UNIT - 2

C++ BASICS

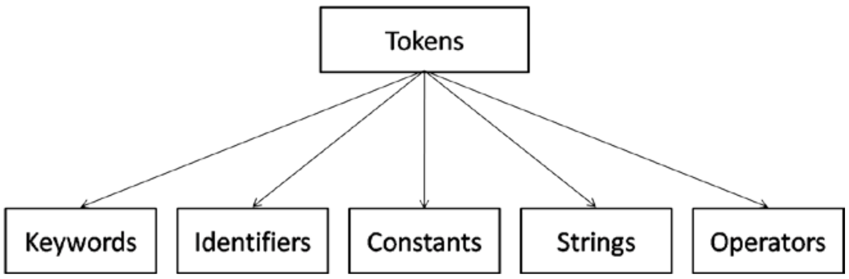
FUNCTIONS

C++ BASICS

Tokens

Smallest indivisible parts of a program are called lexemes and groups of similar lexemes are called tokens. C++ program contains several items and those are identified as tokens by a compiler. C++ tokens are as follows:

- Keywords
- Identifiers
- Constants
- Strings
- Operators



Keywords are words which are reserved by the compiler for specific purpose. Keywords cannot be used as identifiers in programs. Keywords available in C++ are as follows:

C and C++ Common Keywords			
auto	double	int	struct
break	else	long	switch
case	enum	register	typedef
char	extern	return	union
const	float	short	unsigned
continue	for	signed	void
default	goto	sizeof	volatile
do	if	static	while

Additional C++ Keywords							
asm	catch	class	delete	friend	inline	new	operator
private	protected	public	template	this	throw	try	virtual

C++ Keywords Added by ANSI				
bool	const_cast	dynamic_cast	explicit	true
mutable	namespace	reinterpret_cast	static_cast	false
typename	using	wchar_t	export	typeid

Identifiers are names given to variables, arrays, classes, functions, structures, etc.

Variables

What is a variable?

A variable is a placeholder or container in memory (RAM) for storing values. We can store different values in a variable at different points of execution. To use variables in a C++ program, we have to declare and initialize them.

Declaring a variable

Before using a variable in a program, we need to declare it. Syntax for declaring a variable is as follows:

data_type variable_name;

In the above syntax, *data_type* tells the compiler about the type of data (ex: integer, character etc..) that will be stored in the variable with the name *variable_name*.

Quite often we hear the term called **definition**. Defining a variable means specifying the amount of memory that the variable occupies. Above declaration syntax also defines the memory that will be allocated (based on data type) to *variable_name*.

An example for variable declaration is as follows:

int x;

In the above syntax, *x* is the variable name and *int* is a data type which tells the compiler that *x* can store integer values.

We can't write variable names as we like. There are some restrictions that apply to writing variable names. They are:

- Variable name must start with a letter or an underscore.
- Variable names must not contain white spaces.
- Variable names must not contain any special symbols like $, @, # etc.
- Variable names must not be same as any keyword like *if*, *while*, *struct* etc.

Initializing a variable

After declaring a variable, we can assign or store a value in it. This is known as variable initialization. Syntax for initializing a variable is as follows:

variable_name = value;

An example for initializing a variable is as follows:

x = 10;

We can combine variable declaration and initialization in to a single line as shown below:

data_type variable_name = value;

An example for declaring and initializing a variable in a single line is as follows:

int x = 10;

Note: If we don't initialize a variable, it will contain garbage value. It is a good practice to initialize a variable to a default value when we declare it.

A small C++ program demonstrating the use of variables is given below. In this program we add two values by storing them in two variables.

```
#include <iostream>
using namespace std;
int main()
{
	int num1, num2;
	cout<<"Enter a number: ";
	cin>>num1;
	cout<<"Enter another number: ";
	cin>>num2;
	cout<<"Sum of "<<num1<<" and "<<num2<<" is: "<<(num1+num2)<<endl;
	return 0;
}
```

Input and output for the above program is as follows:

```
Enter a number: 10
Enter another number: 29
Sum of 10 and 29 is: 39
```

In the above program, *endl* is a manipulator to print a new line.

Scope of a variable

The scope of a variable tells the compiler in which statements of the program can a variable be accessed. Based on where the variable is declared, variables are divided into two types: local variables and global variables.

A local variable is a variable which is declared within a block (a block is a set of statements enclosed in between braces i.e { and }). The scope of a local variable is within the block in which it is declared. A block cannot have two or more local variables with the same name.

To demonstrate the scope of a local variable, consider the following program:

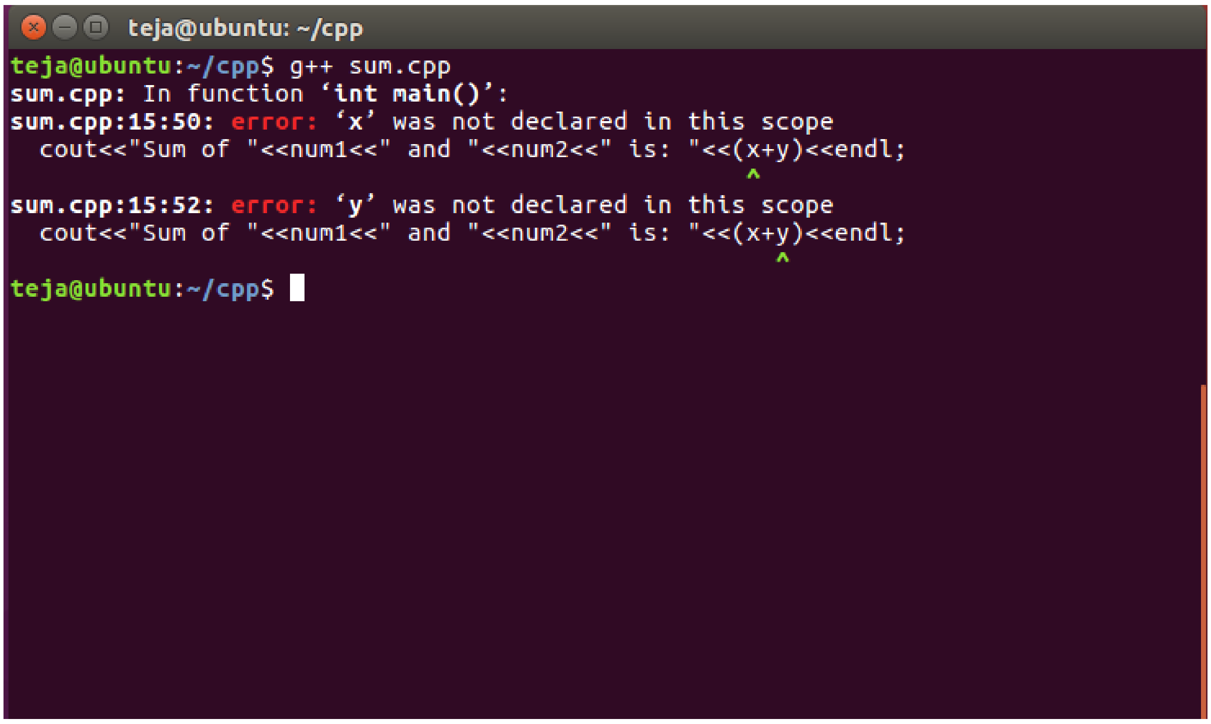
```
#include <iostream>
```

```
using namespace std;
int dosum(int x, int y)
{
        return x+y;
}
int main()
{
        int num1, num2;
        cout<<"Enter a number: ";
        cin>>num1;
        cout<<"Enter another number: ";
        cin>>num2;
        cout<<"Sum of "<<num1<<" and "<<num2<<" is: "<<dosum(num1, num2)<<endl;
        //cout<<"Sum of "<<num1<<" and "<<num2<<" is: "<<(x+y)<<endl;
        return 0;
}
```

Input and output for the above program is as follows:

```
Enter a number: 4
Enter another number: 6
Sum of 4 and 6 is: 10
```

In the above program, *dosum()* is a function. Functions will be explained later. In *dosum()* function, variables *x* and *y* are local to that function. In *main()* function, variables *num1* and *num2* are local to that function. Notice that in the above program the statement before *return 0* line has been commented. If the comments are removed and compiled, you will see the following error messages:



```
teja@ubuntu:~/cpp$ g++ sum.cpp
sum.cpp: In function ‘int main()’:
sum.cpp:15:50: error: ‘x’ was not declared in this scope
  cout<<"Sum of "<<num1<<" and "<<num2<<" is: "<<(x+y)<<endl;
                                                  ^
sum.cpp:15:52: error: ‘y’ was not declared in this scope
  cout<<"Sum of "<<num1<<" and "<<num2<<" is: "<<(x+y)<<endl;
                                                    ^
teja@ubuntu:~/cpp$ 
```

Above error messages are displayed as the variables *x* and *y* are local to *dosum()* function and cannot be accessed in *main()* function.

