

MEPL

# IBPS SO Notes

C LANGUAGE

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MEPL

# C - Quick Guide

## C - Language Overview

C is a general-purpose, high-level language that was originally developed by Dennis M. Ritchie to develop the UNIX operating system at Bell Labs. C was originally first implemented on the DEC PDP-11 computer in 1972.

In 1978, Brian Kernighan and Dennis Ritchie produced the first publicly available description of C, now known as the K&R standard.

The UNIX operating system, the C compiler, and essentially all UNIX applications programs have been written in C. C has now become a widely used professional language for various reasons.

- Easy to learn
- Structured language
- It produces efficient programs.
- It can handle low-level activities.
- It can be compiled on a variety of computer platforms.

### Facts about C

- C was invented to write an operating system called UNIX.
- C is a successor of B language which was introduced around 1970.
- The language was formalized in 1988 by the American National Standard Institute *ANSI*.
- The UNIX OS was totally written in C by 1973.
- Today C is the most widely used and popular System Programming Language.
- Most of the state-of-the-art softwares have been implemented using C.
- Today's most popular Linux OS and RBDMS MySQL have been written in C.

## C - Environment Setup

Before you start doing programming using C programming language, you need the following two software's available on your computer, *a* Text Editor and *b* The C Compiler.

## **Text Editor:**

This will be used to type your program. Examples of few editors include Windows Notepad, OS Edit command, Brief, Epsilon, EMACS, and vim or vi.

Name and version of text editor can vary on different operating systems. For example, Notepad will be used on Windows and vim or vi can be used on windows as well as Linux or UNIX.

The files you create with your editor are called source files and contain program source code. The source files for C programs are typically named with the extension ".c".

Before starting your programming, make sure you have one text editor in place and you have enough experience to write a computer program, save it in a file, compile it and finally execute it.

## **The C Compiler:**

The source code written in source file is the human readable source for your program. It needs to be "compiled", to turn into machine language so that your cpu can actually execute the program as per instructions given.

This C programming language compiler will be used to compile your source code into final executable program. I assume you have basic knowledge about a programming language compiler.

Most frequently used and free available compiler is GNU C/C++ compiler, otherwise you can have compilers either from HP or Solaris if you have respective Operating Systems.

Following section guides you on how to install GNU C/C++ compiler on various OS. I'm mentioning C/C++ together because GNU gcc compiler works for both C and C++ programming languages.

## **Installation on UNIX/Linux**

If you are using **Linux or Unix** then check whether GCC is installed on your system by entering the following command from the command line:

```
$ gcc -v
```

If you have GNU compiler installed on your machine, then it should print a message something as follows:

Using built-in specs.

Target: i386-redhat-linux  
Configured with: ../configure --prefix=/usr .....

Thread model: posix

gcc version 4.1.2 20080704 (Red Hat 4.1.2-46)

If GCC is not installed, then you will have to install it yourself using the detailed instructions available at <http://gcc.gnu.org/install/>

This tutorial has been written based on Linux and all the given examples have been compiled on Cent OS flavour of Linux system.

## Installation on Mac OS

If you use Mac OS X, the easiest way to obtain GCC is to download the Xcode development environment from Apple's web site and follow the simple installation instructions. Once you have Xcode setup, you will be able to use GNU compiler for C/C++.

Xcode is currently available at [developer.apple.com/technologies/tools/](http://developer.apple.com/technologies/tools/).

## Installation on Windows

To install GCC at Windows you need to install MinGW. To install MinGW, go to the MinGW homepage, [www.mingw.org](http://www.mingw.org), and follow the link to the MinGW download page. Download the latest version of the MinGW installation program, which should be named MinGW-<version>.exe.

While installing MinWG, at a minimum, you must install gcc-core, gcc-g++, binutils, and the MinGW runtime, but you may wish to install more.

Add the bin subdirectory of your MinGW installation to your **PATH** environment variable so that you can specify these tools on the command line by their simple names.

When the installation is complete, you will be able to run gcc, g++, ar, ranlib, dlltool, and several other GNU tools from the Windows command line.

## C - Program Structure

Before we study basic building blocks of the C programming language, let us look a bare minimum C program structure so that we can take it as a reference in upcoming chapters.

# C Hello World Example

A C program basically consists of the following parts:

- Preprocessor Commands
- Functions
- Variables
- Statements & Expressions
- Comments

Let us look at a simple code that would print the words "Hello World":

```
#include <stdio.h>

int main()
{
    /* my first program in C */
    printf("Hello, World! \n");

    return 0;
}
```

Let us look various parts of the above program:

1. The first line of the program `#include <stdio.h>` is a preprocessor command, which tells a C compiler to include `stdio.h` file before going to actual compilation.
2. The next line `int main` is the main function where program execution begins.
3. The next line `/*...*/` will be ignored by the compiler and it has been put to add additional comments in the program. So such lines are called comments in the program.
4. The next line `printf...` is another function available in C which causes the message "Hello, World!" to be displayed on the screen.
5. The next line **return 0**; terminates mainfunction and returns the value 0.

## Compile & Execute C Program:

Lets look at how to save the source code in a file, and how to compile and run it. Following are the simple steps:

1. Open a text editor and add the above-mentioned code.
2. Save the file as `hello.c`
3. Open a command prompt and go to the directory where you saved the file.
4. Type `gcc hello.c` and press enter to compile your code.
5. If there are no errors in your code, the command prompt will take you to the next line and would generate `a.out` executable file.
6. Now, type `a.out` to execute your program.
7. You will be able to see "Hello World" printed on the screen

```
$ gcc hello.c
$ ./a.out
Hello, World!
```

Make sure that gcc compiler is in your path and that you are running it in the directory containing source file hello.c.

## C - Basic Syntax

You have seen a basic structure of C program, so it will be easy to understand other basic building blocks of the C programming language.

### Tokens in C

A C program consists of various tokens and a token is either a keyword, an identifier, a constant, a string literal, or a symbol. For example, the following C statement consists of five tokens:

```
printf("Hello, World! \n");
```

The individual tokens are:

```
printf
(
"Hello, World! \n"
)
;
```

### Semicolons ;

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

For example, following are two different statements:

```
printf("Hello, World! \n");
return 0;
```

### Comments

Comments are like helping text in your C program and they are ignored by the compiler. They start with /\* and terminates with the characters \*/ as shown below:

```
/* my first program in C */
```

You cannot have comments within comments and they do not occur within a string or character literals.

## Identifiers

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

C does not allow punctuation characters such as @, \$, and % within identifiers. C is a **case sensitive** programming language. Thus, *Manpower* and *manpower* are two different identifiers in C. Here are some examples of acceptable identifiers:

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

## Keywords

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

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

## Whitespace in C

A line containing only whitespace, possibly with a comment, is known as a blank line, and a C compiler totally ignores it.

Whitespace is the term used in C to describe blanks, tabs, newline characters and comments. Whitespace separates one part of a statement from another and enables the compiler to identify where one element in a statement, such as int, ends and the next element begins. Therefore, in the following statement:

```
int age;
```

There must be at least one whitespace character *usually aspace* between int and age for the compiler to be able to distinguish them. On the other hand, in the following statement:

```
fruit = apples + oranges; // get the total fruit
```

No whitespace characters are necessary between fruit and =, or between = and apples, although you are free to include some if you wish for readability purpose.

