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# C Programming Tutorial

The C is a general-purpose, procedural, imperative computer programming language developed in 1972 by Dennis M. Ritchie at the Bell Telephone Laboratories to develop the UNIX operating system.

The C is the most widely used computer language, it keeps fluctuating at number one scale of popularity along with Java programming language, which is also equally popular and most widely used among modern software programmers.

## Audience

This tutorial is designed for software programmers with a need to understand the C programming language starting from scratch. This tutorial will give you enough understanding on C programming language from where you can take yourself to higher level of expertise.

## Prerequisites

Before proceeding with this tutorial, you should have a basic understanding of Computer Programming terminologies. A basic understanding of any of the programming languages will help you in understanding the C programming concepts and move fast on the learning track.

## Compile/Execute C Programs

For most of the examples given in this tutorial, you will find **Try it** option, so just make use of it and enjoy your learning.

Try following example using **Try it** option available at the top right corner of the below sample code box:

```
#include <stdio.h>

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

    return 0;
}
```

## 1 - C Programming Quick Reference Guide

A quick reference guide for C Programming Professionals.

[C Programming Quick Reference Guide](#)

## 2 - C Programming Useful Resources

A collection of C Programming Sites, Books and Articles is given at this page.

[C Programming Useful Resources](#)

## 3 - C Programming Tutorial in PDF

Download a C Programming Tutorial in PDF format.

[C Programming Tutorial in PDF](#)

## 4 - C Standard Library

All the useful methods from C standard library has been put together for easy access.

[C Standard Library](#)

# 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. The 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 RDBMS MySQL have been written in C.

## Why to use C?

C was initially used for system development work, in particular the programs that make-up the operating system. C was adopted as a system development language because it produces code that runs nearly as fast as code written in assembly language. Some examples of the use of C might be:

- Operating Systems
- Language Compilers
- Assemblers
- Text Editors
- Print Spoolers
- Network Drivers
- Modern Programs
- Databases
- Language Interpreters
- Utilities

## C Programs

A C program can vary from 3 lines to millions of lines and it should be written into one or more text files with extension ".c"; for example, *hello.c*. You can use "vi", "vim" or any other text editor to write your C program into a file.

This tutorial assumes that you know how to edit a text file and how to write source code inside a program file.

# C - Environment Setup

## Try it Option Online

You really do not need to set up your own environment to start learning C programming language. Reason is very simple, we already have set up C Programming environment online, so that you can compile and execute all the available examples online at the same time when you are doing your theory work. This gives you confidence in what you are reading and to check the result with different options. Feel free to modify any example and execute it online.

Try following example using **Try it** option available at the top right corner of the below sample code box:

```
#include <stdio.h>

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

    return 0;
}
```

For most of the examples given in this tutorial, you will find **Try it** option, so just make use of it and enjoy your learning.

## Local Environment Setup

If you are still willing to set up your environment for C programming language, you need the following two softwares 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 flavor 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/](https://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 MinGW, 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 `main()` function 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 a space) 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
1	<b>Basic Types:</b> They are arithmetic types and consists of the two types: (a) integer types and (b) floating-point types.
2	<b>Enumerated types:</b> They are again arithmetic types and they are used to define variables that can only be assigned certain discrete integer values throughout the program.
3	<b>The type void:</b> The type specifier <i>void</i> indicates that no value is available.
4	<b>Derived types:</b> They include (a) Pointer types, (b) Array types, (c) Structure types, (d) Union types and (e) 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. Following is an example to get the size of int type on any machine:

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



```
int main()
{
    printf("Storage size for int : %d \n", sizeof(int));

    return 0;
}
```

When you compile and execute the above program it produces the following result on Linux:

```
Storage size for int : 4
```

## 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. Following example will print storage space taken by a float type and its range values:

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

int main()
{
    printf("Storage size for float : %d \n", sizeof(float));
    printf("Minimum float positive value: %E\n", FLT_MIN );
    printf("Maximum float positive value: %E\n", FLT_MAX );
    printf("Precision value: %d\n", FLT_DIG );

    return 0;
}
```

When you compile and execute the above program, it produces the following result on Linux:

```
Storage size for float : 4
Minimum float positive value: 1.175494E-38
Maximum float positive value: 3.402823E+38
Precision value: 6
```

## 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
1	<b>Function returns as void</b> 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 <b>void exit (int status);</b>
2	<b>Function arguments as void</b> There are various functions in C which do not accept any parameter. A function with no parameter can accept as a void. For example, <b>int rand(void);</b>
3	<b>Pointers to void</b> A pointer of type void * represents the address of an object, but not its type. For example a

	memory allocation function <b>void *malloc( size_t size );</b> 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(one byte). 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 initializer consists of an equal sign followed by a constant expression as follows:

```
type variable_name = value;
```

Some examples are:

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

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

## Variable Declaration in C:

A variable declaration provides assurance to the compiler that there is one variable existing with the given type and name so that compiler proceed for further compilation without needing complete detail about the variable. A variable declaration has its meaning at the time of compilation only, compiler needs actual variable 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 following example, where variables have been declared at the top, but they have been defined and initialized 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;
}
```

## Lvalues and Rvalues in C:

There are two kinds of expressions in C:

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

Variables are lvalues and so may appear on the left-hand side of an assignment. Numeric literals are rvalues and so may not be assigned and 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 */
0xFFeEL     /* 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 **chartype**.

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

Following is the example to show few escape sequence characters:

```
#include <stdio.h>

int main()
{
    printf("Hello\tWorld\n\n");

    return 0;
}
```

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

```
Hello    World
```

## 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 #define Preprocessor

Following is the form to use #define preprocessor to define a constant:

```
#define identifier value
```

Following example explains it in detail:

```
#include <stdio.h>

#define LENGTH 10
#define WIDTH 5
#define NEWLINE '\n'

int main()
```

```
{  
  
    int area;  
  
    area = LENGTH * WIDTH;  
    printf("value of area : %d", area);  
    printf("%c", NEWLINE);  
  
    return 0;  
}
```

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

```
value of area : 50
```

## The const Keyword

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

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

Following example explains it in detail:

```
#include <stdio.h>  
  
int main()  
{  
    const int  LENGTH = 10;  
    const int  WIDTH  = 5;  
    const char NEWLINE = '\n';  
    int area;  
  
    area = LENGTH * WIDTH;  
    printf("value of area : %d", area);  
    printf("%c", NEWLINE);  
  
    return 0;  
}
```

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

```
value of area : 50
```

Note that it is a good programming practice to define constants in CAPITALS.

