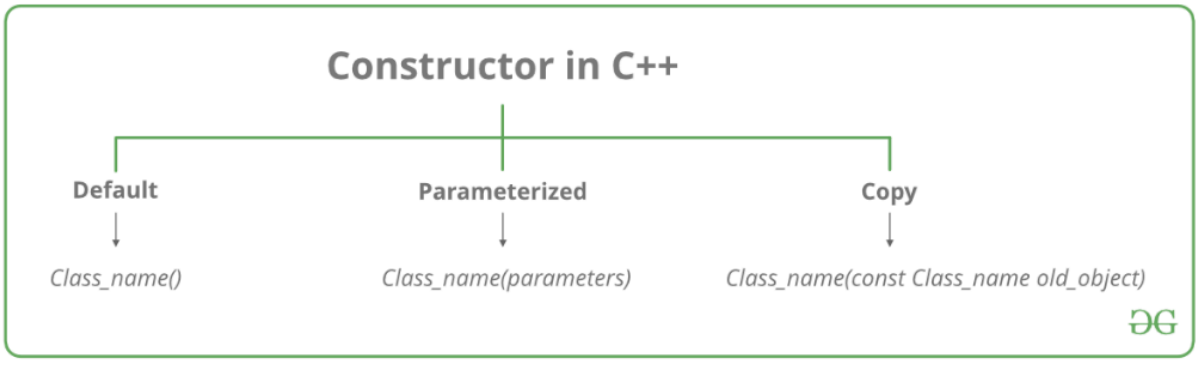
```
int main()
{
	student s;
	s.display();

	return 0;
}
```

```
Enter the RollNo: 30
Enter the Name: ram
Enter the Fee: 20000
30 ram 20000
```

How constructors are different from a normal member function?

A constructor is different from normal functions in following ways:

- Constructor has same name as the class itself
- Default Constructors don’t have input argument however, Copy and Parameterized Constructors have input arguments
- Constructors don’t have return type
- A constructor is automatically called when an object is created.
- It must be placed in public section of class.
- If we do not specify a constructor, C++ compiler generates a default constructor for object (expects no parameters and has an empty body).



Types of Constructors

1. Default Constructors: Default constructor is the constructor which doesn't take any argument. It has no parameters. It is also called a zero-argument constructor.

```
// Cpp program to illustrate the
// concept of Constructors
#include <iostream>
using namespace std;

class construct {
public:
	int a, b;

	// Default Constructor
	construct()
	{
		a = 10;
		b = 20;
	}
};

int main()
{
	// Default constructor called automatically
	// when the object is created
	construct c;
	cout << "a: " << c.a << endl << "b: " << c.b;
	return 1;
}
```

Output
a: 10

b: 20

Note: Even if we do not define any constructor explicitly, the compiler will automatically provide a default constructor implicitly.

```
// Example
#include<iostream>
using namespace std;
class student
{
        int rno;
        char name[50];
        double fee;
        public:
        student()                                       // Explicit Default constructor
        {
                cout<<"Enter the RollNo:";
                cin>>rno;
                cout<<"Enter the Name:";
                cin>>name;
                cout<<"Enter the Fee:";
                cin>>fee;
        }

        void display()
        {
                cout<<endl<<rno<<"\t"<<name<<"\t"<<fee;
        }
};

int main()
{
        student s;
        s.display();
        return 0;
}
```

2. Parameterized Constructors: It is possible to pass arguments to constructors. Typically, these arguments help initialize an object when it is created. To create a parameterized constructor, simply add parameters to it the way you would to any other function. When you define the constructor's body, use the parameters to initialize the object.

Note: when the parameterized constructor is defined and no default constructor is defined explicitly, the compiler will not implicitly call the default constructor and hence creating a simple object as

Student s;

Will flash an error

```
// CPP program to illustrate

// parameterized constructors

#include <iostream>
using namespace std;
class Point {
private:
	int x, y;
public:
	// Parameterized Constructor
	Point(int x1, int y1)
	{
		x = x1;
		y = y1;
	}
	int getX() { return x; }
	int getY() { return y; }
};
int main()
{
	// Constructor called
	Point p1(10, 15);
	// Access values assigned by constructor
	cout << "p1.x = " << p1.getX()
		<< ", p1.y = " << p1.getY();
	return 0;

}
```

Output

```
p1.x = 10, p1.y = 15
```

// Example

```
#include<iostream>
#include<string.h>
using namespace std;
class student
{
        int rno;
        char name[50];
        double fee;
        public:
        student(int,char[],double);
        void display();
};
student::student(int no,char n[],double f)
{
        rno=no;
        strcpy(name,n);
        fee=f;
}
void student::display()
{
        cout<<endl<<rno<<"\t"<<name<<"\t"<<fee;
}
int main()
{
        student s(1001,"Ram",10000);
        s.display();
        return 0;
}
```

- Uses of Parameterized constructor:

    1. It is used to initialize the various data elements of different objects with different values when they are created.
    2. It is used to overload constructors.