## C - Data Types

In the C programming language, data types refer to an extensive system used for declaring variables or functions of different types. The type of a variable determines how much space it occupies in storage and how the bit pattern stored is interpreted.

The types in C can be classified as follows:

### S.N. Types and Description

- |   |   |               |              |
|---|---|---------------|--------------|
|   | <b>Basic</b>  | <b>Types:</b> |              |
| 1 | They are arithmetic types and consists of the two types: <i>a</i> integer types and <i>b</i> floating-point types.                                      |               |              |
|   | <b>Enumerated</b>   | <b>types:</b> |              |
| 2 | They are again arithmetic types and they are used to define variables that can only be assigned certain discrete integer values throughout the program. |               |              |
|   | <b>The</b>  | <b>type</b>   | <b>void:</b> |
| 3 | The type specifier <i>void</i> indicates that no value is available.  |               |              |
|   | <b>Derived</b>  | <b>types:</b> |              |
| 4 | They include <i>a</i> Pointer types, <i>b</i> Array types, <i>c</i> Structure types, <i>d</i> Union types and <i>e</i> Function types.                  |               |              |

The array types and structure types are referred to collectively as the aggregate types. The type of a function specifies the type of the function's return value. We will see basic types in the following section, whereas, other types will be covered in the upcoming chapters.

## Integer Types

Following table gives you details about standard integer types with its storage sizes and value ranges:

Type	Storage size	Value range
char	1 byte	-128 to 127 or 0 to 255
unsigned char	1 byte	0 to 255
signed char	1 byte	-128 to 127
int	2 or 4 bytes	-32,768 to 32,767 or -2,147,483,648 to 2,147,483,647
unsigned int	2 or 4 bytes	0 to 65,535 or 0 to 4,294,967,295
short	2 bytes	-32,768 to 32,767



unsigned short	2 bytes	0 to 65,535
long	4 bytes	-2,147,483,648 to 2,147,483,647
unsigned long	4 bytes	0 to 4,294,967,295

To get the exact size of a type or a variable on a particular platform, you can use the **sizeof** operator. The expressions *sizeof type* yields the storage size of the object or type in bytes.

## Floating-Point Types

Following table gives you details about standard floating-point types with storage sizes and value ranges and their precision:

Type	Storage size	Value range	Precision
float	4 byte	1.2E-38 to 3.4E+38	6 decimal places
double	8 byte	2.3E-308 to 1.7E+308	15 decimal places
long double	10 byte	3.4E-4932 to 1.1E+4932	19 decimal places

The header file `float.h` defines macros that allow you to use these values and other details about the binary representation of real numbers in your programs.

## The void Type

The void type specifies that no value is available. It is used in three kinds of situations:

### S.N. Types and Description

- Function** returns as **void**

There are various functions in C which do not return value or you can say they return void. A function with no return value has the return type as void. For example, **void exit(int status);**
- Function** arguments as **void**

There are various functions in C which do not accept any parameter. A function with no parameter can accept as a void. For example, **int rand(void);**
- Pointers** to **void**

A pointer of type `void *` represents the address of an object, but not its type. For example a memory allocation function **void \*malloc(size\_t size);** returns a pointer to void which can be casted to any data type.

The void type may not be understood to you at this point, so let us proceed and we will cover these concepts in the upcoming chapters.

# C - Variables

A variable is nothing but a name given to a storage area that our programs can manipulate. Each variable in C has a specific type, which determines the size and layout of the variable's memory; the range of values that can be stored within that memory; and the set of operations that can be applied to the variable.

The name of a variable can be composed of letters, digits, and the underscore character. It must begin with either a letter or an underscore. Upper and lowercase letters are distinct because C is case-sensitive. Based on the basic types explained in previous chapter, there will be the following basic variable types:

Type	Description
char	Typically a single octet <i>onebyte</i> . This is an integer type.
int	The most natural size of integer for the machine.
float	A single-precision floating point value.
double	A double-precision floating point value.
void	Represents the absence of type.

C programming language also allows to define various other types of variables, which we will cover in subsequent chapters like Enumeration, Pointer, Array, Structure, Union, etc. For this chapter, let us study only basic variable types.

## Variable Definition in C:

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

```
type variable_list;
```

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

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

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

Variables can be initialized *assigned an initial value* in their declaration. The initialize consists of an equal sign followed by a constant expression as follows:

```
type variable_name = value;
```

Some examples are:

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

For definition without an initializer: variables with static storage duration are implicitly initialized with NULL *allbyteshavethevalue0*; the initial value of all other variables is undefined.

## Variable Declaration in C:

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

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

## Example

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

```
#include <stdio.h>

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

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

    /* actual initialization */
```

```

a = 10;
b = 20;

c = a + b;
printf("value of c : %d \n", c);

f = 70.0/3.0;
printf("value of f : %f \n", f);

return 0;
}

```

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

```

value of c : 30
value of f : 23.333334

```

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

```

// function declaration
int func();

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

// function definition
int func()
{
    return 0;
}

```

## L values and R values in C:

There are two kinds of expressions in C:

1. **lvalue** : An expression that is an lvalue may appear as either the left-hand or right-hand side of an assignment.
2. **rvalue** : An expression that is an rvalue may appear on the right- but not left-hand side of an assignment.

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

```
int g = 20;
```

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

```
10 = 20;
```

## C - Constants and Literals

The constants refer to fixed values that the program may not alter during its execution. These fixed values are also called **literals**.

Constants can be of any of the basic data types like *an integer constant, a floating constant, a character constant, or a string literal*. There are also enumeration constants as well.

The **constants** are treated just like regular variables except that their values cannot be modified after their definition.

### Integer literals

An integer literal can be a decimal, octal, or hexadecimal constant. A prefix specifies the base or radix: 0x or 0X for hexadecimal, 0 for octal, and nothing for decimal.

An integer literal can also have a suffix that is a combination of U and L, for unsigned and long, respectively. The suffix can be uppercase or lowercase and can be in any order.

Here are some examples of integer literals:

```
212      /* Legal */
215u     /* Legal */
0xFeeL  /* Legal */
078     /* Illegal: 8 is not an octal digit */
032UU   /* Illegal: cannot repeat a suffix */
```

Following are other examples of various type of Integer literals:

```
85      /* decimal */
0213    /* octal */
0x4b    /* hexadecimal */
30      /* int */
30u     /* unsigned int */
30l     /* long */
30ul    /* unsigned long */
```

## Floating-point literals

A floating-point literal has an integer part, a decimal point, a fractional part, and an exponent part. You can represent floating point literals either in decimal form or exponential form.

While representing using decimal form, you must include the decimal point, the exponent, or both and while representing using exponential form, you must include the integer part, the fractional part, or both. The signed exponent is introduced by *e* or *E*.

Here are some examples of floating-point literals:

```
3.14159    /* Legal */
314159E-5L /* Legal */
510E      /* Illegal: incomplete exponent */
210f     /* Illegal: no decimal or exponent */
.e55     /* Illegal: missing integer or fraction */
```

## Character constants

Character literals are enclosed in single quotes, e.g., 'x' and can be stored in a simple variable of **char** type.

A character literal can be a plain character *e.g.*, 'x', an escape sequence *e.g.*, '\t', or a universal character *e.g.*, '\u02C0'.