# 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 the 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.

```
#include <stdio.h>  
  
/* function declaration */  
void func(void);  
  
static int count = 5; /* global variable */  
  
main()  
{  
    while(count--)  
    {  
        func();  
    }  
    return 0;  
}  
  
/* function definition */  
void func( void )  
{  
    static int i = 5; /* local static variable */  
    i++;  
  
    printf("i is %d and count is %d\n", i, count);  
}
```



You may not understand this example at this time because I have used *function* and *global variables*, which I have not explained so far. So for now let us proceed even if you do not understand it completely. When the above code is compiled and executed, it produces the following result:

```
i is 6 and count is 4
i is 7 and count is 3
i is 8 and count is 2
i is 9 and count is 1
i is 10 and count is 0
```

## 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 as explained below.

### First File: main.c

```
#include <stdio.h>

int count ;
extern void write_extern();

main()
{
    count = 5;
    write_extern();
}
```

### Second File: support.c

```
#include <stdio.h>

extern int count;

void write_extern(void)
{
    printf("count is %d\n", count);
}
```

Here, *extern* keyword is being used to declare *count* in the second file where as it has its definition in the first file, main.c. Now, compile these two files as follows:

```
$gcc main.c support.c
```

This will produce **a.out** executable program, when this program is executed, it produces the following result:

```
5
```

# C - Operators

An operator is a symbol that tells the compiler to perform specific mathematical or logical manipulations. C language is rich in built-in operators and provides the following types of operators:

- Arithmetic Operators
- Relational Operators
- Logical Operators
- Bitwise Operators
- Assignment Operators
- Misc 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
*	Multiplies 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:

[Show Examples](#)

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

Bitwise operator works on bits and perform bit-by-bit operation. The truth tables for &, |, and ^ are as follows:

p	q	p & q	p   q	p ^ q
0	0	0	0	0
0	1	0	1	1
1	1	1	1	0
1	0	0	1	1

Assume if A = 60; and B = 13; now in binary format they will be as follows:

A = 0011 1100

B = 0000 1101

-----

A&B = 0000 1100

A|B = 0011 1101

A^B = 0011 0001

~A = 1100 0011

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

Show Examples

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 operand.	(A   B) will give 61, which is 0011 1101
^	Binary XOR Operator copies the bit if it is set in one operand but not both.	(A ^ B) 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.
<<	Binary Left Shift Operator. The left operands value is moved left by the number of bits specified by the right operand.	A << 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 >> 2 will give 15

which is  
0000 1111

# Assignment Operators

There are following assignment operators supported by C language:

Show Examples

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 <<= 2 is same as C = C << 2
>>=	Right shift AND assignment operator	C >>= 2 is same as C = C >> 2
&=	Bitwise AND assignment operator	C &= 2 is same as C = C & 2
^=	bitwise exclusive OR and assignment operator	C ^= 2 is same as C = C ^ 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.

Show Examples

Operator	Description	Example
sizeof()	Returns the size of an variable.	sizeof(a), where a is integer, will return 4.
&	Returns the address of an variable.	&a; will give actual 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

Operator precedence determines the grouping of terms in an expression. This affects how an expression is evaluated. Certain operators have higher precedence than others; for example, the multiplication operator has higher precedence than the addition operator.

For example `x = 7 + 3 * 2`; here, `x` is assigned 13, not 20 because operator `*` has higher precedence than `+`, so it first gets multiplied with `3*2` and then adds into 7.

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.

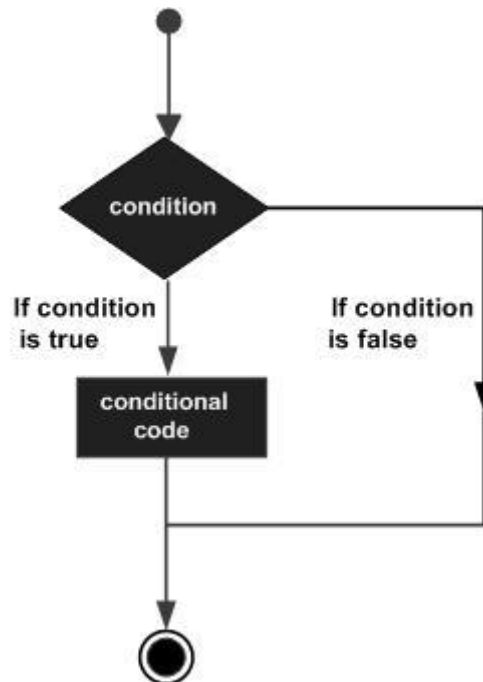
Show Examples

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

Statement	Description
<a href="#">if statement</a>	An <b>if statement</b> consists of a boolean expression followed by one or more statements.
<a href="#">if...else statement</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="#">nested if statements</a>	You can use one <b>if</b> or <b>else if</b> statement inside another <b>if</b> or <b>else if</b> statement(s).
<a href="#">switch statement</a>	A <b>switch</b> statement allows a variable to be tested for equality against a list of values.
<a href="#">nested switch statements</a>	You can use one <b>switch</b> statement inside another <b>switch</b> statement(s).

## The ? : Operator:

We have covered **conditional operator ?** : in previous chapter which can be used to replace **if...else** statements. It has the following general form:

```
Exp1 ? Exp2 : Exp3;
```

Where Exp1, Exp2, and Exp3 are expressions. Notice the use and placement of the colon.

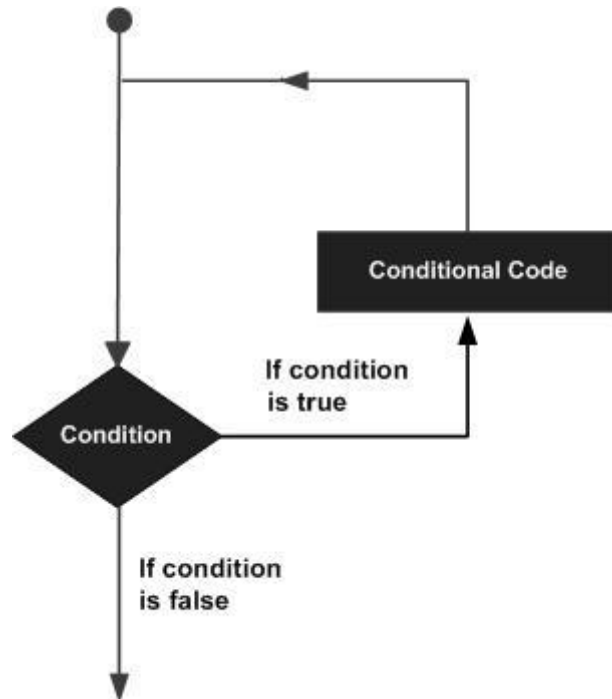
The value of a ? expression is determined like this: Exp1 is evaluated. If it is true, then Exp2 is evaluated and becomes the value of the entire ? expression. If Exp1 is false, then Exp3 is evaluated and its value becomes the value of the expression.