Global Variables

A variable that is declared outside all blocks is called a global variable. The scope of a global variable is the entire program from the point at which it is declared. To demonstrate the scope of a global variable, consider the following program:

```
#include <iostream>
using namespace std;
int dosum(int x, int y)
{
	//cout<<"global = "<<global<<endl;
	return x+y;
}
int global = 10;
int main()
{
	int num1, num2;
	cout<<"Enter a number: ";
	cin>>num1;
	cout<<"Enter another number: ";
	cin>>num2;
	cout<<"Sum of "<<num1<<" and "<<num2<<" is: "<<dosum(num1, num2)<<endl;
	cout<<"global = "<<global<<endl;
	return 0;
}
```

Input and output of the above program is as follows:

```
Enter a number: 3
Enter another number: 8
Sum of 3 and 8 is: 11
global = 10
```

In the above program, *global* is a global variable and observe that it is declared after the *dosum()* function. The variable *global* is not accessible above the line at which it is declared. That is why the print statement inside the *dosum()* is commented out. Removing the comments will produce compilation error.

Data Types

A data type specifies the type of data that we can work with. As C++ is a strongly typed (not truly) language (type is specified before use), type of a variable must be specified before it is used. C++ provides several pre-defined data types. They are as shown in the following table:

Type	Size (in bytes)	Range
char	1	-127 to 127 or 0 to 255
unsigned char	1	0 to 255
int	4	-2147483648 to 2147483647
unsigned int	4	0 to 4294967295
short int	2	-32768 to 32767
unsigned short int	2	0 to 65,535
long int	4	-2147483648 to 2147483647
unsigned long int	4	0 to 4294967295
float	4	+/- 3.4e +/- 38 (~7 digits)
double	8	+/- 1.7e +/- 308 (~15 digits)

Character data type

The *char* data type is used to work with single characters. An example of storing a character into a variable is as follows:

char ch = 's';

In the above statement, *'s'* is a character constant. Size of *char* type is 1 byte which can hold values from -127 to 127 and size of *unsigned char* is 1 byte which can hold values from 0 to 255. Since 256 values are not enough to represent all the characters across the world, C++ is not suitable for developing cross-language applications.

Integer data types

An integer data type is used to work with numbers that don't have any fractional parts. Standard data type for working with integers is *int*. Size of *int* data type is generally 4 bytes. There are variations in *int* data type like *short* and *long*. All of these differ in terms of memory.

Another variation in integer types is *signed* and *unsigned*. In *signed* types, the Most Significant Bit (MSB) is reserved by specifying the sign (0 for positive and 1 for negative). In *unsigned* types, MSB is also used to represent data.

Floating point data types

A floating point type allows us to work with real numbers which have decimal point. Floating point types are *float* and *double*. For example to store the value of mathematical PI value, we can declare a variable as follows:

float PI = 3.1415;

For double precision floating point values, we can use *double* type.

Boolean data type

Boolean data type allows us to work with *true* and *false* values which are known as boolean values. These values can be used to maintain state, flag, available or unavailable kind of information. C++ in the newer versions had provided support to work with boolean values by including *bool* data type. Below example demonstrates *bool* data type:

```
bool flag = true;
```

Can we declare variables without data type?

C++ allows programmers to declare variables without specifying the data type. Data type of such variables will be decided by the value that they are initialized to. Such variables should be declared using the keyword *auto* as shown below:

```
auto flag = false;
```

In the above statement the data type of *flag* variable will be assumed to be *bool* by the compiler based on the value *false*.

typedef keyword

The *typedef* keyword can be used to create convenient names (types) for pre-defined data types. Consider the following example which demonstrates the use of *typedef* keyword:

```
typedef float average;
```

In the above statement we are creating *average* as a type which is a substitute for the pre-defined type *float*. Now we can create variables using *average* type as shown below:

```
average avg;
```

Constants

While programming you might need to store certain values which do not change throughout the program. For example, in mathematical formulae for calculating the area and perimeter of a circle we need the value of PI to be same. Such values are maintained as constants.

A constant is similar to a variable in the sense it is a placeholder in memory. Only difference is value of a constant cannot be changed once initialized. Constants in C++ can be:

- Literal constants (ex: 2, 5.6, 'a', "hi" etc.)
- Declared constants (using *const* keyword)
- Constant expressions (using *constexpr* keyword)
- Enumerated constants (using *enum* keyword)

- Defined constants (using *#define* pre-processor directive. This is not recommended and is deprecated)

Literal Constants

Constants that are used directly in the programs without declaration are literal constants. Literal constants can be:

- Integer constants (ex: 5, 200, -4, etc.)
- Floating point constants (ex: 9.3, 0.3, 12.34343, etc.)
- Character constants (ex: 'd', '4', 'g', '$', etc.)
- String constants(ex: "a", "hi", "C++", "my name", etc.)

Declared Constants (const)

The most important and frequently used type of constants are constants which are declared using the keyword *const*. General syntax for declaring a constant using *const* keyword is as follows:

const data-type constant-name = value;

A constant should be initialized at the time of declaration itself. Let's look at an example for declaring a constant using *const* keyword.

const double PI = 3.1415;

In the above example, *PI* is the constant name and its value is 3.1415. Following is a program which demonstrates the use of *const* keyword.

```
#include <iostream>
using namespace std;
const double PI = 3.1415;
double area(int r)
{
        return PI*r*r;
}
double peri(int r)
{
        return 2*PI*r;
}
int main()
{
        int radius;
        //PI = 3.142;
        cout<<"Enter radius of the circle: ";
        cin>>radius;
        cout<<"Area of the circle is: "<<area(radius)<<endl;
        cout<<"Perimeter of the circle is: "<<peri(radius)<<endl;
        return 0;
}
```

Input and output for the above program is as follows:

```
Enter radius of the circle: 3.6
Area of the circle is: 28.2735
Perimeter of the circle is: 18.849
```

In the above example, *area()* and *peri()* are functions. We will look at functions later. Observe that in the above program, *PI* is a global constant as it is declared outside all blocks.

Also, the line after the statement *int radius* is commented. If you remove the comments, it will result in a compilation errors as constants cannot be initialized again after declaration. The error message will be as follows:

```
ConstDemo.cpp: In function ‘int main()’:
ConstDemo.cpp:15:5: error: assignment of read-only variable ‘PI’
```

Constants expressions (constexpr)

Using *constexpr* we can create constants whose value is determined by evaluating an expression at compile time. We can also use *constexpr* with functions, constructors and objects.