There are certain characters in C when they are preceded by a backslash they will have special meaning and they are used to represent like newline \n or tab \t. Here, you have a list of some of such escape sequence codes:

Escape sequence	Meaning
\\	\ character
\'	' character
\"	" character
\?	? character
\a	Alert or bell
\b	Backspace
\f	Form feed
\n	Newline
\r	Carriage return
\t	Horizontal tab
\v	Vertical tab

`\ooo`                    Octal number of one to three digits  
`\xhh . . .`            Hexadecimal number of one or more digits

## String literals

String literals or constants are enclosed in double quotes `""`. A string contains characters that are similar to character literals: plain characters, escape sequences, and universal characters.

You can break a long line into multiple lines using string literals and separating them using whitespaces.

Here are some examples of string literals. All the three forms are identical strings.

```
"hello, dear"
```

```
"hello, \  
dear"
```

```
"hello, " "d" "ear"
```

## Defining Constants

There are two simple ways in C to define constants:

1. Using **#define** preprocessor.
2. Using **const** keyword.

## The const Keyword

You can use **const** prefix to declare constants with a specific type as follows:

```
const type variable = value;
```

## C - Storage Classes

A storage class defines the scope *visibility* and life time of variables and/or functions within a C Program. These specifiers precede the type that they modify. There are following storage classes which can be used in a C Program

- auto
- register
- static
- extern

## The auto Storage Class

The **auto** storage class is the default storage class for all local variables.

```
{  
    int mount;  
    auto int month;  
}
```

The example above defines two variables with the same storage class, auto can only be used within functions, i.e., local variables.

## The register Storage Class

The **register** storage class is used to define local variables that should be stored in a register instead of RAM. This means that the variable has a maximum size equal to the register size *usually one word* and can't have the unary '&' operator applied to it *as it does not have a memory location*.

```
{  
    register int miles;  
}
```

The register should only be used for variables that require quick access such as counters. It should also be noted that defining 'register' does not mean that the variable will be stored in a register. It means that it **MIGHT** be stored in a register depending on hardware and implementation restrictions.

## The static Storage Class

The **static** storage class instructs the compiler to keep a local variable in existence during the life-time of the program instead of creating and destroying it each time it comes into and goes out of scope. Therefore, making local variables static allows them to maintain their values between function calls.

The static modifier may also be applied to global variables. When this is done, it causes that variable's scope to be restricted to the file in which it is declared.

In C programming, when **static** is used on a class data member, it causes only one copy of that member to be shared by all objects of its class.



## The extern Storage Class

The **extern** storage class is used to give a reference of a global variable that is visible to ALL the program files. When you use 'extern', the variable cannot be initialized as all it does is point the variable name at a storage location that has been previously defined.

When you have multiple files and you define a global variable or function, which will be used in other files also, then *extern* will be used in another file to give reference of defined variable or function. Just for understanding *extern* is used to declare a global variable or function in another file.

The extern modifier is most commonly used when there are two or more files sharing the same global variables or functions.

## C - Operators

This tutorial will explain the arithmetic, relational, logical, bitwise, assignment and other operators one by one.

### Arithmetic Operators

Following table shows all the arithmetic operators supported by C language. Assume variable **A** holds 10 and variable **B** holds 20 then:

Show Examples

Operator	Description	Example
+	Adds two operands	A + B will give 30
-	Subtracts second operand from the first	A - B will give -10
*	Multiples both operands	A * B will give 200
/	Divides numerator by de-numerator	B / A will give 2
%	Modulus Operator and remainder of after an integer division	B % A will give 0
++	Increments operator increases integer value by one	A++ will give 11
--	Decrements operator decreases integer value by one	A-- will give 9

### Relational Operators

Following table shows all the relational operators supported by C language. Assume variable **A** holds 10 and variable **B** holds 20, then:

Show Examples

Operator	Description	Example
==	Checks if the values of two operands are equal or not, if yes then condition becomes true.	$A==B$ is not true.
!=	Checks if the values of two operands are equal or not, if values are not equal then condition becomes true.	$A!=B$ is true.
>	Checks if the value of left operand is greater than the value of right operand, if yes then condition becomes true.	$A>B$ is not true.
<	Checks if the value of left operand is less than the value of right operand, if yes then condition becomes true.	$A<B$ is true.
>=	Checks if the value of left operand is greater than or equal to the value of right operand, if yes then condition becomes true.	$A>=B$ is not true.
<=	Checks if the value of left operand is less than or equal to the value of right operand, if yes then condition becomes true.	$A<=B$ is true.

## Logical Operators

Following table shows all the logical operators supported by C language. Assume variable **A** holds 1 and variable **B** holds 0, then:

Operator	Description	Example
&&	Called Logical AND operator. If both the operands are non-zero, then condition becomes true.	$A \&\& B$ is false.
	Called Logical OR Operator. If any of the two operands is non-zero, then condition becomes true.	$A  B$ is true.
!	Called Logical NOT Operator. Use to reverses the logical state of its operand. If a condition is true then Logical NOT operator will make false.	$!A \&\& B$ is true.

## Bitwise Operators

The Bitwise operators supported by C language are listed in the following table. Assume variable **A** holds 60 and variable **B** holds 13 then:

Operator	Description	Example
&	Binary AND Operator copies a bit to the result if it exists in both operands.	$A \& B$ will give 12 which is 0000 1100
	Binary OR Operator copies a bit if it exists in either	$A B$ will give 61 which is 0011

	operand.	1101
^	Binary XOR Operator copies the bit if it is set in one operand but not both.	$AB$ will give 49 which is 0011 0001
~	Binary Ones Complement Operator is unary and has the effect of 'flipping' bits.	$A$ will give -61 which is 1100 0011 in 2's complement form due to a signed binary number.
<<	Binary Left Shift Operator. The left operands value is moved left by the number of bits specified by the right operand.	$A \ll 2$ will give 240 which is 1111 0000
>>	Binary Right Shift Operator. The left operands value is moved right by the number of bits specified by the right operand.	$A \gg 2$ will give 15 which is 0000 1111

## Assignment Operators

There are following assignment operators supported by C language:

Operator	Description	Example
=	Simple assignment operator, Assigns values from right side operands to left side operand	$C = A + B$ will assign value of $A + B$ into $C$
+=	Add AND assignment operator, It adds right operand to the left operand and assign the result to left operand	$C += A$ is equivalent to $C = C + A$
-=	Subtract AND assignment operator, It subtracts right operand from the left operand and assign the result to left operand	$C -= A$ is equivalent to $C = C - A$
*=	Multiply AND assignment operator, It multiplies right operand with the left operand and assign the result to left operand	$C *= A$ is equivalent to $C = C * A$
/=	Divide AND assignment operator, It divides left operand with the right operand and assign the result to left operand	$C /= A$ is equivalent to $C = C / A$
%=	Modulus AND assignment operator, It takes modulus using two operands and assign the result to left operand	$C \% = A$ is equivalent to $C = C \% A$
<<=	Left shift AND assignment operator	$C \ll = 2$ is same as $C = C \ll 2$
>>=	Right shift AND assignment operator	$C \gg = 2$ is same as $C = C \gg 2$
&=	Bitwise AND assignment operator	$C \& = 2$ is same as $C = C \& 2$
^=	bitwise exclusive OR and assignment operator	$C \wedge = 2$ is same as $C = C \wedge 2$
=	bitwise inclusive OR and assignment operator	$C  = 2$ is same as $C = C   2$

## Misc Operators → sizeof & ternary

There are few other important operators including **sizeof** and **? :** supported by C Language.

