**Introduction to C Programming**

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 application programs have been written in C. C has now become a widely used professional language for various reasons −

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

**Facts about C**

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

**Why use C?**

C was initially used for system development work, particularly 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 the 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

**Example:/\*Program to Display a message\*/**

**#include<stdio.h>**

**main()**

**{ clrscr();**

**printf(“Hello,World”);**

**return(0);**

**}**

Let us take a look at the various parts of the above program −

* 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.
* The next line *int main()* is the main function where the program execution begins.
* 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.
* The next line *printf(...)* is another function available in C which causes the message "Hello, World!" to be displayed on the screen.
* The next line **return 0;** terminates the main() function and returns the value

# C - Basic Syntax

You have seen the basic structure of a 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 a 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.

Given below 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 terminate 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, 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 constants or variables 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 to increase readability.

# C - Data Types

Data types in c 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.

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

type variable\_list;

Here, **type** must be a valid C data type including char, w\_char, int, float, double, bool, or any user-defined object; 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;

# C - Constants & Literals

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

# C - Operators

An operator is a symbol that tells the compiler to perform specific mathematical or logical functions. 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

**Arithmetic Operators**

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

|  |  |  |
| --- | --- | --- |
| **Operator** | **Description** | **Example** |
| + | Adds two operands. | A + B = 30 |
| − | Subtracts second operand from the first. | A − B = 10 |
| \* | Multiplies both operands. | A \* B = 200 |
| / | Divides numerator by de-numerator. | B / A = 2 |
| % | Modulus Operator and remainder of after an integer division. | B % A = 0 |
| ++ | Increment operator increases the integer value by one. | A++ = 11 |
| -- | Decrement operator decreases the integer value by one. | A-- = 9 |

**Relational Operators**

The following table shows all the relational operators supported by C. Assume variable **A** holds 10 and variable **B** holds 20 then −

|  |  |  |
| --- | --- | --- |
| **Operator** | **Description** | **Example** |
| == | Checks if the values of two operands are equal or not. If yes, then the condition becomes true. | (A == B) is not true. |
| != | Checks if the values of two operands are equal or not. If the values are not equal, then the 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 the 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 the 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 the 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 the condition becomes true. | (A <= B) is true. |

**Logical Operators**

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

|  |  |  |
| --- | --- | --- |
| **Operator** | **Description** | **Example** |
| && | Called Logical AND operator. If both the operands are non-zero, then the condition becomes true. | (A && B) is false. |
| || | Called Logical OR Operator. If any of the two operands is non-zero, then the condition becomes true. | (A || B) is true. |
| ! | Called Logical NOT Operator. It is used to reverse the logical state of its operand. If a condition is true, then Logical NOT operator will make it false. | !(A && B) is true. |

**Assignment Operators**The following table lists the assignment operators supported by the C language −

|  |  |  |
| --- | --- | --- |
| **Operator** | **Description** | **Example** |
| = | Simple assignment operator. Assigns values from right side operands to left side operand | C = A + B will assign the value of A + B to C |
| += | Add AND assignment operator. It adds the right operand to the left operand and assign the result to the left operand. | C += A is equivalent to C = C + A |
| -= | Subtract AND assignment operator. It subtracts the right operand from the left operand and assigns the result to the left operand. | C -= A is equivalent to C = C - A |
| \*= | Multiply AND assignment operator. It multiplies the right operand with the left operand and assigns the result to the left operand. | C \*= A is equivalent to C = C \* A |

# C - Decision Making

Decision making structures require that the programmer specifies 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.

Show below 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 the following types of decision making statements.

**The ? : Operator**

We have covered **conditional operator ? :** in the 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

You may encounter situations, when a block of code needs to be executed 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. Given below is the general form of a loop statement in most of the programming languages −

.

# 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 is such that 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, **strcat()** to concatenate two strings, **memcpy()** to copy one memory location to another location, and many more functions.

A function can also be referred as 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 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**

Given below is the source code for a function called **max()**. This function takes two parameters num1 and num2 and returns the maximum value 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(), the function declaration is as follows −

int max(int num1, int num2);

Parameter names are not important in function declaration only their type is required, so the following is also a 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, the program control is transferred to the called function. A called function performs a defined task and when its return statement is executed or when its function-ending closing brace is reached, it returns the program control back to the main program.

To call a function, you simply need to pass the required parameters along with the function name, and if the function returns a value, then you can store the 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;

}

# C - Arrays

Arrays a kind of data structure that 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];

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

## Initializing Arrays

You can initialize an 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 { } cannot 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 the 5th element in the array with a value of 50.0. All arrays have 0 as the index of their first element which is also called the base index and the last index of an array will be total size of the array minus 1. Shown below is the pictorial representation of the 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 the 10th element from the array and assign the value to salary variable. The following example Shows how to use all the three above mentioned concepts viz. declaration, assignment, and accessing arrays −

#include <stdio.h>

int main () {

int n[ 10 ]; /\* n is an array of 10 integers \*/

int i,j;

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

for ( i = 0; i < 10; i++ ) {

n[ i ] = i + 100; /\* set element at location i to i + 100 \*/

}

/\* output each array element's value \*/

for (j = 0; j < 10; j++ ) {

printf("Element[%d] = %d\n", j, n[j] );

}

return 0;

}

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

Element[0] = 100

Element[1] = 101

Element[2] = 102

Element[3] = 103

Element[4] = 104

Element[5] = 105

Element[6] = 106

Element[7] = 107

Element[8] = 108

Element[9] = 109

# C - Pointers

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 prints 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 the following result −

Address of var1 variable: bff5a400

Address of var2 variable: bff5a3f6

## 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 using 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 \* used to declare a pointer is the same asterisk used for multiplication. However, in this statement the asterisk is being used to designate a variable as a pointer. Take a look at some of the valid pointer declarations −

int \*ip; /\* pointer to an integer \*/

double \*dp; /\* pointer to a double \*/

float \*fp; /\* pointer to a float \*/

char \*ch /\* pointer to a character \*/

# C - Strings

Strings are actually one-dimensional array of characters 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 the above defined string in C/C++ −



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 the 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 the following result −

Greeting message: Hello

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

|  |  |
| --- | --- |
| **S.N.** | **Function & Purpose** |
| 1 | **strcpy(s1, s2);**  Copies string s2 into string s1. |
| 2 | **strcat(s1, s2);**  Concatenates string s2 onto the end of string s1. |
| 3 | **strlen(s1);**  Returns the length of string s1. |
| 4 | **strcmp(s1, s2);**  Returns 0 if s1 and s2 are the same; less than 0 if s1<s2; greater than 0 if s1>s2. |
| 5 | **strchr(s1, ch);**  Returns a pointer to the first occurrence of character ch in string s1. |
| 6 | **strstr(s1, s2);**  Returns a pointer to the first occurrence of string s2 in string s1. |

The following example uses some 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 lenghth 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 the following result −

strcpy( str3, str1) : Hello

strcat( str1, str2): HelloWorld

strlen(str1) : 10

# C - Structures

Arrays allow to define type of variables that can hold several data items of the same kind. Similarly **structure** is another user defined data type available in C that allows 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. The format of the struct statement is as follows −

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 the keyword **struct** to define variables of structure type. The following example shows how to use a structure in a program −

#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