# 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 the following types of loop to handle looping requirements. Click the following links to check their detail.

Loop Type	Description
<a href="#">while loop</a>	Repeats a statement or group of statements while a given condition is true. It tests the condition before executing the loop body.
<a href="#">for loop</a>	Execute a sequence of statements multiple times and abbreviates the code that manages the loop variable.
<a href="#">do...while loop</a>	Like a while statement, except that it tests the condition at the end of the loop body
<a href="#">nested loops</a>	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
<a href="#">break statement</a>	Terminates the <b>loop</b> or <b>switch</b> statement and transfers execution to the statement immediately following the loop or switch.

<u><a href="#">continue statement</a></u>	Causes the loop to skip the remainder of its body and immediately retest its condition prior to reiterating.
<u><a href="#">goto statement</a></u>	Transfers control to the labeled statement. Though it is not advised to use goto statement in your program.

## The Infinite Loop:

A loop becomes infinite loop if a condition never becomes false. The **for** loop is traditionally used for this purpose. Since none of the three expressions that form the for loop are required, you can make an endless loop by leaving the conditional expression empty.

```
#include <stdio.h>

int main ()
{
    for( ; ; )
    {
        printf("This loop will run forever.\n");
    }

    return 0;
}
```

When the conditional expression is absent, it is assumed to be true. You may have an initialization and increment expression, but C programmers more commonly use the for(;;) construct to signify an infinite loop.

**NOTE:** You can terminate an infinite loop by pressing Ctrl + C keys.



# 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 source code for a function called **max()**. This function takes two parameters num1 and num2 and returns the maximum between the two:

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

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

    return result;
}
```

## Function Declarations:

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

A function declaration has the following parts:

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

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

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

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

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

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

## Calling a Function:

While creating a C function, you give a definition of what the function has to do. To use a function, you will have to call that function to perform the defined task.

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

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

```
#include <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
```

## Function Arguments:

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

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

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

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

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

# 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. Here all the variables a, b and c are local to main() function.

```
#include <stdio.h>

int main ()
{
    /* local variable declaration */
    int a, b;
    int c;

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

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

    return 0;
}
```

## 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. Following is the example using global and local variables:

```
#include <stdio.h>

/* global variable declaration */
int g;

int main ()
{
    /* local variable declaration */
    int a, b;

    /* actual initialization */
    a = 10;
    b = 20;
    g = a + b;

    printf ("value of a = %d, b = %d and g = %d\n", a, b, g);

    return 0;
}
```

A program can have same name for local and global variables but value of local variable inside a function will take preference. Following is an example:

```
#include <stdio.h>

/* global variable declaration */
int g = 20;

int main ()
{
```

```

/* local variable declaration */
int g = 10;

printf ("value of g = %d\n", g);

return 0;
}

```

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

```
value of g = 10
```

## Formal Parameters

Function parameters, formal parameters, are treated as local variables with-in that function and they will take preference over the global variables. Following is an example:

```

#include <stdio.h>

/* global variable declaration */
int a = 20;

int main ()
{
    /* local variable declaration in main function */
    int a = 10;
    int b = 20;
    int c = 0;

    printf ("value of a in main() = %d\n", a);
    c = sum( a, b);
    printf ("value of c in main() = %d\n", c);

    return 0;
}

/* function to add two integers */
int sum(int a, int b)
{
    printf ("value of a in sum() = %d\n", a);
    printf ("value of b in sum() = %d\n", b);

    return a + b;
}

```

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

```

value of a in main() = 10
value of a in sum() = 10
value of b in sum() = 20
value of c in main() = 30

```

## Initializing Local and Global Variables

When a local variable is defined, it is not initialized by the system, you must initialize it yourself. Global variables are initialized automatically by the system when you define them as follows:

Data Type	Initial Default Value
int	0
char	'\0'
float	0
double	0
pointer	NULL

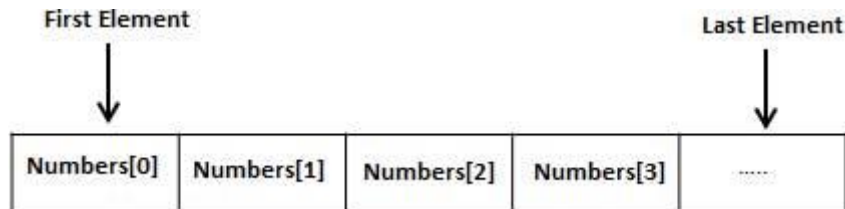
It is a good programming practice to initialize variables properly otherwise, your program may produce unexpected results because uninitialized variables will take some garbage value already available at its memory location.

# 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 variable array which is sufficient to hold upto 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 `[ ]`.

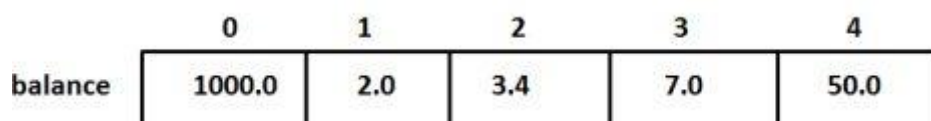
If you omit the size of the array, an array just big enough to hold the initialization is created. Therefore, if you write:

```
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. Following is an example to assign a single element of the array:

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

The above statement assigns element number 5th in the array with a value of 50.0. All arrays have 0 as the index of their first element which is also called base index and last index of an array will be total size of the array minus 1. Following is the pictorial representation of the same array we discussed above:



## 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 Arrays in Detail

Arrays are important to C and should need lots of more details. There are following few important concepts related to array which should be clear to a C programmer:

Concept	Description
<a href="#">Multi-dimensional arrays</a>	C supports multidimensional arrays. The simplest form of the multidimensional array is the two-dimensional array.
<a href="#">Passing arrays to functions</a>	You can pass to the function a pointer to an array by specifying the array's name without an index.
<a href="#">Return array from a function</a>	C allows a function to return an array.
<a href="#">Pointer to an array</a>	You can generate a pointer to the first element of an array by simply specifying the array name, without any index.