Operator	Description	Example
sizeof	Returns the size of an variable.	sizeof a, where a is interger, will return 4.
&	Returns the address of an variable.	&a; will give actaul address of the variable.
*	Pointer to a variable.	*a; will pointer to a variable.
?:	Conditional Expression	If Condition is true ? Then value X : Otherwise value Y

## Operators Precedence in C

Here operators with the highest precedence appear at the top of the table, those with the lowest appear at the bottom. Within an expression, higher precedence operators will be evaluated first.

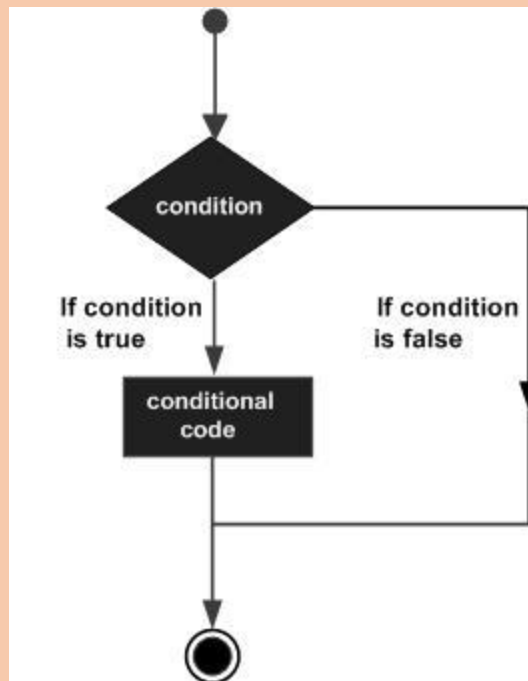
### Show Examples

Category	Operator	Associativity
Postfix	[] -> . ++ --	Left to right
Unary	+ - ! ~ ++ -- <i>type*</i> & sizeof	Right to left
Multiplicative	* / %	Left to right
Additive	+ -	Left to right
Shift	<< >>	Left to right
Relational	< <= > >=	Left to right
Equality	== !=	Left to right
Bitwise AND	&	Left to right
Bitwise XOR	^	Left to right
Bitwise OR		Left to right
Logical AND	&&	Left to right
Logical OR		Left to right
Conditional	?:	Right to left
Assignment	= += -= *= /= %= => >>= <<= &= ^=  =	Right to left
Comma	,	Left to right

# C - Decision Making

Decision making structures require that the programmer specify one or more conditions to be evaluated or tested by the program, along with a statement or statements to be executed if the condition is determined to be true, and optionally, other statements to be executed if the condition is determined to be false.

Following is the general form of a typical decision making structure found in most of the programming languages:



C programming language assumes any **non-zero** and **non-null** values as **true** and if it is either **zero** or **null** then it is assumed as **false** value.

C programming language provides following types of decision making statements. Click the following links to check their detail.

<b>Statement</b>	<b>Description</b>
<a href="#"><u>if statement</u></a>	An <b>if statement</b> consists of a boolean expression followed by one or more statements.
<a href="#"><u>if...else statement</u></a>	An <b>if statement</b> can be followed by an optional <b>else statement</b> , which executes when the boolean expression is false.
<a href="#"><u>switch statement</u></a>	A <b>switch</b> statement allows a variable to be tested for equality against a list of values.
<a href="#"><u>nested if statements</u></a>	You can use one <b>if</b> or <b>else if</b> statement inside another <b>if</b> or <b>else</b>

**if** statements.

nested switch statements

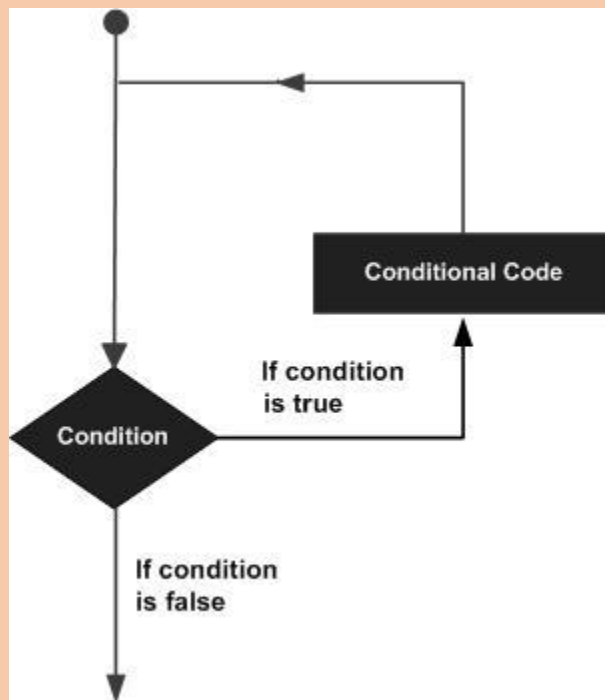
You can use one **switch** statement inside another **switch** statements.

## C - Loops

There may be a situation when you need to execute a block of code several number of times. In general statements are executed sequentially: The first statement in a function is executed first, followed by the second, and so on.

Programming languages provide various control structures that allow for more complicated execution paths.

A loop statement allows us to execute a statement or group of statements multiple times and following is the general form of a loop statement in most of the programming languages:



C programming language provides following types of loop to handle looping requirements. Click the following links to check their detail.

### **Loop Type**

### **Description**

while loop

Repeats a statement or group of statements while a given condition is true. It tests the condition before executing the loop body.

for loop

Execute a sequence of statements multiple times and abbreviates the code that manages the loop variable.

do...while loop

Like a while statement, except that it tests the condition at the end of the loop body

nested loops

You can use one or more loop inside any another while, for or do..while loop.

## Loop Control Statements:

Loop control statements change execution from its normal sequence. When execution leaves a scope, all automatic objects that were created in that scope are destroyed.

C supports the following control statements. Click the following links to check their detail.

### Control Statement

### Description

break statement

Terminates the **loop** or **switch** statement and transfers execution to the statement immediately following the loop or switch.

continue statement

Causes the loop to skip the remainder of its body and immediately retest its condition prior to reiterating.

goto statement

Transfers control to the labeled statement. Though it is not advised to use goto statement in your program.

## C - Functions

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

You can divide up your code into separate functions. How you divide up your code among different functions is up to you, but logically the division usually is so each function performs a specific task.

A function **declaration** tells the compiler about a function's name, return type, and parameters. A function **definition** provides the actual body of the function.

The C standard library provides numerous built-in functions that your program can call. For example, function **strcat** to concatenate two strings, function **memcpy** to copy one memory location to another location and many more functions.

A function is known with various names like a method or a sub-routine or a procedure, etc.

## Defining a Function:

The general form of a function definition in C programming language is as follows:

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

A function definition in C programming language consists of a *function header* and a *function body*. Here are all the parts of a function:

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

## Example:

Following is the example of implementing a function the C programming language:

```
#include <stdio.h>

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

int main ()
{
/* local variable definition */
int a = 100;
int b = 200;
int ret;

/* calling a function to get max value */
ret = max(a, b);

printf( "Max value is : %d\n", ret );

return 0;
}

/* function returning the max between two numbers */
int max(int num1, int num2)
```



```
        {
        /* local variable declaration */
        int result;

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

        return result;
        }
```

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

Max value is : 200

## C - Scope Rules

A scope in any programming is a region of the program where a defined variable can have its existence and beyond that variable can not be accessed. There are three places where variables can be declared in C programming language:

1. Inside a function or a block which is called **local** variables,
2. Outside of all functions which is called **global** variables.
3. In the definition of function parameters which is called **formal** parameters.