When used along with a function, it will be treated as an inline function which can improve the performance of the program. Following is an example which demonstrates the use of *constexpr* keyword:

```
#include <iostream>
using namespace std;
constexpr double PI = 22.0 / 7;
constexpr double area(int r)
{
	return PI*r*r;
}
constexpr double peri(int r)
{
	return 2*PI*r;
}
int main()
{
	int radius;
	cout<<"Enter radius of the circle: ";
	cin>>radius;
	cout<<"Area of the circle is: "<<area(radius)<<endl;
	cout<<"Perimeter of the circle is: "<<peri(radius)<<endl;
	return 0;
}
```

Input and output for the above program is as follows:

```
teja@ubuntu:~/cpp$ g++ ConstDemo.cpp -std=c++11
```

```
teja@ubuntu:~/cpp$ ./a.out

Enter radius of the circle: 3.56
Area of the circle is: 28.2857
Perimeter of the circle is: 18.8571
```

Note: *constexpr was introduced in C++11 version. To enable g++ compiler to use C++11, we should use the flag "*-std=c++11". Otherwise when we compile the program, it will raise several errors.

Enumerated Constants (enum)

In some scenarios we might want a variable to have a limited set of values like days of a week or months in a year etc. For these situations we can use an enumerated constant which can be declared using the *enum* keyword. General syntax of creating enumerated constants is as follows:

enum constant-name{value1, value2, ..., valueN};

An example of using *enum* is as follow:

enum days{Mon, Tue, Wed, Thu, Fri, Sat, Sun};

In the above example *days* is just like a variable but only accepts the given constant values. By default compiler assigns numeric value to each constant and the starting value is 0 and the subsequent constants are given previous value plus one. So, value of *Mon* is 0, *Tue* is 1, and so on. We can also assign our own values to the constants as demonstrated in the following program:

```
#include <iostream>
using namespace std;
int main()
{
	enum days{Mon = 1, Tue, Wed, Thu, Fri, Sat, Sun};
	days bday = Fri;
	cout<<"Day is: "<<bday<<endl;
	return 0;
}
```

Output of the above program is as follows:

```
Day is: 5
```

In the above program *Mon* is assigned 1. So, value of *Tue* is 2 and so on. We can use the enumerated constant like a type and declare new variables. In the above example *bday* is such variable declared using the enumerated constant *days*.

Defined Constants (#define)

Another way of declaring constants is by using the *#define* pre-processor directive.

This method of declaring constants is not recommended and is deprecated. Syntax for declaring a constant using *#define* is as follows:

#define Constant-Name Value

Notice that in the above syntax there is no semi-colon at the end of the statement. An example for using *#define* is as follows:

#define PI 3.1415

Following is a program which demonstrates the use of *#define* pre-processor directive:

```
#include <iostream>
#define PI 3.1415
using namespace std;
int main()
{
	cout<<"Value of PI is: "<<PI<<endl;
	return 0;
}
```

Output of the above program is as follows:

```
Value of PI is: 3.1415
```

Operators

It is common in programming to use various kinds of operations like addition, subtraction, multiplication etc. C++ supports wide variety of operators which can be broadly divided in to following categories:

- Arithmetic operators
- Relational operators
- Logical operators
- Bitwise operators
- Other operators

Assignment Operator

The assignment operator (=) is used to assign the value of an expression to a variable and can be used within any valid expression. We need to know about two important terms frequently encountered in compiler error messages: *lvalue* and *rvalue*. Lvalue refers to the variable on the left hand side of the assignment operator and Rvalue refers to the expression on the right hand side of the assignment operator.

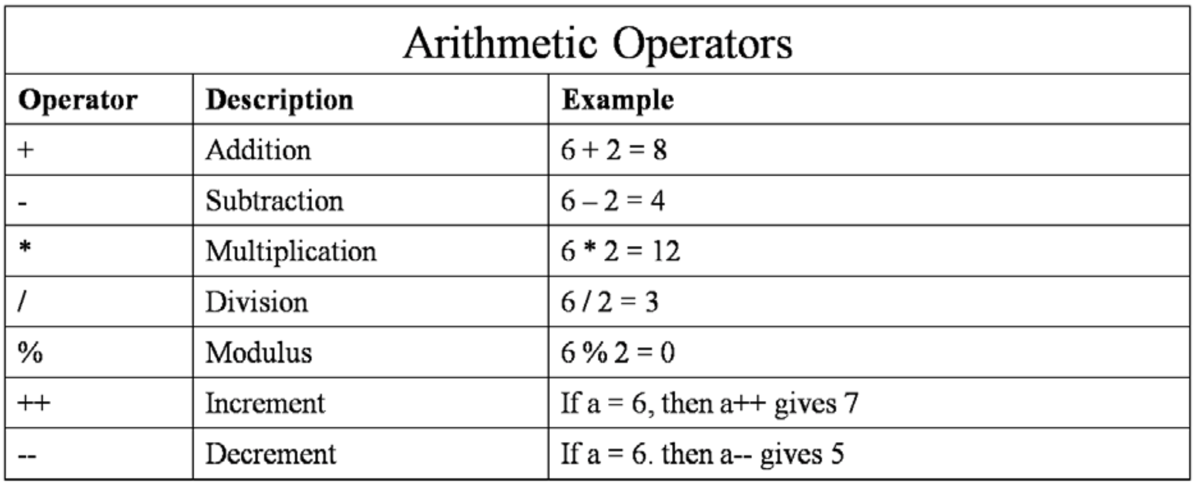
The expression on the right hand side can be a constant or a variable or a complex expression. Left hand side should never be a function or a constant.

Multiple variables can be assigned the same value using assignment operator as shown below:

int a, b, c;
a = b = c = 0;

Arithmetic Operators

Perhaps arithmetic operators are the most frequently used operators in programs. Arithmetic operators contains operators for performing addition, subtraction, multiplication, division and modulus (remainder). Remember that floating point values cannot be used along with modulus operator. Arithmetic operators are as follows:



Arithmetic Operators

Operator	Description	Example
+	Addition	6 + 2 = 8
-	Subtraction	6 – 2 = 4
*	Multiplication	6 * 2 = 12
/	Division	6 / 2 = 3
%	Modulus	6 % 2 = 0
++	Increment	If a = 6, then a++ gives 7
--	Decrement	If a = 6. then a-- gives 5

Also increment (++) and decrement (--) operators are included in this category. Increment operator increments the value of operand by one and decrement operator decrements the value of the operand by one. Both of these operators are unary operators i.e they are used along with a single operand.

Increment and decrement operators can be used before or after the operand. If they are used before the operand, they are called as pre increment / decrement operator or if they are used after the operand, they are called as post increment / decrement operator.

In expressions, post and pre increment / decrement operators have different effects. Consider the following example:

```
a = 5;
b = a++;
```

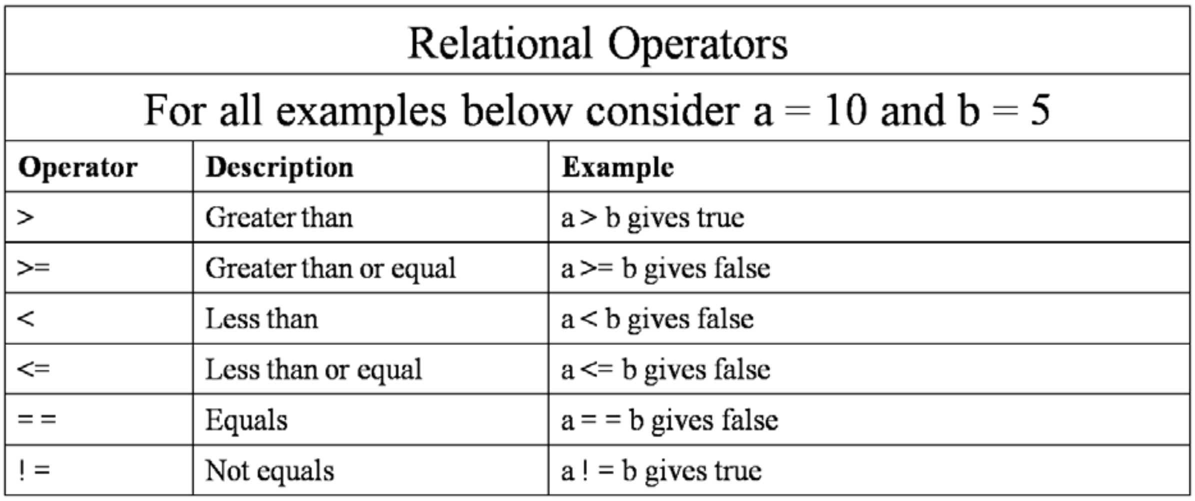
While using post increment, value of the operand is fetched, used in the expression and then it is incremented. So, value of b is 5 in the above example. Now, consider another example:

```
a = 5;
b = ++a;
```

While using pre increment, value of the operand is fetched, incremented and then used in the expression. So, value of b is 6 in the above example.