# C - Pointers

Pointers in C are easy and fun to learn. Some C programming tasks are performed more easily with pointers, and other tasks, such as dynamic memory allocation, cannot be performed without using pointers. So it becomes necessary to learn pointers to become a perfect C programmer. Let's start learning them in simple and easy steps.

As you know, every variable is a memory location and every memory location has its address defined which can be accessed using ampersand (&) operator, which denotes an address in memory. Consider the following example, which will print the address of the variables defined:

```
#include <stdio.h>

int main ()
{
    int var1;
    char var2[10];

    printf("Address of var1 variable: %x\n", &var1 );
    printf("Address of var2 variable: %x\n", &var2 );

    return 0;
}
```

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

```
Address of var1 variable: bff5a400
Address of var2 variable: bff5a3f6
```

So you understood what is memory address and how to access it, so base of the concept is over. Now let us see what is a pointer.

## What Are 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
```

## NULL Pointers in C

It is always a good practice to assign a NULL value to a pointer variable in case you do not have exact address to be assigned. This is done at the time of variable declaration. A pointer that is assigned NULL is called a **null** pointer.

The NULL pointer is a constant with a value of zero defined in several standard libraries. Consider the following program:

```
#include <stdio.h>

int main ()
{
    int *ptr = NULL;

    printf("The value of ptr is : %x\n", ptr );

    return 0;
}
```

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

```
The value of ptr is 0
```

On most of the operating systems, programs are not permitted to access memory at address 0 because that memory is reserved by the operating system. However, the memory address 0 has special significance; it signals that the pointer is not intended to point to an accessible memory location. But by convention, if a pointer contains the null (zero) value, it is assumed to point to nothing.

To check for a null pointer you can use an if statement as follows:

```
if(ptr)      /* succeeds if p is not null */
if(!ptr)     /* succeeds if p is null */
```

## C Pointers in Detail:

Pointers have many but easy concepts and they are very important to C programming. There are following few important pointer concepts which should be clear to a C programmer:

Concept	Description
<a href="#">C - Pointer arithmetic</a>	There are four arithmetic operators that can be used on pointers: ++, --, +, -
<a href="#">C - Array of pointers</a>	You can define arrays to hold a number of pointers.
<a href="#">C - Pointer to pointer</a>	C allows you to have pointer on a pointer and so on.
<a href="#">Passing pointers to functions in C</a>	Passing an argument by reference or by address both enable the passed argument to be changed in the calling function by the called function.
<a href="#">Return pointer from functions in C</a>	C allows a function to return a pointer to local variable, static variable and dynamically allocated memory as well.

# 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	<b>strcpy(s1, s2);</b> Copies string s2 into string s1.
2	<b>strcat(s1, s2);</b> Concatenates string s2 onto the end of string s1.
3	<b>strlen(s1);</b> Returns the length of string s1.
4	<b>strcmp(s1, s2);</b> Returns 0 if s1 and s2 are the same; less than 0 if s1<s2; greater than 0 if s1>s2.
5	<b>strchr(s1, ch);</b> Returns a pointer to the first occurrence of character ch in string s1.
6	<b>strstr(s1, s2);</b> Returns a pointer to the first occurrence of string s2 in string s1.

Following example makes use of few of the above-mentioned functions:

```

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

int main ()
{
    char str1[12] = "Hello";
    char str2[12] = "World";
    char str3[12];
    int len ;

    /* copy str1 into str3 */
    strcpy(str3, str1);
    printf("strcpy( str3, str1) :  %s\n", str3 );

    /* concatenates str1 and str2 */
    strcat( str1, str2);
    printf("strcat( str1, str2):   %s\n", str1 );

    /* total length of str1 after concatenation */
    len = strlen(str1);
    printf("strlen(str1) :  %d\n", len );

    return 0;
}

```

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

```

strcpy( str3, str1) :  Hello
strcat( str1, str2):   HelloWorld
strlen(str1) :  10

```

You can find a complete list of c string related functions in C Standard Library.

# 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
Book 2 book_id : 6495700

```

## Structures as Function Arguments

You can pass a structure as a function argument in very similar way as you pass any other variable or pointer. You would access structure variables in the similar way as you have accessed in the above example:

```

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

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

/* function declaration */
void printBook( struct Books book );
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 */
    printBook( Book1 );

    /* Print Book2 info */
    printBook( Book2 );

    return 0;
}

void printBook( struct Books book )
{
    printf( "Book title : %s\n", book.title);
    printf( "Book author : %s\n", book.author);
    printf( "Book subject : %s\n", book.subject);
    printf( "Book book_id : %d\n", book.book_id);
}

```

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

```
Book title : C Programming
Book author : Nuha Ali
Book subject : C Programming Tutorial
Book book_id : 6495407
Book title : Telecom Billing
Book author : Zara Ali
Book subject : Telecom Billing Tutorial
Book book_id : 6495700
```

## Pointers to Structures

You can define pointers to structures in very similar way as you define pointer to any other variable as follows:

```
struct Books *struct_pointer;
```

Now, you can store the address of a structure variable in the above defined pointer variable. To find the address of a structure variable, place the & operator before the structure's name as follows:

```
struct_pointer = &Book1;
```

To access the members of a structure using a pointer to that structure, you must use the -> operator as follows:

```
struct_pointer->title;
```

Let us re-write above example using structure pointer, hope this will be easy for you to understand the concept:

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

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

/* function declaration */
void printBook( struct Books *book );
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 by passing address of Book1 */
    printBook( &Book1 );

    /* print Book2 info by passing address of Book2 */
    printBook( &Book2 );

    return 0;
}

void printBook( struct Books *book )
{
    printf( "Book title : %s\n", book->title);
    printf( "Book author : %s\n", book->author);
    printf( "Book subject : %s\n", book->subject);
    printf( "Book book_id : %d\n", book->book_id);
}
```

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