Let us explain what are **local** and **global** variables and **formal** parameters.

### Local Variables

Variables that are declared inside a function or block are called local variables. They can be used only by statements that are inside that function or block of code. Local variables are not known to functions outside their own. Following is the example using local variables.

### Global Variables

Global variables are defined outside of a function, usually on top of the program. The global variables will hold their value throughout the lifetime of your program and they can be accessed inside any of the functions defined for the program.

A global variable can be accessed by any function. That is, a global variable is available for use throughout your entire program after its declaration.

## Formal Parameters

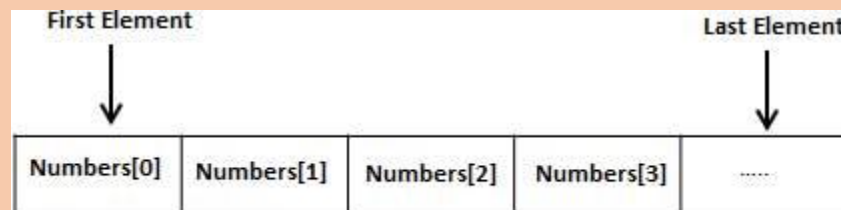
Function parameters, formal parameters, are treated as local variables within that function and they will take preference over the global variables.

## C - Arrays

C programming language provides a data structure called **the array**, which can store a fixed-size sequential collection of elements of the same type. An array is used to store a collection of data, but it is often more useful to think of an array as a collection of variables of the same type.

Instead of declaring individual variables, such as `number0`, `number1`, ..., and `number99`, you declare one array variable such as `numbers` and use `numbers[0]`, `numbers[1]`, and ..., `numbers[99]` to represent individual variables. A specific element in an array is accessed by an index.

All arrays consist of contiguous memory locations. The lowest address corresponds to the first element and the highest address to the last element.



## Declaring Arrays

To declare an array in C, a programmer specifies the type of the elements and the number of elements required by an array as follows:

```
type arrayName [ arraySize ];
```

This is called a *single-dimensional* array. The **arraySize** must be an integer constant greater than zero and **type** can be any valid C data type. For example, to declare a 10-element array called **balance** of type `double`, use this statement:

```
double balance[10];
```

Now, *balance* is a variable array which is sufficient to hold up to 10 double numbers.

## Initializing Arrays

You can initialize array in C either one by one or using a single statement as follows:

```
double balance[5] = {1000.0, 2.0, 3.4, 7.0, 50.0};
```

The number of values between braces { } can not be larger than the number of elements that we declare for the array between square brackets [ ]. Following is an example to assign a single element of the array:

If you omit the size of the array, an array just big enough to hold the initialization is created. Therefore, if you write:

```
double balance[] = {1000.0, 2.0, 3.4, 7.0, 50.0};
```

You will create exactly the same array as you did in the previous example.

```
balance[4] = 50.0;
```

The above statement assigns element number 5th in the array a value of 50.0. Array with 4th index will be 5th ie. last element because all arrays have 0 as the index of their first element which is also called base index. Following is the pictorial representation of the same array we discussed above:

	0	1	2	3	4
balance	1000.0	2.0	3.4	7.0	50.0

## Accessing Array Elements

An element is accessed by indexing the array name. This is done by placing the index of the element within square brackets after the name of the array. For example:

```
double salary = balance[9];
```

The above statement will take 10th element from the array and assign the value to salary variable. Following is an example which will use all the above mentioned three concepts viz. declaration, assignment and accessing arrays:

```
#include <stdio.h>

int main ()
{
    int n[ 10 ]; /* n is an array of 10 integers */
    int i,j;

    /* initialize elements of array n to 0 */
```

```

for ( i = 0; i < 10; i++ )
{
    n[ i ] = i + 100; /* set element at location i to i + 100 */
}

/* output each array element's value */
for ( j = 0; j < 10; j++ )
{
    printf("Element[%d] = %d\n", j, n[j] );
}

return 0;
}

```

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

```

Element[0] = 100
Element[1] = 101
Element[2] = 102
Element[3] = 103
Element[4] = 104
Element[5] = 105
Element[6] = 106
Element[7] = 107
Element[8] = 108
Element[9] = 109

```

## C - Pointers

A **pointer** is a variable, whose value is the address of another variable, i.e., direct address of the memory location. Like any variable or constant, you must declare a pointer before you can use it to store any variable address. The general form of a pointer variable declaration is:

```
type *var-name;
```

Here, **type** is the pointer's base type; it must be a valid C data type and **var-name** is the name of the pointer variable. The asterisk \* you used to declare a pointer is the same asterisk that you use for multiplication. However, in this statement the asterisk is being used to designate a variable as a pointer. Following are the valid pointer declaration:

```

int *ip; /* pointer to an integer */
double *dp; /* pointer to a double */
float *fp; /* pointer to a float */
char *ch /* pointer to a character */

```

The actual data type of the value of all pointers, whether integer, float, character, or otherwise, is the same, a long hexadecimal number that represents a memory address. The only difference between pointers of different data types is the data type of the variable or constant that the pointer points to.

## How to use Pointers?

There are few important operations, which we will do with the help of pointers very frequently. *a* we define a pointer variable *b* assign the address of a variable to a pointer and *c* finally access the value at the address available in the pointer variable. This is done by using unary operator `*` that returns the value of the variable located at the address specified by its operand. Following example makes use of these operations:

```
#include <stdio.h>

int main ()
{
    int var = 20; /* actual variable declaration */
    int *ip;     /* pointer variable declaration */

    ip = &var; /* store address of var in pointer variable*/

    printf("Address of var variable: %x\n", &var );

    /* address stored in pointer variable */
    printf("Address stored in ip variable: %x\n", ip );

    /* access the value using the pointer */
    printf("Value of *ip variable: %d\n", *ip );

    return 0;
}
```

When the above code is compiled and executed, it produces result something as follows:

```
Address of var variable: bffd8b3c
Address stored in ip variable: bffd8b3c
Value of *ip variable: 20
```

## C - Strings

The string in C programming language is actually a one-dimensional array of characters which is terminated by a **null** character `'\0'`. Thus a null-terminated string contains the characters that comprise the string followed by a **null**.

The following declaration and initialization create a string consisting of the word "Hello". To hold the null character at the end of the array, the size of the character array containing the string is one more than the number of characters in the word "Hello."

```
char greeting[6] = {'H', 'e', 'l', 'l', 'o', '\0'};
```

If you follow the rule of array initialization then you can write the above statement as follows:

```
char greeting[] = "Hello";
```

Following is the memory presentation of above-defined string in C/C++:

Index	0	1	2	3	4	5
Variable	H	e	l	l	o	\0
Address	0x23451	0x23452	0x23453	0x23454	0x23455	0x23456

Actually, you do not place the *null* character at the end of a string constant. The C compiler automatically places the '\0' at the end of the string when it initializes the array. Let us try to print above mentioned string:

```
#include <stdio.h>

int main ()
{
    char greeting[6] = {'H', 'e', 'l', 'l', 'o', '\0'};

    printf("Greeting message: %s\n", greeting );

    return 0;
}
```

When the above code is compiled and executed, it produces result something as follows:

Greeting message: Hello

C supports a wide range of functions that manipulate null-terminated strings:

### S.N. Function & Purpose

- 1 **strcpy1,s2;**  
Copies string s2 into string s1.
- 2 **strcat1,s2;**  
Concatenates string s2 onto the end of string s1.
- 3 **strlen1;**  
Returns the length of string s1.
- 4 **strcmp1,s2;**  
Returns 0 if s1 and s2 are the same; less than 0 if s1<s2; greater than 0 if s1>s2.
- 5 **strchr1,ch;**  
Returns a pointer to the first occurrence of character ch in string s1.
- 6 **strstr1,s2;**

Returns a pointer to the first occurrence of string s2 in string s1.