Relational Operators

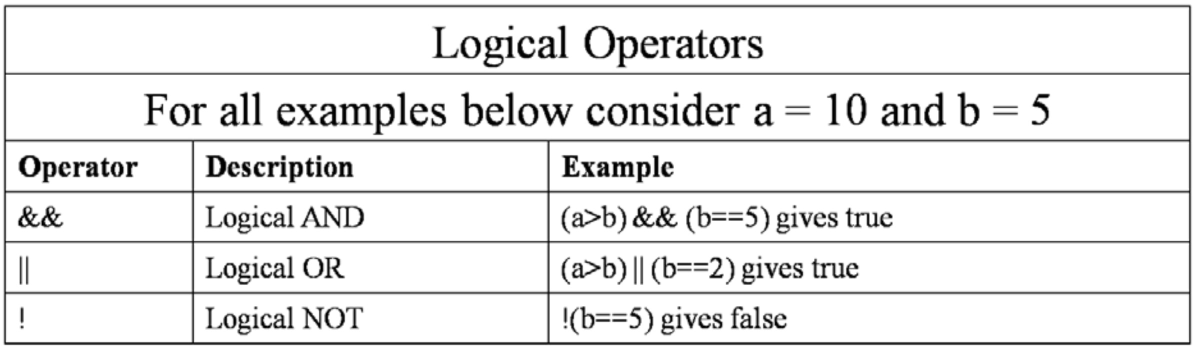
Whenever we want to compare two values or variables, we can use relational operators. These operators return *true* or *false* based on the values or variables used in the expression. Relational operators in C++ are as follows:



Relational Operators		
For all examples below consider a = 10 and b = 5		
Operator	**Description**	**Example**
>	Greater than	a > b gives true
>=	Greater than or equal	a >= b gives false
<	Less than	a < b gives false
<=	Less than or equal	a <= b gives false
= =	Equals	a = = b gives false
! =	Not equals	a ! = b gives true

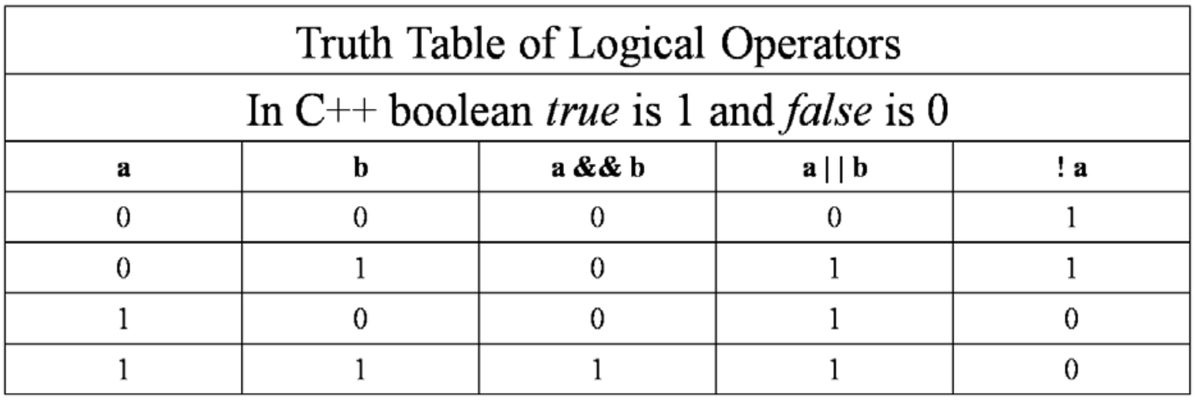
Logical Operators

Operators which are frequently used in conjunction with relational operators to measure the logical (boolean) value of an expression are the logical operators. Expressions with logical operators always evaluates to either *true* or *false*. Logical operators in C++ are as follows:



Logical Operators		
For all examples below consider a = 10 and b = 5		
Operator	**Description**	**Example**
&&	Logical AND	(a>b) && (b==5) gives true
||	Logical OR	(a>b) || (b==2) gives true
!	Logical NOT	!(b==5) gives false

The truth table of the above mentioned logical operators is as follows:



Truth Table of Logical Operators				
In C++ boolean *true* is 1 and *false* is 0				
a	**b**	**a && b**	**a | | b**	**! a**
0	0	0	0	1
0	1	0	1	1
1	0	0	1	0
1	1	1	1	0

The logical operators && and || are called short-circuit operators. In a boolean expression having logical AND (&&), when left expression is *false*, right expression is never evaluated. Similarly in a boolean expression having logical OR (||), when left expression is *true*, right expression is never evaluated.

Bitwise Operators

All the operators discussed until now operate at value or variable level. As C++ is a superset of C language, C++ also supports low-level programming. In low-level programming it is common to manipulate individual bits. Such bit-level programming is supported by bitwise operators. Bitwise operators in C++ are as follows:

Bitwise Operators		
For all examples below consider a = 10 and b = 5		
Operator	**Description**	**Example**
&	Bitwise AND	a & b gives 0
|	Bitwise OR	a | b gives 15
^	Bitwise Ex-OR	a ^ b gives 15
~	1's complement (NOT)	~a gives some negative value
<<	Left shift	a << 1 gives 20
>>	Right shift	a >> 1 gives 5

Truth table for the bitwise operators is as follows:

Truth Table of Bitwise Operators					
In C++ boolean *true* is 1 and *false* is 0					
a	**b**	**a & b**	**a | b**	**a ^ b**	**~ a**
0	0	0	0	0	1
0	1	0	1	1	1
1	0	0	1	1	0
1	1	1	1	0	0

Performing left shift once is equivalent to multiplying the value by 2 and performing right shift once is equivalent to dividing the value by 2.

Bitwise operators are used in low-level programming like writing device drivers, printer routines etc.

Special Operators

Apart from general operators there are other operators which are used for special purpose.

? Operator

C++ supports a powerful operator called conditional operator (?) which is an equivalent to some of the if-then-else statements (will be explained later). Conditional operator is a ternary operator. General form of conditional operator is as follows:

expr1 ? expr2 : expr3;

In the above syntax, *expr1*, *expr2*, and *expr3* are expressions. First *expr1* is evaluated. If *expr1* evaluates to *true* then *expr2* is executed. Otherwise, *expr3* is executed. Consider the following example for conditional operator.

```
int a = 10, b = 5, c;
c = (a>b) ? 20 : 12;
```

In the above example, *a>b* evaluates to true and *c* will be assigned the value of 20.

& and * Operators

A pointer (will be explained in detail later) is a memory address. A pointer variable is a variable which is capable of holding the address of another memory location. We use two operators along with pointers. They are address (&) operator and dereferencing (*) operator.

The syntax for declaring a pointer is a follows:

data-type *pointer-name;

So, while declaring a pointer variable we have to use *. Let's declare an integer pointer.

int *p;

In the above example *p* is a pointer of the type *int*. It is capable of storing the address of a memory location which holds an integer value. Now, we can obtain the address of a variable using & operator as shown below:

```
int a = 10;
int *p;
p = &a;
```

In the above example we are retrieving the address of variable *a* using & operator and assigning it to pointer *p*. Now, we can modify the value of variable *a* indirectly by using the pointer *p* as follows:

```
*p = 20;
```

In the above example, **p* can be read as *value stored at the address pointed by p.*

sizeof Operator

sizeof is a unary compile-time operator which returns the size of operand in bytes.