```
Book title : C Programming
Book author : Nuha Ali
Book subject : C Programming Tutorial
Book book_id : 6495407
Book title : Telecom Billing
Book author : Zara Ali
Book subject : Telecom Billing Tutorial
Book book_id : 6495700
```

## Bit Fields

Bit Fields allow the packing of data in a structure. This is especially useful when memory or data storage is at a premium. Typical examples:

- Packing several objects into a machine word. e.g. 1 bit flags can be compacted.
- Reading external file formats -- non-standard file formats could be read in. E.g. 9 bit integers.

C allows us do this in a structure definition by putting :bit length after the variable. For example:

```
struct packed_struct {
    unsigned int f1:1;
    unsigned int f2:1;
    unsigned int f3:1;
    unsigned int f4:1;
    unsigned int type:4;
    unsigned int my_int:9;
} pack;
```

Here, the packed\_struct contains 6 members: Four 1 bit flags f1..f3, a 4 bit type and a 9 bit my\_int.

C automatically packs the above bit fields as compactly as possible, provided that the maximum length of the field is less than or equal to the integer word length of the computer. If this is not the case then some compilers may allow memory overlap for the fields whilst other would store the next field in the next word.

# 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. Following is the example which will display total memory size occupied by the above union:

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

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

int main( )
{
    union Data data;

    printf( "Memory size occupied by data : %d\n", sizeof(data));

    return 0;
}
```

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

```
Memory size occupied by data : 20
```

## Accessing Union Members

To access any member of a union, we use the **member access operator (.)**. 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. Following is the example to explain usage of union:

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

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



```

int main( )
{
    union Data data;

    data.i = 10;
    data.f = 220.5;
    strcpy( data.str, "C Programming");

    printf( "data.i : %d\n", data.i);
    printf( "data.f : %f\n", data.f);
    printf( "data.str : %s\n", data.str);

    return 0;
}

```

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

```

data.i : 1917853763
data.f : 4122360580327794860452759994368.000000
data.str : C Programming

```

Here, we can see that values of **i** and **f** members of union got corrupted because final value assigned to the variable has occupied the memory location and this is the reason that the value if **str** member is getting printed very well. Now let's look into the same example once again where we will use one variable at a time which is the main purpose of having union:

```

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

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

int main( )
{
    union Data data;

    data.i = 10;
    printf( "data.i : %d\n", data.i);

    data.f = 220.5;
    printf( "data.f : %f\n", data.f);

    strcpy( data.str, "C Programming");
    printf( "data.str : %s\n", data.str);

    return 0;
}

```

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

```

data.i : 10
data.f : 220.500000
data.str : C Programming

```

Here, all the members are getting printed very well because one member is being used at a time.

# 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 up to 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. Let us check the following example to understand the concept:

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

/* define simple structure */
struct
{
    unsigned int widthValidated;
    unsigned int heightValidated;
} status1;

/* define a structure with bit fields */
struct
{
    unsigned int widthValidated : 1;
    unsigned int heightValidated : 1;
} status2;

int main( )
{
    printf( "Memory size occupied by status1 : %d\n", sizeof(status1));
    printf( "Memory size occupied by status2 : %d\n", sizeof(status2));

    return 0;
}
```

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

```
Memory size occupied by status1 : 8
Memory size occupied by status2 : 4
```

## Bit Field Declaration

The declaration of a bit-field has the form inside a structure:

```
struct
{
    type [member_name] : width ;
};
```

Below the description of variable elements of a bit field:

Elements	Description
----------	-------------

type	An integer type that determines how the bit-field's value is interpreted. The type may be int, signed int, unsigned int.
member_name	The name of the bit-field.
width	The number of bits in the bit-field. The width must be less than or equal to the bit width of the specified type.

The variables defined with a predefined width are called **bit fields**. A bit field can hold more than a single bit for example if you need a variable to store a value from 0 to 7 only then you can define a bit field with a width of 3 bits as follows:

```
struct
{
    unsigned int age : 3;
} Age;
```

The above structure definition instructs C compiler that age variable is going to use only 3 bits to store the value, if you will try to use more than 3 bits then it will not allow you to do so. Let us try the following example:

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

struct
{
    unsigned int age : 3;
} Age;

int main( )
{
    Age.age = 4;
    printf( "Sizeof( Age ) : %d\n", sizeof(Age) );
    printf( "Age.age : %d\n", Age.age );

    Age.age = 7;
    printf( "Age.age : %d\n", Age.age );

    Age.age = 8;
    printf( "Age.age : %d\n", Age.age );

    return 0;
}
```

When the above code is compiled it will compile with warning and when executed, it produces the following result:

```
Sizeof( Age ) : 4
Age.age : 4
Age.age : 7
Age.age : 0
```

# 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. For example you can use typedef with structure to define a new data type and then use that data type to define structure variables directly as follows:

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

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

int main( )
{
    Book book;

    strcpy( book.title, "C Programming");
    strcpy( book.author, "Nuha Ali");
    strcpy( book.subject, "C Programming Tutorial");
    book.book_id = 6495407;

    printf( "Book title : %s\n", book.title);
    printf( "Book author : %s\n", book.author);
    printf( "Book subject : %s\n", book.subject);
    printf( "Book book_id : %d\n", book.book_id);

    return 0;
}
```

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

```
Book  title : C Programming
Book  author : Nuha Ali
Book  subject : C Programming Tutorial
Book  book_id : 6495407
```

## typedef vs #define

The **#define** is a C-directive which is also used to define the aliases for various data types similar to **typedef** but with following differences:

- The **typedef** is limited to giving symbolic names to types only where as **#define** can be used to define alias for values as well, like you can define 1 as ONE etc.
- The **typedef** interpretation is performed by the compiler where as **#define** statements are processed by the pre-processor.

Following is a simplest usage of **#define**:

```
#include <stdio.h>

#define TRUE  1
#define FALSE 0

int main( )
{
    printf( "Value of TRUE : %d\n", TRUE);
    printf( "Value of FALSE : %d\n", FALSE);
    return 0;
}
```

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

```
Value of TRUE : 1  
Value of FALSE : 0
```

# 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 getchar(void)** 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 putchar(int c)** 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. Check the following example:

```
#include <stdio.h>
int main( )
{
    int c;

    printf( "Enter a value :");
    c = getchar( );

    printf( "\nYou entered: ");
    putchar( c );

    return 0;
}
```

When the above code is compiled and executed, it waits for you to input some text when you enter a text and press enter then program proceeds and reads only a single character and displays it as follows:

```
$/a.out
Enter a value : this is test
You entered: t
```

## The gets() & puts() functions

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

The **int puts(const char \*s)** function writes the string **s** and a trailing newline to **stdout**.