## C - Structures

C arrays allow you to define type of variables that can hold several data items of the same kind but **structure** is another user defined data type available in C programming, which allows you to combine data items of different kinds.

Structures are used to represent a record, suppose you want to keep track of your books in a library. You might want to track the following attributes about each book:

- Title
- Author
- Subject
- Book ID

### Defining a Structure

To define a structure, you must use the **struct** statement. The struct statement defines a new data type, with more than one member for your program. The format of the struct statement is this:

```
struct [structure tag]
{
    member definition;
    member definition;
    ...
    member definition;
} [one or more structure variables];
```

The **structure tag** is optional and each member definition is a normal variable definition, such as `int i;` or `float f;` or any other valid variable definition. At the end of the structure's definition, before the final semicolon, you can specify one or more structure variables but it is optional. Here is the way you would declare the Book structure:

```
struct Books
{
    char title[50];
    char author[50];
    char subject[100];
    int book_id;
} book;
```

### Accessing Structure Members

To access any member of a structure, we use the **member access operator** `..`. The member access operator is coded as a period between the structure variable name and the structure member that

we wish to access. You would use **struct** keyword to define variables of structure type. Following is the example to explain usage of structure:

```
#include <stdio.h>
#include <string.h>

struct Books
{
    char title[50];
    char author[50];
    char subject[100];
    int book_id;
};

int main()
{
    struct Books Book1;    /* Declare Book1 of type Book */
    struct Books Book2;    /* Declare Book2 of type Book */

    /* book 1 specification */
    strcpy( Book1.title, "C Programming");
    strcpy( Book1.author, "Nuha Ali");
    strcpy( Book1.subject, "C Programming Tutorial");
    Book1.book_id = 6495407;

    /* book 2 specification */
    strcpy( Book2.title, "Telecom Billing");
    strcpy( Book2.author, "Zara Ali");
    strcpy( Book2.subject, "Telecom Billing Tutorial");
    Book2.book_id = 6495700;

    /* print Book1 info */
    printf( "Book 1 title : %s\n", Book1.title);
    printf( "Book 1 author : %s\n", Book1.author);
    printf( "Book 1 subject : %s\n", Book1.subject);
    printf( "Book 1 book_id : %d\n", Book1.book_id);

    /* print Book2 info */
    printf( "Book 2 title : %s\n", Book2.title);
    printf( "Book 2 author : %s\n", Book2.author);
    printf( "Book 2 subject : %s\n", Book2.subject);
    printf( "Book 2 book_id : %d\n", Book2.book_id);

    return 0;
}
```

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

```
Book 1 title : C Programming
Book 1 author : Nuha Ali
Book 1 subject : C Programming Tutorial
Book 1 book_id : 6495407
Book 2 title : Telecom Billing
Book 2 author : Zara Ali
Book 2 subject : Telecom Billing Tutorial
```



## C - Unions

A **union** is a special data type available in C that enables you to store different data types in the same memory location. You can define a union with many members, but only one member can contain a value at any given time. Unions provide an efficient way of using the same memory location for multi-purpose.

### Defining a Union

To define a union, you must use the **union** statement in very similar was as you did while defining structure. The union statement defines a new data type, with more than one member for your program. The format of the union statement is as follows:

```
union [union tag]
{
    member definition;
    member definition;
    ...
    member definition;
} [one or more union variables];
```

The **union tag** is optional and each member definition is a normal variable definition, such as `int i;` or `float f;` or any other valid variable definition. At the end of the union's definition, before the final semicolon, you can specify one or more union variables but it is optional. Here is the way you would define a union type named `Data` which has the three members `i`, `f`, and `str`:

```
union Data
{
    int i;
    float f;
    char str[20];
} data;
```

Now, a variable of **Data** type can store an integer, a floating-point number, or a string of characters. This means that a single variable ie. same memory location can be used to store multiple types of data. You can use any built-in or user defined data types inside a union based on your requirement.

The memory occupied by a union will be large enough to hold the largest member of the union. For example, in above example `Data` type will occupy 20 bytes of memory space because this is the maximum space which can be occupied by character string.

## Accessing Union Members

To access any member of a union, we use the **member access operator .** in similar way as you access structure members. The member access operator is coded as a period between the union variable name and the union member that we wish to access. You would use **union** keyword to define variables of union type.

## C - Bit Fields

Suppose your C program contains a number of TRUE/FALSE variables grouped in a structure called status, as follows:

```
struct
{
    unsigned int widthValidated;
    unsigned int heightValidated;
} status;
```

This structure requires 8 bytes of memory space but in actual we are going to store either 0 or 1 in each of the variables. The C programming language offers a better way to utilize the memory space in such situation. If you are using such variables inside a structure then you can define the width of a variable which tells the C compiler that you are going to use only those number of bytes. For example, above structure can be re-written as follows:

```
struct
{
    unsigned int widthValidated : 1;
    unsigned int heightValidated : 1;
} status;
```

Now, the above structure will require 4 bytes of memory space for status variable but only 2 bits will be used to store the values. If you will use upto 32 variables each one with a width of 1 bit , then also status structure will use 4 bytes, but as soon as you will have 33 variables then it will allocate next slot of the memory and it will start using 8 bytes.

## C - typedef

The C programming language provides a keyword called **typedef**, which you can use to give a type a new name. Following is an example to define a term **BYTE** for one-byte numbers:

```
typedef unsigned char BYTE;
```

After this type definitions, the identifier **BYTE** can be used as an abbreviation for the type **unsigned char**, for example:.

```
BYTE b1, b2;
```

By convention, uppercase letters are used for these definitions to remind the user that the type name is really a symbolic abbreviation, but you can use lowercase, as follows:

```
typedef unsigned char byte;
```

You can use **typedef** to give a name to user defined data type as well.

## C - Input & Output

When we are saying **Input** that means to feed some data into program. This can be given in the form of file or from command line. C programming language provides a set of built-in functions to read given input and feed it to the program as per requirement.

When we are saying **Output** that means to display some data on screen, printer or in any file. C programming language provides a set of built-in functions to output the data on the computer screen as well as you can save that data in text or binary files.

### The Standard Files

C programming language treats all the devices as files. So devices such as the display are addressed in the same way as files and following three file are automatically opened when a program executes to provide access to the keyboard and screen.

Standard File	File Pointer	Device
Standard input	stdin	Keyboard
Standard output	stdout	Screen
Standard error	stderr	Your screen

The file points are the means to access the file for reading and writing purpose. This section will explain you how to read values from the screen and how to print the result on the screen.