General syntax of *sizeof* operator is as follows:

sizeof(operand)

When using *sizeof* along with variables, we can omit parentheses. But, when using with basic data types like *int*, *double*, etc., we have to use parentheses also. Consider the following example which demonstrates *sizeof* operator:

```
int a = 10;
cout<<Size of a is:<<sizeof a<<endl;
cout<<Size of int is:<<sizeof(int)<<endl;
```

In the above example, both statements will give the same size of 4 bytes (size of an integer).

Dot (.) and Arrow (->) Operators

Both of these operators are used to access the members of structures, unions and classes in C++. In case of structures and unions, dot operator is used when accessing the members directly. Arrow operator is used while accessing members using a pointer. These two operators will be explained in detail later.

[ ] and ( ) Operators

Square brackets are used along with arrays to reference the array elements and parentheses are used to increase the precedence of expressions and are also used along with functions.

Comma (,) Operator

The comma operator is used to join several expressions together. The left side of the comma operator is always evaluated as *void*. When used in an assignment statement, the value of the last expression (right-most) is the value to be assigned.

Remember that when using along with assignment (=) operator, enclose comma separated expressions inside parentheses as comma operator has lower precedence (importance) than assignment operator. Consider the following example which demonstrates the use of comma operator:

```
int a, b, c;
c = (a=5, b=5, a+b);
```

In the above example, first *a* is assigned 5, then *b* is assigned 5 and finally 10 (a+b) is assigned to *c*.

Scope Resolution Operator (::)

The scope resolution operator helps in resolving the scope of a variable or a class member. When the C++ program contains two variables with same name i.e. for example one global and another local variable, we can access the global variable using the scope resolution operator. Consider the following code:

```
int x; //global variable
```

```
void myfun( )
{
	int x; //local variable
	...
	...
	x = 20; //refers to local x
	..
	..
	::x = 20; //refers to global x
	..
}
```

In the above code sample, ::x refers to the global variable *x*.

Memory Management Operators

As C language provides *malloc()* and *free()* for allocating and deallocating memory, C++ provides *new* and *delete* operators for allocating and deallocating memory. Since the memory allocated and deallocated by these operators is at runtime, they are called as *dynamic allocation operators*.

The *new* operator is used to allocate dynamic memory. It returns a pointer to the newly created memory. There is no need to specify the size of the memory to allocate and cast the pointer to respective type. It is done automatically by the *new* operator. General syntax of *new* is as follows:

p-var = new type;

In the above syntax, *p-var* is a pointer variable and *type* is the data type of value to be stored in the newly allocated memory location.

Dynamic memory is allocated on the heap (area in memory) and this heap is of limited size. When the heap is filled out, *new* will raise an exception *bad_alloc* which must be caught. More about exceptions and exception handling later.

The *delete* operator is used to deallocate the memory. General syntax of *delete* operator is as follows:

delete p-var;

In the above syntax, *p-var* is the pointer variable which holds the pointer to the dynamic memory. Consider the following example which demonstrates both *new* and *delete* operators:

```
int *p;
p = new int;
*p = 150;
delete p;
```

Namespace

It is common in large programs or projects to create multiple files and declare variables, functions, classes, etc. with same names which results in collisions of names. In order to eliminate collisions, C++ introduced the concept of *namespaces* which is a logical space for creating names.

A namespace can be created using the keyword *namespace* and its syntax is as follows:

```
namespace  name
{
        //declarations
        ...
        ...
        ...
}
```

Essentially a namespace creates a scope of for all the elements inside it. Syntax for accessing an element outside the namespace is as follows:

namespace::element

If we are accessing a member of the namespace at multiple spots within a program, it will become cumbersome to use the above syntax at every point. Instead we use the *using* keyword to use the namespace once. We can use the entire namespace or only a single member of the namespace using the following syntax:

using namespace name;
using name::member;

In the above syntax, *name* is the name of the namespace we want to use and *member* is the name of the element we want to access in our program.

Control Statements

When a program is executed, the statements are executed sequentially one after another if there are no control statements. However, in general, in almost every program there will be need to skip some statements, repeat a set statements or execute a set of statements based on a condition. Such types of execution can be achieved through control statements.

Control statements are generally divided into three categories: 1) Selection statements, 2) Iterative statements, and 3) Jump statements.

Selection statements

These statements allows programmers to execute a set of statements based on the value of a condition. Selection statements in C++ are if...else, nested if, else if ladder and switch statement.

if...else

The if...else statement is a two way selection statement. The syntax of if...else statement is as follows:

```
if(condtion)
{
	//Execute statements when condition is true
	...
}
else
{
	//Execute statements when condition is false
	...
}
```

In the above syntax, when *condition* evaluates to *true*, *if* block is executed. Otherwise, *else* block is executed.

Consider the following program which prints out the largest number among two numbers using *if...else* statement:

```
#include<iostream>
using namespace std;
int main()
{
	int a, b;
	cout<<"Enter first number: ";
	cin>>a;
	cout<<"Enter second number: ";
	cin>>b;
	if(a>b)
		cout<<a<<" is the largest number"<<endl;
	else
		cout<<b<<" is the largest number"<<endl;
	return 0;
}
```

Input and output of the above program is as follows:

```
Enter first number: 15
Enter second number: 7
15 is the largest number
```

In the above program as the condition *a>b* returns *true*, only the *if* block is executed.

Note: Remember that the *else* part in *if...else* is entirely optional. But, on the contrary you can't write *else* without an *if* statement.

Note: When *if* block and *else* block contains only one statement, braces can be removed.

Nested if

To check multiple conditions we can use logical operators or we can use nested *if* statement. Syntax of nested *if* is as follows:

```
if(condtion)
{
        //Execute statements when condition is true
        if(another condition)
        {
                //Execute statements when condition is true
                ...
        }
        else
        {
                //Execute statements when condition is false
                ...
        }
}
else
{
        //Execute statements when condition is false
        ...
}
```

In the above syntax if first *condition* is true, then next condition is evaluated and so on. Consider the following program to find out the largest among three numbers using nested if statement:

```
#include<iostream>
using namespace std;
int main()
{
        int a, b, c;
        cout<<"Enter first number: ";
        cin>>a;
        cout<<"Enter second number: ";
        cin>>b;
        cout<<"Enter third number: ";
        cin>>c;
        if(a>b)
        {
                if(a>c)
                        cout<<a<<" is the largest number"<<endl;
        }
        else if(b>c)
                cout<<b<<" is the largest number"<<endl;
        else
                cout<<c<<" is the largest number"<<endl;
        return 0;
}
```

Input and output of the above program is as follows:

```
Enter first number: 5
Enter second number: 10
Enter third number: 20
20 is the largest number
```

else if Ladder

The *else if* ladder is a multi-way selection statement that allows us to select one set of statements among multiple sets. The set of statements to be executed is based on a condition. Syntax of *else if* ladder is as follows:

```
if(condition 1)
{
	//Statements to execute
}
else if(condition 2)
{
	//Statements to execute
}
else if(condition 3)
{
	//Statements to execute
}
...
else if(condition n)
{
	//Statements to execute
}
else
{
	//Statements to execute
}
```

In the above syntax, only one block will be executed based on which condition evaluates to *true*. If one of the condition is *true*, remaining conditions will be skipped. Final *else* is optional.