```
#include <stdio.h>
int main( )
{
    char str[100];

    printf( "Enter a value :");
    gets( str );

    printf( "\nYou entered: ");
    puts( str );
}
```

```
    return 0;
}
```

When the above code is compiled and executed, it waits for you to input some text when you enter a text and press enter then program proceeds and reads the complete line till end and displays it as follows:

```
$/a.out
Enter a value : this is test
You entered: This is test
```

## The scanf() and printf() functions

The **int scanf(const char \*format, ...)** function reads input from the standard input stream **stdin** and scans that input according to **format** provided.

The **int printf(const char \*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. For now let us proceed with a simple example which makes things clear:

```
#include <stdio.h>
int main( )
{
    char str[100];
    int i;

    printf( "Enter a value :");
    scanf("%s %d", str, &i);

    printf( "\nYou entered: %s %d ", str, i);

    return 0;
}
```

When the above code is compiled and executed, it waits for you to input some text when you enter a text and press enter then program proceeds and reads the input and displays it as follows:

```
$/a.out
Enter a value : seven 7
You entered: seven 7
```

Here, it should be noted that scanf() expect input in the same format as you provided %s and %d, which means you have to provide valid input like "string integer", if you provide "string string" or "integer integer" then it will be assumed as wrong input. Second, while reading a string scanf() stops reading as soon as it encounters a space so "this is test" are three strings for scanf().

# C - File I/O

Last chapter explained about standard input and output devices handled by C programming language. This chapter we will see how C programmers can create, open, close text or binary files for their data storage.

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 (OS level) 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, const char \*format, ...)** function as well to write a string into a file. Try the following example:

Make sure you have **/tmp** directory available, if its not then before proceeding, you must create this directory on your machine.

```
#include <stdio.h>

main()
{
    FILE *fp;

    fp = fopen("/tmp/test.txt", "w+");
    fprintf(fp, "This is testing for fprintf...\n");
    fputs("This is testing for fputs...\n", fp);
    fclose(fp);
}
```

When the above code is compiled and executed, it creates a new file **test.txt** in **/tmp** directory and writes two lines using two different functions. Let us read this file in next section.

## 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, const char \*format, ...)** function to read strings from a file but it stops reading after the first space character encounters.

```
#include <stdio.h>

main()
{
    FILE *fp;
    char buff[255];

    fp = fopen("/tmp/test.txt", "r");
    fscanf(fp, "%s", buff);
    printf("1 : %s\n", buff );

    fgets(buff, 255, (FILE*)fp);
    printf("2: %s\n", buff );

    fgets(buff, 255, (FILE*)fp);
    printf("3: %s\n", buff );
    fclose(fp);
}
```

When the above code is compiled and executed, it reads the file created in previous section and produces the following result:

```
1 : This
2: is testing for fprintf...

3: This is testing for fputs...
```

Let's see a little more detail about what happened here. First **fscanf()** method read just **This** because after that it encountered a space, second call is for **fgets()** which read the remaining line till it encountered end of line. Finally last call **fgets()** read second line completely.

## 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:

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

## Preprocessors Examples

Analyze the following examples to understand various directives.

```
#define MAX_ARRAY_LENGTH 20
```

This directive tells the CPP to replace instances of MAX\_ARRAY\_LENGTH with 20. Use *#define* for constants to increase readability.

```
#include <stdio.h>
#include "myheader.h"
```

These directives tell the CPP to get stdio.h from **System Libraries** and add the text to the current source file. The next line tells CPP to get **myheader.h** from the local directory and add the content to the current source file.

```
#undef FILE_SIZE
#define FILE_SIZE 42
```

This tells the CPP to undefine existing FILE\_SIZE and define it as 42.

```
#ifndef MESSAGE
    #define MESSAGE "You wish!"
#endif
```

This tells the CPP to define MESSAGE only if MESSAGE isn't already defined.

```
#ifdef DEBUG
    /* Your debugging statements here */
#endif
```

This tells the CPP to do the process the statements enclosed if `DEBUG` is defined. This is useful if you pass the `-DDEBUG` flag to gcc compiler at the time of compilation. This will define `DEBUG`, so you can turn debugging on and off on the fly during compilation.

## 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.

Macro	Description
<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.

Let's try the following example:

```
#include <stdio.h>

main()
{
    printf("File :%s\n", __FILE__ );
    printf("Date :%s\n", __DATE__ );
    printf("Time :%s\n", __TIME__ );
    printf("Line :%d\n", __LINE__ );
    printf("ANSI :%d\n", __STDC__ );
}
```

When the above code in a file **test.c** is compiled and executed, it produces the following result:

```
File :test.c
Date :Jun 2 2012
Time :03:36:24
Line :8
ANSI :1
```

## Preprocessor Operators

The C preprocessor offers following operators to help you in creating macros:

### Macro Continuation (\)

A macro usually must be contained on a single line. The macro continuation operator is used to continue a macro that is too long for a single line. For example:

```
#define message_for(a, b) \
    printf("#a " and " #b ": We love you!\n")
```

### Stringize (#)

The stringize or number-sign operator ('#'), when used within a macro definition, converts a macro parameter into a string constant. This operator may be used only in a macro that has a specified argument or parameter list. For example:

```
#include <stdio.h>

#define message_for(a, b) \
    printf("#a " and " #b ": We love you!\n")

int main(void)
{
    message_for(Carole, Debra);
    return 0;
}
```

```
}
```

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

```
Carole and Debra: We love you!
```

## Token Pasting (##)

The token-pasting operator (##) within a macro definition combines two arguments. It permits two separate tokens in the macro definition to be joined into a single token. For example:

```
#include <stdio.h>

#define tokenpaster(n) printf ("token" #n " = %d", token##n)

int main(void)
{
    int token34 = 40;

    tokenpaster(34);
    return 0;
}
```

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

```
token34 = 40
```

How it happened, because this example results in the following actual output from the preprocessor:

```
printf ("token34 = %d", token34);
```

This example shows the concatenation of token##n into token34 and here we have used both **stringize** and **token-pasting**.

## The defined() Operator

The preprocessor **defined** operator is used in constant expressions to determine if an identifier is defined using **#define**. If the specified identifier is defined, the value is true (non-zero). If the symbol is not defined, the value is false (zero). The defined operator is specified as follows:

```
#include <stdio.h>

#if !defined (MESSAGE)
    #define MESSAGE "You wish!"
#endif

int main(void)
{
    printf("Here is the message: %s\n", MESSAGE);
    return 0;
}
```

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