### The getchar & putchar functions

The **int getcharvoid** function reads the next available character from the screen and returns it as an integer. This function reads only single character at a time. You can use this method in the loop in case you want to read more than one characters from the screen.

The **int putcharintc** function puts the passed character on the screen and returns the same character. This function puts only single character at a time. You can use this method in the loop in case you want to display more than one character on the screen.

## The gets & puts functions

The **char \*getschar\*s** function reads a line from **stdin** into the buffer pointed to by **s** until either a terminating newline or EOF.

The **int putsconstchar\*s** function writes the string **s** and a trailing newline to **stdout**.

## The scanf and printf functions

The **int scanfconstchar\*format,...** function reads input from the standard input stream **stdin** and scans that input according to **format** provided.

The **int printfconstchar\*format,...** function writes output to the standard output stream **stdout** and produces output according to a format provided.

The **format** can be a simple constant string, but you can specify %s, %d, %c, %f etc to print or read strings, integer, character or float respectively. There are many other formatting options available which can be used based on requirements. For a complete detail you can refer to a man page for these function.

## C - File I/O

A file represents a sequence of bytes, does not matter if it is a text file or binary file. C programming language provides access on high level functions as well as low level *OSlevel* calls to handle file on your storage devices. This chapter will take you through important calls for the file management.

### Opening Files

You can use the **fopen** function to create a new file or to open an existing file, this call will initialize an object of the type **FILE**, which contains all the information necessary to control the stream. Following is the prototype of this function call:

```
FILE *fopen( const char * filename, const char * mode );
```

Here, **filename** is string literal which you will use to name your file and access **mode** can have one of the following values:

#### Mode Description

- r Opens an existing text file for reading purpose.
- w Opens a text file for writing, if it does not exist then a new file is created. Here your program will start writing content from the beginning of the file.
- a Opens a text file for writing in appending mode, if it does not exist then a new file is

created. Here your program will start appending content in the existing file content.

r+ Opens a text file for reading and writing both.

w+ Opens a text file for reading and writing both. It first truncate the file to zero length if it exists otherwise create the file if it does not exist.

a+ Opens a text file for reading and writing both. It creates the file if it does not exist. The reading will start from the beginning but writing can only be appended.

If you are going to handle binary files then you will use below mentioned access modes instead of the above mentioned:

"rb", "wb", "ab", "rb+", "r+b", "wb+", "w+b", "ab+", "a+b"

## Closing a File

To close a file, use the `fclose` function. The prototype of this function is:

```
int fclose( FILE *fp );
```

The **fclose** function returns zero on success, or **EOF** if there is an error in closing the file. This function actually, flushes any data still pending in the buffer to the file, closes the file, and releases any memory used for the file. The **EOF** is a constant defined in the header file **stdio.h**.

There are various functions provide by C standard library to read and write a file character by character or in the form of a fixed length string. Let us see few of the in the next section.

## Writing a File

Following is the simplest function to write individual characters to a stream:

```
int fputc( int c, FILE *fp );
```

The function **fputc** writes the character value of the argument `c` to the output stream referenced by `fp`. It returns the written character written on success otherwise **EOF** if there is an error. You can use the following functions to write a null-terminated string to a stream:

```
int fputs( const char *s, FILE *fp );
```

The function **fputs** writes the string `s` to the output stream referenced by `fp`. It returns a non-negative value on success, otherwise **EOF** is returned in case of any error. You can use **int fprintf(FILE\*fp,constchar\*format,...** function as well to write a string into a file.

## Reading a File

Following is the simplest function to read a single character from a file:

```
int fgetc( FILE * fp );
```

The **fgetc** function reads a character from the input file referenced by fp. The return value is the character read, or in case of any error it returns **EOF**. The following functions allow you to read a string from a stream:

```
char *fgets( char *buf, int n, FILE *fp );
```

The functions **fgets** reads up to n - 1 characters from the input stream referenced by fp. It copies the read string into the buffer **buf**, appending a **null** character to terminate the string.

If this function encounters a newline character '\n' or the end of the file EOF before they have read the maximum number of characters, then it returns only the characters read up to that point including new line character. You can also use **int fscanf(FILE\*fp,constchar\*format,...** function to read strings from a file but it stops reading after the first space character encounters.

## Binary I/O Functions

There are following two functions which can be used for binary input and output:

```
size_t fread(void *ptr, size_t size_of_elements,  
             size_t number_of_elements, FILE *a_file);
```

```
size_t fwrite(const void *ptr, size_t size_of_elements,  
             size_t number_of_elements, FILE *a_file);
```

Both of these functions should be used to read or write blocks of memories - usually arrays or structures.

## C - Preprocessors

The **C Preprocessor** is not part of the compiler, but is a separate step in the compilation process. In simplistic terms, a C Preprocessor is just a text substitution tool and they instruct compiler to do required pre-processing before actual compilation. We'll refer to the C Preprocessor as the CPP.

All preprocessor commands begin with a pound symbol #. It must be the first nonblank character, and for readability, a preprocessor directive should begin in first column. Following section lists down all important preprocessor directives:

<b>Directive</b>	<b>Description</b>
<code>#define</code>	Substitutes a preprocessor macro
<code>#include</code>	Inserts a particular header from another file
<code>#undef</code>	Undefines a preprocessor macro
<code>#ifdef</code>	Returns true if this macro is defined
<code>#ifndef</code>	Returns true if this macro is not defined
<code>#if</code>	Tests if a compile time condition is true
<code>#else</code>	The alternative for <code>#if</code>
<code>#elif</code>	<code>#else</code> an <code>#if</code> in one statement
<code>#endif</code>	Ends preprocessor conditional
<code>#error</code>	Prints error message on <code>stderr</code>
<code>#pragma</code>	Issues special commands to the compiler, using a standardized method

## Predefined Macros

ANSI C defines a number of macros. Although each one is available for your use in programming, the predefined macros should not be directly modified.

<b>Macro</b>	<b>Description</b>
<code>__DATE__</code>	The current date as a character literal in "MMM DD YYYY" format
<code>__TIME__</code>	The current time as a character literal in "HH:MM:SS" format
<code>__FILE__</code>	This contains the current filename as a string literal.
<code>__LINE__</code>	This contains the current line number as a decimal constant.
<code>__STDC__</code>	Defined as 1 when the compiler complies with the ANSI standard.

## C - Header Files

A header file is a file with extension `.h` which contains C function declarations and macro definitions and to be shared between several source files. There are two types of header files: the files that the programmer writes and the files that come with your compiler.

You request the use of a header file in your program by including it, with the C preprocessing directive `#include` like you have seen inclusion of `stdio.h` header file, which comes along with your compiler.

Including a header file is equal to copying the content of the header file but we do not do it because it will be very much error-prone and it is not a good idea to copy the content of header file in the source files, specially if we have multiple source file comprising our program.

A simple practice in C or C++ programs is that we keep all the constants, macros, system wide global variables, and function prototypes in header files and include that header file wherever it is required.

## Include Syntax

Both user and system header files are included using the preprocessing directive **#include**. It has following two forms:

```
#include <file>
```

This form is used for system header files. It searches for a file named file in a standard list of system directories. You can prepend directories to this list with the **-I** option while compiling your source code.

```
#include "file"
```

This form is used for header files of your own program. It searches for a file named file in the directory containing the current file. You can prepend directories to this list with the **-I** option while compiling your source code.