Consider the following program which checks whether the entered character is a vowel or not using *else if* ladder:

```
#include<iostream>
using namespace std;
int main()
{
	char ch;
	cout<<"Enter a character: ";
	cin>>ch;
	if(ch == 'a')
```

```
        cout<<"a is a vowel"<<endl;
    else if(ch == 'e')
        cout<<"e is a vowel"<<endl;
    else if(ch == 'i')
        cout<<"i is a vowel"<<endl;
    else if(ch == 'o')
        cout<<"o is a vowel"<<endl;
    else if(ch == 'u')
        cout<<"u is a vowel"<<endl;
    else
        cout<<ch<<" is not a vowel"<<endl;
    return 0;
}
```

Input and output for the above program is as follows:

First run:

```
Enter a character: e
e is a vowel
```

Second run:

```
Enter a character: o
o is a vowel
```

Third run:

```
Enter a character: h
h is not a vowel
```

switch

The *switch* statement is also a multi-way selection statement and is similar to *else if* in functionality. Frequently used keywords along with *switch* are: *case, break,* and *default*. The syntax of a *switch* statement is as follows:

```
switch(expression)
{
    case Label1:
        //Statements to execute
        break;
    case Label2:
        //Statements to execute
        break;
    ...
    case LabelN:
        //Statements to execute
        break;
    default:
        //Statements to execute
}
```

In the above syntax, the value of *expression* is matched against one of the labels *Label1, Label2, ..., LabelN*. All the labels must be constants. If none of the labels match, the *default* block is executed. The *default* block is optional.

At the end of each case you can see a *break* statement which is optional. The execution stops whenever the *break* is encountered. Otherwise, the execution continues with the next case until a *break* is encountered or it reaches the end of *switch*.

Consider the following program which checks whether the entered character is a vowel or not using *switch*:

```
#include<iostream>
using namespace std;
int main()
{
        char ch;
        cout<<"Enter a character: ";
        cin>>ch;
        switch(ch)
        {
                case 'a':
                        cout<<"a is a vowel"<<endl;
                        break;
                case 'e':
                        cout<<"e is a vowel"<<endl;
                        break;
                case 'i':
                        cout<<"i is a vowel"<<endl;
                        break;
                case 'o':
                        cout<<"o is a vowel"<<endl;
                        break;
                case 'u':
                        cout<<"u is a vowel"<<endl;
                        break;
                default:
                        cout<<ch<<" is not a vowel"<<endl;
        }
        return 0;
}
```

Input and output for the program is as follows:

First run:

```
Enter a character: e
e is a vowel
```

Second run:

```
Enter a character: v
v is not a vowel
```

Iterative statements or Looping statements

Iterative statements are used to repeat a set of statements in a loop based on a condition. Iterative or looping statements in C++ are *while*, *do-while*, and *for*.

while Loop

A *while* loop is pre test loop which is used to repeat a set of statements as long as the condition is true. Syntax of *while* is as follows:

```
while(condition)
{
	//Statements to be executed repeatedly
	...
}
```

Consider the following program which prints 1-10 using a *while* loop:

```
#include<iostream>
using namespace std;
int main()
{
	int i = 1;
	while(i<=10)
	{
		cout<<i<<" ";
		i++;
	}
	cout<<endl;
	return 0;
}
```

Output of the above program is as follows:

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

do-while Loop

A *do-while* loop is a post test loop i.e., the body of loop is executed and then the condition is evaluated. Speciality of do-while loop is, the body of this loop is guaranteed to be executed at least once. Syntax of do-while loop is as follows:

```
do
{
	//Statements to be executed repeatedly
	...
}while(condition);
```

Consider the following program which prints 1-10 using do-while loop:

```
#include<iostream>
```

```
using namespace std;
int main()
{
	int i = 1;
	do
	{
		cout<<i<<" ";
		i++;
	}while(i<=10);
	cout<<endl;
	return 0;
}
```

Output of the above program is as follows:

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

for Loop

Compared to the other two loops, *for* loop is somewhat complex. Syntax of *for* loop is as follows:

```
for(initialization; condition; update)
{
	//Statements to be executed repeatedly
	...
}
```

In *for* loop, *initialization* is executed first followed by the evaluation of *condition*. If it is true, body of *for* loop is executed followed by execution of *update*. Then *condition* is again evaluated and so on.

Consider the following program which prints 1-10 using *for* loop:

```
#include<iostream>
using namespace std;
int main()
{
	for(int i=1;i<=10;i++)
	{
		cout<<i<<" ";
	}
	cout<<endl;
	return 0;
}
```

Output of the above program is as follows:

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

Jump Statements

Jump statements in C++ are used to transfer control unconditionally. Jumps statements in C++ consists of *break*, *continue, return,* and *goto*. Usage of jump statements must be limited in programs as they might decrease readability or cause undesired effects. Especially usage of *goto* is strictly not recommended as it might lead to spaghetti code.

break

We already used *break* in *switch* statement. It can also be used inside loops to transfer control outside the loop. Generally such transfer control is associated with a condition evaluation. Consider the following program which demonstrates the use of *break*:

```
#include<iostream>
using namespace std;
int main()
{
        for(int i=1;i<=10;i++)
        {
                if(i==5) break;
                cout<<i<<" ";
        }
        cout<<endl;
        return 0;
}
```

Output of the above program is as follows:

```
1 2 3 4
```

In the above program when *i* becomes 5, condition *i==5* becomes true and the control is transferred to the next statement outside the *for* loop.

continue

The *continue* statement can be used only inside loops. When used inside a loop, statements after the *continue* statement inside the loop body are skipped and execution again starts from the first statement inside the loop. Consider the following program which demonstrates the use of *continue*:

```
#include<iostream>
using namespace std;
int main()
{
        for(int i=1;i<=10;i++)
        {
                if(i==5) continue;
                cout<<i<<" ";
        }
        cout<<endl;
        return 0;
}
```

Output for the above program is as follows:

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

In the above program, when *i* becomes 5, statement after *continue* is skipped and execution again starts from beginning of the loop.

return

The *return* statement is generally used inside functions to return control to the calling function which is in general *main()* function. When a *return* statement is encountered, control exits the current function and starts with the next statement after the function call. We will learn about *return* statement in details later in functions topic.

goto

The *goto* statement is used to transfer control to a point backward or forward from the current line. The point of transfer is identified by a label. Syntax of *goto* is as follows:

```
{
        ...
        Label:
        ...
        ...
        goto Label;
        ...
        ...
}
```

We can use *goto* anywhere in a program and also the *Label* can be placed before or after the *goto* statement. Since use of *goto* is strictly prohibited, we will not discuss about it further.

Arrays

Introduction

An array is *a group of elements forming a complete unit*. Characteristics of an array are as follows:

- An array is a collection of elements.
- All elements in an array are of the same type.
- Collection of elements forms a complete set.

Elements in an array are stored in order and sequentially inside the memory.

Need for arrays

Think that we have to store five values in a program. We can declare five variables to store those five values as follows:

```
int var1;
int var2;
int var3;
int var4;
int var5;
```

We can declare an array which can store five integers to solve the above problem as follows:

```
int numbers[5] = {0};
```

In the above statement, *numbers* is the array name and 5 is the number of elements we can store in the array. All the 5 elements in the array will have an initial value of 0 which is specified by {0}.

Now, let's think that we have to store 5000 values. It is inappropriate to declare 5000 variables to store those values. Instead we can declare a single array which can store 5000 values as follows:

```
int numbers[5000] = {0};
```

The arrays which you have seen above are called as ***static arrays*** because the number of elements the array contains and its memory is fixed at the compilation time.

Declaring and initializing static arrays

In C++ the syntax for declaring a static array is as follows:

type array-name[no. of elements];

Consider the following example for array declaration:

int nums[10];

In the above statement *nums* is the name of the array which is capable to store 10 integers and the data type of all the elements is *int*.

We can declare and initialize all the elements in the array as shown in the below example.

int nums[5] = {1, 4, 2, 3, 6};

We can initialize all the elements in an array to a default value as shown in the below example:

int nums[5] = {10};

We can initialize only some of the elements in an array as shown below:

int nums[5] = {2, 6};

In the above statement, the first two elements are initialized to 2 and 6. Remaining elements contain garbage value or some compilers might initialize them to 0.