3. Copy Constructor:

A copy constructor is a member function that initializes an object using another object of the same class. A detailed article on Copy Constructor.

Whenever we define one or more non-default constructors(with parameters) for a class, a default constructor(without parameters) should also be explicitly defined as the compiler will not provide a default constructor in this case. However, it is not necessary but it's considered to be the best practice to always define a default constructor.

Copy constructor takes a reference to an object of the same class as an argument.

```
Sample(Sample &t)
        {
```

```
                id=t.id;
        }
// Illustration
#include <iostream>
using namespace std;

class point {
private:
        double x, y;

public:
        // Non-default Constructor &
        // default Constructor
        point(double px, double py) { x = px, y = py; }
};

int main(void)
{

        // Define an array of size
        // 10 & of type point
        // This line will cause error
        point a[10];

        // Remove above line and program
        // will compile without error
        point b = point(5, 6);
}
```

Output:
Error: point (double px, double py): expects 2 arguments, 0 provided
// Implicit copy constructor

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

class Sample
{               int id;
        public:
        void init(int x)
        {
                id=x;
        }
        void display()
        {
                cout<<endl<<"ID="<<id;
```

```
        }
};

int main()
{
        Sample obj1;
        obj1.init(10);
        obj1.display();

        Sample obj2(obj1); //or obj2=obj1;
        obj2.display();
        return 0;
}
```

Copy Constructor

The copy constructor in C++ is used to copy data of one object to another.

Example : C++ Copy Constructor

```
#include<iostream>
usingnamespacestd;
// declare a class
classWall {
private:
double length;
double height;
public:
// initialize variables with parameterized constructor
Wall(doublelen, doublehgt) {
length = len;
height = hgt;
 }
// copy constructor with a Wall object as parameter
// copies data of the obj parameter
Wall(Wall &obj) {
length = obj.length;
height = obj.height;
 }
doublecalculateArea(){
return length * height;
 }
};
intmain(){
// create an object of Wall class
Wall wall1(10.5, 8.6);
// copy contents of wall1 to wall2
 Wall wall2 = wall1;
```

```
// print areas of wall1 and wall2
cout<<"Area of Wall 1: "<< wall1.calculateArea() <<endl;
cout<<"Area of Wall 2: "<< wall2.calculateArea();
return0;
}
```
Output
Area of Wall 1: 90.3
Area of Wall 2: 90.3

Destructor

A destructor destroys an object after it is no longer in use. The destructor, like constructor, is a member function with the same name as the class name. But it will be preceded by the character Tilde (~).A destructor takes no arguments and has no return value. Each class has exactly one destructor.

```
// A Program showing working of constructor and destructor
#include<iostream.h>
#include<conio.h>
classMyclass{
public:
int x;
Myclass(){ //Constructor
x=10; }
~Myclass(){ //Destructor
cout<<"Destructing…." ;
}
int main(){
Myclass ob1, ob2;
cout<<ob1.x<<" "<<ob2.x;
return 0; }
```
Output:
10 10
Destructing……..
Destructing……..

Special Characteristics of destructors are :

(i) These are called automatically when the objects are destroyed.
(ii) Destructor functions follow the usual access rules as other member functions.
(iii) These de-initialize each object before the object goes out of scope.
(iv) No argument and return type (even void) permitted with destructors.
(v) These cannot be inherited.
(vi) Static destructors are not allowed.
(vii) Address of a destructor cannot be taken.
(viii) A destructor can call member functions of its class.
(ix) An object of a class having a destructor cannot be a member of a union.

Inline member function.

A member function that is defined inside its class member list is called an inline member function. Member functions containing a few lines of code are usually declared inline. In the above example, add() is an inline member function. If you define a member function outside of its class definition, it must appear in a namespace scope enclosing the class definition. You must also qualify the member function name using the scope resolution (::) operator.

An equivalent way to declare an inline member function is to either declare it in the class with the inline keyword (and define the function outside of its class) or to define it outside of the class declaration using the inline keyword.

In the following example, member function Y::f() is an inline member function:

```
struct Y {
private:
char* a;
public:
char* f() { return a; }
};
```

The following example is equivalent to the previous example; Y::f() is an inline member function:

```
struct Y {
private:
char* a;
public:
char* f();
};
inline char* Y::f() { return a; }
```

Static Member Function

The static is a keyword in the C and C++ programming language. We use the static keyword to define the static data member or static member function inside and outside of the class. Let's understand the static data member and static member function using the programs.

Static data member

When we define the data member of a class using the static keyword, the data members are called the static data member. A static data member is similar to the static member function because the static data can only be accessed using the static data member or static member function. And, all the objects of the class share the same copy of the static member to access the static data.

Syntax

1. static data_type data_member;

Here, the static is a keyword of the predefined library.

The data_type is the variable type in C++, such as int, float, string, etc.

The data_member is the name of the static data.No. of objects created in the class: 2

Static Member Functions

The static member functions are special functions used to access the static data members or other static member functions. A member function is defined using the static keyword. A

static member function shares the single copy of the member function to any number of the class' objects. We can access the static member function using the class name or class' objects. If the static member function accesses any non-static data member or non-static member function, it throws an error.

Syntax

class_name::function_name (parameter);

Here, the class_name is the name of the class.

function_name: The function name is the name of the static member function.

parameter: It defines the name of the passarguments to the static member function.

Example 2: Let's create another program to access the static member function using the class name in the C++ programming language.

```
#include <iostream>
using namespace std;
class Note
{
// declare a static data member
static int num;
public:
// create static member function
static int func ()
{
return num;
}
};
// initialize the static data member using the class name and the scope resolution operator
int Note :: num = 5;

int main ()
{
// access static member function using the class name and the scope resolution
cout << " The value of the num is: " << Note:: func () << endl;
return 0;
}
```

Output

The value of the num is: 5

Friend function

In general, only other members of a class have access to the private members of the class. The function is declared with friend keyword. But while defining friend function, it does not use either keyword friend or :: operator. A function can be a friend of more than one class. A friend, function has following characteristics.

- It is not in the scope of the class to which it has been declared as friend.
- A friend function cannot be called using the object of that class. If can be invoked like a normal function without help of any object.
- It cannot access the member variables directly & has to use an object name dot

membership operator with member name.
It can be declared either in the public or the private part of a class without affecting its meaning.
Usually, it has the object as arguments.
A friend function can access the private and protected data of a class. We declare a friend function using the friend keyword inside the body of the class.

```
classclassName {
 ... .. ...
friendreturnTypefunctionName(arguments);
 ... .. ...
}
```

```
// C++ program to demonstrate the working of friend function
#include <iostream>
using namespace std;
class Distance {
private:
int meter;
// friend function
friendintaddFive(Distance);
public:
Distance() : meter(0) {}
};
// friend function definition
intaddFive(Distance d) {
//accessing private members from the friend function
d.meter += 5;
returnd.meter;
}
int main() {
 Distance D;
cout<< "Distance: " <<addFive(D);
return 0;
}
```

Output

```
Distance: 5
```

Dynamic memory allocation

There are times where the data to be entered is allocated at the time of execution. For example, a list of employees increases as the new employees are hired in the organization and similarly reduces when a person leaves the organization. This is called managing the memory. So now, let us discuss the concept of dynamic memory allocation.

Memory allocation

Reserving or providing space to a variable is called memory allocation. For storing the data, memory allocation can be done in two ways -

o **Static allocation or compile-time allocation** - Static memory allocation means

providing space for the variable. The size and data type of the variable is known, and it remains constant throughout the program.
o **Dynamic allocation or run-time allocation** - The allocation in which memory is allocated dynamically. In this type of allocation, the exact size of the variable is not known in advance. Pointers play a major role in dynamic memory allocation.

Why Dynamic memory allocation?
Dynamically we can allocate storage while the program is in a running state, but variables cannot be created "on the fly". Thus, there are two criteria for dynamic memory allocation -
o A dynamic space in the memory is needed.
o Storing the address to access the variable from the memory
Similarly, we do memory de-allocation for the variables in the memory.

In C++, memory is divided into two parts -
o Stack - All the variables that are declared inside any function take memory from the stack.
o Heap - It is unused memory in the program that is generally used for dynamic memory allocation.
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References:

https://www.geeksforgeeks.org/
https://www.javatpoint.com/
Object Oriented Programming with C++ by E Balaguruswamy, 2001, Tata McGraw-Hill