## C - Type Casting

Type casting is a way to convert a variable from one data type to another data type. For example, if you want to store a long value into a simple integer then you can type cast long to int. You can convert values from one type to another explicitly using the **cast operator** as follows:

```
(type_name) expression
```

## Integer Promotion

Integer promotion is the process by which values of integer type "smaller" than **int** or **unsigned int** are converted either to **int** or **unsigned int**. Consider an example of adding a character in an int:

```
#include <stdio.h>

main()
{
    int i = 17;
    char c = 'c'; /* ascii value is 99 */
    int sum;

    sum = i + c;
    printf("Value of sum : %d\n", sum );
}
```



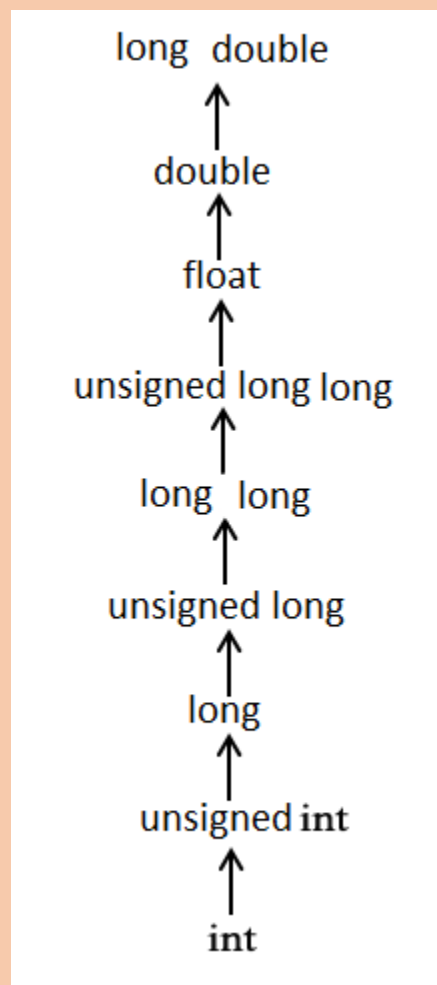
When the above code is compiled and executed, it produces the following result:

Value of sum : 116

Here, value of sum is coming as 116 because compiler is doing integer promotion and converting the value of 'c' to ascii before performing actual addition operation.

## Usual Arithmetic Conversion

The **usual arithmetic conversions** are implicitly performed to cast their values in a common type. Compiler first performs *integer promotion*, if operands still have different types then they are converted to the type that appears highest in the following hierarchy:



The usual arithmetic conversions are not performed for the assignment operators, nor for the logical operators && and ||. Let us take following example to understand the concept:

```

#include <stdio.h>

main()
{
    int i = 17;
    char c = 'c'; /* ascii value is 99 */
    float sum;

    sum = i + c;
    printf("Value of sum : %f\n", sum );

}

```

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

Value of sum : 116.000000

## C - Error Handling

As such C programming does not provide direct support for error handling but being a system programming language, it provides you access at lower level in the form of return values. Most of the C or even Unix function calls return -1 or NULL in case of any error and sets an error code **errno** is set which is global variable and indicates an error occurred during any function call. You can find various error codes defined in <error.h> header file.

So a C programmer can check the returned values and can take appropriate action depending on the return value. As a good practice, developer should set **errno** to 0 at the time of initialization of the program. A value of 0 indicates that there is no error in the program.

### The **errno**, **perror** and **strerror**

The C programming language provides **perror** and **strerror** functions, which can be used to display the text message associated with **errno**.

- The **perror** function displays the string you pass to it, followed by a colon, a space, and then the textual representation of the current **errno** value.
- The **strerror** function, which returns a pointer to the textual representation of the current **errno** value.

Let's try to simulate an error condition and try to open a file which does not exist. Here I'm using both the functions to show the usage, but you can use one or more ways of printing your errors. Second important point to note is that you should use **stderr** file stream to output all the errors.

```

#include <stdio.h>
#include <errno.h>
#include <string.h>

extern int errno ;

```

```

int main ()
{
FILE * pf;
int errnum;
pf = fopen ("unexist.txt", "rb");
if (pf == NULL)
{
errnum = errno;
fprintf(stderr, "Value of errno: %d\n", errno);
perror("Error printed by perror");
fprintf(stderr, "Error opening file: %s\n", strerror( errnum ));
}
else
{
fclose (pf);
}
return 0;
}

```

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

```

Value of errno: 2
Error printed by perror: No such file or directory
Error opening file: No such file or directory

```

## C - Variable Arguments

Sometimes, you may come across a situation, when you want to have a function, which can take variable number of arguments i.e. parameters, instead of predefined number of parameters. The C programming language provides a solution for this situation and you are allowed to define a function which can accept variable number of parameters based on your requirement. The following example shows the usage:

```

#include <stdio.h>
#include <stdarg.h>

double average(int num,...)
{

va_list valist;
double sum = 0.0;
int i;

/* initialize valist for num number of arguments */
va_start(valist, num);

/* access all the arguments assigned to valist */
for (i = 0; i < num; i++)
{
sum += va_arg(valist, int);
}
}

```

```

        /* clean memory reserved for valist */
        va_end(valist);

        return sum/num;
    }

    int main()
    {
        printf("Average of 2, 3, 4, 5 = %f\n", average(4, 2,3,4,5));
        printf("Average of 5, 10, 15 = %f\n", average(3, 5,10,15));
    }

```

When the above code is compiled and executed, it produces the following result. It should be noted that the function **average** has been called twice and each time first argument represents the total number of variable arguments being passed. Only ellipses will be used to pass variable number of arguments.

```

Average of 2, 3, 4, 5 = 3.500000
Average of 5, 10, 15 = 10.000000

```

## C - Memory Management

The C programming language provides several functions for memory allocation and management. These functions can be found in the `<stdlib.h>` header file.

### S.N. Function and Description

- |   |  |  |
|---|--|--|
| 1 | <b>void</b><br>This function allocates an array of <b>num</b> elements each of whose size in bytes will be <b>size</b> . | <b>*callocintnum,intsize;</b>          |
| 2 | <b>void</b><br>This function release a block of memory block specified by address.                                       | <b>freevoid*address;</b>               |
| 3 | <b>void</b><br>This function allocates an array of <b>num</b> bytes and leave them initialized.                          | <b>*mallocintnum;</b>                  |
| 4 | <b>void</b><br>This function re-allocates memory extending it upto <b>newsiz</b> .                                       | <b>*reallocvoid*address,intnewsiz;</b> |

## C - Command Line Arguments

It is possible to pass some values from the command line to your C programs when they are executed. These values are called **command line arguments** and many times they are important for your program specially when you want to control your program from outside instead of hard coding those values inside the code.

The command line arguments are handled using main function arguments where **argc** refers to the number of arguments passed, and **argv[]** is a pointer array which points to each argument

passed to the program. Following is a simple example, which checks if there is any argument supplied from the command line and take action accordingly:

```
#include <stdio.h>

int main( int argc, char *argv[] )
{
    if( argc == 2 )
    {
        printf("The argument supplied is %s\n", argv[1]);
    }
    else if( argc > 2 )
    {
        printf("Too many arguments supplied.\n");
    }
    else
    {
        printf("One argument expected.\n");
    }
}
```

When the above code is compiled and executed with a single argument, it produces the following result.

```
./a.out testing
The argument supplied is testing
```