We can also leave out the size of array in its declaration. But we have to specify the values as shown below:

int nums[ ] = {2, 4, 6, 8, 10};

In the above statement compiler automatically deduces the size of array *nums* as 5 based on the number of values.

We can also initialize array elements individually as shown in below example:

```
int nums[3];
nums[0] = 10;
nums[1] = 20;
nums[2] = 30;
```

Accessing and modifying array elements

Elements of an array can be accessed using the *index* or *subscript*. The index value of arrays starts from 0. The index of Nth element is N-1. For example index of 5th element is 4. Syntax for accessing an array element is as follows:

array-name[index]

Consider the following program which demonstrates reading and displaying array elements:

```
#include<iostream>
using namespace std;
int main()
{
        int nums[5] = {0};
        cout<<"Enter five values: ";
        for(int i=0;i<5;i++)
        {
                cin>>nums[i];
        }
        cout<<"Elements in the array are: ";
        for(int i=0;i<5;i++)
        {
                cout<<nums[i]<<" ";
        }
        cout<<endl;
        return 0;
}
```

Input and output for the above program is as follows:

```
Enter five values: 2 4 1 5 8
Elements in the array are: 2 4 1 5 8
```

Note: Remember that while accessing elements outside the array bounds does not give any errors. Such access might lead to undesirable behavior and often might lead to program crash. So, it is a good practice to check whether the array access is within the bounds or not.

Multidimensional Arrays

Until now the arrays we discussed are one-dimensional arrays. C++ also supports storing data in multiple dimensions. A two-dimensional array can represent tabular data i.e., in rows and columns. Syntax for declaring a two-dimensional array is as follows:

type array-name[rows][coulumns];

We can initialize a two-dimensional array at the time of declaration itself as shown below:

int data[3][3] = {{1,2,3},{4,5,6},{7,8,9}};

In the above statement, *data* is a two-dimensional array having three rows and three columns. We can imagine a two-dimensional array as an array of arrays. Consider the following program which demonstrates reading and displaying elements in a two-dimensional array:

```
#include<iostream>
using namespace std;
int main()
{
	int data[3][3];
	cout<<"Enter data for three rows and three columns: ";
	for(int i=0;i<3;i++)
	{
		for(int j=0;j<3;j++)
		{
			cin>>data[i][j];
		}
	}
	cout<<"Elements in the array are: "<<endl;
	for(int i=0;i<3;i++)
	{
		for(int j=0;j<3;j++)
		{
			cout<<data[i][j]<<" ";
		}
		cout<<endl;
	}
	cout<<endl;
	return 0;
}
```

Input and output for the above program is as follows:

```
Enter data for three rows and three columns:
1 2 3
4 5 6
7 8 9
Elements in the array are:
1 2 3
4 5 6
7 8 9
```

Observe how nested for loops are used to read and print the array elements effectively.

Dynamic Arrays

Consider you are writing a program to store student records which are bound to increase over time. There is now way to assume the size of the array before hand. In such cases static arrays are a bad choice. Instead, use dynamic arrays.

Dynamic arrays can be created in C++ programs using *vector* class which is available in the header file *vector*. Since *vector* uses template syntax and they are not at discussed, let's look at a program which demonstrates creating and using a *vector*:

```
#include<iostream>
#include<vector>
using namespace std;
int main()
{
        vector<int> nums(3);
        nums[0] = 1;
        nums[1] = 2;
        nums[2] = 3;
        cout<<"Size of the array is: "<<nums.size()<<endl;
        cout<<"Enter a number to store in the array: ";
        int n;
        cin>>n;
        nums.push_back(n);
        cout<<"New size of the array is: "<<nums.size()<<endl;
        return 0;
}
```

Input and output for the above program is as follows:

```
Size of the array is: 3
Enter a number to store in the array: 10
New size of the array is: 4
```

In the above program, *size()* function returns the size of the vector (array) and *push_back()* function inserts the given element at the end of the vector (array).

Strings

It is common in many programs to work with strings. A string is a collection of characters. Those who are familiar with C language know that strings are maintained using character arrays. Also people face many problems with the string termination character '\0' in C strings.

C++ eliminates such difficulties altogether by providing pre-defined *string* class. It is available in the header file *string*.

Creating strings

We can create strings in two ways using the *string* class. First way is create a variable with type *string* and assign a string literal to it as shown below:

string str = "hello";

Second way is to use the *string* constructor which accepts a single string parameter to initialize the *string* variable as shown below:

string str("hello");

Consider the following program which demonstrates reading strings as well as concatenating, copying, and finding the size of the string.

```
#include<iostream>
#include<string>
using namespace std;
int main()
{
	string str1;
	cout<<"Enter first string: ";
	getline(cin, str1);
	string str2;
	cout<<"Enter second string: ";
	getline(cin, str2);
	cout<<"First string is: "<<str1<<endl;
	cout<<"Second string is: "<<str2<<endl;
	string catstr;
	catstr = str1+" "+str2;
	cout<<"Concatenated string is: "<<catstr<<endl;
	string copystr;
	copystr = catstr;
	cout<<"Copied string is: "<<copystr<<endl;
	cout<<"Length of copied string is: "<<copystr.length()<<endl;
	cout<<"Size of copied string is: "<<copystr.size()<<endl;
	return 0;
}
```

Input and output for the above program is as follows:

```
Enter first string: hello
Enter second string: world
First string is: hello
Second string is: world
Concatenated string is: hello world
Copied string is: hello world
Size of copied string is: 11
Size of copied string is: 11
```

Functions

Introduction

While writing large programs, *main()* function will become quite complex to maintain and soon you will lose track of what is happening. This is where functions will aid programmers.

Functions allows the programmer to divide a large program into logical chunks. Each function is a self contained block that does a non-trivial task. The *main()* function will call other functions which in turn solves the problem. This model of programming using functions is known as modular programming or structured programming.

Consider the following program which calculates the area and perimeter of a circle using functions.

```
#include<iostream>
double area(double);
double peri(double);
const double PI = 3.1415;
using namespace std;
int main()
{
        double radius;
        cout<<"Enter radius of cricle: ";
        cin>>radius;
        cout<<"Area of the circle is: "<<area(radius)<<endl;
        cout<<"Perimeter of the circle is: "<<peri(radius)<<endl;
        return 0;
}
double area(double r)
{
        return PI*r*r;
}
double peri(double r)
{
        return 2*PI*r;
}
```

Input and output of the above program is as follows:

```
Enter radius of cricle: 5
Area of the circle is: 78.5375
Perimeter of the circle is: 31.415
```

In the above program, following two lines are known as *function prototypes:*

```
double area(double);
double peri(double);
```

A function prototype tells the compiler that there is a function with the specified name, with the specified type and parameters.

Following two lines are function calls to respective functions:

```
area(radius)
peri(radius)
```

Following two code segments are called function definitions of respective functions:

```
//Function definition of function area
double area(double r)
{
	return PI*r*r;
}

//Function definition of function peri
double peri(double r)
{
	return 2*PI*r;
}
```

Function Prototype

A function prototype tells the compiler what is the function name, how many parameters a function accepts and the types of those parameters and the type of value that a function returns to its caller. General syntax of function prototype (declaration) is as follows:

return-type function-name(type, type, ..., type);

In the above syntax, parameters are optional. When the function does not return any value, the return type must be specified as *void*.

Function Definition

The body or implementation of a function is known as function definition. A function definition always consists of a block made up of braces. General syntax of a function definition is as follows:

```
return-type  function-name(type var1, type var2, ..., type varN)
{
        //Statements to execute
        ...
        ...
        [return value / expression;]
}
```

If the return type of the function is *void*, there is no need to write the *return* statement. Remember that a function can return only one value using the *return* statement.