```
Here is the message: You wish!
```

# Parameterized Macros

One of the powerful functions of the CPP is the ability to simulate functions using parameterized macros. For example, we might have some code to square a number as follows:

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

We can rewrite above code using a macro as follows:

```
#define square(x) ((x) * (x))
```

Macros with arguments must be defined using the **#define** directive before they can be used. The argument list is enclosed in parentheses and must immediately follow the macro name. Spaces are not allowed between and macro name and open parenthesis. For example:

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

```
#define MAX(x,y) ((x) > (y) ? (x) : (y))

int main(void)
{
    printf("Max between 20 and 10 is %d\n", MAX(10, 20));
    return 0;
}
```

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

```
Max between 20 and 10 is 20
```

# 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.

## Include Operation

The **#include** directive works by directing the C preprocessor to scan the specified file as input before continuing with the rest of the current source file. The output from the preprocessor contains the output already generated, followed by the output resulting from the included file, followed by the output that comes from the text after the **#include** directive. For example, if you have a header file header.h as follows:

```
char *test (void);
```

and a main program called *program.c* that uses the header file, like this:

```
int x;
#include "header.h"

int main (void)
{
    puts (test ());
}
```

the compiler will see the same token stream as it would if program.c read

```
int x;
char *test (void);

int main (void)
{
    puts (test ());
}
```

## Once-Only Headers

If a header file happens to be included twice, the compiler will process its contents twice and will result an error. The standard way to prevent this is to enclose the entire real contents of the file in a conditional, like this:

```
#ifndef HEADER_FILE
#define HEADER_FILE

the entire header file file

#endif
```

This construct is commonly known as a wrapper **#ifndef**. When the header is included again, the conditional will be false, because **HEADER\_FILE** is defined. The preprocessor will skip over the entire contents of the file, and the compiler will not see it twice.

# Computed Includes

Sometimes it is necessary to select one of several different header files to be included into your program. They might specify configuration parameters to be used on different sorts of operating systems, for instance. You could do this with a series of conditionals as follows:

```
#if SYSTEM_1
    # include "system_1.h"
#elif SYSTEM_2
    # include "system_2.h"
#elif SYSTEM_3
    ...
#endif
```

But as it grows, it becomes tedious, instead the preprocessor offers the ability to use a macro for the header name. This is called a **computed include**. Instead of writing a header name as the direct argument of **#include**, you simply put a macro name there instead:

```
#define SYSTEM_H "system_1.h"
...
#include SYSTEM_H
```

SYSTEM\_H will be expanded, and the preprocessor will look for system\_1.h as if the **#include** had been written that way originally. SYSTEM\_H could be defined by your Makefile with a -D option.



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
```

Consider the following example where the cast operator causes the division of one integer variable by another to be performed as a floating-point operation:

```
#include <stdio.h>

main()
{
    int sum = 17, count = 5;
    double mean;

    mean = (double) sum / count;
    printf("Value of mean : %f\n", mean );
}
```

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

```
Value of mean : 3.400000
```

It should be noted here that the cast operator has precedence over division, so the value of **sum** is first converted to type **double** and finally it gets divided by count yielding a double value.

Type conversions can be implicit which is performed by the compiler automatically, or it can be specified explicitly through the use of the **cast operator**. It is considered good programming practice to use the cast operator whenever type conversions are necessary.

## 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 );
}
```

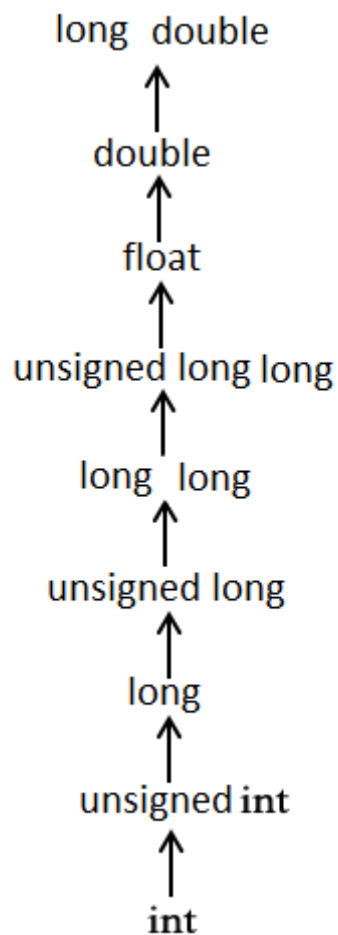
When the above code is compiled and executed, it produces the following result:

```
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
```

Here, it is simple to understand that first c gets converted to integer but because final value is double, so usual arithmetic conversion applies and compiler convert i and c into float and add them yielding a float result.

# 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
```

## Divide by zero errors

It is a common problem that at the time of dividing any number, programmers do not check if a divisor is zero and finally it creates a runtime error.

The code below fixes this by checking if the divisor is zero before dividing:

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

main()
{
    int dividend = 20;
    int divisor = 0;
    int quotient;

    if( divisor == 0){
        fprintf(stderr, "Division by zero! Exiting...\n");
        exit(-1);
    }
    quotient = dividend / divisor;
```

```
    fprintf(stderr, "Value of quotient : %d\n", quotient );  
  
    exit(0);  
}
```

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

```
Division by zero! Exiting...
```

## Program Exit Status

It is a common practice to exit with a value of EXIT\_SUCCESS in case of programming is coming out after a successful operation. Here, EXIT\_SUCCESS is a macro and it is defined as 0.

If you have an error condition in your program and you are coming out then you should exit with a status EXIT\_FAILURE which is defined as -1. So let's write above program as follows:

```
#include <stdio.h>  
#include <stdlib.h>  
  
main()  
{  
    int dividend = 20;  
    int divisor = 5;  
    int quotient;  
  
    if( divisor == 0){  
        fprintf(stderr, "Division by zero! Exiting...\n");  
        exit(EXIT_FAILURE);  
    }  
    quotient = dividend / divisor;  
    fprintf(stderr, "Value of quotient : %d\n", quotient );  
  
    exit(EXIT_SUCCESS);  
}
```

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

```
Value of quotient : 4
```

# C - Recursion

Recursion is the process of repeating items in a self-similar way. Same applies in programming languages as well where if a programming allows you to call a function inside the same function that is called recursive call of the function as follows.