Function Call

Invoking or calling a function is known as a function call. General syntax of a function call is as follows:

```
function-name(arg1, arg2, ..., argN);
```

A function call starts the execution of corresponding function definition. The arguments in the function call are known as *actual parameters* and the parameters in the function definition are known as *formal parameters*.

Function parameters (in general) are like local variables. Their scope is within the function block. Each time a function executes, memory is allocated for parameters and when execution goes back to the caller, memory is deallocated and they are no longer accessible.

Function Parameters with Default Values

The parameters in a function declaration can be assigned a default value as shown below:

```
double area(double radius, double Pi = 3.14);
```

We can declare multiple parameters with default values. But, all suck kind of parameters must be at the last of the parameters list. We can assign our custom value for the parameter as shown below:

```
area(2.5, 3.1415);
```

For the above function call, Pi value will be taken as 3.1415 instead of the default value 3.14.

Following program demonstrates parameters with default values:

```
#include<iostream>
double area(double radius, double Pi = 3.14);
using namespace std;
int main()
{
	double radius;
	cout<<"Enter radius of cricle: ";
	cin>>radius;
	cout<<"Area of the circle is: "<<area(radius)<<endl;
	cout<<"Area of the circle is: "<<area(radius, 3.1415)<<endl;
	return 0;
}
double area(double r, double Pi)
{
	return Pi*r*r;
}
```

Input and output for the above program is as follows:

```
Enter radius of cricle: 2.5
Area of the circle is: 19.625
Area of the circle is: 19.6344
```

Recursion

A function invoking itself is known as recursion. Recursion is an alternative to iteration. Recursion is very close to mathematical way of solving a given problem.

Advantages of recursion are, it is straight forward and easy. Disadvantage of recursion is, it occupies more memory on the stack when compared to iteration.

Note: Remember to write an exit condition while using recursion. If there is no exit condition, then the function will call itself infinitely.

Consider the following program which calculates the factorial of a number using recursion:

```
#include<iostream>
using namespace std;
int fact(int n)
{
	if(n==0 || n==1) return 1;
	else return n*fact(n-1);
}
int main()
{
	int num;
	cout<<"Enter a number: ";
	cin>>num;
	cout<<"Factorial of "<<num<<" is: "<<fact(num)<<endl;
	return 0;
}
```

Input and output for the above program is as follows:

```
Enter a number: 5
Factorial of 5 is: 120
```

In the above program the exit condition is *if(n==0 || n==1) return 1;*

The recursive call is *fact(n-1).*

Note: In the above program there is no function declaration (prototype) for the function *fact()*. If the function definition is written before *main()*, there is no need of writing function declaration.

Passing an Array as a Parameter

Like we are able to pass variables, we can also pass arrays as arguments to a function. A function prototype which accepts an array and its size as parameters is as follows:

void PrintArray(int nums[ ], int size);

Consider the following program which contains a function that takes an array and its size as arguments and calculates the largest element in the array:

```
#include<iostream>
using namespace std;
int largest(int nums[], int size)
{
	int max = nums[0];
	for(int i=1; i<size; i++)
	{
		if(max<nums[i])
		{
			max = nums[i];
		}
	}
	return max;
}
int main()
{
	int nums[5] = {1,2,5,3,4};
	cout<<"Largest element in the array is: "<<largest(nums, 5)<<endl;
	return 0;
}
```

Output of the above program is as follows:

```
Largest element in the array is: 5
```

Note that in the above program there is no need to write square brackets in the function call *largest(nums, 5)*.

Parameter Passing Techniques

In C++ we have three ways for passing arguments to a function. They are: *pass-by-value, pass-by-reference,* and *pass-by-address*.

Pass-by-value

Generally used way to pass arguments is pass-by-value. In this method, the arguments passed in the function call are copied to formal parameters in the function definition. So, any changes made to the formal parameters are not reflected on the actual parameters. Consider the following swap function which demonstrates pass-by-value:

```
void swap(int x, int y)
{
        int temp = x;
        x = y;
        y = temp;
}
```

Let's assume that in the *main()* function we are writing the following code:

```
int a = 10, b = 20;
swap(a, b);
```

Although the values of *x* and *y* are being interchanged, since they are copies of *a* and *b*, the values of *a* and *b* remains the same i.e., 10 and 20 respectively.

Pass-by-reference

To make the changes on formal parameters reflect on actual parameters, we can use pass-by-reference. In pass-by-reference method we pass reference to argument instead of a copy. So, both actual and formal parameters refer to the same memory location. Using this method, our swap function will be as follows:

```
void swap(int &x, int &y)
{
        int temp = x;
        x = y;
        y = temp;
}
```

Remember to precede the formal parameters with &.

Pass-by-address

In pass-by-address, we pass address of the argument to formal parameters. Both pass-by-reference and pass-by-address are semantically same. The only difference is, in pass-by-reference, the formal parameters are guaranteed to alias valid memory locations. Whereas in pass-by-address, the formal parameters are pointers and can even point to null.

Our swap function using pass-by-address will look as follows:

```
void swap(int *x, int *y)
{
	int temp = *x;
	*x = *y;
	*y = temp;
}
```

and the code for calling our swap function will be as follows:

```
int a=10, b=20;
swap(&a, &b);
```

The complete program which demonstrates all the three methods to pass arguments is as follows:

```
#include<iostream>
using namespace std;
int swapval(int x, int y)
{
	int temp = x;
	x = y;
	y = temp;
}
int swapref(int &x, int &y)
{
	int temp = x;
	x = y;
	y = temp;
}
int swapadd(int *x, int *y)
{
	int temp = *x;
	*x = *y;
	*y = temp;
}
int main()
{
        int a=10, b=20;
        swapval(a,b);
        cout<<"After swap (call by value): a="<<a<<",b="<<b<<endl;
        swapref(a,b);
        cout<<"After swap (call by reference): a="<<a<<",b="<<b<<endl;
        swapadd(&a,&b);
        cout<<"After swap (call by address): a="<<a<<",b="<<b<<endl;
        return 0;
}
```

Output for the above program is as follows:

```
After swap (call by value): a=10,b=20
After swap (call by reference): a=20,b=10
After swap (call by address): a=10,b=20
```

Inline Functions

A normal function call would involve stack operations and processor to shift to the first instruction in the function definition which might take significant time. For small functions with one or two lines this time is unnecessary. Such functions can be declared as inline functions using the keyword *inline*.

In general, inline functions are faster than normal functions. When the compiler comes across a call to a inline function, it directly substitutes the function definition in the place of function which might increase the size of code. So, the use of *inline* keyword in programs should be minimal. Consider the following inline function that demonstrates the use of *inline* keyword:

```
inline int square(int x)
{
        return x*x;
}
```

Rules for declaring a function as inline are as follows:

1. Function should not use recursion.
2. Function should not use static variables.
3. Function should not return a value.
4. Function should not contain any go to, switch, or iterative statements.

Function Overloading

Two or more functions with the same name but different set of parameters or different number of parameters are said to be overloaded and this concept is known as function overloading.

It is common to create functions which does the same thing but on different parameters. For example, we might have to create functions to add integers as well as floating-point numbers. In C, to do this, we have to create two functions with different names. But in C++ we can use the same function name to create multiple functions.

Consider the following program which demonstrates the use of function overloading:

```
#include<iostream>
using namespace std;
int sum(int x, int y)
{
	return x+y;
}
double sum(double x, double y)
{
	return x+y;
}
int main()
{
	cout<<"Sum of 3 and 5 is: "<<sum(3,5)<<endl;
	cout<<"Sum of 2.55 and 6.5 is: "<<sum(2.55,6.5)<<endl;
	return 0;
}
```

Output of the above program is as follows:

```
Sum of 3 and 5 is: 8
Sum of 2.55 and 6.5 is: 9.05
```