```
void recursion()
{
    recursion(); /* function calls itself */
}

int main()
{
    recursion();
}
```

The C programming language supports recursion, i.e., a function to call itself. But while using recursion, programmers need to be careful to define an exit condition from the function, otherwise it will go in infinite loop.

Recursive function are very useful to solve many mathematical problems like to calculate factorial of a number, generating Fibonacci series, etc.

## Number Factorial

Following is an example, which calculates factorial for a given number using a recursive function:

```
#include <stdio.h>

int factorial(unsigned int i)
{
    if(i <= 1)
    {
        return 1;
    }
    return i * factorial(i - 1);
}

int main()
{
    int i = 15;
    printf("Factorial of %d is %d\n", i, factorial(i));
    return 0;
}
```

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

```
Factorial of 15 is 2004310016
```

## Fibonacci Series

Following is another example, which generates Fibonacci series for a given number using a recursive function:

```
#include <stdio.h>

int fibonaci(int i)
{
    if(i == 0)
    {
        return 0;
    }
    if(i == 1)
    {
        return 1;
    }
    return fibonaci(i-1) + fibonaci(i-2);
}

int main()
{
    int i;
    for (i = 0; i < 10; i++)
    {
        printf("%d\t", fibonaci(i));
    }
}
```

```
}  
    return 0;  
}
```

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

0	1	1	2	3	5	8	13	21	34
---	---	---	---	---	---	---	----	----	----

# 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 definition of such a function.

```
int func(int, ... )
{
    .
    .
    .
}

int main()
{
    func(1, 2, 3);
    func(1, 2, 3, 4);
}
```

It should be noted that function **func()** has last argument as ellipses i.e. three dots (...) and the one just before the ellipses is always an **int** which will represent total number variable arguments passed. To use such functionality you need to make use of **stdarg.h** header file which provides functions and macros to implement the functionality of variable arguments and follow the following steps:

- Define a function with last parameter as ellipses and the one just before the ellipses is always an **int** which will represent number of arguments.
- Create a **va\_list** type variable in the function definition. This type is defined in **stdarg.h** header file.
- Use **int** parameter and **va\_start** macro to initialize the **va\_list** variable to an argument list. The macro **va\_start** is defined in **stdarg.h** header file.
- Use **va\_arg** macro and **va\_list** variable to access each item in argument list.
- Use a macro **va\_end** to clean up the memory assigned to **va\_list** variable.

Now let us follow the above steps and write down a simple function which can take variable number of parameters and returns their average:

```
#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

This chapter will explain dynamic memory management in C. 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 *calloc(int num, int size);</b> This function allocates an array of <b>num</b> elements each of which size in bytes will be <b>size</b> .
2	<b>void free(void *address);</b> This function release a block of memory block specified by address.
3	<b>void *malloc(int num);</b> This function allocates an array of <b>num</b> bytes and leave them initialized.
4	<b>void *realloc(void *address, int newsize);</b> This function re-allocates memory extending it upto <b>newsize</b> .

## Allocating Memory Dynamically

While doing programming, if you are aware about the size of an array, then it is easy and you can define it as an array. For example to store a name of any person, it can go max 100 characters so you can define something as follows:

```
char name[100];
```

But now let us consider a situation where you have no idea about the length of the text you need to store, for example you want to store a detailed description about a topic. Here we need to define a pointer to character without defining how much memory is required and later based on requirement we can allocate memory as shown in the below example:

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

int main()
{
    char name[100];
    char *description;

    strcpy(name, "Zara Ali");

    /* allocate memory dynamically */
    description = malloc( 200 * sizeof(char) );
    if( description == NULL )
    {
        fprintf(stderr, "Error - unable to allocate required memory\n");
    }
    else
    {
        strcpy( description, "Zara ali a DPS student in class 10th");
    }
    printf("Name = %s\n", name );
    printf("Description: %s\n", description );
}
```

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

```
Name = Zara Ali
Description: Zara ali a DPS student in class 10th
```

Same program can be written using **calloc()** only thing you need to replace malloc with calloc as follows:

```
calloc(200, sizeof(char));
```

So you have complete control and you can pass any size value while allocating memory unlike arrays where once you defined the size can not be changed.



# Resizing and Releasing Memory

When your program comes out, operating system automatically release all the memory allocated by your program but as a good practice when you are not in need of memory anymore then you should release that memory by calling the function **free()**.

Alternatively, you can increase or decrease the size of an allocated memory block by calling the function **realloc()**. Let us check the above program once again and make use of **realloc()** and **free()** functions:

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

int main()
{
    char name[100];
    char *description;

    strcpy(name, "Zara Ali");

    /* allocate memory dynamically */
    description = malloc( 30 * sizeof(char) );
    if( description == NULL )
    {
        fprintf(stderr, "Error - unable to allocate required memory\n");
    }
    else
    {
        strcpy( description, "Zara ali a DPS student.");
        /* suppose you want to store bigger description */
        description = realloc( description, 100 * sizeof(char) );
        if( description == NULL )
        {
            fprintf(stderr, "Error - unable to allocate required memory\n");
        }
        else
        {
            strcat( description, "She is in class 10th");
        }

        printf("Name = %s\n", name );
        printf("Description: %s\n", description );

        /* release memory using free() function */
        free(description);
    }
}
```

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

```
Name = Zara Ali
Description: Zara ali a DPS student.She is in class 10th
```

You can try above example without re-allocating extra memory and **strcat()** function will give an error due to lack of available memory in description.

# 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
```

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

```
./a.out testing1 testing2
Too many arguments supplied.
```

When the above code is compiled and executed without passing any argument, it produces the following result.

```
./a.out
One argument expected
```

It should be noted that **argv[0]** holds the name of the program itself and **argv[1]** is a pointer to the first command line argument supplied, and **\*argv[n]** is the last argument. If no arguments are supplied, **argc** will be one, otherwise and if you pass one argument then **argc** is set at 2.

You pass all the command line arguments separated by a space, but if argument itself has a space then you can pass such arguments by putting them inside double quotes "" or single quotes ". Let us re-write above example once again where we will print program name and we also pass a command line argument by putting inside double quotes:

```
#include <stdio.h>

int main( int argc, char *argv[] )
{
    printf("Program name %s\n", argv[0]);

    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 separated by space but inside double quotes, it produces the following result.

```
$/a.out "testing1 testing2"
```

```
Program name ./a.out
```

```
The argument supplied is testing1 testing2
```